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References to HQ AETC/SGD should be changed to AFMOA/SGD throughout the document.

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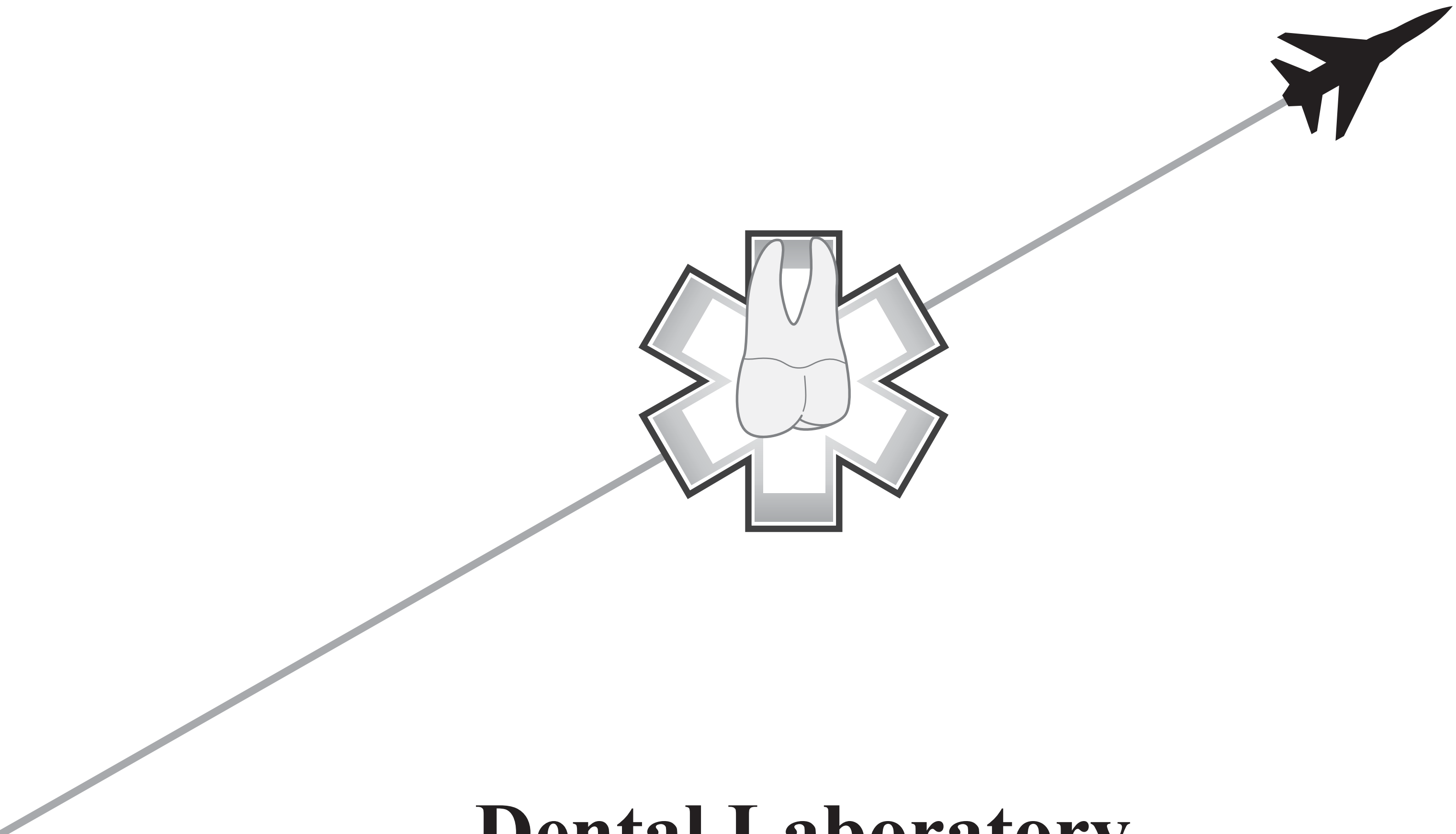

Dental Laboratory Technology

Fixed and Special Prosthodontics

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BY ORDER OF THE SECRETARY OF THE AIR FORCE

AIR FORCE PAMPHLET 47-103 VOLUME 2

15 NOVEMBER 2005

Dental

DENTAL LABORATORY TECHNOLOGY—FIXED AND SPECIAL PROSTHODONTICS

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(MSgt Andrea E. Bates)
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This pamphlet implements AFPD 47-1, *Dental Services*. It is the second of two volumes that form the training foundation for the Tri-Service Dental Laboratory Apprentice Course, J3ABR4Y032-005 (available at https://etca.randolph.af.mil), and the Air Force Career Development Course (4Y052). In addition, it is a working reference for all dental laboratory technicians.

This volume covers basic knowledge and procedures necessary to construct fixed and special prostheses in the dental laboratory. Volume 2 defines the dental laboratory specialty and its mission, presents subject knowledge necessary to deal with technical problems and work as a dental laboratory technician, introduces laboratory safety and infection control practices, and details procedures necessary to construct removable dental prostheses and orthodontic appliances. It is to be used by the Dental Corps of the Medical Service, resident dental laboratory courses, 381 TRS, and all dental laboratories in the US Air Force.

Send comments and recommendations for improving this publication to 381 TRS/XWAA, 917 Missile Road, Sheppard AFB TX 76311-2246. Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with AFMAN 37-123, *Management of Records,* and disposed of in accordance with the Air Force Records Disposition Schedule (RDS) located at https://afrims.amc.af.mil/rds/index.cfm. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

See Attachment 1 (Glossary of References and Supporting Information), Attachment 2 (Prefixes and Suffixes), and Attachment 3 (Subject Index).

SUMMARY OF REVISIONS

This instruction is substantially revised and must be completely reviewed.

This volume and Volume 1 incorporate all of the material in the previous three volumes of AFP 162-6. This volume updates basic knowledge and procedures necessary to construct fixed and special prostheses in the dental laboratory. It adds information on the In-Ceram® System, porcelain laminate veneers, the IPS Empress® system (pressable ceramics), Targis all-resin crowns, Sinfony resin-veneered metal crowns, dental implants, sleep apnea appliances, and custom earpieces. It deletes pontics with prefabricated porcelain or plastic facings and porcelain jacket crowns.

Chapter 1—CONVENTIONAL FIXED PROSTHODONTIC RESTORATIONS

Section 1A Definitions

1.1. Fixed Prosthesis ... 14
1.2. Die ... 14
1.3. Wax Pattern ... 14

Section 1B Types of Fixed Prostheses

1.4. Inlays ... 14
Figure 1.1. Inlay Classifications ... 15
Figure 1.2. MOD (Class II) Inlay ... 15
1.5. Pinledges ... 15
1.6. Onlays and Veneers ... 15
1.7. Artificial Crowns ... 16
Figure 1.3. Some Types of Artificial Crowns ... 16
1.8. Fixed Partial Denture (FPD) ... 16
Figure 1.4. Post Crown ... 17
Figure 1.5. Parts of a Typical FPD ... 17
Figure 1.6. Prefabricated Pontics and Backings ... 18
Figure 1.7. Nonrigid Connector ... 19
1.9. Fixed Splints ... 19
1.10. Interim FPD ... 20

Section 1C Fixed Cast Restoration

1.11. Procedural Overview ... 20

Section 1D Occlusion Factors Pertaining to Fixed Prosthodontics

1.12. Increasing Occlusal Stability ... 20
Figure 1.8. Avoiding a "Locked" Bite ... 22
Figure 1.9. Centric Contact Points (Closure Stoppers and Equalizers) ... 22
Figure 1.10. Location of Closure Stoppers and Equalizers (Sagittal View) ... 23

Section 1E Diagnostic Casts, Interim Fixed Prostheses, and Custom Trays

1.13. Preliminary Impressions and Diagnostic Casts ... 24
1.14. Interim (Provisional) Fixed Restorations ... 24
Figure 1.11. Vacuum-Forming Method for Interim Prostheses ... 25
Figure 1.12. Silicone Template Method for Interim FPDs ... 27
1.15. Custom Trays ... 27
Figure 1.13. Maxillary and Mandibular Acrylic Resin Custom Trays ... 28

Section 1F Dies and Working Casts

1.16. Overview ... 28
Figure 1.14. Improved Stone Die Made From a Tube Impression ... 29
1.17. Individual Dies Made From Tube Impressions ... 29
1.18. Removable Die Systems ... 30
1.19. Dowel Pin Systems ... 30
1.20. Saw-Out Technique for Elastomeric Impressions ... 30
Figure 1.15. Dowel Pin Removable Dies (Saw-Out Technique) ... 31
1.21. Saw-Out Technique for Reversible Hydrocolloid Impressions ... 33
1.22. Matrix Band Shim Method ... 33
Figure 1.16. Dowel Pin Removable Dies (Shim Method) ... 33
1.23. Pindex Instrument and Technique ... 35

1.24. Silver-Plating Polysulfide and Silicone Impressions 35
Figure 1.17. Dowel Pin Removable Dies (Pindex Method) 36
1.25. Removable Dies and a Working Cast Made From a Combination of a Tube Impression, Transfer Copings, and a Tray Impression 37
1.26. Solid Working Casts 38
Figure 1.18. Solid Working Cast With Augmenting Individual Dies 39
Figure 1.19. One-Piece Die for an FPD 39

Section 1G Cast-Mounting Procedures
1.27. Overview 39
1.28. Die Extension Access 39
1.29. Mounting the Maxillary Cast 40
1.30. Mounting the Mandibular Cast 41
1.31. Semiadjustable Articulator Settings (Hanau H2 and Whip-Mix) 42
Figure 1.20. Adjusting Horizontal and Lateral Condylar Guidance (Whip-Mix Articulator) 44
1.32. Microscope Utilization 45
1.33. Die and Working Cast Preparation Before Waxing 45
Figure 1.21. Preparation Forms 46
Figure 1.22. Margin Styles 46
Figure 1.23. Pattern Contour Influenced by Die Trimming 47
Figure 1.24. Bulk-Trimming and Refining a Die Margin 47

Section 1H Esthetics
1.34. Overview 48
1.35. Morphology of Anterior Teeth 48
Figure 1.25. Attrition of Maxillary Incisors With Aging 49
Figure 1.26. Exposed Dentin Caused by Attrition of Mandibular Incisors 50
Figure 1.27. Attrition and Soft Tissue Recession of Maxillary Teeth With Aging 51
Figure 1.28. Effect of Patient Profile on the Surface Form of Teeth 51
1.36. Improving Esthetics 52
Figure 1.29. Surface Characterization of Maxillary Anterior Teeth 53
Figure 1.30. Making Narrow Teeth Appear Wider 53
Figure 1.31. Making Wide Teeth Appear Narrower 53
Figure 1.32. Cervical Collar and Shading To Reduce Length 54

Section 1I Waxing Individual Cast Restorations and FPD Retainers
1.37. Overview 54
Figure 1.33. Effect of Subtle Axial Rotation on Appearance 55
Figure 1.34. Effect of Rotation on Apparent Width 55
1.38. Determining the Occlusion Scheme for the Fixed Prosthesis and Setting the Incisal Guide Table 55
Figure 1.35. Setting the Incisal Guide Table 56
1.39. Instruments 57
1.40. Materials 58
1.41. Steps in Waxing a Pattern 58
Figure 1.36. Negative Waxing of a Pattern 59
1.42. Anatomic Versus Functional Contouring of Wax Patterns 59
1.43. Labial and Lingual Contours 60
Figure 1.37. Emergence Profile 60
Figure 1.38. Facial and Lingual Heights of Contour of Posterior Teeth 61

1.44. Contours for Intracoronal Restoration Patterns (Inlays) 61
1.45. Contours for Anterior Extracoronal Restoration Patterns
(Partial and Complete Crowns) 61
Figure 1.39. Proximal Contact Relationships Among Anterior Teeth 62
1.46. Contours for Posterior Extracoronal Restoration Patterns
(Partial and Complete Crowns, Onlays) 62
Figure 1.40. Posterior Contact Area and Embrasure Characteristics 63
Figure 1.41. Maxillary and Mandibular Contact Areas (Occlusal View) 63

Section 1J Wax-Added Technique
1.47. Overview 64
1.48. Standardized Waxing Sequence 64
1.49. Specific Steps in the Waxing Sequence 65
Figure 1.42. Placement of Maxillary and Mandibular Stamp Cusp Cones 65
Figure 1.43. Cusp-Fossa MI Contacts 66
Figure 1.44. Placement of Maxillary and Mandibular Shearing Cusp Cones 67
Figure 1.45. Placement of Marginal Ridge Segments 68
Figure 1.46. Marginal Ridge Contours (Buccal View) 68
Figure 1.47. Placement of Stamp Cusp and Shearing Cusp Triangular Ridges 69
Figure 1.48. Stamp Cusp Working and Balancing Paths Out of a Fossa MI 70
Figure 1.49. Placement of Secondary Anatomy and a Cross-Section View of Cusp Placement 71

Section 1K Casting Production
1.50. Overview 71
1.51. Rules of Casting 71
Table 1.1. Rules of Casting 73
1.52. Spruing 74
Figure 1.50. Examples of Direct Spruing 75
Figure 1.51. Directly Sprued Wax Pattern Attached to a Sprue Base 75
Figure 1.52. Auxiliary Spruing of Single Patterns 76
Figure 1.53. Indirect Spruing of Multiple Joined Patterns 76
Figure 1.54. Indirect Spruing of Multiple Independent Patterns 77
Figure 1.55. Schematic View of a Sprued Pattern in a Casting Ring 78
1.53. Venting a Sprued Pattern 78
Figure 1.56. Vented Pattern 78
1.54. Investing 79
Figure 1.57. Investing With a Vacuum Spatulator 80
Figure 1.58. Hygroscopic Expansion Water Bath 81
Figure 1.59. Breaking the Top Surface Glaze of the Set Investment 82
1.55. Wax Elimination (Burnout) 82
Figure 1.60. Placement of Rings in the Burnout Furnace 83
1.56. Casting With a Gas-Air Torch and Centrifugal Casting Machine 84
Figure 1.61. Parts of a Gas-Air Torch Flame 85
1.57. Cleaning and Pickling (Deoxidizing) the Casting 86
Figure 1.62. Melting the Gold Alloy and Positioning the Ring in the Casting Machine 87
Figure 1.63. Microblasting Process 88
Figure 1.64. Pickling a Casting 88
1.58. Finishing and Polishing the Casting 88
Figure 1.65. Finishing and Polishing a Casting for Try-In 90
Figure 1.66. Final Polish 91

Section 1L FPDs (Retainers, Pontics, and Connectors)
1.59. Overview ... 91
Figure 1.67. Parts of an FPD ... 92
1.60. FPD Designs ... 92
Figure 1.68. Intermediate Abutment ... 93
1.61. Steps in FPD Construction ... 93
1.62. Materials Used in Making FPDs ... 93
1.63. Retainer Construction ... 94
Figure 1.69. Fabricating a Posterior FPD ... 94
1.64. Pontic Designs ... 95
Figure 1.70. Modified Ridgelap Pontic Forms ... 95
Figure 1.71. Modified Ridegelap Pontic Gingival Contact Area ... 96
Figure 1.72. Conical Pontic Design ... 96
1.65. Pontic Construction (Figure 1.69) ... 96
Figure 1.73. Hygienic Pontic Design ... 97
Figure 1.74. Positioning the Cervical Line of an Anterior Pontic ... 98
Figure 1.75. Mesiodistal Convexity ... 98
1.66. Pontic Occlusion ... 99
1.67. Pontic Occlusal Surface Area ... 99
Figure 1.76. Occlusal Table Width Compared to Overall Buccal-Lingual Width ... 99
1.68. FPD Connectors ... 99
Figure 1.77. Single-Piece Casting of an FPD ... 100
Figure 1.78. Semiprecision Attachment ... 101
Figure 1.79. Fabricating an FPD With a Semiprecision Attachment ... 102
Figure 1.80. Technician-Fabricated Key and Keyway ... 103
1.69. Completing the Wax-Up ... 104
Figure 1.81. Refine the Margins and Smooth the Wax Patterns ... 104
1.70. Spruing ... 105
Figure 1.82. Spruing an FPD ... 105
1.71. Investing ... 105
1.72. Burnout ... 105
1.73. Casting ... 105
1.74. Finishing the FPD ... 105
1.75. Soldering ... 105
Figure 1.83. Solder Joint Between Two Posterior Castings (Proximal View) ... 106
Figure 1.84. Solder Joint Between Two Posterior Castings (Buccal View) ... 106
Figure 1.85. Testing the Width of the Solder Gap ... 107
Figure 1.86. Stone Index Method of Fabricating a Solder Investment Patty ... 108
Figure 1.87. Resin Method ... 109
Figure 1.88. Secondary Laboratory Solder Relationship Index ... 110
Figure 1.89. Soldering an FPD ... 111
1.76. Repairing Metal Castings ... 112
Figure 1.90. Adding a Proximal Contact ... 112
Figure 1.91. Repairing Casting Voids ... 113

Section 1M Remounting Casts with Low-Fusing Metal
1.77. Overview ... 113
1.78. Remount Procedures ... 114

Section 1N Post and Core Castings
1.79. Construction Procedures ... 114
Figure 1.92. Post and Core Castings for Anterior and Posterior Teeth ... 114
Figure 1.93. Post and Core Construction ... 115

Chapter 2—METAL-CERAMIC RESTORATIONS

Section 2A Metal-Ceramic System
2.1. Overview ... 117
2.2. Physical Characteristics of the Metal-Ceramic System ... 117
Figure 2.1. Veneer and Metal Thickness ... 118

Section 2B Color and Shade Selection
2.3. Color ... 119
Figure 2.2. Color Wheel ... 120
2.4. Selecting a Shade ... 121

Section 2C Substructure Design and Fabrication
2.5. Factors in Substructure Design ... 121
Figure 2.3. Typical Tooth Preparation for Anterior Metal-Ceramic Restorations ... 122
Figure 2.4. Balancing the Compressive Strength of Porcelain ... 123
Figure 2.5. Creating a 90-Degree Angle Butt Joint for Porcelain ... 123
Figure 2.6. Porcelain Shoulder Margin ... 124
Figure 2.7. Metal-Ceramic Design for Anterior Crowns ... 124
Figure 2.8. Placement of the Metal-Ceramic Junction on Posterior Occlusals ... 125
Figure 2.9. Improper Placement of the Metal-Ceramic Junction ... 126
Figure 2.10. Typical Metal-Ceramic Substructure for Anterior FPDs ... 126
2.6. Waxing ... 126
Figure 2.11. Metal-Ceramic Design for Pontics ... 127
Figure 2.12. Facial Core Used To Check Cutback ... 127
Figure 2.13. Cutback Technique for Crown Patterns ... 128
Figure 2.14. Cutback Technique for FPD Patterns ... 129
2.7. Spruing ... 129
Figure 2.15. Direct Spruing of Wax Substructure Patterns ... 130
Figure 2.16. Placement of Chill Vents on a Substructure Pattern ... 131
Figure 2.17. Placement of Metal-Ceramic Patterns Outside the Thermal Zone ... 131
2.8. Investing ... 132
2.9. Burnout ... 132
2.10. Casting ... 133
2.11. Finishing ... 133
Figure 2.18. Surface Preparation of a Metal-Ceramic FPD ... 134
Figure 2.19. Law of Beams ... 135

Section 2D Porcelain Application and Firing
2.12. Pretreatment of the Metal Surface ... 136
2.13. Opaque Porcelain ... 138
2.14. Porcelain Application ... 139
Figure 2.20. Layering Technique for Porcelain Application ... 140
Figure 2.21. Separating the Units ... 144
Figure 2.22. Building Porcelain Cusps ... 145
Figure 2.23. Wraparound Effect of Enamel ... 146

Figure 2.24. Margin Designs for Collarless Crowns 146
Figure 2.25. Wax Patterns for Porcelain Margin Technique 147
Figure 2.26. Applying Shoulder Porcelain in the Porcelain Margin Technique 148
Figure 2.27. Dentin Effects in Dental Porcelain 149
Figure 2.28. Incisal Effects in Dental Porcelain 150
2.15. First Dentin-Enamel Firing 151

Section 2E Anatomical Contouring
2.16. Shaping the Sintered Porcelain Veneer 152
Figure 2.29. Contouring Metal-Ceramic Restorations 152
2.17. Establishing the Overall Contour 153
2.18. Characterizing the Veneer Surface 154
2.19. Establishing Occlusal Surfaces 154
2.20. Shaping FPDs 154
Figure 2.30. Types of Diamonds Used To Carve Porcelain Occlusals 155
Figure 2.31. Separation Between Units of Anterior FPDs 155
2.21. Second or Corrective Dentin-Enamel Firing 155
2.22. Repairing Porcelain (Low-Fusing, Air-Fired) 156

Section 2F Staining
2.23. Shade Modification and Characterization 156
Figure 2.32. Extrinsic Staining of Metal-Ceramic Crowns 157
Figure 2.33. Painting-Off Technique 158

Section 2G Glazing
2.24. Overview 159
2.25. Autogenous Method 159
2.26. Overglaze Method 160

Section 2H Soldering
2.27. Presolder 160
2.28. Postsolder Technique 161
Figure 2.34. Presolder Technique 162
Figure 2.35. Postsolder Technique 163
Figure 2.36. Investing a Metal-Ceramic Restoration (Cross-Section) 163

Section 2I Resin-Bonded FPDs (Maryland Bridge)
2.29. Design Factors 164
Figure 2.37. Resin-Bonded FPD Design 164
Figure 2.38. Seating Stops for Resin-Bonded FPDs 165
2.30. Framework Fabrication 165
Figure 2.39. Pulled Pattern Technique for a Resin-Bonded FPD 167
2.31. Bonding Preparation 168

Chapter 3—BASE METAL ALLOYS FOR FIXED PROSTHESES
3.1. Overview 169
3.2. Prosthodontic Uses 169
3.3. Alloy Composition 169
3.4. Possible Hazards 169
3.5. Technique Differences 169
3.6. Pattern Spruing 170

3.7. Investment and Burnout Procedures 171
3.8. Casting 171
3.9. Finishing Base Metal Castings........ 172

Chapter 4—ALL-CERAMIC FIXED PROSTHODONTIC RESTORATIONS

Section 4A Introduction
4.1. Overview........ 174
4.2. Preparation Requirements........ 174

Section 4B In-Ceram® System
4.3. Overview........ 174
Figure 4.1. Preparation Requirements for All-Ceramic Crowns........ 175
4.4. Procedures........ 175
Figure 4.2. Die Preparation for In-Ceram® Restoration........ 175
Figure 4.3. Fabrication of Refractory Cast for In-Ceram® Restoration 176
Figure 4.4. Mixing and Applying Slip Material for In-Ceram® Restoration 177
Figure 4.5. Sintering and Finishing In-Ceram® Restoration 178
Figure 4.6. Glass Infiltration of an In-Ceram® Crown........ 178
Figure 4.7. In-Ceram® Restoration Porcelain Application........ 179

Section 4C IPS Empress® System
4.5. Overview........ 179
4.6. Staining Technique 179
4.7. Layering Technique 179
Figure 4.8. Wax-Up for an IPS Empress® Crown........ 180
Figure 4.9. Spruing and Investing an IPS Empress® Crown........ 181
Figure 4.10. Burnout and Pressing an IPS Empress® Crown........ 181
Figure 4.11. Recovery of a Pressed IPS Empress® Crown 182
Figure 4.12. Stumpf Die Fabrication for an IPS Empress® Crown........ 183
Figure 4.13. Completion of an IPS Empress® Crown 183

Section 4D Porcelain Laminate Veneers
4.8. Overview........ 184
4.9. Refractory Technique........ 184
Figure 4.14. Master Cast Technique for Porcelain Laminate Veneers 185
Figure 4.15. Porcelain Application and Contouring........ 186
Figure 4.16. Sectioning the Cast Into Individual Dies 186
Figure 4.17. Completing the Veneers........ 187

Chapter 5—FIXED RESIN PROSTHODONTIC RESTORATIONS

Section 5A Introduction
5.1. Overview........ 188

Section 5B Targis™ All Resin Crown
5.2. Overview........ 188
5.3. Cast Preparation........ 188
5.4. Metal-Free Bridge Framework Fabrication 188
Figure 5.1. Wax Pontic Placement........ 189
Figure 5.2. Vectris™ Pontic Placement 189
Figure 5.3. Vectris™ VS1 Curing Unit........ 190

Figure 5.4. Vectris™ Framework Application 191
Figure 5.5. Vectris™ Framework Completion 191
5.5. Targis™ Dentin and Enamel Buildup 191
Figure 5.6. Targis™ Dentin and Enamel Buildup 192

Section 5C Sinfony® Resin-Veneered Metal Crown
5.6. Overview 193
Figure 5.7. Sinfony® Resin-Veneered Crown 194

Chapter 6—DENTAL IMPLANTS
6.1. Introduction 196
Figure 6.1. Implant Prosthesis 196
6.2. Standard Components for Implant Systems 196
Figure 6.2. Components of the Implant System 197
6.3. Procedural Overview 199
6.4. Osseointegration Process 199
Figure 6.3. Fabricating a Fixed Implant 200
6.5. Implant Surgery 200
6.6. Radiographic Templates 201
Figure 6.4. Fabricating a Partially Edentulous Radiographic Template 202
6.7. Surgical Guide Templates 203
Figure 6.5. Fabricating a Partially Edentulous Surgical Guide Template 203
6.8. Custom Tray 204
Figure 6.6. Fabricating an Implant Custom Tray 204
6.9. Master Cast 205
Figure 6.7. Master Cast Procedures 206
6.10. Provisional Restorations 206
Figure 6.8. Laboratory-Fabricated Provisional 207
6.11. Procedures for Single-Tooth, Cemented Restoration 208
6.12. Ceramic Cap Restoration 208
Figure 6.9. Cement-Retained, Ceramic-Cap Implant 208
6.13. Gold Cylinder Restoration 209
6.14. Burnout Cap Restoration 209
6.15. Procedures for Screw-Retained Restorations 209
Figure 6.10. Cement-Retained, Burnout-Cap Implant 210
Figure 6.11. Screw-Retained, Cast-To-Restoration 211
Figure 6.12. Screw-Retained, Castable Substructure 213
6.16. Procedures for Implant-Retained Removable Prosthesis 214
6.17. Bar and Clip Retained Overdenture 214
Figure 6.13. Bar and Clip Overdenture Procedures 215

Chapter 7—SPECIAL PROSTHESES

Section 7A Treatment Appliances
7.1. Types of Basic Orthopedic Appliances 217
Figure 7.1. Basic Orthopedic Appliance 218
7.2. Soft Acrylic Mandibular Orthopedic Appliance 220
7.3. Other Basic Orthopedic Appliance Designs 220
7.4. Fabricating a Thermoplastic Vinyl Mouth Protector 220
Figure 7.2. Mouth Protector Fabrication 221

7.5.	Sleep Apnea Appliance	222
Figure 7.3.	Sleep Apnea Appliance	223
7.6.	Surgical Splints	224
Figure 7.4.	Acrylic Resin Fixation Splint	225
Figure 7.5.	Gunning Splint	227
7.7.	Specifications and Laboratory Procedures for Cast Arch Bars	227
7.8.	Impressions and Jaw Relationship Record for Cast Arch Bars	227
7.9.	Construction Specifications for Cast Arch Bars	227
Figure 7.6.	Cast Arch Bar Seated on the Working Cast	228
Figure 7.7.	Cast Arch Bar With Denture Base Modification	229
7.10.	Laboratory Procedures for Cast Arch Bars	229
Figure 7.8.	Blockout and Relief of the Master Cast	230
Section 7B	***Face Form Cast (Moulage)***	
7.11.	Custom-Fitted Mask	230
7.12.	Procedures for Making a Face Form Cast	230
Figure 7.9.	Required Equipment and Materials	231
Figure 7.10.	Patient Reclined in a Horizontal Position	231
Figure 7.11.	Measuring Facial Diameter With a Length of Wire Solder	232
Figure 7.12.	Tracing Facial Diameter on a Cardboard Sheet	232
Figure 7.13.	Cutting the Facial Outline From the Cardboard	232
Figure 7.14.	Patient Prepared for the Impression	233
Figure 7.15.	Applying Alginate Mix to the Face	234
Figure 7.16.	Trimming Excess Alginate After Completion of the Impression	234
Figure 7.17.	Shielding Straws While Spraying Adhesive for Alginate	235
Figure 7.18.	Applying Supporting Stone to the Alginate Impression	235
Figure 7.19.	Supporting Stone Layer Completed to a Depth of 1/2 Inch	236
Figure 7.20.	Looking Into the Completed Impression	236
Figure 7.21.	Oblique View Showing Cast Thickness	236
Figure 7.22.	Lateral View of the Face Form Cast	237
Figure 7.23.	Frontal View of the Face Form Cast	237
Section 7C	***Cleft Palates and Obturators***	
7.13.	Cleft Palates	237
Figure 7.24.	Cleft Palates	238
7.14.	Obturator	238
7.15.	Retention Factors	238
Figure 7.25.	Normal and Cleft Palate Anatomy Contrasted	239
Figure 7.26.	Parts of the Obturator	240
7.16.	Fabrication Procedures	240
Figure 7.27.	Obturator Fabrication	240
Section 7D	***Custom Earpiece***	
7.17.	Introduction	241
7.18.	Fabricating a Custom Earpiece	242
Figure 7.28.	Fabricating a Custom Earpiece	243
Chapter 8—WEIGHTS AND MEASURES		
8.1.	Carat and Fineness of Gold Alloy	245
Table 8.1.	Carat and Fineness Conversion Chart	245

8.2. Measuring Temperature ... 246
Figure 8.1. Centigrade-Fahrenheit Conversion Scale ... 246
8.3. Systems of Measuring Weight ... 247
Figure 8.2. Comparison of Weight Measurements ... 247
8.4. Measurements of Length ... 248
Figure 8.3. Comparison of Metric and Equivalent Linear Lengths ... 248
8.5. Measure of Liquid or Volume ... 248
8.6. Standards ... 248
8.7. Melting Points of Pure Metals ... 248
Figure 8.4. One Cubic Centimeter ... 249
Figure 8.5. Comparison of Apothecaries and Metric Equivalents ... 249
Table 8.2. Brown and Sharpe Gauge (or American Wire Gauge) ... 250

Chapter 9—DENTAL LABORATORY EQUIPMENT IDENTIFICATION, PREVENTIVE MAINTENANCE, AND SAFETY

9.1. Introduction ... 251
9.2. Articulator ... 251
Figure 9.1. Whip-Mix and Hanau H2 158 Articulators ... 251
9.3. Autoduplicator ... 252
Figure 9.2. Ticonium® Autoduplicator ... 252
9.4. Hygroscopic Water Bath ... 252
Figure 9.3. Hygroscopic Water Bath ... 253
9.5. Shell or Sand Blaster ... 253
Figure 9.4. Shell or Sand Blaster ... 254
9.6. Bunsen Burner ... 254
Figure 9.5. Hanau Touch-O-Matic® Burner ... 254
9.7. Casting Machine (General) ... 254
Figure 9.6. Casting Machine (Unitek® Autocast) ... 255
9.8. Broken-Arm Casting Machine With Safety Lid ... 255
Figure 9.7. Broken-Arm Casting Machine With Safety Lid ... 256
Figure 9.8. Broken-Arm Casting Machine ... 256
9.9. Ticomatic® Electric Casting Machine ... 256
Figure 9.9. Ticomatic® Casting Machine ... 257
9.10. Pneumatic Chisel ... 257
9.11. Wells® Quick-Release Chuck ... 257
Figure 9.10. Ticomatic® Casting Arm ... 258
Figure 9.11. Pneumatic Chisel ... 258
Figure 9.12. Wells® Quick-Release Chuck ... 259
9.12. Ultrasonic Cleaning Unit ... 259
Figure 9.13. Ultrasonic Cleaning Unit ... 259
9.13. Hanau Model II® Curing Unit ... 260
Figure 9.14. Hanau Model II® Curing Unit ... 260
9.14. Ivocap® Curing Unit ... 261
Figure 9.15. Ivocap® Curing Unit ... 261
9.15. Pindex® Dowel Pin Drill ... 261
Figure 9.16. Pindex® Dowel Pin Drill ... 262
9.16. Ticonium® Electro Polisher ... 262
9.17. Denture Flask ... 262

Figure 9.17. Ticonium® Electro Polisher 263
Figure 9.18. Denture Flask (Closed) 263
Figure 9.19. Denture Flask (Exposed View) 263
9.18. Electric Handpiece 264
Figure 9.20. Electric Handpiece 264
9.19. Beeswax Heater 264
Figure 9.21. Beeswax Heater 265
9.20. Dura Dip® Electronic Wax Heater 265
Figure 9.22. Dura Dip® Electronic Wax Heater 265
9.21. Electric Wax Heater (General) 266
Figure 9.23. Electric Wax Heater 266
9.22. High Speed Turbine Handpiece 266
Figure 9.24. High Speed Turbine Handpiece 266
9.23. Whip-Mix® Vacuum Investor 267
Figure 9.25. Whip-Mix® Vacuum Investor 267
9.24. Reline Jig 267
Figure 9.26. Jectron® Reline Jig 268
9.25. Bench-Mounted Lathe 268
Figure 9.27. Bench-Mounted Lathe 268
9.26. Lathe Polishing Unit 269
Figure 9.28. Kavo® Polishing Unit 269
Figure 9.29. Floor-Mounted Lathe 269
9.27. High-Speed, Metal-Finishing Lathe 270
Figure 9.30. High-Speed, Metal-Finishing Lathe 270
9.28. Comco® Microblaster and Work Station 270
Figure 9.31. Comco® Microblaster and Work Station 271
9.29. ESPE Rocatector® Microblaster 272
Figure 9.32. ESPE Rocatector® Microblaster 272
9.30. Microscope 272
Figure 9.33. Stereo Microscope 273
9.31. Dehydrating Oven 273
Figure 9.34. Dehydrating Oven 273
9.32. Fixed Prosthetic Burnout Oven 274
Figure 9.35. Fixed Prosthetic Burnout Oven (Jelenko Accu-Therm II 750®) 274
9.33. Porcelain Oven 274
Figure 9.36. Dentsply® Multimat 99 Porcelain Oven With Moveable Muffle 275
Figure 9.37. Jelenko® Commodore 100 With Stationary Muffle 275
Figure 9.38. Ivoclar® Programat P-80 With Hinge Muffle 276
9.34. Ticonium® Super Oven 276
Figure 9.39. Ticonium® Super Oven 276
9.35. Pressure Pot 277
Figure 9.40. Pressure Pot 277
9.36. Carrier Flask Press 278
Figure 9.41. Carrier Flask Press 278
9.37. Hydraulic Flask Press 278
9.38. Pneumatic Flask Press 278
Figure 9.42. Ivocap® Hydraulic Flask Press 279
Figure 9.43. Pneumatic Flask Press 279

9.39. Biostar® Pressure-Moulding Machine 279
Figure 9.44. Ivocap® Pneumatic Press 280
Figure 9.45. Biostar® Pressure-Moulding Machine 280
9.40. Vacuum Pump 280
Figure 9.46. Vacuum Pump 281
9.41. Laboratory Electronic Scale 281
Figure 9.47. Laboratory Electronic Scale 281
9.42. Precious Metals Balance Scale 282
Figure 9.48. Precious Metal Balance Scale 282
9.43. Electric Soldering Unit 282
9.44. Hydroflame® Soldering Unit 282
Figure 9.49. Electric Soldering Unit 283
Figure 9.50. Hydroflame® Soldering Unit 283
9.45. Steam Cleaner 284
Figure 9.51. Steam Cleaner 284
9.46. Boilout Tanks 284
Figure 9.52. Boilout Tanks 285
9.47. Gas and Air Casting Torch (Multiorifice Blowpipe) 285
Figure 9.53. Gas and Air Casting Torch 285
9.48. Alcohol Torch 285
Figure 9.54. Alcohol Torch 286
9.49. Cast Trimmer 286
Figure 9.55. Cast Trimmer 286
9.50. Ticonium® Twin Controller 287
Figure 9.56. Ticonium® Twin Controller 287
9.51. Vacuum Former 287
Figure 9.57. Vacuum Former 288
9.52. Vibrator 288
Figure 9.58. Vibrator 288
9.53. Electric Waxing Unit 289
Figure 9.59. Electric Waxing Unit 289

Attachment 1—GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION 290

Attachment 2—PREFIXES AND SUFFIXES 320

Attachment 3—SUBJECT INDEX 324

Chapter 1

CONVENTIONAL FIXED PROSTHODONTIC RESTORATIONS

Section 1A—Definitions

1.1. Fixed Prosthesis. A *fixed prosthesis* is any of a variety of replacements for a missing tooth or a part of a tooth a dentist attaches to the mouth and the patient cannot remove. Restoration such as inlays, pinledge castings, onlays, crowns, veneers, and fixed partial dentures (FPD) fall into this category. A fixed prosthesis may be constructed entirely from cast metal alloy, acrylic resin, or a variety of porcelains. It may also be constructed from a combination of these materials.

1.2. Die. A *die* is a positive reproduction of a prepared tooth made from a suitable, hard substance (improved artificial stone or metal). A die can be constructed from a complete arch, partial arch, or individual tooth impression. Fixed prostheses are made by either the direct or indirect method. The dentist uses the *direct method* when carving the form of the restoration on the natural tooth in the patient's mouth. The dentist or technician uses the *indirect method* when forming the shape of the restoration outside of the mouth on a die. Because there is such overwhelming dependence on dies in fixed prosthetic dentistry, a die has to be extraordinarily accurate and methods of maintaining the positions of dies on casts must be perfectly dependable.

1.3. Wax Pattern. With the exception of complete porcelain or resin restorations, at least part of a fixed prosthesis is cast in metal. Castings are made from wax patterns. A *wax pattern* is an exact wax replica of a desired shape. When the wax pattern is invested and burned out, a casting can be made in the resultant mold. If the dentist carves the pattern wax in the patient's mouth, it is a *direct pattern.* Small inlays and complete crown cores are sometimes done this way. If the wax pattern is adapted and carved on a die, it is a *indirect pattern.*

Section 1B—Types of Fixed Prostheses

1.4. Inlays:

1.4.1. An *inlay* is a dental restoration that fits *into* a prepared cavity. It is held in place by its precision fit and by using a bonding composite method or a cementing medium. Because inlays are, for the most part, surrounded by intact tooth structure, they are often called *intracoronal restorations.* The various forms of inlays are primarily used to restore individual tooth contours and function. In the majority of cases, an inlay is not a suitable anchor casting (retainer) for an FPD. Inlays are usually cast in medium hard gold, but they can be made of porcelain or acrylic resin. There are five classes of inlays, based on the location of the surfaces being restored (shown in Figure 1.1 and as follows):

1.4.1.1. Class I—Located on the occlusal surfaces of premolars or molars.

1.4.1.2. Class II—Located on an occlusal surface combined with one or both proximal surfaces.

1.4.1.3. Class III—Made for the mesial or distal surfaces of anterior teeth. This classification does not involve incisal angles.

1.4.1.4. Class IV—Made for the mesial and distal surface of an anterior tooth plus one or both of its incisal angles.

1.4.1.5. Class V—Limited to the facial surface of any of the teeth.

1.4.2. A more specific way of naming an inlay is to cite the tooth surfaces it restores. Examples include a disto-incisal (DI) inlay, mesio-inciso-distal (MID) inlay, mesio-occlusal (MO) inlay, and mesio-occluso-distal (MOD) inlay (shown in Figure 1.2).

Figure 1.1. Inlay Classifications.

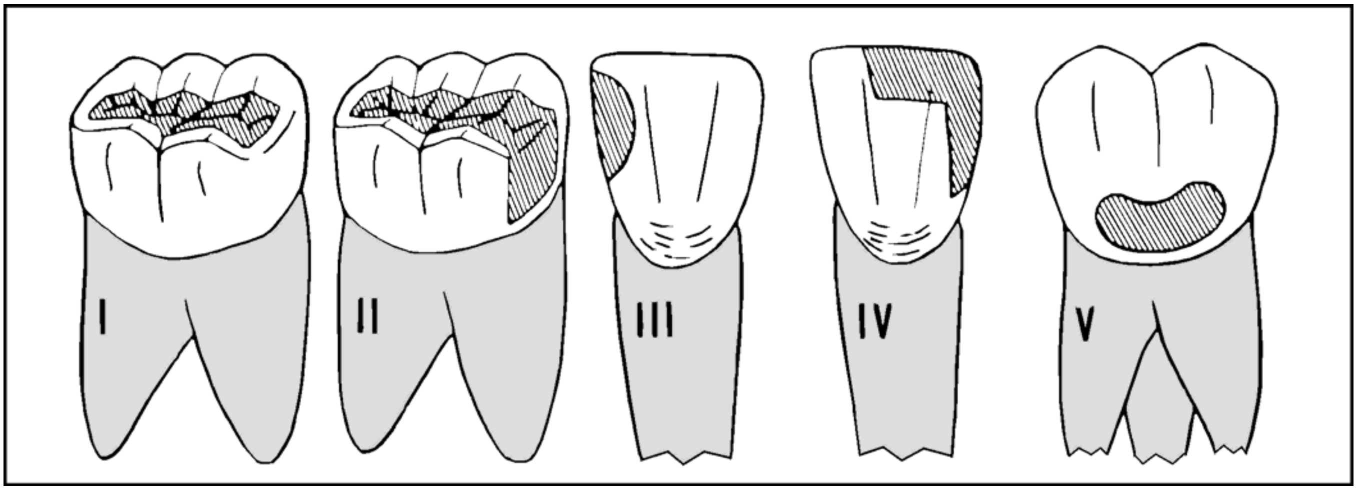
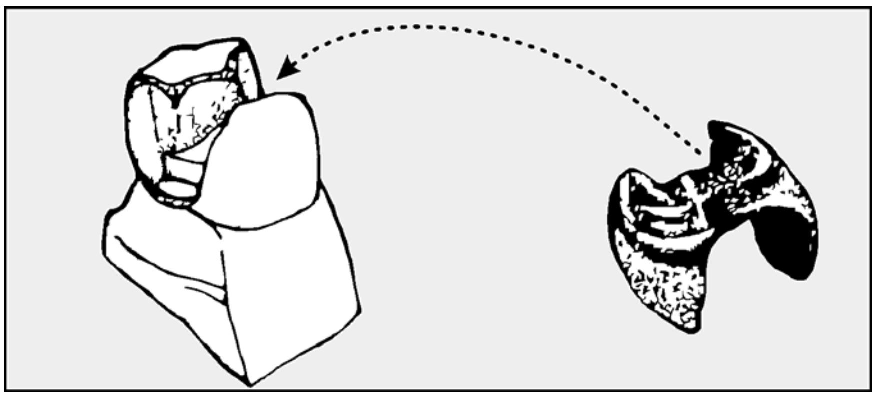


Figure 1.2. MOD (Class II) Inlay.



1.5. Pinledges:

1.5.1. A *pinledge* is a thin, cast restoration that covers the lingual and one proximal surface of an anterior tooth. It is usually categorized as a specialized form of inlay. What distinguishes it from a conventional inlay is that it has two or three parallel pins, about 1.5 to 2 millimeters (mm) long, that penetrate the lingual dentin for retention. The thinness of the casting and the small diameter of the pins require that the pinledge be constructed of a hard, nonprecious metal or gold alloy (Type IV gold).

1.5.2. A modification to the preparation may be seen with resin-bonded FPDs. It is the least reliable of inlay restorations and potentially destructive to an abutment tooth. A pinledge functions best as filling for a cavity and should not ordinarily be expected to do more.

1.6. Onlays and Veneers. Onlay restorations are made from cast gold or ceramic materials that ordinarily cover the MOD surfaces of posterior teeth. On the anterior teeth, porcelain veneers may cover facial, incisal, and lingual surfaces. An onlay differs from an inlay in this respect. An onlay covers the entire occlusal surface of a tooth to include the cusps. An onlay is the smallest of the fixed prosthetic restorations classified as *extracoronal.* Whereas an intracoronal replacement like an inlay fits *into* a tooth, an extracoronal restoration fits *around* what remains of a tooth. For many dentists, an onlay is the minimum restoration adequate to act as a FPD retainer.

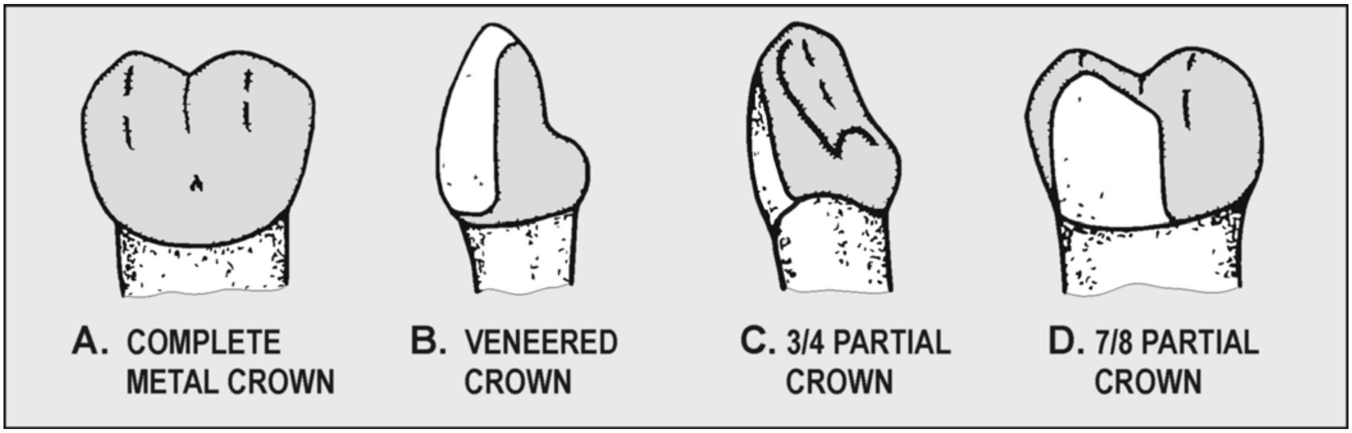
1.7. Artificial Crowns. An artificial crown is a fixed prosthetic restoration that covers more than half of the tooth's surface exposed to view in the patient's mouth (Figure 1.3). Onlays are classified as extracoronal restoration, and the following kinds of crowns make up the balance of extracoronal category:

1.7.1. Complete Crown—Covers the entire surface anatomy of a tooth's clinical crown as follows:

1.7.1.1. Metal—Constructed entirely of a noncorrosive metal such as gold (Figure 1.3-A).

1.7.1.2. Veneered—A complete coverage; that is, a metal substructure overlaid with porcelain or resin for esthetic effect (Figure 1.3-B).

Figure 1.3. Some Types of Artificial Crowns.



1.7.1.3. Jacket—A complete crown for an anterior tooth made entirely from porcelain or from acrylic resin.

1.7.1.4. Post Crown—A complete crown of any kind (complete metal, veneer) supported by a metal extension (post) into a tooth's root canal. *Endodontically treated teeth* are teeth that have had the pulps removed and root canals filled. Such teeth eventually become brittle and are prone to fracture. In many instances, there is little coronal substance left and restorations continually come loose from them. To maintain an endodontically treated tooth as an abutment capable of supporting and retaining a crown, it is common practice to cement a post about 2/3 of the way into a root canal. The part of the post that protrudes from the root canal is called the *core*. Combined with the remains of the coronal part of the tooth, the core, is built to resemble a complete crown preparation. After the post and core are cemented into the root, a complete crown is fabricated on top of this foundation (Figure 1.4).

1.7.2. Partial Crown—Made entirely from metal that covers more than half, but less than the entire tooth's clinical crown. A partial crown is named according to the fractional amount of the clinical crown it covers. Examples include half, three-quarters (Figure 1.3-C), four-fifths, and seven-eighths crowns (Figure 1.3-D).

1.8. Fixed Partial Denture (FPD). An FPD is a restoration designed to replace one or more missing natural teeth. In contrast to a removable partial denture (RPD), the dentist attaches an FPD to natural teeth, roots, or implants by cementation or screws. A *primary abutment* is a tooth or root used for support and anchorage of one of the ends of an FPD. An *intermediate abutment* is a tooth without other natural teeth in proximal contact, situated between two primary abutments. The typical FPD consists of the parts shown in Figure 1.5 and as follows:

Figure 1.4. Post Crown.

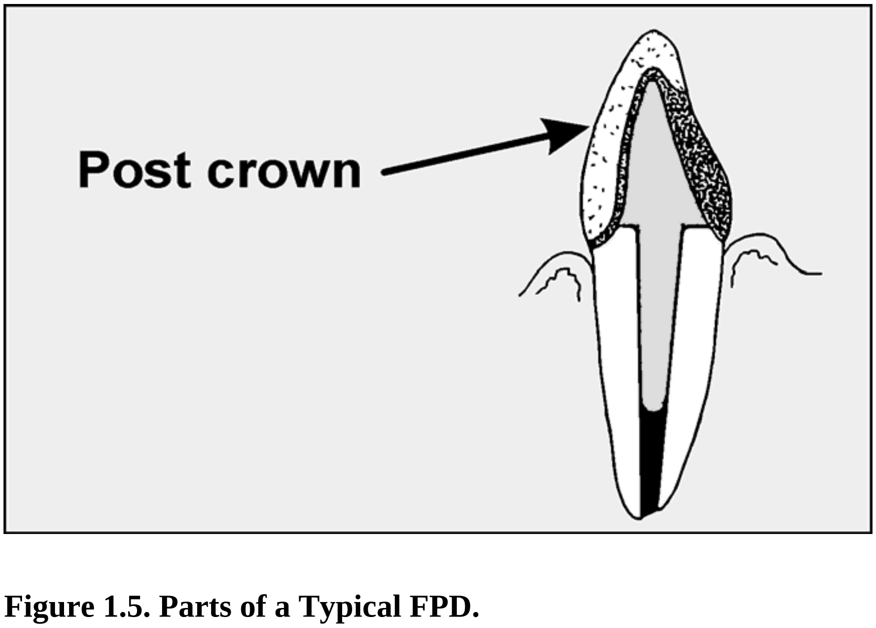
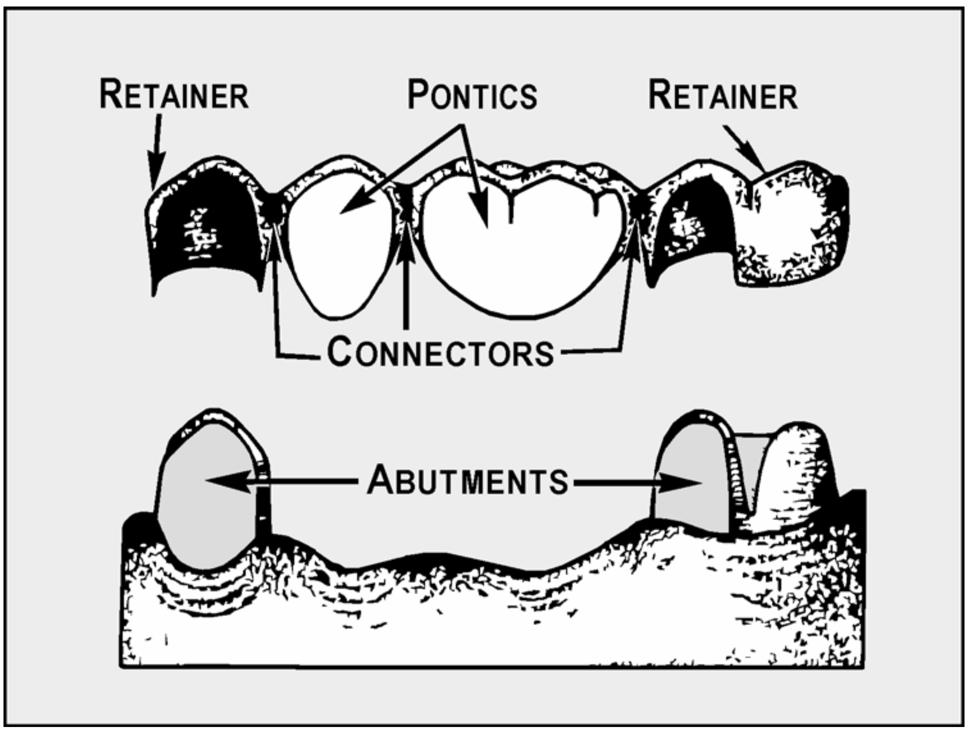


Figure 1.5. Parts of a Typical FPD.



1.8.1. **Retainers.** A retainer is a casting the dentist attaches to an abutment tooth to secure and support the FPD's artificial tooth or teeth.

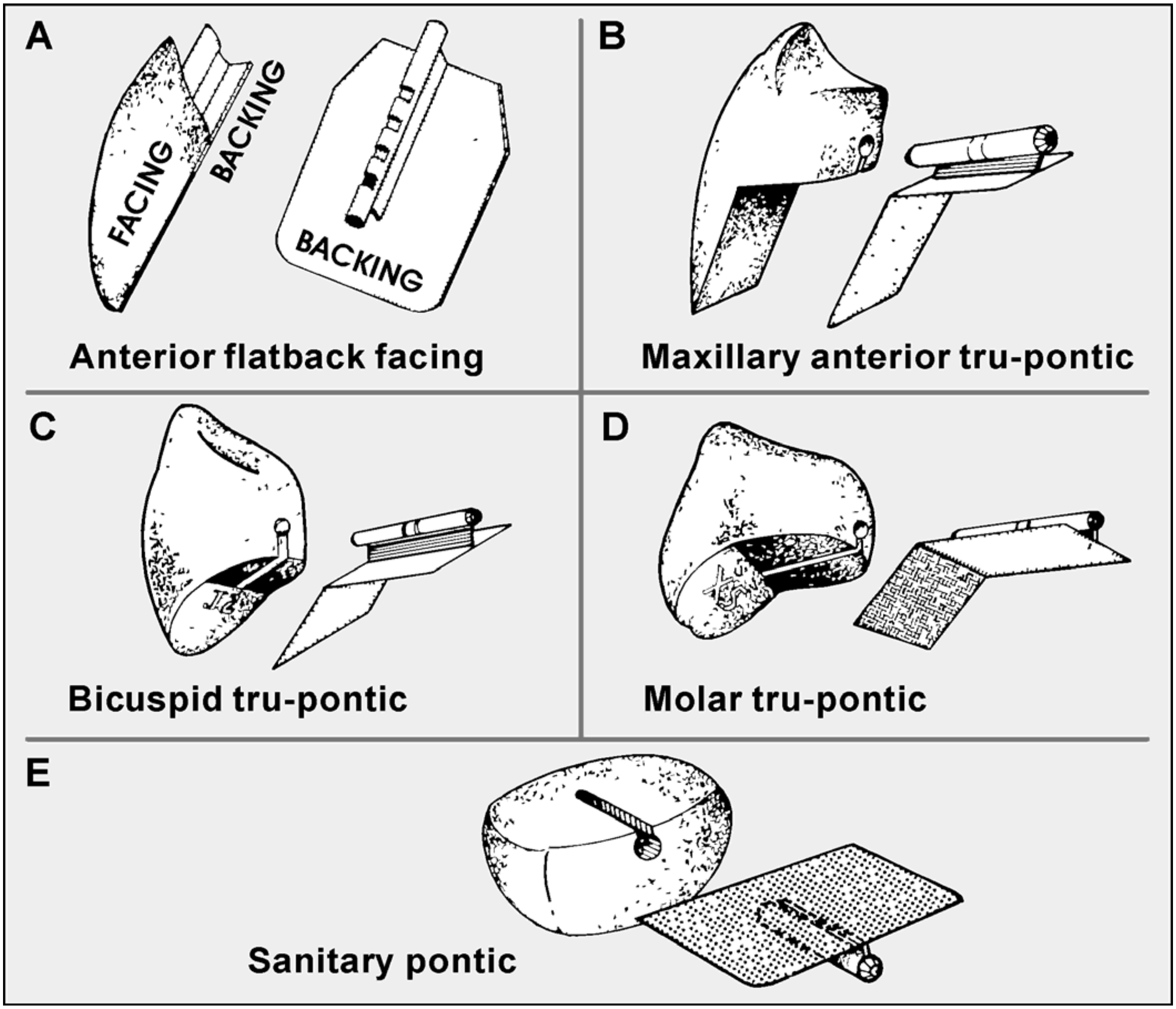
1.8.2. **Pontics.** Pontic is the general name for any artificial tooth suspended from a retainer. Pontics are classified according to the kinds of materials used to make them and according to the way they relate to gingival tissue under them (gingival adaptation), as follows:

1.8.2.1. **Classification of Pontics Based on Materials Used in Construction:**

1.8.2.1.1. **Complete Metal Pontic.** Use of these pontics is limited to the posterior areas of the mouth where they are not likely to be seen.

1.8.2.1.2. **Cast Metal Combined With Prefabricated Resin or Porcelain Blank.** Blanks are commercially available in anterior and posterior tooth forms and in a selection of sizes and shades. The dentist selects the appropriate blank and custom grinds it to fit an edentulous space. The rest of the artificial tooth, whether a backing for an anterior or an occlusal surface for a posterior, is waxed and cast in metal. The dentist then cements the modified resin or porcelain blank to its retaining post on the metal casting. Figure 1.6 shows types of prefabricated pontics and backings.

Figure 1.6. Prefabricated Pontics and Backings.



1.8.2.1.3. **Veneered Pontic.** The majority of the pontic's substructure is cast metal; the balance consists of a layer of acrylic resin or porcelain processed onto it. Acrylic veneers are mechanically retained by incorporating retention beads or loops into the casting. Porcelain is retained by baking and fusing it directly to the metal substructure. The tip of a pontic is usually made to contact gingival tissue. If the part of a pontic contacting the gingiva is made from a material that is chemically active or collects debris, inflammation will probably result. Glazed porcelain and highly polished gold provoke minimal tissue reaction. Acrylic resin is second best. Food tends to stick more to a plastic surface, bacteria grow in the debris, and produce toxic products that irritate tissue. In time, resin will absorb oral fluids and acquire an unpleasant odor.

1.8.2.2. **Classification of Pontics Based on Gingival Adaptation:** (***NOTE:*** Paragraph 1.64 contains a detailed description of these pontics.)

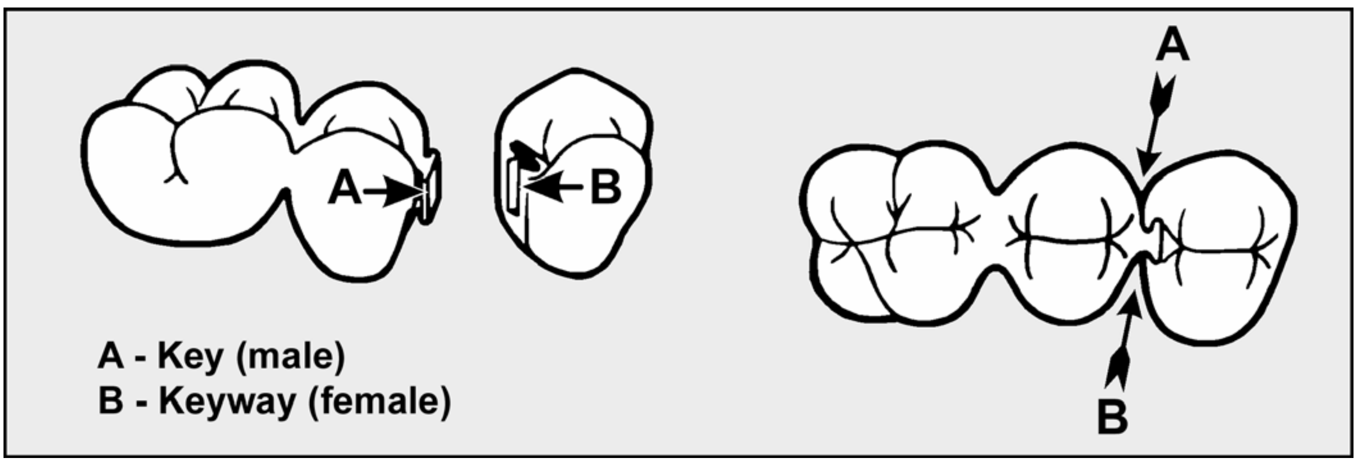
1.8.2.2.1. Modified ridgelap pontic.

1.8.2.2.2. “Egg” shaped in contact with a residual ridge.

1.8.2.2.3. Hygienic (conventional or modified).

1.8.3. **Connectors.** A connector is that part of an FPD that unites a pontic to a retainer or joins pontics together. Connectors are classified as rigid (soldered joint) or nonrigid (key-to-keyway arrangements known as semiprecision attachments). The term *stress breaker* is commonly applied to nonrigid connectors (Figure 1.7). Rigid connectors are by far the most popular option. There are problem situations where a stress-broken FPD is the restoration of choice. A stress-broken joint is indicated when there is no common path of insertion for the retainers or when an FPD includes an intermediate abutment.

Figure 1.7. Nonrigid Connector.



1.9. Fixed Splints:

1.9.1. There are ways to make a number of teeth share the load being placed on one of them to help prolong the life of teeth that are loose or have lost supporting bone.

1.9.2. Stabilizing a mobile tooth or teeth is called *splinting.* When stabilizing a tooth from adjacent, connected castings that have been cemented to place in the mouth, it becomes a form of *fixed splinting.* Such splints are made the same as an FPD. The only difference is that there are no pontics involved.

1.9.3. The overall size of FPDs and fixed splints is expressed in *units.* Each replacement tooth or retainer counts as a unit. For example, an FPD with three retainers and two pontics has five units; a fixed splint with four castings has four units.

1.10. Interim FPD. This is a rigid, provisional restoration that replaces missing teeth and is generally made from self-curing resin. Its purpose is to protect cut tooth surfaces and hold the abutment teeth in position while the definitive FPD is being made.

Section 1C—Fixed Cast Restoration

1.11. Procedural Overview. Production of a fixed cast restoration usually progresses as follows:

1.11.1. The dentist determines a patient requires prosthodontic treatment and makes preliminary maxillary and mandibular impressions.

1.11.2. The technician first pours the diagnostic casts and makes custom trays if requested. Frequently, the diagnostic cast is also used to prepare a diagnostic wax-up to determine occlusal and esthetic requirements and also to construct provisional restorations or protheses.

1.11.3. The dentist prepares the natural teeth in the patient's mouth.

1.11.4. Using the custom tray, the dentist makes a final impression. If a need is apparent, the dentist will make a jaw relationship record. He or she then cements the interim fixed replacement in place with a weak cementing medium.

1.11.5. After receiving the final impression, the technician:

1.11.5.1. Fabricates dies and master (working) casts.

1.11.5.2. Mounts maxillary and mandibular casts in an articulator.

1.11.5.3. Adapts wax to dies and builds contours to harmonize and function with natural teeth.

1.11.5.4. Sprues, invests, and casts the wax pattern.

1.11.5.5. Joins the units by soldering if necessary.

1.11.5.6. Gives the restoration a preliminary surface finish.

1.11.5.7. Applies porcelain or resin veneers at this time or after the final adjustments to the prosthesis have been made in the patient's mouth.

1.11.6. The dentist tests the prosthesis in the patient's mouth and makes occlusion and margin adjustments. If many prosthetic units are involved, the dentist may send the case back to the laboratory for remount and adjustment of the occlusion in an articulator. The dentist furnishes another jaw relationship record if remount is necessary.

1.11.7. The technician final-finishes and polishes the restoration.

1.11.8. The dentist cements the completed restoration into place.

Section 1D—Occlusion Factors Pertaining to Fixed Prosthodontics

1.12. Increasing Occlusal Stability. Many factors can improve the occlusal and functional stability of natural and prosthodontic teeth. Such factors include:

1.12.1. **Balanced Centric Contact.** The teeth close into maximum intercuspation (MI) at the end of each swallowing cycle. This occurs several thousand times each day for most people. Obviously, simultaneous and even contact of all stamp cusps must occur at the moment of closure into MI if maximum stability is to be achieved. Two factors that can prevent balanced centric contact are uneven cusp height and inaccurate cusp placement, as follows:

1.12.1.1. **Uneven Cusp Height.** Uneven cusp height causes overloading and possible damage to teeth that come into contact sooner or more heavily than others. It may also cause lightly loaded teeth to overerupt into positions that upset the centric and eccentric relationships that have been developed.

1.12.1.2. **Inaccurate Cusp Placement.** Inaccurate cusp placement causes a hit-and-slide contact pattern. This can result in occlusal forces not in line with the long axis, early wear, and instability of the teeth involved. It may also cause the patient to develop the destructive habit of bruxism.

1.12.2. **Uniform Centric Contact.** All of the posterior teeth contact exactly at the same time and with uniform pressure when the jaw is closed in MI. Nonuniform contact may be either anteroposterior with heavy molar or premolar contact, or cross-arch with one side hitting ahead of the other. In either case, the following adverse conditions could result:

1.12.2.1. **Heavy Contact.** The teeth in heavy contact would carry all of the pressure and be overloaded. Such pressures would probably not be in line with the long axis, and therefore would cause adverse occlusal leverages and forces.

1.12.2.2. **Teeth Not In Contact.** The teeth not in occlusion would tend to erupt into contact, thereby creating occlusal instability. Also, as they erupt into occlusion, they may cause a deflected malocclusion in the excursive movements, a situation that would create adverse leverages and wear.

1.12.2.3. **Involvement of the Temporomandibular Joint.** The natural condylar guidance of the temporomandibular joint can be overpowered by inharmonious occlusal contacts. This can cause uneven loading and painful and possibly damaging stress on the tissues of the temporomandibular joint.

1.12.3. **Forces Directed In Line With the Long Axis of the Teeth.** The uniform centric contacts should be directed in line with the long axis of the teeth from a mechanical leverage standpoint. Ideally, tipped or tilted teeth should be straightened orthodontically.

1.12.4. **Tripodism.** For dental purposes, tripodism means each cusp contact should be a three-point contact, rather than a single-point, contact system of occlusion. The actual cusp tip should never contact anything at any time, any where. Rather, the ridges around the cusp tip should contact the ridges forming the fossa of the opposing tooth. Tripodism is encouraged as a system of occlusion for use in the fabrication of crowns and FPDs for following reasons:

1.12.4.1. **To Establish Stability.** Because it is very much like a three-legged stool (as opposed to a one-, two-, or four-legged stool), tripodism is considered to be a very stable system of occlusion.

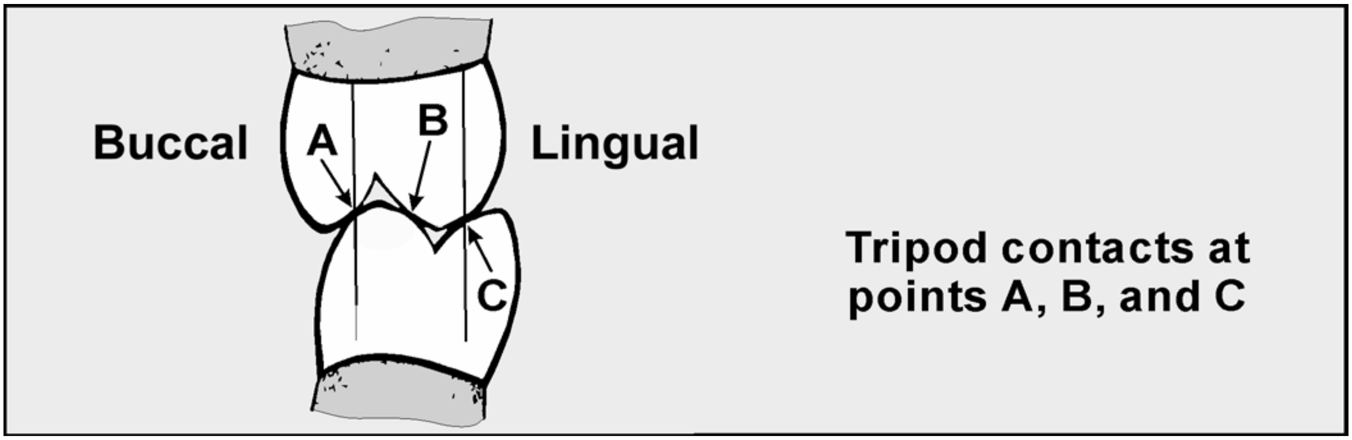
1.12.4.2. **To Maintain Stability.** Relying on single-point contacts on a premolar, for example, gives only four connecting points for stability; that is, two stamp cusps contacting two fossae. Missing only one pair of these contacts causes a significant loss of stability. With tripodism, 12 pinpoint areas of contact are developed so a loss of contact between one or two pairs does not greatly reduce stability.

1.12.4.3. **To Distribute Forces.** Tripodism creates many pinpoint-type contacts rather than a few large areas of contact. Therefore, it produces a better distribution of the applied force.

1.12.4.4. **To Avoid a "Locked" Bite.** A study of natural, unworn tooth anatomy indicates cusp ridges are convex. This makes it impossible for the tip of a cusp to contact the center of a fossa without creating a "locked" bite. The tripod type of contact is one answer to an "unlocked" occlusion. It permits lateral excursive movements to be made with a minimum of locking effect. Think of this type of contact as a ball-bearing resting in the fossa, rather than the intermeshing of precision gears (Figure 1.8).

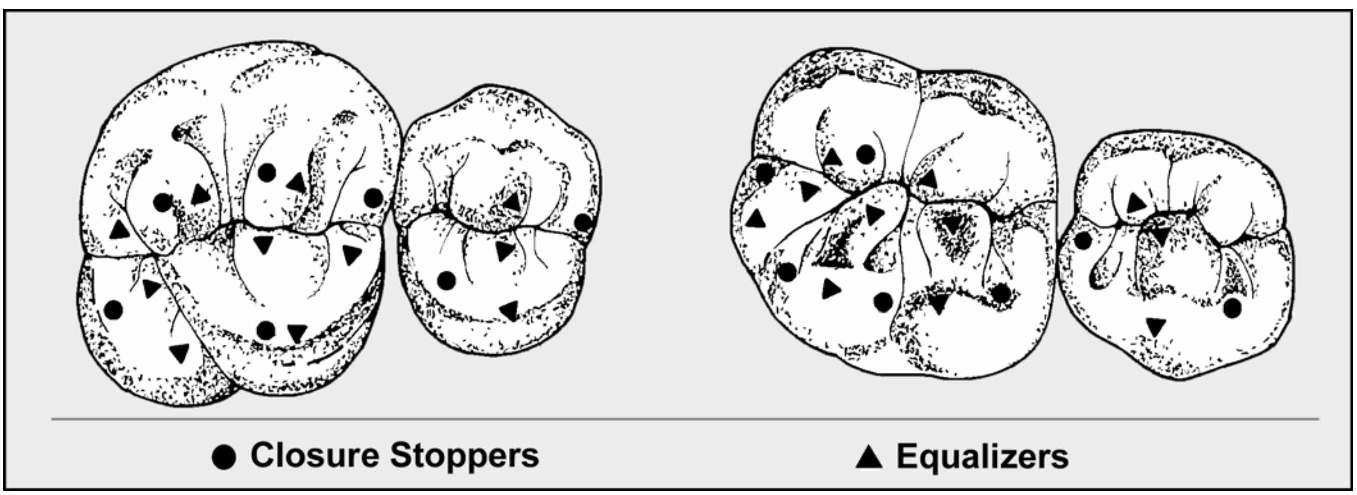
1.12.5. **Twin Centric Contact (Cross-Tooth Stability).** The stamp cusps are the buccal cusps of the mandibular teeth as they contact the fossa of the opposing maxillary teeth, and they are the lingual cusps of the maxillary teeth as they contact the fossa of the mandibular. Both groups of stamp cusps must occlude evenly and simultaneously. This cross-tooth contact (or twin buccolingual cusp contact) is essential for the following reasons:

Figure 1.8. Avoiding a "Locked" Bite.



1.12.5.1. **It Improves the Stability of Tripodism.** Twin centric contact is essential to maintaining the many contact points established by tripodism (Figure 1.9).

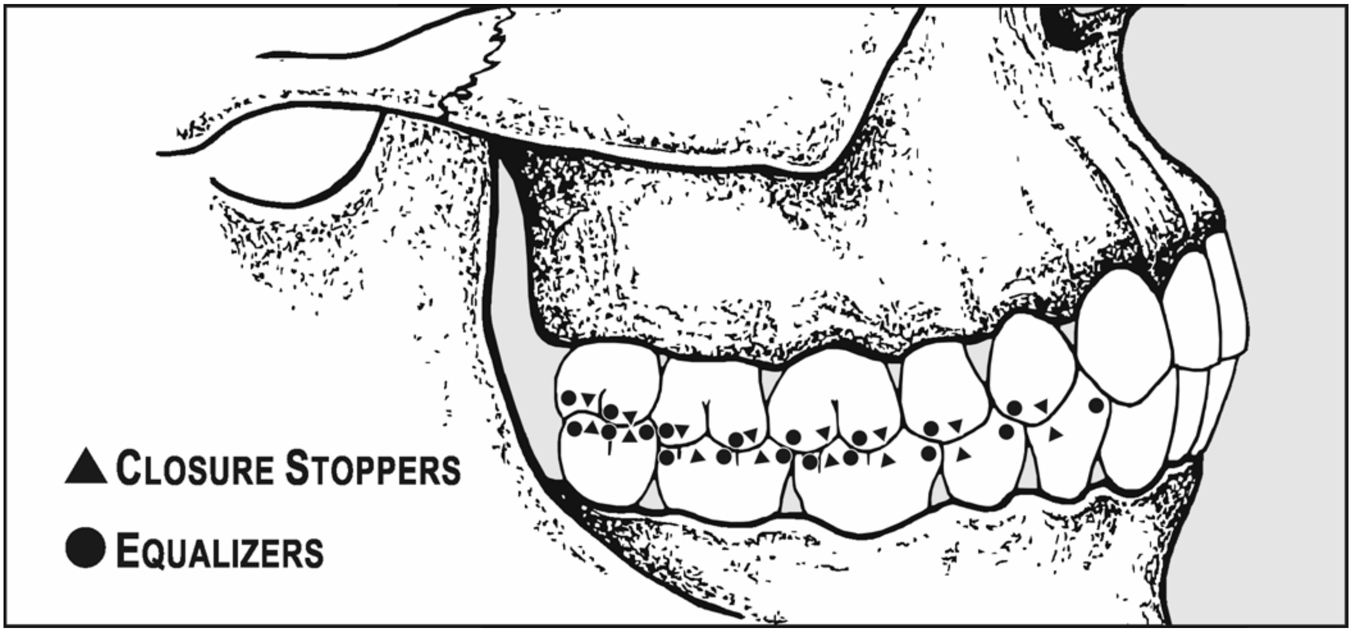
Figure 1.9. Centric Contact Points (Closure Stoppers and Equalizers).



1.12.5.2. **It Eliminates Damaging Contacts.** If the lingual stamp cusp of the maxillary tooth does not contact the central fossa of the opposing mandibular tooth, the tendency exists for the maxillary tooth to erupt in a tilted pattern until that cusp does make contact. As shown in Figure 1.8, the occlusal forces are centered over the long axis of the teeth when the A, B, and C areas are all in contact. If you lose the B contact, the resulting forces of A and C would tend to displace the mandibular tooth lingually or the maxillary tooth buccally. If this occurs, the overerupted lingual cusp could constitute a heavy balancing side contact during lateral excursive movements. The result would be instability and a heavy balancing contact recognized as the most detrimental tooth contact possible (Class II Lever System).

1.12.6. **Closure Stoppers and Equalizers (Figure 1.10).** A, B, and C interocclusal contacts (shown in Figure 1.8) are as also designated as being either *closure stoppers* or *equalizers.* Closure stoppers and equalizers stop the closure of the mandible and equalize the forces to prevent buccal or lingual and mesial or distal movement of the posterior teeth, as follows:

Figure 1.10. Location of Closure Stoppers and Equalizers (Sagittal View).



1.12.6.1. **Closure Stoppers.** Closure stoppers stop the hinge closure of the mandible as it centrically relates to the maxilla. They also offset or neutralize the forces exerted by equalizers. Closure stoppers are located on the distal inclines of maxillary posterior teeth and on the mesial inclines of mandibular posterior teeth, primarily on marginal ridges. However, they can also be located on triangular, supplemental, or central ridges.

1.12.6.2. **Equalizers.** Equalizers offset (equalize) the forces exerted by closure stoppers, gaining mesial-distal stability. Equalizers also ensure buccal-lingual stability. They are located on the mesial inclines of maxillary posterior teeth and in the distal inclines of mandibular posterior teeth. They are primarily located on triangular, supplemental, and central ridges. Only rarely are they located on marginal ridges.

1.12.7. **Limited Occlusal Table Width.** The buccolingual width of prosthodontic teeth, especially of crowns or units of FTDs, must *never* exceed the width of the natural tooth structure they replace. In most cases, whether fabricating a single unit restoration or a long span FPD, the buccolingual width must be made the *same width* or *narrower* than the original teeth. This is true for the following reasons:

1.12.7.1. **Increased Occlusal Load.** Increasing the occlusal table width directly increases the surface area of a crown or FTD. Increasing the surface area during the chewing cycle increases the area of opposition to occlusal forces and adds directly to the functional load applied to abutment teeth. Increasing the functional load puts additional stress on the root systems of abutment teeth. This stress often results in a loss of periodontal support and increasing mobility of the abutment teeth.

1.12.7.2. **Forces Not In Line With the Long Axis.** Increasing the occlusal width puts occlusal stresses further from the long axis of abutment teeth. This increases the leverage forces felt by the root system of the abutment tooth. It can also lead to a loss of periodontal support and mobility of the teeth under stress.

Section 1E—Diagnostic Casts, Interim Fixed Prostheses, and Custom Trays

1.13. Preliminary Impressions and Diagnostic Casts:

1.13.1. Because of natural tooth and soft tissue undercuts, elastic impression materials are used for fixed prosthodontic impressions. Irreversible hydrocolloid (alginate) is the material used for making preliminary impressions.

1.13.2. Diagnostic casts are poured from preliminary impressions made in stock trays. In complete denture and RPD work, diagnostic casts are used for evaluating the patient's problems and for constructing a custom tray. A diagnostic cast has additional value in fixed prosthodontic treatment procedures—it is frequently used for making interim (provisional) fixed restorations.

1.13.3. For a more detailed description of the care and pouring of alginate impressions and trimming specifications of casts, consult the following sections or paragraphs in Volume 1 of this pamphlet:

1.13.3.1. Paragraph 2.40, Hydrocolloids.

1.13.3.2. Section 7C, General Rules for Pouring, Trimming, and Handling Casts.

1.13.3.3. Paragraph 7.24, Preliminary Impressions; paragraph 7.25, Two-Step Pouring of Diagnostic Casts; and paragraph 7.26, One-Step Pouring of Casts.

1.14. Interim (Provisional) Fixed Restorations. Provisional resin restorations, made with the indirect method, are routinely constructed for onlay, crown, and FPD situations. The diagnostic cast is a major aid in making these prostheses. Some technicians then use the more accurate first cast to make the interim restoration. Once the cast is made, there are a number of ways to either make, or help the dentist make, an interim fixed prosthesis. It is helpful to mount the cast in a simple, fixed-guide articulator that will hold the casts in MI. Index the casts and paint the bases with separator before mounting them. The following methods can be used to make interim restorations:

1.14.1. **Vacuum-Forming Methods.** To begin, you must have access to a vacuum-forming machine and the proper kind of thermoplastic material (Clear Temporary Splint Material, 0.020 inch, Buffalo Mfg Co). Then follow the procedures in Method #1 or #2 below:

1.14.1.1. **Method #1:**

1.14.1.1.1. If the teeth the dentist intends to prepare are broken down, complete a diagnostic wax-up to restore tooth form and function. Duplicate this wax-up in dental stone and then make a clear matrix for the interim restoration. If the provisional prosthesis is for a proposed FPD site, also adapt mismatched, uncarded resin denture teeth to the edentulous space and adjust the occlusion.

1.14.1.1.2. Take the cast off its mounting and vacuum-form the clear splint material over the cast. Cut out the part of the formed plastic that includes the region of the fixed prosthesis PLUS one or two uninvolved teeth anterior and posterior to it.

1.14.1.1.3. Give the clear plastic template to the dentist to use as a mold to form a self-curing, provisional prosthesis in the patient's mouth. (Uninvolved teeth are a part of the template so they can act as a seating index.)

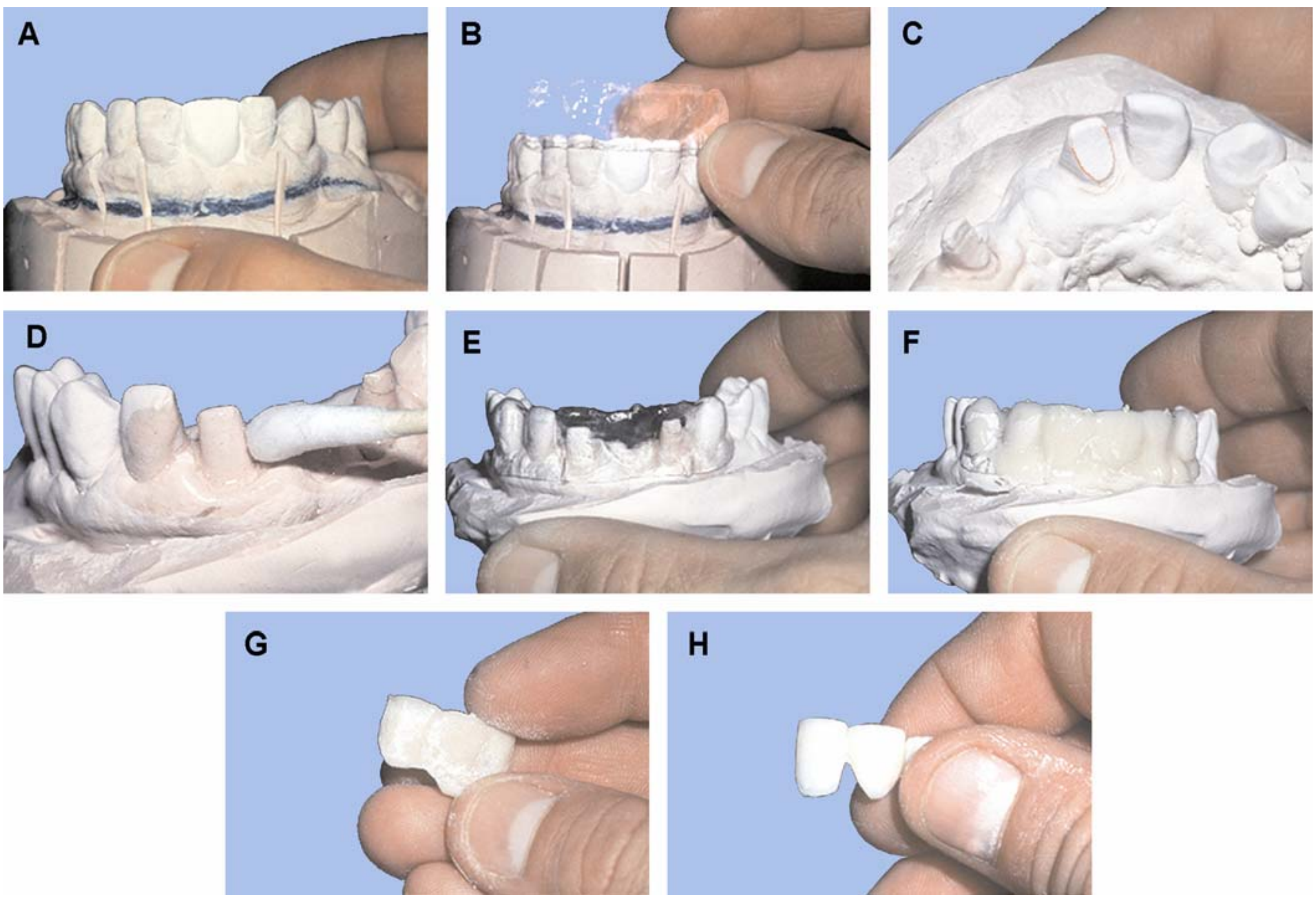
1.14.1.2. **Method #2:**

1.14.1.2.1. Produce a template as described in Method #1.

1.14.1.2.2. Remove any denture teeth used to fill edentulous areas and save them for reuse on other cases.

1.14.1.2.3. Carefully shave away about 1 mm of dental stone from each coronal surface of the cast that corresponds to the tooth surface the dentist intends to prepare (Figure 1.11). Remove enough of the occlusal and axial surfaces to eliminate all undercut areas. Feather the axial reductions to a knife edge at the crest of the gingival margin. Apply tinfoil substitute to the parts of the cast the template covers.

Figure 1.11. Vacuum-Forming Method for Interim Prostheses.



1.14.1.2.4. Place a fluid mix of tooth-colored resin in the template. Self-curing resin as well as light cured resin will work for the interim prosthesis. Seat the template on the cast and hold it there until polymerization begins.

1.14.1.2.5. To accelerate polymerization and to help reduce porosity, cure the resin according to the manufacturer's recommendations.

1.14.1.2.6. After curing is complete, remove the template from the interim prosthesis. Place the cast on its mounting in the articulator and adjust the occlusion.

1.14.1.2.7. Take the prosthesis off the cast. Finish and polish it, being careful to preserve the anatomical contours of the occlusal and axial surfaces.

1.14.1.2.8. Disinfect and place the provisional prosthesis in a plastic bag with a moist cotton roll for delivery to the dentist.

1.14.2. **Alternative Methods.** You should also be aware of the following alternatives to vacuum-forming a template when the equipment required for that technique is not available: (***NOTE:*** In any alternative method chosen, the problem focuses around making a template.)

1.14.2.1. **Alginate Impression Template Method.** In the vacuum-forming technique, tooth defects were filled with dental stone, resin denture teeth were adapted to edentulous spaces, and relatively heat resistant materials were used because hot plastic was going to be sucked down over the cast. In the alginate impression method, there is no requirement for intense heating of the template material.

1.14.2.1.1. Fill in tooth defects with a white inlay wax and provide replacement teeth for the edentulous spaces.

1.14.2.1.2. Soak the cast in saturated calcium sulphate dihydrate solution (SDS) for 5 minutes.

1.14.2.1.3. Take a stock, rim-lock tray and make an alginate impression of the cast. Cut back excess alginate to the borders of the tray.

1.14.2.1.4. Remove any tooth replacements from the edentulous spaces. Shave the occlusal, incisal, and axial surfaces of the teeth the dentist will prepare. Follow directions given in Method #2 (paragraph 1.14.1.2). Paint the cast with a tinfoil substitute.

1.14.2.1.5. Cut a small, V-shaped wedge out of the sidewall of the impression. This channel should lead from the edge of the tray into the bulkiest part of the provisional prosthesis. The channel will serve as an escape route for excess acrylic resin.

1.14.2.1.6. Prepare a fluid mix of tooth-colored autopolymerizing resin and flow it into the appropriate part of the alginate impression. Wait for the resin surface to lose its gloss and seat the impression on the cast.

1.14.2.1.7. For the remainder of the procedure, follow directions in Method #2, paragraphs 1.14.1.2.5 through 1.14.1.2.8.

1.14.2.2. **Silicone Template Method (Figure 1.12):**

1.14.2.2.1. Use white inlay wax to correct defects in all the teeth the dentist is going to prepare and form replacements for the missing teeth. Use old, uncarded resin denture teeth as natural tooth substitutes if they are available.

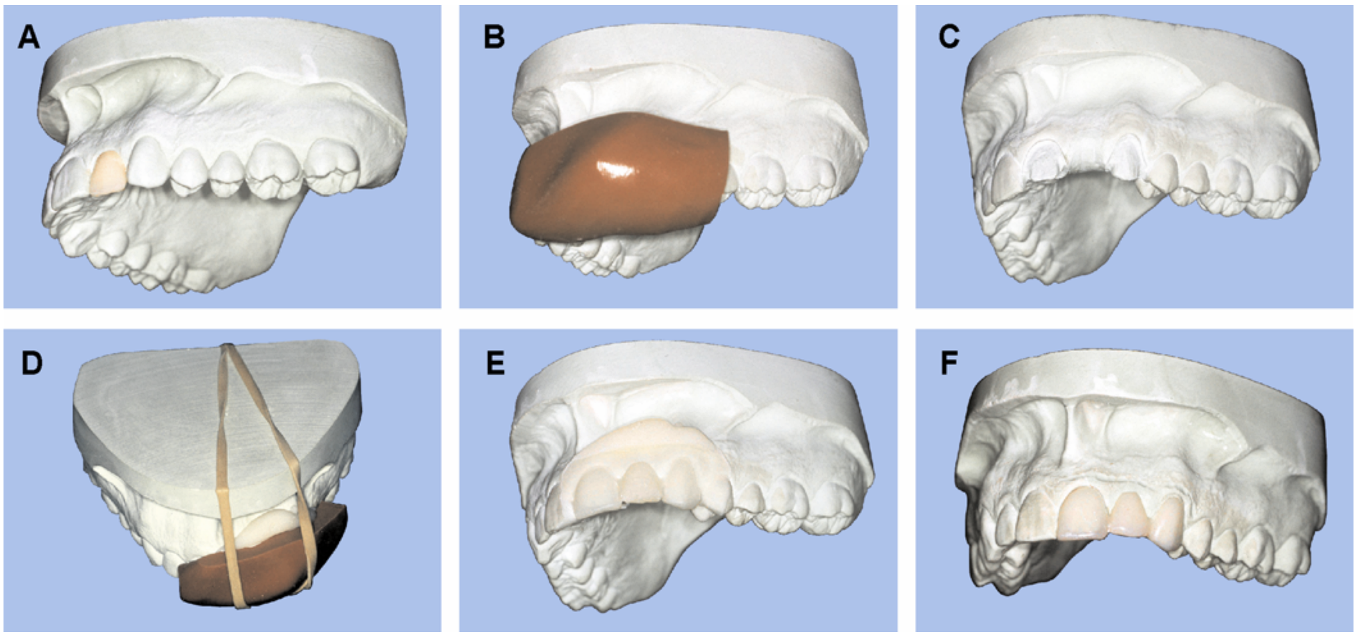
1.14.2.2.2. Mix the silicone impression material and adapt it over the region of the fixed prosthesis, to include at least one uninvolved tooth anterior and posterior to it. The template should be 6 to 8 mm thick to provide adequate stability. After the material has set remove the template and trim any excess material.

1.14.2.2.3. Remove any tooth replacements from the edentulous spaces. Shave the occlusal, incisal, and axial surfaces of the teeth the dentist will prepare. Follow directions given in Method #2 (paragraph 1.14.1.2.3). Apply a tinfoil substitute to the parts of the cast the template covers.

1.14.2.2.4. Mix tooth-colored, self-curing acrylic resin in a glass jar as directed by the manufacturer. Wait for the early dough stage and pack a slight excess of resin into the template. Seat the template on the cast. Use a small rubber band to hold the template and cast together during the curing of the acrylic resin.

1.14.2.2.5. For the remainder of the procedure, follow directions in Method #2, paragraphs 1.14.1.2.5 through 1.14.1.2.8.

Figure 1.12. Silicone Template Method for Interim FPDs.



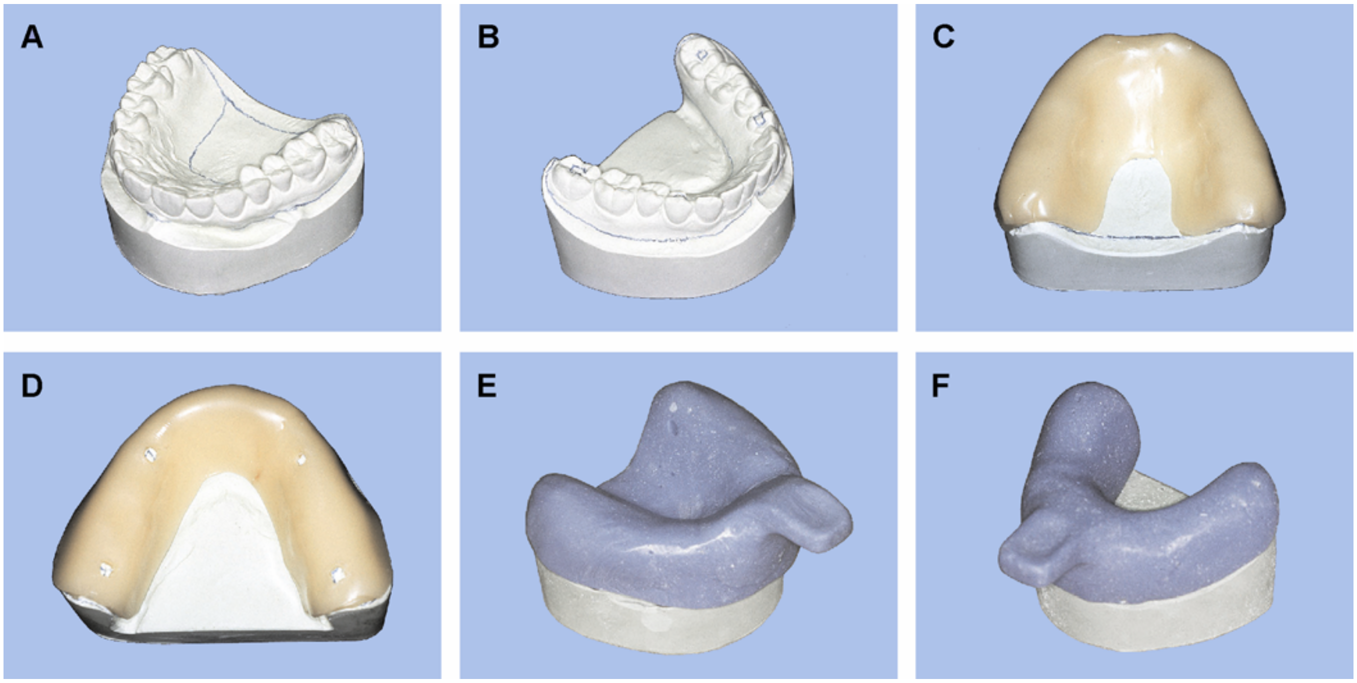
1.15. Custom Trays:

1.15.1. In fixed prosthetic dentistry, custom trays are used almost entirely with elastomeric impression materials (Figure 1.13). For the elastomers to register an impression accurately and show acceptable elastic behavior, it has to have adequate thickness. This is why custom trays are routinely made over *spacers*.

1.15.2. It is one thing to create space, but quite another to maintain it. To guarantee that the tray is being held out of contact with the dentist's tooth preparations by a measurement at least equal to the thickness of the spacer, *stops* are incorporated into the tissue side of the tray. Maxillary custom trays are made with a single, large, palatal stop. Occasionally, however, stops are placed on tooth surfaces. In the mandibular arch, the occlusal and incisal surfaces of teeth are the only solid places for stops to hit. Such stop contacts are undesirable, but unavoidable. Stops are NEVER placed over teeth the dentist intends to prepare.

1.15.3. Custom trays can be made with self-curing resin, vacuum-forming material (0.125 inch), or light-cured acrylic resin. Because the dentist has to exert considerable force on the handle of the tray, be sure to make it strong enough. Mold and trim the custom tray according to directions given in Volume 1, Section 7E, but note the following differences in *spacer* requirements:

Figure 1.13. Maxillary and Mandibular Acrylic Resin Custom Trays.



1.15.3.1. **Self-Curing Acrylic Resin and Light-Cured Trays.** Block out facial and lingual soft tissue undercuts with baseplate wax. Adapt two sheets of baseplate wax to cast. Cut the borders of the wax to match the tray's outline as drawn by the dentist. (See Figure 1.13-D for suggested placement of stops.) Form the tray in self-curing resin. Trim the borders back to design and round off the edges. If the wax spacer is to peel out of a resin tray cleanly, polymerization has to be complete and the plastic must be cool. One way to make sure wax does not stick to the tissue surface of the tray is to adapt tinfoil over the spacer before molding the resin. Another way is to substitute a sheet of plastic film for the tinfoil.

1.15.3.2. **Vacuum-Forming Trays.** The shape and thickness of a maxillary or mandibular arch spacer for a vacuum-forming tray is the same as for an acrylic resin tray. The important difference is that wet tissue is substituted for the wax. ***NOTE:*** Rubber base impressions can be very difficult to remove from the patient's mouth.

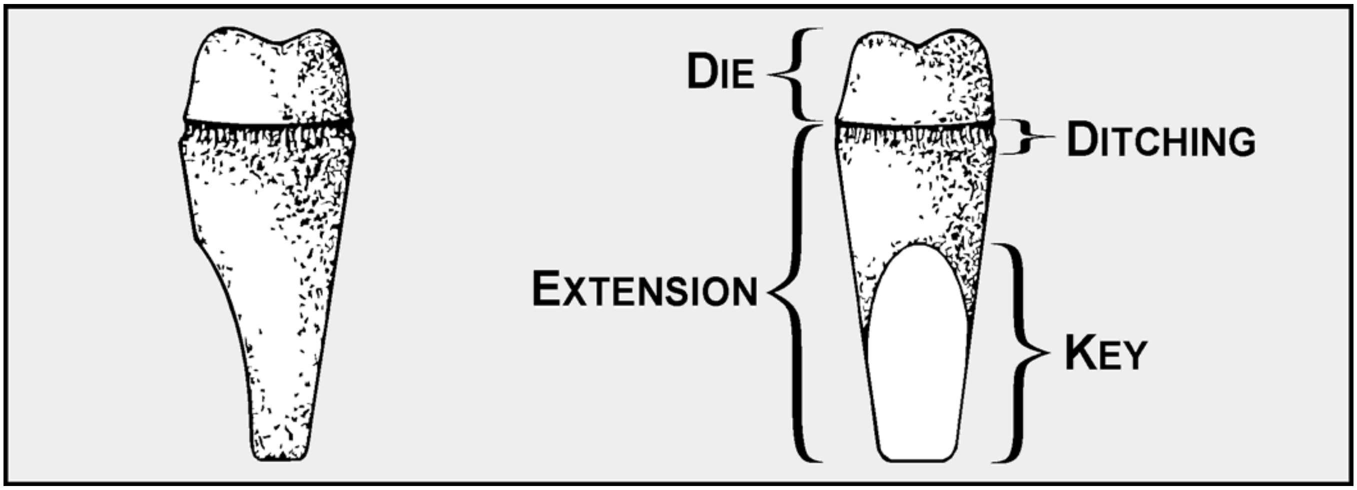
Section 1F—Dies and Working Casts

1.16. Overview:

1.16.1. A *working cast* is a cast used to duplicate the patient's prepared tooth (teeth), the other teeth present in the arch, and all associated soft tissue structures. It is used to establish the shape, proximal contacts, occlusion, and fit of fixed prostheses, from the simplest inlay to the most complicated complete mouth rehabilitation.

1.16.2. A *die* is a positive reproduction of the prepared portion of a tooth in a hard, stable material such as improved stone, dental amalgam, acrylic resin, epoxy resin, or electrodeposits of metal. Dies are composed of two parts, the duplicate of the prepared tooth and an extension (Figure 1.14). By itself, a die has limited value until its relationship with adjacent and opposing teeth is established.

Figure 1.14. Improved Stone Die Made From a Tube Impression.



1.16.3. A working cast contains one or more dies. Dies are either part of a working cast or they are not. For those dies that are not, the extension is a convenient grip and nothing more. Dies that are part of a working cast are frequently made to be *removable*, and their extensions are *keyed* in some manner. Because of the key, the die will not rotate and it can be placed back in the cast in the same position after every removal. Dies can be keyed in a variety of ways; for example, carve facets on the extension or make the extension from a commercially available, metal dowel pin (paragraph 1.20.2).

1.17. Individual Dies Made From Tube Impressions:

1.17.1. The dentist has access to a stock of short metal tubes or bands that are made from copper or aluminum. He or she can use these bands as miniature trays to make impressions of single teeth. Rubber base and modeling plastic are the impression materials most often employed. Dies derived from tube impressions can be keyed and subsequently incorporated into a working cast. Tube impressions are most frequently poured in improved stone.

1.17.2. Because tubes made from copper or aluminum bend easily, the tube impression should be handled gently. Rinse the impression with room temperature water to rid it of saliva and debris and dry it with gentle blasts of compressed air.

1.17.3. “Box” the rim of the band with 28-gauge sheet wax or cellophane tape. The boxing material should be wide enough to produce an extension that is 2.5 centimeters (cm) long after the impression is poured. When using wax, seal the “box” at the side lap and at the junction with the band. Be careful not to heat the impression material.

1.17.4. Mix a sufficient volume of die stone according to the manufacturer’s directions. The water-to-powder ratio and the manner of spatulation will determine the hardness, density, and surface smoothness of the stone. When possible, use vacuum spatulation and mix the stone from 10 to 15 seconds. Avoid lengthy mixing because it causes the stone to set very rapidly.

1.17.5. Gently vibrate a small amount of the mix into the boxed impression until the deep parts are filled. Without trapping air, add more of the mix until the box is filled. Let the stone reach final set.

1.17.6. If the impression is made of nonelastic modeling compound, place the impression and die stone assembly in warm water at 140 ^{o}F for 3 to 5 minutes. When the modeling compound becomes soft, extract the die. Failure to wait until the modeling compound softens may result in unacceptable die abrasion or outright breakage. If you are using an elastic material to make the impression, extract the die without applying heat to the impression material.

1.17.7. Trim the die's extension to a smooth even taper. If the die is going to become a removable die in a working cast, cut at least one flat facet on the extension portion to act as a key (Figure 1.14).

1.18. Removable Die Systems. There are a great variety of removable die systems; some are good and others are poor. Besides ease of fabrication and subsequent convenient handling, the overriding requirement is that dies, once removed, have to go back to exactly the same place. Dies that do not satisfy this requirement have greatly diminished value. Paragraphs 1.19 through 1.26 describe these systems in detail.

1.19. Dowel Pin Systems:

1.19.1. A working cast can be made with removable stone dies by pouring the arch portion of an impression first and then pouring the rest of the working cast around commercially fabricated die extensions (dowel pins).

1.19.2. One of the improved stones is used for both pours. Occasionally, the technician reproduces the dentition and prepared teeth in a working cast, using electrically deposited silver or epoxy resin. He or she then completes the cast, using improved stone and one of the conventional pinning techniques.

1.19.3. Keyed and tapered metal dowel pins with serrated heads are used as die extensions. Dies having these keyed dowel pin extensions will travel to place and seat in a working cast in only one way. Dowel pins can be placed in any kind of impression. The differences in technique focus on two points: (1) the way the dowel pins are held in position while the first pour of stone is setting, and (2) the way separation between the die and working cast is achieved.

1.19.4. Tooth preparation sites (dies) are not the only areas of an arch that are made removable with dowel pins. It is very common practice to make the unaltered teeth next to the dies removable. Contact areas on finished castings are better evaluated when this is done. Sometimes, the only way a die will come out of the base pour is to make adjacent teeth removable, too. Making the edentulous ridge between two abutments removable has definite advantages in shaping and finishing FPD pontics.

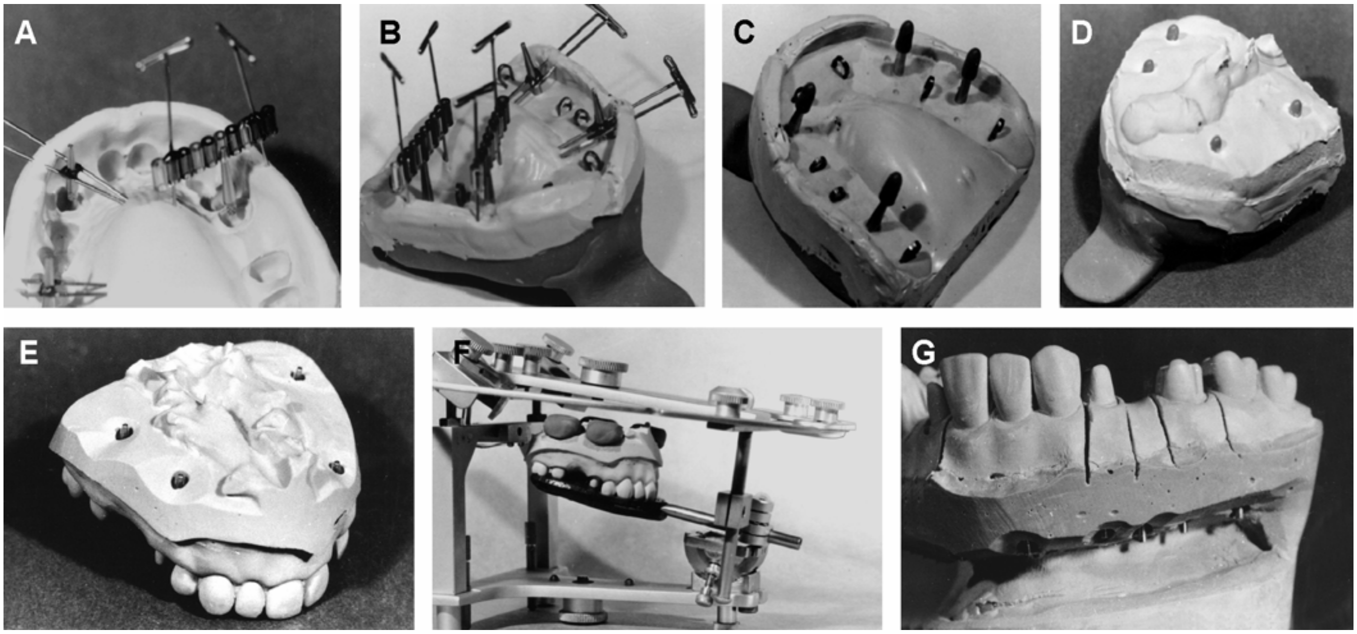
1.19.5. A final impression for a fixed prosthesis may be made from elastomeric material or reversible hydrocolloid. Impressions made with elastomeric impression materials have several advantages over those made with hydrocolloid. Elastomers are much less susceptible to temperature and humidity changes, and they are stronger than hydrocolloid. Two successive casts from the same elastomeric impression may be poured to make the second cast a duplicate of the first. However, if the impression is being made from reversible hydrocolloid, another impression will have to be made to pour a second cast.

1.19.6. See paragraphs 1.20 through 1.24 for various techniques and methods pertaining to this system.

1.20. Saw-Out Technique for Elastomeric Impressions. This technique is shown below and in Figure 1.15:

1.20.1. Rinse the rubber base final impression in room temperature water to flush away saliva and debris. Disinfect and carefully dry the impression with a gentle stream of air.

Figure 1.15. Dowel Pin Removable Dies (Saw-Out Technique).



1.20.2. Above each preparation site and adjacent unprepared tooth (teeth), drive two straight pins from the buccal flange through to the lingual aspect of the impression. The distance between the straight pins should be a little greater than the width of a dowel pin. The thinner and sharper the straight pins, the lesser the chances of distorting the impression. The 28-gauge disposable injection needles work best (Figure 1.15-A).

1.20.3. Position a dowel pin between a set of two straight pins and centered above the cervical margin of the preparation site or tooth imprint, flat side to the distal and long axis of the dowel pin parallel to the long axis of the tooth's root. Besides being as parallel as possible to the long axis of the tooth's root, the dowel pins placed in adjacent areas should parallel each other. Neatly sticky wax the dowel pins to the straight pins. ***NOTE:*** A variation of this method is where the dowel pins are held in place by commercially available plastic tubing bridged across vertically oriented straight pins. Dowel pins can also be held in place with bobby pins fastened to the impression with straight pins and sticky wax (Figure 1.15-A).

1.20.4. Pour the impression in two steps (stages). The first stage takes in the tooth preparations, unaltered teeth, and edentulous areas (Figure 1.15-B and -C). Pour the second stage on top of the first and form the base of the cast (Figure 1.15-D). To prevent entrapment of air bubbles caused by the surface tension of the dental stone, use a wetting agent on the impression before flowing in the first stage.

1.20.5. Vacuum spatulate the die stone according to the manufacturer's directions. Starting in a heel area, vibrate the stone into the impression and make it run to the opposite side. Be careful not to trap bubbles. The depth of the first pour should come to a level slightly below the straight pins and sticky wax. Embed staples (washers, paper clips) into all segments of the first pour that are not programmed to be removable; that is, any part without a dowel pin. ***NOTE:*** Polysiloxane impression materials are extremely hydrophobic. Before pouring the impression, ensure that no moisture has collected in crevices, blocking out the fine detail.

1.20.6. After the first pour has reached final set, remove the straight pins and clean the sticky wax from around the dowel pins. At the place where the dowel pin enters the first pour, cut away the flash of stone and create a butt junction. Cut two hemispherical indexing dimples into the base of each doweled part, one buccal and one lingual to the dowel pin. Use a #8 round bur. Do not sink the bur into the stone further than one-half the diameter of the bur head.

1.20.7. Apply a separator to the bases of the parts that contain dowel pins. If this is not done, the areas in the first stage that are programmed to be removable will not separate cleanly from the second stage.

1.20.8. Moisten the surface of the first pour and proceed to build a stone base for the working cast. Stack the stone to reach near the tips of the dowel pins without actually burying them. Do not attach balls of wax or clay to the dowel pin tips to act as pin locators. If wax or clay residues find their way into a dowel pinhole, a removable die will not seat. A better option is to place red plastic covers on the tips of the dowel pins (Figure 1.15-C and -D). Such covers are part of the "placement kit, tooth" previously mentioned. If the plastic covers or something similar are not available, do not use anything.

1.20.9. Next, place retention nodules onto the stone surface so the working cast stays attached to an articulator mounting ring when mounting time comes (Figure 1.15-D). Place the handle of the tray into an appropriate holder and let the stone set, impression side up. ***NOTE:*** Casts sent to another laboratory for appliance fabrication must have smooth bases so they can be separated from their mountings and returned with the finished restoration.

1.20.10. Wait until the second pour reaches final set and separate the cast from the impressions (Figure 1.15-E). ***NOTE:*** Polyether impression materials are very stiff, making separation of the cast from impressions difficult.

1.20.11. Next, trim the cast. The slush that splashes off a trimming wheel can ruin a working cast. If precautions are not taken, debris will cling to cast surfaces, making them rough and inaccurate. Before trimming a cast, soak it in SDS for about a minute. The slush will have fewer tendencies to stick. As additional protection, cover the cast's arch form with wet tissue paper. After trimming the cast, rinse it thoroughly in SDS. Blow it dry and set it aside for 30 minutes.

1.20.12. Clear any stone away from the tops of the pins, ensuring about 2 mm is exposed to view. If covers were used, remove them.

1.20.13. Before dies are sawed and tapped out for the first time, accurately seat the working cast in a jaw relationship record (Figure 1.15-F) and mount the working cast in an articulator (according to cast mounting procedures in Section 1G). Then proceed to the next step in the current process.

1.20.14. Using a flat-bladed die saw or fine-bladed coping saw, extend cuts from the gingival crest areas mesial and distal to a preparation or doweled tooth, down to the junction between the first and second pours of the working cast. If a die does not have other removable segments adjacent to it, the two saw cuts should converge toward the base of the cast. If there are a number of consecutive dies and doweled teeth present, the most mesial and most distal cuts should converge toward the base of the cast and all intermediate cuts should bisect the angle made by the converging outer cuts (Figure 1.15-G).

1.20.15. With the cast held low over a table and cradled in the palm of the hand, exert downward pressure on the tip of a dowel pin with an flat instrument. The doweled area should pop loose. ***NOTE:*** Never saw out dies or doweled teeth and pop them loose before the cast trimming procedure is done. Once removed, a die will not return to place if slurry from the trimming wheel gets into the dowel pinholes.

1.20.16. The next step is to trim the dies (paragraph 1.33.1).

1.21. Saw-Out Technique for Reversible Hydrocolloid Impressions:

1.21.1. Review the procedures described in paragraph 1.20 for obtaining removable dies and a working cast from an elastomeric impression by the saw-out technique. This method is almost identical. It only differs in the way dowel pins are positioned because reversible hydrocolloid does not retain straight pins well, is weak, and splits easily.

1.21.2. Certain ingredients in some reversible hydrocolloid impression materials detrimentally affect the surface hardness of dental stone. To compensate for the problem, immerse the impression in a 2 percent solution of potassium sulfate for about 5 minutes before continuing. This is called "fixing."

1.21.3. Using an indelible pencil, make marks buccal and lingual to preparation sites and adjacent teeth. The marks should be up high enough to still be visible after the first stage of the working cast has been poured.

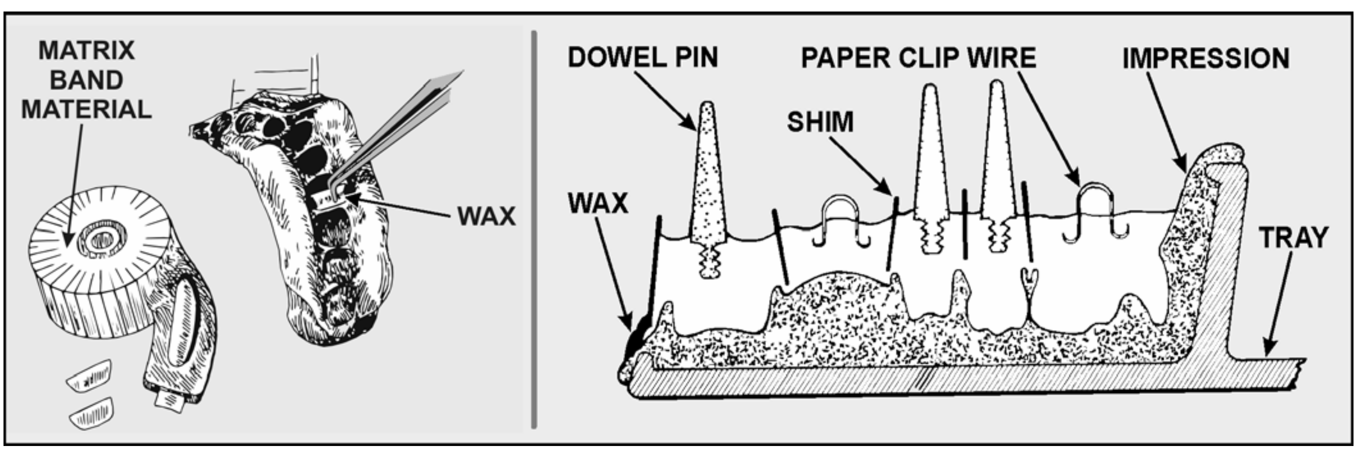
1.21.4. Place a dowel pin in a bobby pin. The intent is for the dowel pin to hang into a preparation site or adjacent tooth imprint while suspended from the bobby pin. The buccal and lingual walls of the impression support the bobby pin. Align the dowel pins in the areas selected according to the manner described for rubber-base impressions. Sticky-wax the dowel pin to the bobby pin and lay the assembly aside.

1.21.5. Pour the first stage of the working cast. Using the indelible pencil marks as guides, position the dowel pin or bobby pin assemblies in their proper places. A dowel pin is parallel to the long axis of a tooth and multiple and consecutive dowel pins are parallel to each other.

1.21.6. Let the stone of the first stage reach final set. Remove the bobby pins and clean the sticky wax from the dowel pins. Prepare butt junctions where the dowel pins enter the first stage.

1.22. Matrix Band Shim Method. A saw can not be used to full advantage in an interproximal area where the preparations are too close to each other or to adjacent teeth. The *shim method of* making removable dies is helpful in these kinds of cases (Figure 1.16). Two-thousandths (2/1000) of an inch matrix band material can be used to separate adjacent dies from each other and from the rest of the dental arch in the first stage pour. After the second stage pour has set, the remove metal shims, which should almost eliminate the need for sawing. The matrix band material is available in 5/16- and 7/16-inch widths. Use the width that works best for a given situation.

Figure 1.16. Dowel Pin Removable Dies (Shim Method).



1.22.1. **Rubber-Base Impressions:**

1.22.1.1. Cut trapezoid-shaped shims (dividers) from 2/1000 of an inch stainless steel matrix band material. Place these shims mesially and distally to a tooth preparation site or adjacent tooth imprint. Use only one shim in each interproximal area. The shims, together with the sidewalls of the impressions, will form a "box" around each area of interest. Shape each shim to conform to the facial, lingual, and gingival contours of the impression without quite touching them. Be sure to allow about 1 mm of space between the impression of the proximal gingival crests and the band material. Lay aside the cut shims in their proper sequence to help in placing them accurately.

1.22.1.2. Carefully apply a 1 or 2 mm thickness of utility wax to the facial and lingual aspects of the impression above the imprints of prepared and adjacent teeth. Warm a shim in an open flame sufficient for it to melt the utility wax and go to place easily. Converge the shims apically on an isolated abutment. For multiple, adjacent doweled areas, the most mesial and distal shims in the segment should converge apically. All intermediate shims should bisect the angle made by the converging outer shims.

1.22.1.3. Position the dowel pins by using the straight pin or bobby pin methods described in paragraph 1.20. ***NOTE:*** Some technicians place dowel pins in soft stone "freehand" immediately after the first stage has been poured. This method can be used successfully, but the technician has minimum control over dowel pin alignment.

1.22.1.4. Minimize entrapment of air bubbles by using a surface tension reducing agent over the rubber base material. Pour a vacuum spatulated mix of die stone into the impression to produce the working cast's first stage. Leave about 0.5 mm of the shim tops visible. If the dowel pins were not previously positioned with straight pins, align them now. Provide mechanical retention in all segments of the first stage not destined to be removable. Use small washers, wire loops, or small nodules of stone.

1.22.1.5. After final set of the first stage, drill small indexing depressions to the buccal and lingual of a dowel pin with a #8 round bur. Paint a separator onto the bases of the doweled parts and pour the second stage of the working cast as previously described in paragraphs 1.20.8 through 1.20.10. Do not bury the ends of the dowel pins.

1.22.1.6. Trim the working cast, taking care not to get stone slush all over it. Mount the working cast and its opponent in an articulator (Section 1G).

1.22.1.7. Using a #0000 jeweler saw blade, carefully cut from a proximal gingival crest down to the shim. Remove each doweled part by pressing on the dowel pin and popping it out. To do this successfully, first expose the buccal, lingual, and gingival edges of the shims with a #25 knife blade.

1.22.2. **Reversible Hydrocolloid Impressions:**

1.22.2.1. Submerge reversible hydrocolloid impressions in a 2 percent potassium sulfate solution for about 5 minutes. This improves the surface hardness of the set stone.

1.22.2.2. In a rubber-base impression, undersized shims were waxed to place. In a reversible hydrocolloid impression, the shims are cut slightly *oversized* bucco-lingually so they can be embedded in the impression's sidewalls. To avoid distorting the impression, a shim should clear the gingival crest proximally by about 1 mm.

1.22.2.3. The rest of the technique is the same as described in paragraph 1.22.1.

1.23. Pindex Instrument and Technique:

1.23.1. The Pindex instrument or similar drilling device simplifies paralleling and centering dowel pins for removable stone dies made in elastomeric or hydrocolloid impressions (Figure 1.17). This technique is useful when it is more advantageous to pin the die after the first pour is complete. Such is the case in a difficult-to-pin hydrocolloid impression or when an epoxy resin technique of cast construction is used.

1.23.2. Make the first stage pour sufficiently thick—at least 15 mm from the bottom to the marginal extension. Carefully remove the arch from the impression and trim the base against a cast trimmer to create a flat surface (Figure 1.17-A). The finished first stage pour should be 15 mm from the base to marginal extension. The first stage pour should be slightly damp before drilling the pinholes (Figure 1.17-B).

1.23.3. Using a pencil, plot each pinhole location on the surface of the first stage pour. Drill *two* holes, one buccal and the other lingual, centered on each prepared posterior tooth (Figure 1.17-C). Ensure the holes are far enough apart that they won't interfere with seating of the plastic sleeves that cover each pin. Drill *one* hole lingual to each prepared anterior tooth. Drill individual pinholes in adjacent areas that will be removable or used for placing retentive devices. After all holes are drilled, use compressed air to clean any debris from the holes.

1.23.4. Select the proper pin for each location and cement it in place with cyanoacrylate glue (Figure 1.17-D). Place the corresponding plastic or metal sleeve over the metal pin (Figure 1.17-E). Regular brass dowel pins with the tapered end bent over can be used for retention areas. Use the *dual pin* with corresponding metal sleeves for anteriors to compensate for narrow arch sizes. Use this pin without the metal sleeve if space is limited. When using the dual pin, make a small indexing notch lingual to each hole with a separating disc. Use the *long pin* with a white plastic sleeve as a dowel pin for posterior teeth. Use the *short pin* and gray sleeve with the long pins for indexing the die.

1.23.5. Paint a separator on the base of all areas you intend to saw out. Before constructing the second stage, place a strip of utility wax over the pin extensions to access the pins and to close over the opening of the gray sleeves. Bead and box the first pour with wax or use the rubber molds to form the base. Moisten the surface of the first pour before filling the mold to form the base. Be sure to flow stone in and around the sleeves before inverting the arch into the stone-filled base mold (Figure 1.17-F and -G).

1.23.6. Trim the cast and section the dies as previously described (Figure 1.17-H through -J).

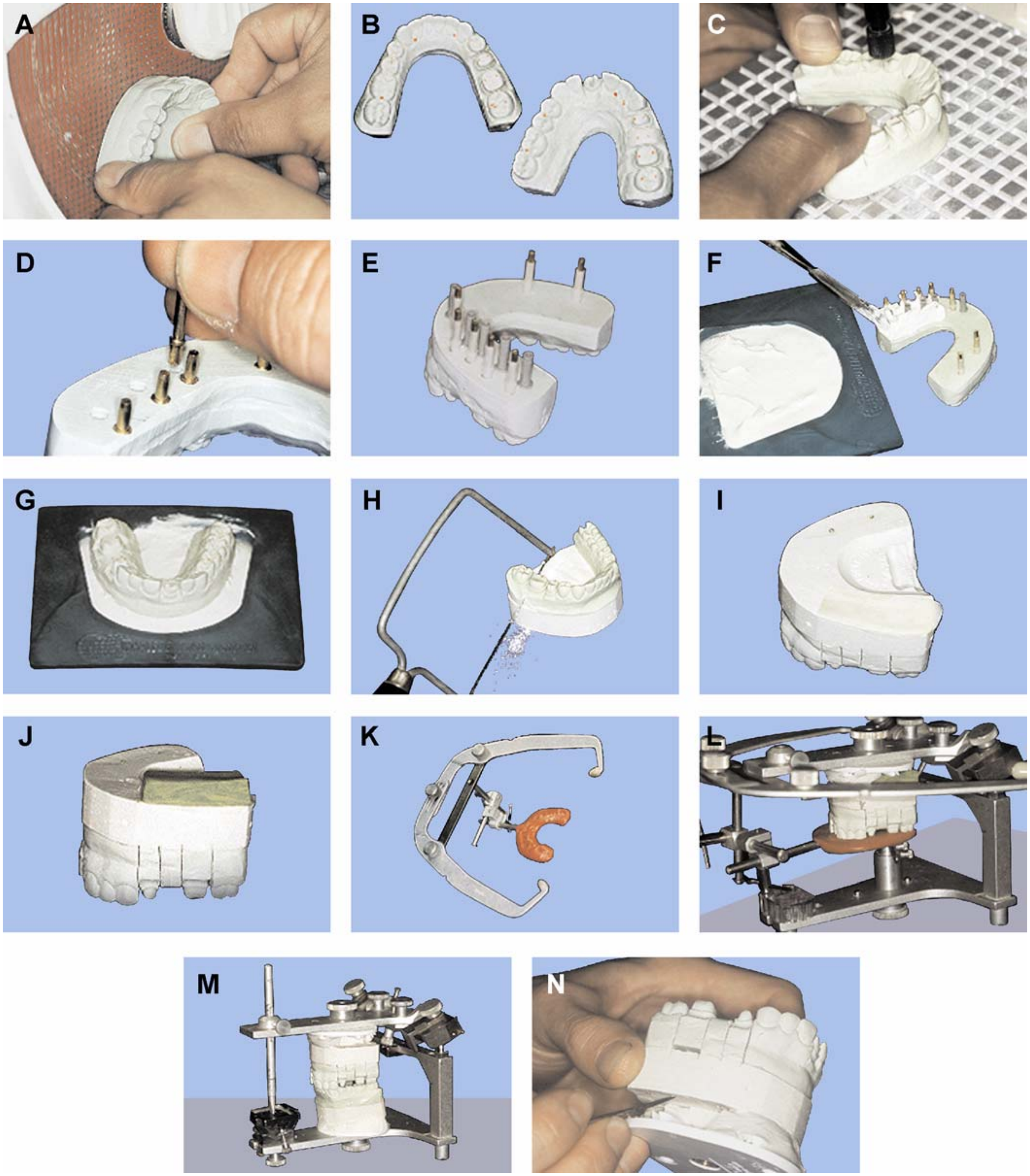
1.24. Silver-Plating Polysulfide and Silicone Impressions:

1.24.1. Electroplated dies have the following advantages over other die materials: harder surfaces, more abrasion resistance, and generally superior surface detail. These advantages make electroplated dies an excellent choice for use in making porcelain restorations. ***NOTE:*** Toxic fumes produced by the silver cyanide solution are extremely dangerous. Use the solution under an exhaust hood. Although it is possible to silver-plate silicone impressions, distortion can be a problem. Do not attempt to plate polyether impressions.

1.24.2. Thoroughly clean and dry the impression because the metalizing powder will not adhere to wet surfaces and tends to collect in corners.

1.24.3. Insert the cathode wire through the impression in the buccal sulcus area and fix it firmly in place to prevent twisting and loss of contact with the impression material.

Figure 1.17. Dowel Pin Removable Dies (Pindex Method).



1.24.4. Paint the surface of the area to be plated with silver powder. Avoid excess pools of silver powder in the impression and ensure the wire makes contact with the powder. Pay close attention to undercut areas, making sure they are adequately covered. Dust away all surplus powder and lightly dry the impression with compressed air. You may also use commercially available aerosol silver sprays.

1.24.5. Fill the preparations and the teeth with the electrolytic solution by using an eyedropper to prevent air bubbles and resulting voids.

1.24.6. Completely submerge the impression in the plating solution. Attach the cathode wire to the negative side of the unit and connect the anode of pure silver to the positive side. Switch on the plating unit and adjust the output for a complete arch impression to approximately 150 (mA) or less for smaller sections. After 1 hour of plating, inspect the impression and even deposition of metal to ensure there are no voids. If voids are present, remetalize those areas with silver powder and resume plating.

1.24.7. Remove the plated impression after approximately 15 hours and wash it thoroughly under running water. Dry the impression, using compressed air.

1.24.8. Pin and pour the impression as you normally would.

1.25. Removable Dies and a Working Cast Made From a Combination of a Tube Impression, Transfer Copings, and a Tray Impression. Individual dies made from plastic tube impressions can be changed into removable dies in a working cast by using transfer copings and a tray impression. Although this technique is time-consuming and has more potential for error than with dowel pin systems. It continues to persist because it is occasionally impossible to make an impression of the prepared teeth in a tray.

1.25.1. **Making Dies From a Tube Impression.** Take the tube impression and construct a dental stone die. Have the dentist trim the margins of the die. *Taper and key the die's extension.*

1.25.2. **Making Dies From Transfer Copings.** An individual die cannot be inserted into a tray impression made from an elastic material with full confidence that the die is correctly related to the rest of the dental arch. There are always doubts about how accurately the die is seated or whether the weight of the die is making it lean from its proper orientation. Transfer copings help to resolve most of the doubts. A *coping* is a thin, shell-like cap fabricated over a die of a complete crown preparation. A coping can be cast from metal or made from a resin like *Dura Lay®* (Reliance Dental Mfg Co, Worth, IL). This metal or plastic cap becomes a *transfer coping* when used for seating an individual die in an impression tray with greater accuracy. Metal copings are thought to give better results than the plastic variety, but plastic copings are much easier to make and work well enough for simple cases, as follows:

1.25.2.1. Apply a tinfoil substitute to a stone die.

1.25.2.2. Use the *brush technique* to build up a Dura Lay® coping on the die. The brush technique consists of adding increments of resin polymer with a brush and using the same brush to wet each polymer increment with monomer. ***NOTE:*** Because acrylic resin shrinks as it polymerizes, a circumferential coping made as a single unit tends to lock onto the die. To minimize this tendency, build the coping in halves down to the die margin. For example, apply the facial half and let it polymerize before layering on the lingual portion. Be sure the resin layer is uniform and sufficiently thick to be rigid.

1.25.2.3. Take the coping off the die and cut its gingival margin 0.5 mm short of the die margin. Carefully cut a small "window" into the coping's facioincisal edge. Place the coping back on the die. Look into the window and make sure it seats. Attach resin spurs to the coping's facial and lingual surfaces well above the plastic margin. Store the completed coping on its die.

1.25.2.4. Note that the dentist places the copings on their respective preparations in the patient's mouth and looks into the windows to check the copings for fit. Next, the dentist might make a plaster index to encase all of the copings as a unit. To relate this assembly to the rest of the dental arch, the dentist will make a complete arch alginate impression over the index while it is seated in the mouth. ***NOTE:*** The impression received will have copings embedded in a plaster index which, in turn, will be embedded in an alginate impression.

1.25.2.5. Apply separating medium to any exposed plaster in the impression and seat the tapered, keyed, individual dies into the copings. Seal each die in position by flowing a little baseplate wax around the die's junction with the impression. Further stabilize the die by extending a common straight pin from facial lingual across the ridge area and seal the die to the pin with sticky wax.

1.25.2.6. Lubricate the extension of each die. Pour the cast, leaving about 2 mm of the tips of the dies exposed. Place retention nodules on the top of the soft stone so the cast can be retained on a mounting ring without difficulty.

1.25.2.7. Separate the cast from the impression. Trim the cast, mount the cast against the opposing arch in an articulator, and pop the dies loose.

1.26. Solid Working Casts. A solid working cast can be a great asset in the fabrication of fixed prostheses. Following are two methods for fabricating solid casts and their use in the laboratory:

1.26.1. **Solid Working Cast With Augmenting Individual Dies (Figure 1.18):**

1.26.1.1. Some dentists prefer to use a solid working cast (no removable dies) to develop the occlusal surfaces and the proximal, buccal, and lingual contours of wax patterns. The patterns are then transferred to individual dies for completion of the margins. A working cast with augmenting individual dies can be made by pouring a rubber base impression twice; first, to pour the dies of the individual abutments, and second, to pour the cast. Do not use reversible hydrocolloid impressions because the material is susceptible to change.

1.26.1.2. Before pouring the dies, "box" the imprint of each abutment with matrix band strips to confine the die material. An alternative is to pour a sectional or partial cast that includes several dies and saw the dies apart later. Add enough die material to form an extension that is adequate for easy handling of the die. Allow this first pour to set for 45 minutes.

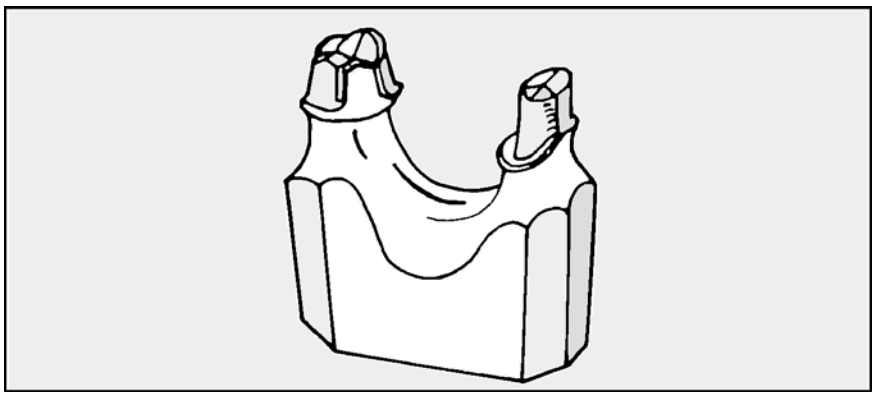
1.26.1.3. Remove the first pour from the impression and set it aside where it will not be damaged. Before repouring the impression, wax a ring of boxing wax around the top of each abutment margin. This ring will expose the margin so the wax pattern can be made and the casting can be seated on the cast. Immediately repour the impression to construct a complete, solid working cast.

1.26.1.4. After removing the working cast from the impression, trim it on a cast trimmer and let the cast dry. Use this cast to establish the occlusal form, proximal contacts, and occlusal two-thirds of the axial contours of the wax patterns. Use the trimmed individual dies to complete the final adaptation of the wax pattern margins.

1.26.1.5. Using this technique, make a single-piece die for FPDs (Figure 1.19). Leave the die for each abutment joined to the other by a common base. Because the dies are never separated from each other, greater accuracy can be expected. Pour the involved part of the arch and die stone for an adequate base. When trimming the one-piece die, be sure to cut back the edentulous ridge area, allowing good access for contouring the interproximals and for finishing the margins.

Figure 1.18. Solid Working Cast With Augmenting Individual Dies.

Figure 1.19. One-Piece Die for an FPD.



1.26.2. **Solid Working Cast With Dowel Pinned Cast.** The extreme stability of polyvinylsiloxane impression material allows the production of multiple and nearly identical casts from one impression. For fixed prosthodontics, it is most useful to have one pinned and sectioned cast (paragraph 1.19) and one "solid" cast. These two casts allow the production of an extremely accurate prostheses.

Section 1G—Cast-Mounting Procedures

1.27. Overview. The most convenient time to unseat a removable die for the first time is before mounting the working cast. You have maximum access to the tips of the die extensions. However, the best time to mount a cast is before the first release of removable dies from their seats. A working cast has a better chance of fitting against an opposing cast or into a jaw relationship record with the greatest possible accuracy. The accuracy of the mounting is the primary consideration. The problem then becomes one of providing access to the tips of die extensions in the working cast's mounting.

1.28. Die Extension Access:

1.28.1. Cover the tips of the extensions with any type of tape that sticks to damp surfaces (Figure 1.17-I).

1.28.2. Place a mound of clay on top of the tape and shape it so the stone used in mounting the cast will not block direct access to the extension tips (Figure 1.17-J).

1.28.3. Mount the maxillary cast with facebow (Figures 1.17-K and -L).

1.28.4. Mount the mandibular cast (Figure 1.17-M).

1.28.5. Peel out the clay and tape after the stone sets (Figure 1.17-M).

1.28.6. Pop loose the dies and all other removable areas of the cast (Figure 1.17-N).

1.29. Mounting the Maxillary Cast:

1.29.1. **Average Method.** See Volume 1, paragraph 6.12.

1.29.2. **Facebow Transfer.** An occlusion rim is part of the facebow transfer apparatus for an edentulous or nearly edentulous maxillary arch. In fixed prosthodontic cases, a significant number of maxillary teeth are usually present and an occlusion rim is not often used. Instead, the dentist will cover the facebow's bite fork with a uniform thickness of base plate wax or modeling compound. The dentist will warm the material and impresses it against the maxillary teeth, picking up a series of incisal edge and occlusal surface indentations. After the facebow transfer has been sent to the laboratory, set the maxillary cast in the indentations when the facebow is being related to the articulator as follows:

1.29.2.1. **Hanau H2 Articulator.** See the description in Volume 1, paragraph 7.47.2) The only difference in the description is that the occlusal plane formed by stone teeth (instead of the plane of an occlusion rim) is oriented parallel to the base of the articulator.

1.29.2.2. **Whip-Mix Articulator:**

1.29.2.2.1. **Prepare the Articulator for the Cast-Mounting Procedure:**

1.29.2.2.1.1. The lower frame of the articulator has the letters L (large), M (medium), and S (small) engraved on each of its corners on the back side. Screw the two condylar elements into the setting that corresponds with the patient's condylar width of L, M, or S as recorded on the front of the facebow by the dentist.

1.29.2.2.1.2. Tighten the condylar elements firmly in place with the box wrench. Then set the upper frame of the articulator to the same width of L, M, or S by removing or adding the correct number of spacers on the shafts of the condylar guides.

1.29.2.2.1.3. Use two spacers on each shaft for L, one on each shaft for M, and none for S. Make sure the shafts are replaced so the spacers are in tight contact on both sides between the articulator frame and the condylar guides. When spaces are using spacers, always place those with the beveled sections closest to the condylar guides, with the bevels next to the guides. Also be sure the horizontal line on each spacer aligns with the one on the back of the condylar guide.

1.29.2.2.1.4. Spacers are not interchangeable between articulators. When spacers are not in use, place them on the incisal guide pin so they stay with the same instrument. Set the condylar guides at a 30-degree angulation in preparation for attaching the facebow assembly. The side shift guide settings are irrelevant at this time. Firmly secure clean mounting plates on both the upper and lower frames of the articulator. Be sure the adjustable incisal guide table is in place on the lower frame and remove the incisal guide pin.

1.29.2.2.2. **Secure the Facebow to the Upper Frame:**

1.29.2.2.2.1. The Whip-Mix facebow is most conveniently used with a Whip-Mix articulator. The facebow is designed so neither side arm can be moved laterally without the other arm moving a corresponding distance. The facebow is attached to the upper frame of the articulator by placing the holes in the medial side of the plastic earpieces over the pins provided on the outside flange of the condylar guides.

1.29.2.2.2.2. Remove the plastic nasion relator and its bracket from the crossbar of the facebow and loosen the three thumb screws slightly. To secure the facebow in place, hold it in one hand and with the other and lift off the upper member of the articulator.

1.29.2.2.2.3. While holding one arm of the facebow against your body, guide first one pin and then the other onto the outer flanges of the condylar guides and into the holes on the medial side of the plastic earpieces. Allow the anterior end of the upper frame of the articulator to rest on the crossbar of the facebow and then tighten the three thumb screws while still pressing the facebow arms firmly against your body.

1.29.2.2.2.4. Replace the upper frame with attached facebow onto the lower frame, allowing the fork toggle of the facebow to rest on the incisal guide table.

1.29.2.2.3. **Mount the Maxillary Cast:**

1.29.2.2.3.1. Seat the cast in the face bow fork registration. Then lift the upper arm of the articulator and apply a mound of well-mixed stone to the base of the cast. Using one hand for support to prevent any movement of the facebow fork or cast, close the upper arm of the articulator until it again touches the crossbar of the facebow, sinking the mounting plate into the soft mounting stone. Hold the cast in position until the mounting stone has set and then remove the facebow from the articulator.

1.29.2.2.3.2. When a facebow transfer is made to a Whip-Mix articulator, expect the occlusal plane to have an anterior tilt with reference to the horizontal plane of the articulator. If the occlusal plane and the articulator's horizontal plane happen to coincide, it is pure chance.

1.30. Mounting the Mandibular Cast:

1.30.1. **Mounting at the Patient's Actual or Estimated Occlusal Vertical Dimension.** This is characteristic of two kinds of cast relating methods, dentulous casts fitted together in MI and occlusion rim-jaw relationship records. Follow the pin-flush rule below with this kind of mounting:

1.30.1.1. Mount the upper cast by the average or the facebow transfer method. Mount the upper cast while the incisal guide pin is flush with the upper member of the articulator. In the Whip-Mix facebow transfer procedure, remove the pin before placing the face bow on the articulator. After facebow mounting of the maxillary cast is finished, replace the incisal guide pin (pin-flush).

1.30.1.2. Lock the condylar elements down in the most retruded position. The Hanau articulator has centric locks to accomplish this. On the Whip-Mix articulator, set the side shift guide on each side in an extreme negative position and outward as far as possible. While this will lock the condyles in a retruded position, be careful not to force the articulator into an overopened position because the instrument could be seriously damaged.

1.30.1.3. Invert the articulator.

1.30.1.4. Place opposing dentulous casts in the best MI possible or position casts in an occlusion rim record, if provided.

1.30.1.5. Stabilize the assembly with wires and modeling plastic.

1.30.1.6. Apply a mound of stone to the base of the lower cast and close the articulator into it. The condyle elements should be in their most retruded positions in the condyle guides.

1.30.2. **Mounting at a Vertical Dimension Other Than the Patient's Actual or Estimated Occlusal Vertical Dimension:**

1.30.2.1. This condition is characteristic of mountings made with interocclusal jaw relationship records. An *interocclusal record* is one that has been made between the teeth of opposing arches. Interocclusal records are made in different ways. Some are made from wax wafers, others are made from zinc oxide and eugenol paste carried into the mouth on a perforated metal plate, and still others are made with zinc oxide and eugenol paste supported by gauze held in a frame.

1.30.2.2. The one thing all interocclusal records have in common is *thickness.* Because they have thickness, they usually hold opposing teeth apart at a vertical dimension that is *open* from the patient's occlusal vertical dimension. It is common practice to compensate for the thickness of an interocclusal record before the lower cast is attached to its mounting ring.

1.30.2.3. Mount the maxillary cast with a facebow transfer supplied by the dentist. The thicker the interocclusal record, the greater the need for a facebow transfer. Opposing casts mounted at an open vertical dimension without benefit of a facebow transfer will be inaccurately related when the articulator is subsequently closed to the patient's actual or estimated occlusal vertical dimension.

1.30.2.4. Make an estimate of how thick the record is. Using the pin-flush position as the starting point, open the vertical dimension accordingly. The range of compensation varies from about 1 mm for a gauze-supported record to 5 mm for a record made with wax or with metal plates.

1.30.2.5. Invert the articulator and position the interocclusal record on the teeth of the maxillary cast. Place the teeth of the mandibular cast in their corresponding indentations. Stabilize the assembly with wires and modeling plastic. A good interocclusal record will show the indentations of incisal edges and the cusp tips of posterior teeth, but no more. Records showing more than the requirements have to be trimmed with the sharpest knife possible until only incisal edges and cusp tips are visible. It is unacceptable practice to force a cast into a record that laps onto the facial or lingual surfaces of teeth. There is a strong possibility the record will warp. There is no way of determining whether the cast is fully seated in the record.

1.30.2.6. Mount the mandibular cast. After it has been mounted, remove the interocclusal record. Decrease the vertical dimension to the patient's actual or estimated occlusal vertical dimension. Make a note of the final pin setting on the upper cast's stone mounting.

1.31. Semiadjustable Articulator Settings (Hanau H2 and Whip-Mix):

1.31.1. **Average Method:**

1.31.1.1. Note that the occlusal plane is parallel to the horizontal plane of the articulator.

1.31.1.2. Remember, the scale should read "+30^{o}." If, for some reason, the occlusal plane has not been mounted parallel to the horizontal plane of the articulator, set the horizontal condylar guidance other than +30^{o} to compensate for the amount of deviation (Volume 1, Chapter 6). For example, many dentists like to use a facebow transfer with average settings on a Whip-Mix articulator. The occlusal plane will rarely come out parallel to the articulator's horizontal plane after a Whip-Mix facebow transfer. Expect a positive deviation of about 10 to 15 degrees. In order for the horizontal condylar guide (slope of the patient's articular eminence) and the occlusal plane to intersect at the statistical average of +30°, set the horizontal guidance at the + 40° to + 45° mark on the scale.

1.31.1.3. Note that lateral condylar guidance equals 15 degrees.

1.31.1.4. Set the incisal guide table initially at 0°. Make adjustments to the table after determining the occlusion scheme for the prosthesis.

1.31.1.5. On a Whip-Mix articulator, use the "medium" intercondylar distance setting. (For a Whip-Mix articulator with immediate sideshift guides, use the 0.5 mm setting.)

1.31.2. **Semiadjustable Method:**

1.31.2.1. **Hanau H2 Articulator:**

1.31.2.1.1. Mount the maxillary cast with a facebow transfer.

1.31.2.1.2. Use a protrusive jaw relationship record to set the horizontal condylar guidance. First, mount the maxillary and mandibular casts in the centric position (centric relation, MI) the dentist wants. Then, loosen the horizontal condylar guidance lockscrews. The guidances should rotate freely within their housings. Also loosen the centric locks to permit movement of the condyle elements within their guides.

1.31.2.1.3. Fit the supplemental protrusive jaw relationship record provided by the dentist onto the teeth of the mandibular cast and fit the maxillary teeth into their corresponding indentations. Rotate the horizontal guidances back and forth within their housings until settings are found where the maxillary cast seats solidly on all indentations in the record. Tighten the guidance lockscrews and remove the protrusive record.

1.31.2.1.4. Use the following lateral condylar guidance formula: $L = \frac{H}{8} + 12$. See Volume 1, Chapter 6, for an explanation.

1.31.2.1.5. Set the incisal guide table at 0° until plans for the fixed prosthesis occlusion are made.

1.31.2.2. **Whip-Mix Articulator (Figure 1.20):**

1.31.2.2.1. Use the facebow transfer to set the intercondylar distance and to mount the maxillary cast.

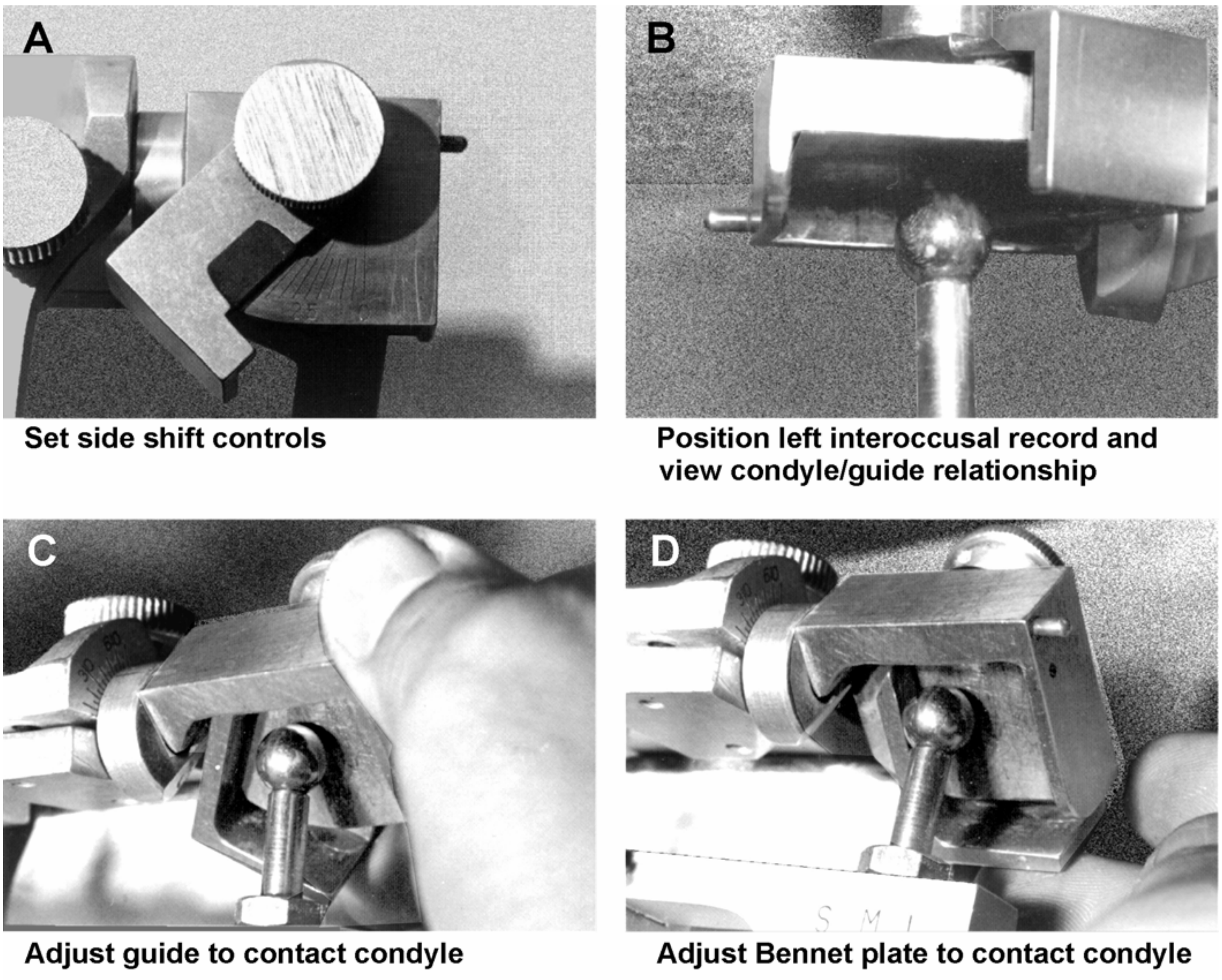
1.31.2.2.2. To set horizontal and lateral condylar guidances, use a set of right and left lateral excursion interocclusal records. First, mount the maxillary and mandibular casts in the centric position ordered by the dentist (centric relation, MI).

1.31.2.2.3. After removing the registration record, set both condylar guides at zero inclination and the side shift controls at their most open position (45°) (Figure 1.20-A). Raise the incisal guide pin to prevent interference. With the upper frame and its cast inverted, carefully seat the left lateral excursion interocclusal record on the upper cast. Holding the upper frame in one hand and the lower frame in the other, place the left condylar element in the left condylar guide. Gently seat the lower cast into the indents of the lateral record and lightly hold the articulator and casts in position with one hand.

1.31.2.2.4. Notice in Figure 1.20-B that the right condylar element has moved away from both the superior and posterior surfaces of the condylar guide and, in most cases, toward the median line. To set the inclination of this right guide, loosen its holding screw and rotate the guide toward the condylar element until contact is established. It is advisable that contact be judged by sight, rather than by depending on the sense of touch (Figure 1.20-C). This helps to ensure that the casts are not forced out of position from the interocclusal record. Tighten the locking screw to fix the guide in this position.

1.31.2.2.5. The next step is to get the correct amount side shift by loosening the side shift guide locking screw and then moving the guide into contact with the condylar element (Figure 1.20-D). Retighten the locking screw. After the right horizontal and lateral condylar guidances have been set, adjust the left side of the articulator with the right lateral excursion record.

Figure 1.20. Adjusting Horizontal and Lateral Condylar Guidance (Whip-Mix Articulator).



1.31.2.2.6. Some Whip-Mix articulators are purchased with an immediate side shift guide option. The option consists of four sets of guides that permit from 0.25 to 1 mm of immediate side shift, depending on the set chosen. The rule for selecting a set is in Volume 1, Chapter 6. Substitute the chosen set for the set already on the articulator.

1.31.2.2.7. Remember, the incisal guide table is initially set at 0 ^{o}. Make adjustments to the table after determining the occlusion scheme for the prosthesis.

1.32. Microscope Utilization:

1.32.1. The use of a microscope can greatly enhance the quality of fixed prosthodontics. Many procedures during the fabrication process benefit from magnification to achieve a quality product.

1.32.2. Microscopes are available with a swivel-type attachment to the bench or a bench top model. The swivel arm allows the technician to ergonomically work directly under the microscope. It also allows several workstations access to a single instrument, thereby reducing equipment costs. The bench top model does not allow the technician to ergonomically work at the laboratory workstation and should only be used for interim periods.

1.32.3. Generally, the power of magnification for laboratory use is in the range of 10x to 30x. Microscopes may be used anytime detailed intricate work is being performed. Their most common uses are for die trimming and marking the margins on fixed restorations, achieving adaptation of wax to the margin areas of fixed restorations, seating fixed restorations on the die after casting, and quality control assessment of completed restorations. All of these procedures are shown in this chapter.

1.33. Die and Working Cast Preparation Before Waxing: (***NOTE:*** The assumptions are that the working cast is mounted against its opponent in an articulator and the removable dies are removed from the cast and ready for trimming.)

1.33.1. **Trimming the Die.** The combination of cuts a dentist makes on a natural tooth for purposes of receiving a restoration is called a *preparation.* The most peripheral extent (outline form) of a preparation is the *margin.* A fixed prosthetic restoration, such as an onlay or a crown, has to cover the entire tooth surface a dentist has cut or prepared. The margin of the preparation also represents the border or margin of a proposed restoration. Depending on the kind of preparation the dentist has made, part or the entire margin will be below gingival tissue. Before a die can be used to make a restoration, any dental stone that covers the margin of a preparation has to be trimmed away. ***NOTE:*** Although die trimming is the dentist's responsibility, a technician is occasionally called on to do it under the dentist's supervision. If a technician is to trim dies, make wax patterns, and finish castings competently, he or she must have knowledge of basic preparation forms and margin styles (Figure 1.21).

1.33.1.1. **Margin Styles (Figure 1.22):**

1.33.1.1.1. **Shoulder.** A shoulder margin is one that intersects with the surface of a tooth at a 90-degree angle. The junction of a restoration with a preparation at a shoulder is called a butt joint. This kind of margin is almost exclusively reserved for all-ceramic crowns or metal-ceramic restorations with facial porcelain margins because of porcelain's limitations as a restorative material. When fabricating an all-ceramic crown, the 90-degree angle between the margin and facial surface must be rounded or radial to prevent porcelain from fracturing. A thin, sharp margin would contribute toward better sealing a restoration to a tooth, but the physical properties of porcelain do not permit it to be used in that way.

1.33.1.1.2. **Chamfer.** The chamfer is usually the margin of choice for complete and partial metal crowns and pinledges.

1.33.1.1.3. **Knife Edge.** In most cases, the knife edge (or chisel edge) is considered an adequate substitute for the chamfer margin.

Figure 1.21. Preparation Forms.

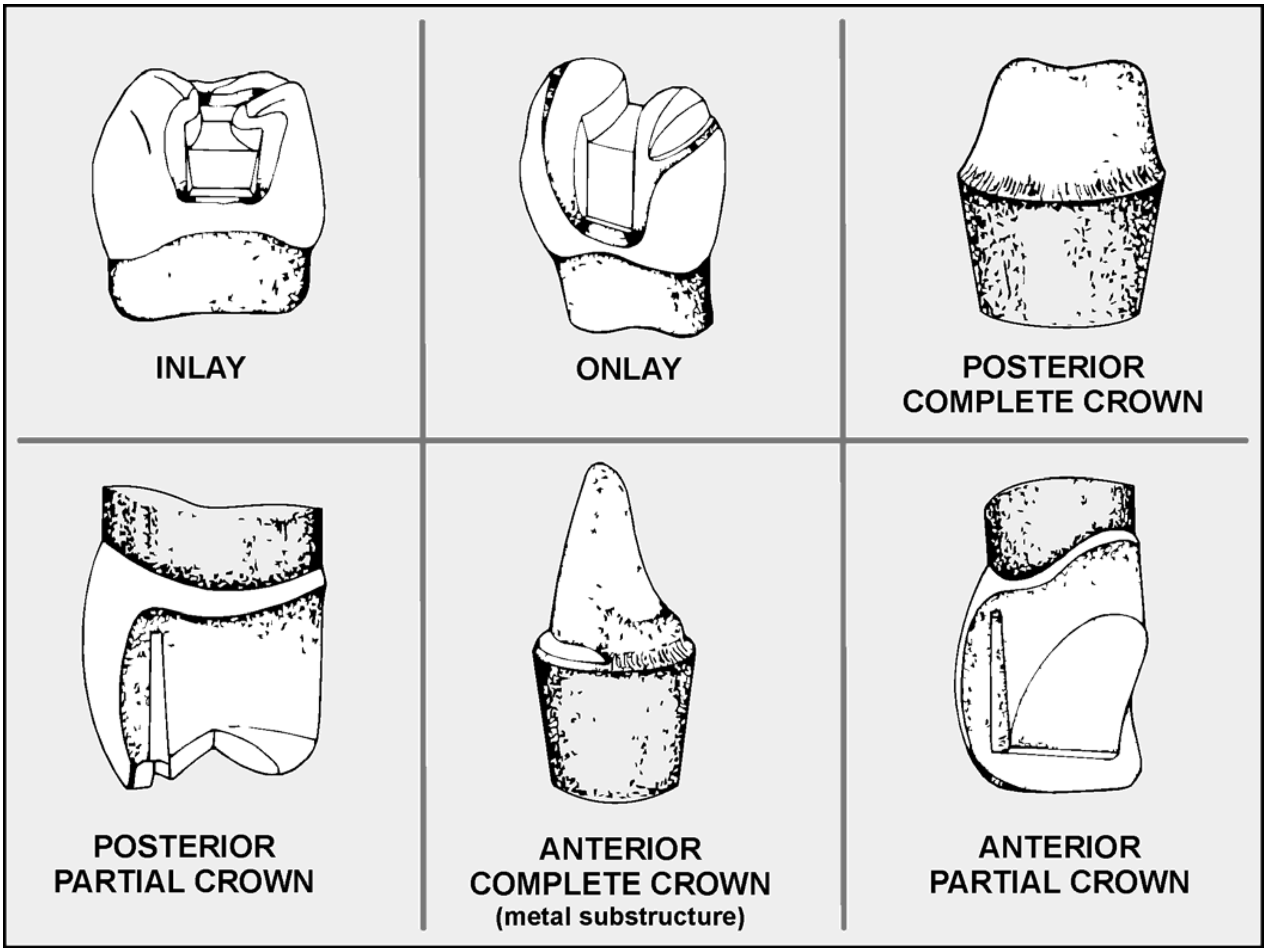
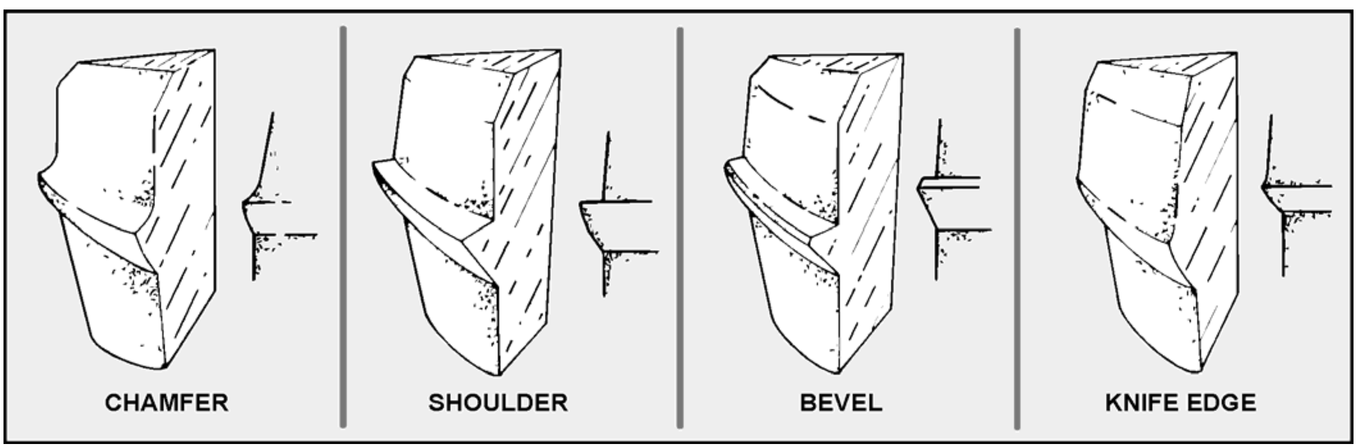


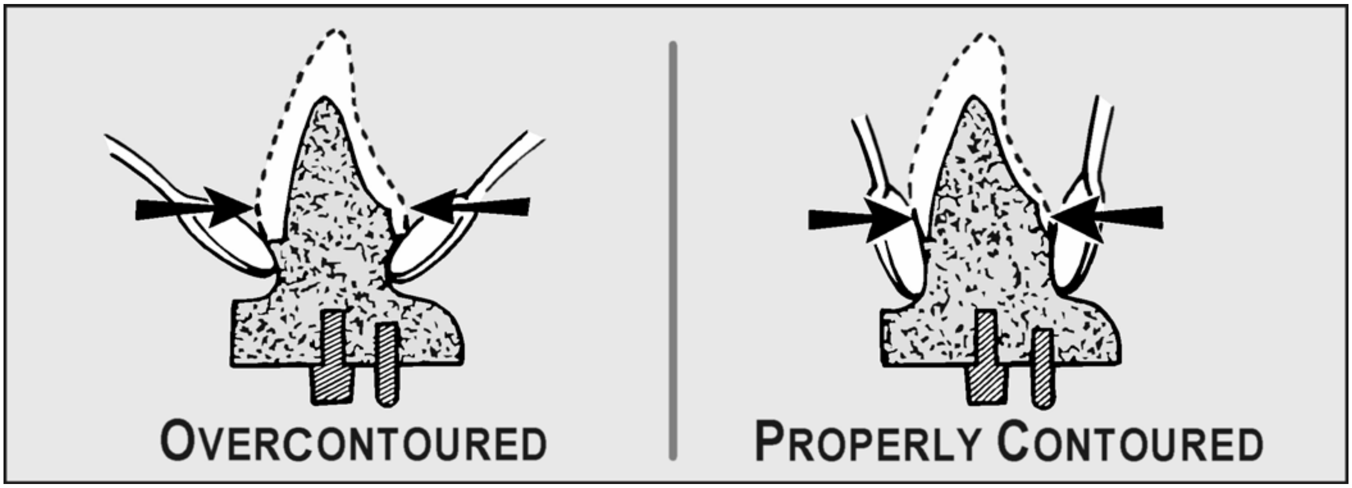
Figure 1.22. Margin Styles.



1.33.1.1.4. **Bevel.** There are many areas in the various preparations for reception of a metal casting where shoulder-like cuts are made. Examples include the gingival seat of an inlay or onlay and the faciogingival area of a complete anterior crown. The place where a conventional shoulder would join with the surface of a tooth at 90 degrees is changed into a 45-degree angle. This alteration, called a *bevel,* has the desirable effect of lengthening and sharpening a restoration's margin.

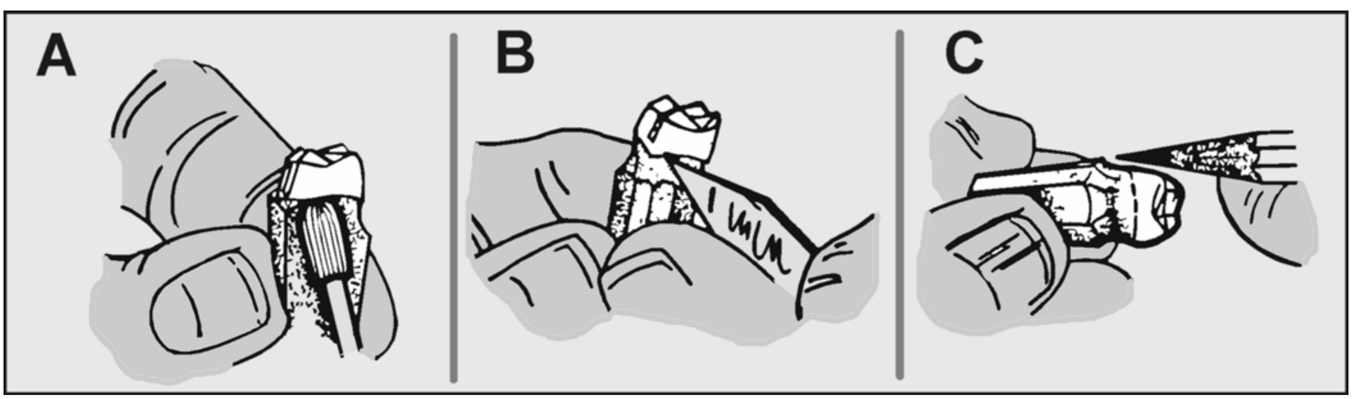
1.33.1.2. **Die Trimming.** Define margins and reshape the area immediately below the margins before making wax patterns. Use a microscope to perform these steps to be able to clearly see the margin. When refining the wax margins of a pattern, rest the instrument on the die base. Figure 1.23 shows how a deeply ditched die can influence overcontouring of the pattern. The margin definition can be performed in two steps: (1) remove excess stone next to the gingival margin of the preparation, and (2) define the gingival margin by careful carving.

Figure 1.23. Pattern Contour Influenced by Die Trimming.



1.33.1.2.1. **Bulk Trimming.** Do the initial bulk trimmings with a pear-shaped bur (Figure 1.24). Expose about 4 mm of stone below the margin without creating a *deep* recess. The die contours should resemble the root portion of a natural tooth.

Figure 1.24. Bulk-Trimming and Refining a Die Margin.



1.33.1.2.2. **Define the Margin.** Do the final trimming with a #25 Bard Parker blade or beaver blade. At the mesial and distal surfaces, make the cuts *straight down* because the proximal contours of patterns are fairly straight. On the facial and lingual areas, strive for about 0.5 mm of undercut. Define only the gingival margins, not those prepared as supragingival (above the gingival crevice, as in a 3/4-crown preparation).

1.33.2. **Preparing the Die:**

1.33.2.1. **Mark the Margins.** To ensure the margins are highly visible, lightly outline them with a red wax pencil. Do not use a lead pencil because lead transferred to the investment mold can create pits in the casting. Then apply a very thin surface hardener over the marked margins. This prevents the red pencil line from smudging and maintains marginal integrity during the fabrication process.

1.33.2.2. **Paint On the Die Spacer.** Note that cement used during insertion exerts pressure (hydraulic effect) on a precision casting, which may prevent complete seating. The die spacer allows enough room for the film thickness of cement so the casting will seat completely. The covering must stop about 1 mm from the margin of the preparation. Properly applied, the material will measure between 20 to 40 microns thick.

1.33.2.3. **Edentulous Ridge Modifications.** These instructions apply to FPD cases. *A dentist has to request the modifications.* Pontics are supposed to be in positive contact with an edentulous ridge or constructed at an elevated level, totally out of contact. At times, contact is difficult to maintain. Sometimes, a pontic raises up slightly as a result of a soldering procedure. Occasionally, contact is finished and polished away. When pontic contact with the edentulous ridge is the goal, smooth off edentulous area irregularities just enough to permit correspondingly smooth contouring of the gingival surface of the pontic. Next, use a pencil to carbonize only the tissue contact areas and then carefully shave away the carbon. Shaving away two or three such carbon applications should give sufficient contact of the finished prosthesis with the edentulous ridge.

Section 1H—Esthetics

1.34. Overview. In most cases, try to duplicate the patient's original teeth in color, form, and texture. (It is indeed especially helpful when the dentist sends a diagnostic cast of the patient's original dentition or the provisional prosthesis.) If a diagnostic cast is not available, rely on personal knowledge and experience. Sometimes, certain subtle changes or even a major change is indicated to preserve the smile and personality of the patient.

1.35. Morphology of Anterior Teeth. A thorough understanding of tooth morphology is essential to meet the esthetic demands of the patient. The eye is extremely sensitive to the outline form of objects, even more so when teeth are being viewed prominently silhouetted against the dark oral cavity. In fact, small differences in color will go unnoticed if the form and texture of the teeth are correct. Some technicians unknowingly create the *same* morphological features in every restoration they make. This approach lacks the personalization needed so the restoration will harmonize with the patient's physical characteristics. For a detailed discussion of tooth morphology, review Volume 1, Chapter 4. Discussion of morphology in this chapter will be limited to *anterior* teeth only.

1.35.1. **Diagnostic Aids:**

1.35.1.1. The exact size and form of the original tooth is usually produced in the restoration. However, because the technician is normally not directly involved with the patient and must rely only on the information present, this task can be very difficult. Examples of diagnostic aids that should be available include preoperative casts and casts made from impressions of diagnostic wax-ups or provisional restorations.

1.35.1.2. If a corresponding natural tooth exists in the opposite side (contralateral tooth), its form may be duplicated in the final restoration. Also, the patient's remaining natural anterior and posterior teeth show characteristics common to all the teeth, but there are many instances where no diagnostic aids are available. Therefore, it may be desirable to save discarded maxillary and mandibular casts displaying different morphological features. These casts can be used as references when simulating the morphology of natural teeth in fixed prosthodontics.

1.35.2. **Outline Form.** The space available for crowns and FPDs will determine the dimensions of the restoration. A general guide, similar to that used for removable prosthodontics (Volume 1, Chapter 7), can be used to determine the sizes of anterior teeth. According to this guide the central incisor is one-sixteenth of the length and width in relation to the length and width of the patient's face. Also, the basic forms of teeth (square, square tapering, tapering, and ovoid) should agree with the face form.

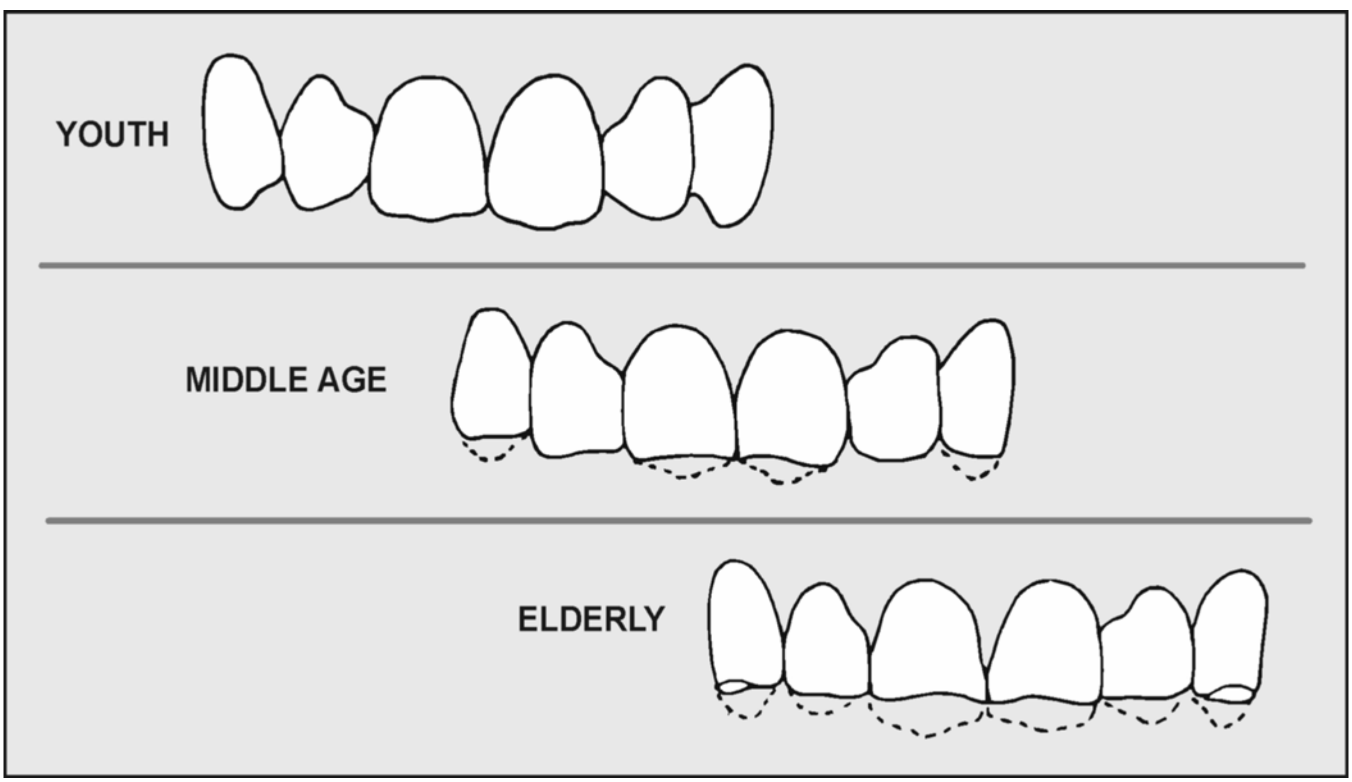
1.35.3. **Sex.** The idea that a person's sex determines the surface form of his or her teeth is invalid. Dental morphology seems to depend more on the patient's face form and personality than on his or her sex. The traditional feminine and masculine forms are now thought of as displaying youthfulness or advancing age (wear).

1.35.4. **Age.** The changes that occur with aging can be attributed to attrition, abrasion, and/or soft tissue recession, as follows:

1.35.4.1. **Attrition (Abrasion):**

1.35.4.1.1. Attrition is most noticeable in the maxillary arch, but it also reveals some interesting details about the mandibular arch. The lack of wear due to youth is shown by the full length of the clinical crown in Figure 1.25. Also note the effect attrition has on the incisal embrasures. At middle age, the incisal edges of the centrals are worn, but the laterals show only minimal wear. In later years, the lateral incisors begin to wear, resulting in a straight line extending from lateral to lateral.

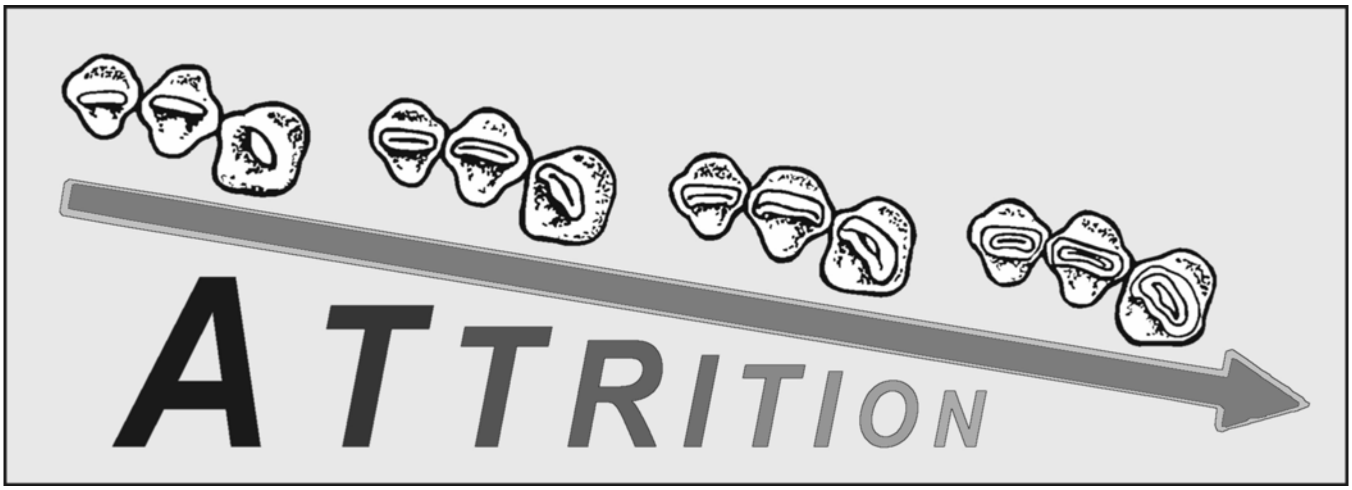
Figure 1.25. Attrition of Maxillary Incisors With Aging.



1.35.4.1.2. Attrition with aging has a dramatic effect on the patient's smile. In youth, more of incisal edge extends below the lip and results in a vigorous appearance. As the length of the incisal edge shortens, an older appearance results.

1.35.4.1.3. The wear patterns associated with attrition are affected by the position of the teeth, direction of mandibular movement, and condition of the antagonists. Once these factors have been analyzed, reproduce the restoration's proper wear pattern, assuming the case is well mounted on a programmed articulator. If attrition advances, the dentin is exposed and a roughened surface results. The exposed dentin is porous and quickly stains to an orange-brown color. Especially apparent in the mandibular teeth (Figure 1.26), this is helpful to simulate aging changes.

Figure 1.26. Exposed Dentin Caused by Attrition of Mandibular Incisors.



1.35.4.2. **Soft Tissue Recession.** The architecture of a person's gingiva changes with age (Volume 1, Figure 7.91). The soft tissues supporting the teeth recede gradually with age as shown in Figure 1.27. As the narrower root portions of the teeth are exposed, the teeth begin to appear triangular. This effect is also partially due to attrition at the incisal edge.

1.35.5. **Patient Profile.** In considering the effect patient profile has, the gingivoincisal profile of teeth may be straight, convex, or slightly concave (Figure 1.28). Most teeth exhibit a "rounding in" of the labial surface form in the incisal third. This reduces the forward light reflection and prevents the incisal edges from appearing grossly protruded. The mesiodistal profile may be straight, convex, or concave, depending on the shape of the zygomatic arch.

1.35.6. **Embrasures.** All of the four embrasures (incisal, gingival, labial, and lingual) are important. The incisal embrasure is particularly important because it has the most effect on outline form. The location of the contact areas separates the embrasures from each other and helps shape the embrasure form. Generally, teeth with square outlines have contact areas longer than those with more tapered outlines. When more separation between teeth is desired, shorten the contact area to expose more space and tissue in the interproximal. The labial surface and embrasure form also has a significant effect on appearance. A convex labial surface with widened embrasure form will scatter reflected light rays and appear narrower than a flat labial surface with closed embrasure form.

Figure 1.27. Attrition and Soft Tissue Recession of Maxillary Teeth With Aging.

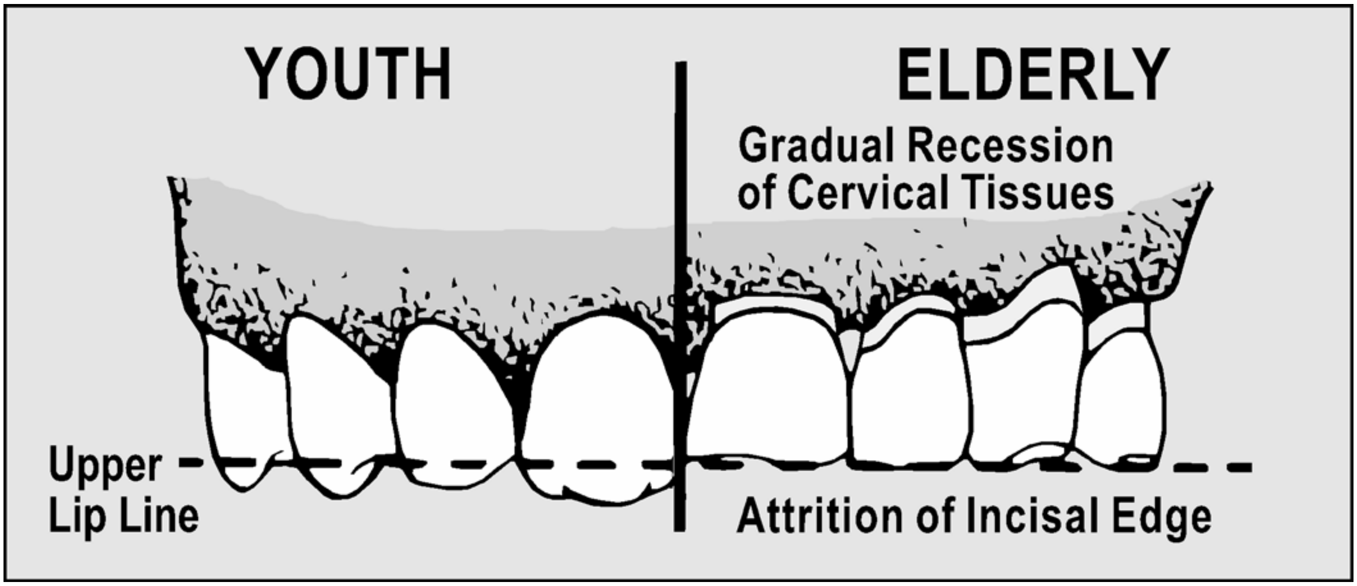
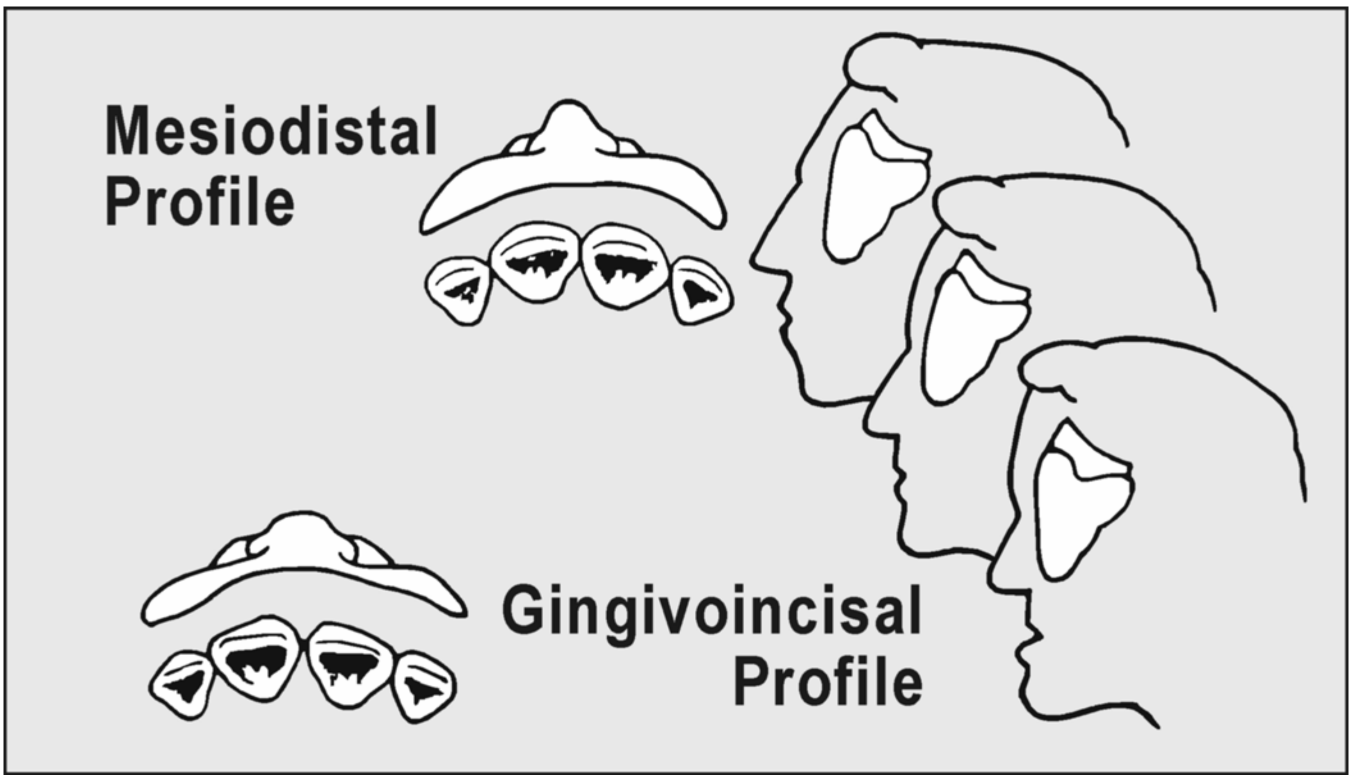


Figure 1.28. Effect of Patient Profile on the Surface Form of Teeth.



1.35.7. **Long Axis.** Line angles, heights of contour, and the incisal edge determine the long axis. Restorations should appear as if they are actually growing in place. The long axes of restorations should be in line with the inclination of the root eminences. It is helpful to scribe lines on the cast to indicate this inclination. With anteriors, the root generally inclines distally and, as a result, the apical crest is often formed in the distal third of the cervical portion. A restoration improperly contoured in the cervical area will not only look unnatural, but may also cause tissue inflammation. The long axis is generally at right angles to the incisal edge. When teeth lap over or under each other, their long axes change and the incisal edges must be made to reflect that change. When all of these factors have been met, harmony will be present.

1.35.8. **Midline.** The dental midline is best determined by the patient's facial midline. Many believe the midline of the restoration should match the opposing arch. The exact position of the midline relative to the opposing arch is not as important as the *size* and *arrangement* of teeth. At a glance, you remember the arrangement and size of teeth before noticing anything else.

1.35.9. **Incisal One-Third.** The incisal one-third of mandibular anteriors is often in the "esthetic zone." The incisal edge is gradually lost with aging. Attrition occurs on the lingual surface of the maxillary incisors and the labial surface of the mandibular incisors. As attrition proceeds, concavities on the lingual fossa become more apparent. Give careful consideration to these areas when carving the lingual fossae and lingual embrasures.

1.35.10. **Surface Characterization.** If the surface characterization of restorations is not accurately simulated, reflection from the surface and luster will differ from those of the adjacent teeth, making the restoration appear artificial.

1.35.10.1. **Ridges and Grooves.** Anterior teeth usually have three labial ridges and two shallow labial grooves between them. In the cervical third, one to four horizontal grooves exist with horizontal ridges between them. There may also be many other irregularities, such as fine developmental lines, particularly in younger dentition (Figure 1.29). The older the person, the less characterization is present and the smoother the tooth surfaces are. If corresponding teeth on the opposite side are present, simply reproduce those surface characterizations in the restoration. However, if the contralateral forms are not available, the remaining dentition will show surface characteristics typical of that patient.

1.35.10.2. **Surface Textures.** The surface texture of a restoration should be slightly more emphasized than the adjacent teeth being matched. A textured surface will diffuse and scatter light in an irregular manner. Surface texturing may help to conceal slight differences in color and make the restoration appear more natural.

1.36. Improving Esthetics:

1.36.1. **Changes in Tooth Width:**

1.36.1.1. **Narrow Spaces.** A narrow space can be treated by overlapping at the incisal edge (Figure 1.30-A). Another way to treat the same problem is to flatten the facial surface and move the contact facioincisally (Figure 1.30-B).

1.36.1.2. **Wide Spaces.** When the space to be filled is wider than normal, the problem is more difficult. Figure 1.31-A shows how to treat this wide space by rounding the labial surface and moving the contact gingivally. This moves the visible labial line angles to the center of the tooth, giving the illusion that the tooth is narrower than the space it occupies. Still another method would be to recontour the restoration in a lingual direction and move the contact areas lingually (Figure 1.31-B). (Movement of the contact areas labially has the opposite effect, which is to make the tooth appear wider.) Vertical lines on the labial surface will also make teeth appear narrower.

Figure 1.29. Surface Characterization of Maxillary Anterior Teeth.

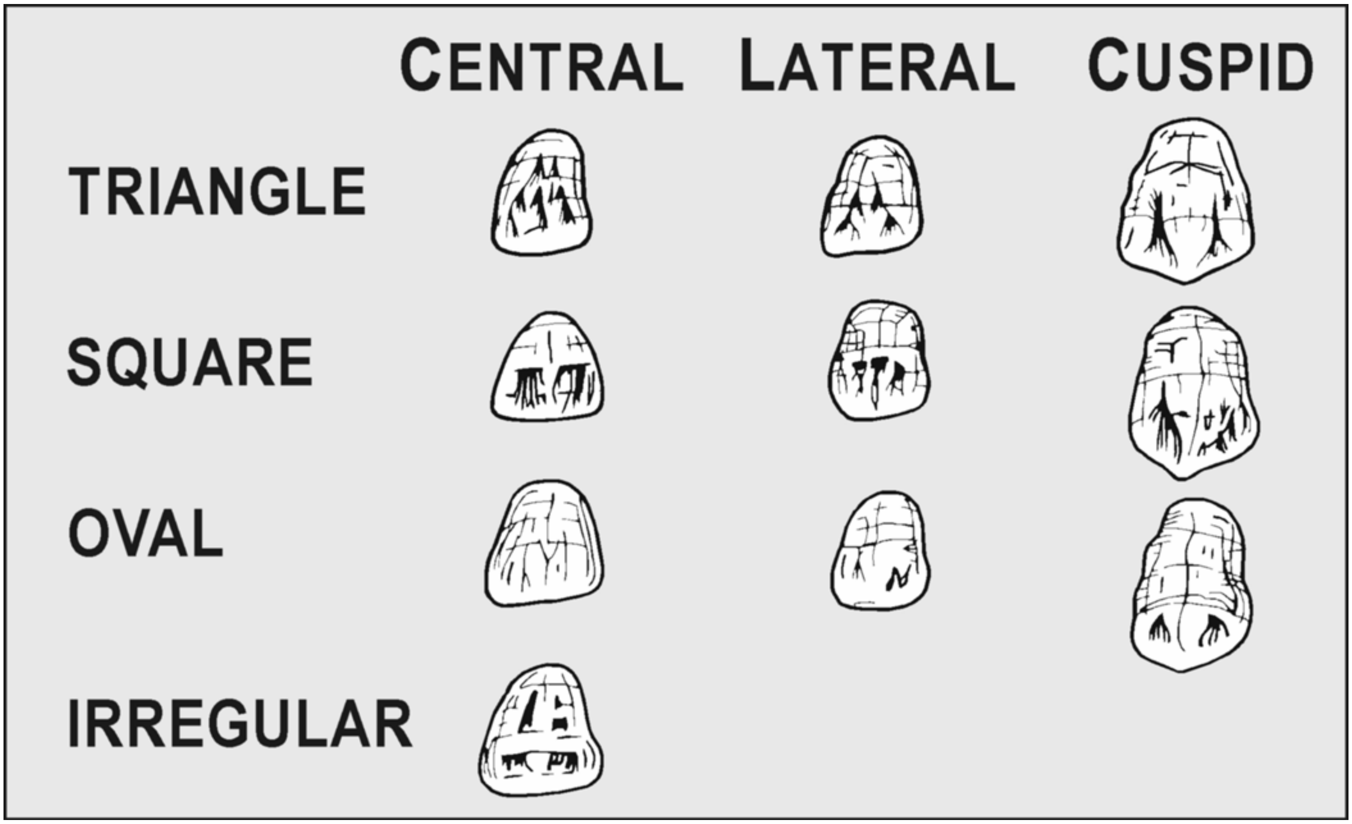


Figure 1.30. Making Narrow Teeth Appear Wider.

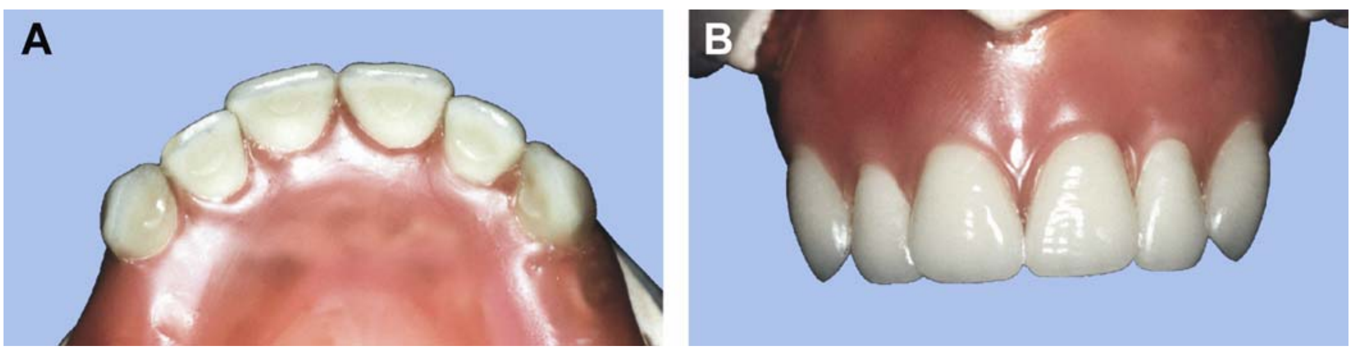
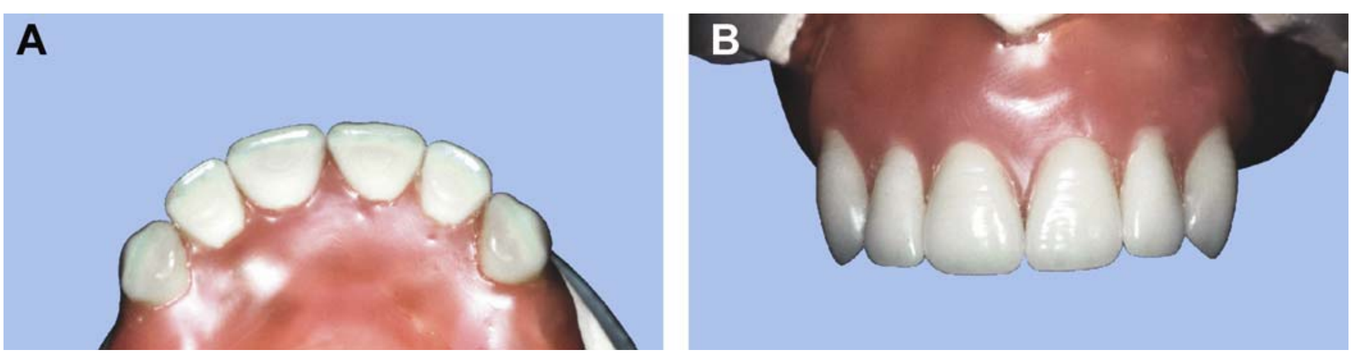


Figure 1.31. Making Wide Teeth Appear Narrower.



1.36.2. **Changes in Tooth Length:**

1.36.2.1. **Long Crown Length.** Teeth that have become periodontally involved have extra long clinical crowns which can be made to appear shorter by creating a definite cervical line (Figure 1.32). Placement of the cervical line is determined by the adjacent natural teeth and overall appearance of crown length. The crown can be made to appear even shorter by adding gingival stain to the root portion. An alternative approach would be to reduce the cervical collar and add gingival shade porcelain to restore the contour. Gingival shade porcelain may be supplied by the manufacturer or made by combining various amounts of modifiers to dentin porcelain.

Figure 1.32. Cervical Collar and Shading To Reduce Length.

1.36.2.2. **Short Crown Lengths.** Short teeth can be made to seem longer by adding vertical lines or a vertical concavity to the surface texture. These procedures will give the illusion of length, but only to a limited degree. A greater increase in length can only be made by surgically repositioning the gingival margin.

1.36.3. **Changes in Tooth Position.** The effect of tooth position and alignment of a tooth within the arch may be more important than the actual form of the tooth itself. This can be demonstrated by using three sets of teeth of the same mold and shade. If each set were arranged into three different arch forms (square, tapering, and ovoid), the teeth in the squarely aligned arch would appear square, those in the tapering form would appear tapered, and those in the ovoid arrangement would appear ovoid.

1.36.4. **Tooth Rotation.** Rotating a tooth about its axis to create an overlay allows the placement of a wider tooth mesiodistally into a smaller space. Subtle axial rotation (Figure 1. 33) gives a natural appearance to the arrangement of teeth, but taking it to the extreme will have an opposite effect and may not be pleasing esthetically. A tooth may lose some of its identity, depending on the degree of rotation. Figure 1.34 shows how dramatic this change might be if the distals of the six anterior teeth are rotated in and the mesials out. Notice how much narrower the teeth appear even though they occupy the same relative positions.

Section 1I—Waxing Individual Cast Restorations and FPD Retainers

1.37. Overview. The procedures described in this section deal with choosing a scheme of occlusion and waxing a pattern.

Figure 1.33. Effect of Subtle Axial Rotation on Appearance.

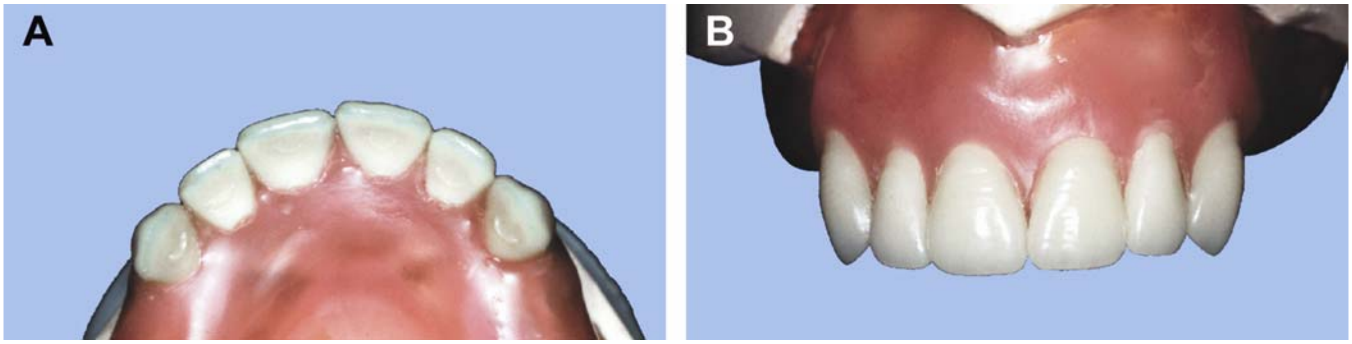
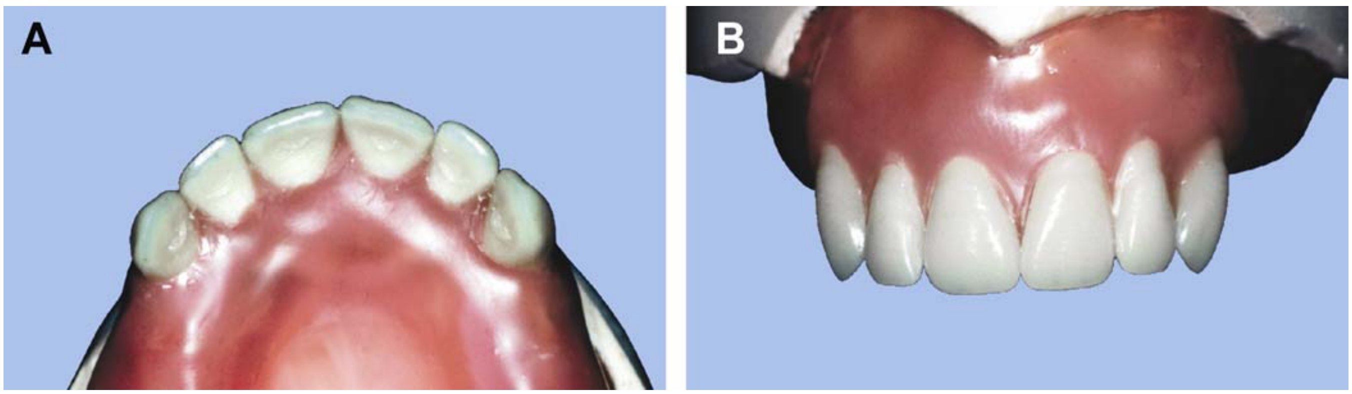


Figure 1.34. Effect of Rotation on Apparent Width.



1.38. Determining the Occlusion Scheme for the Fixed Prosthesis and Setting the Incisal Guide Table:

1.38.1. The first step in selecting an occlusion scheme for a fixed prosthesis is to analyze what kind of occlusion the patient has. Once this has been decided, the dentist has the option of imitating it or changing it when ordering the restoration. The technician must have enough basic knowledge to understand and follow the dentist's directions.

1.38.2. There are complex cases where there is no definite way of telling what kind of occlusion the patient originally had. In these cases, the dentist is forced to choose a scheme of occlusion based on educated guess rather than drawing conclusions from directly observable tooth relationships. The standards for recognizing natural tooth occlusions are in Volume 1, Chapter 5.

1.38.3. In fixed prosthetic dentistry, an incisal guide table is used to protect the dental stone teeth against abrasion, to program the movement of an articulator so a restoration can be made that conforms to the movement, or for both reasons. Decide on MI and eccentric occlusion patterns as follows:

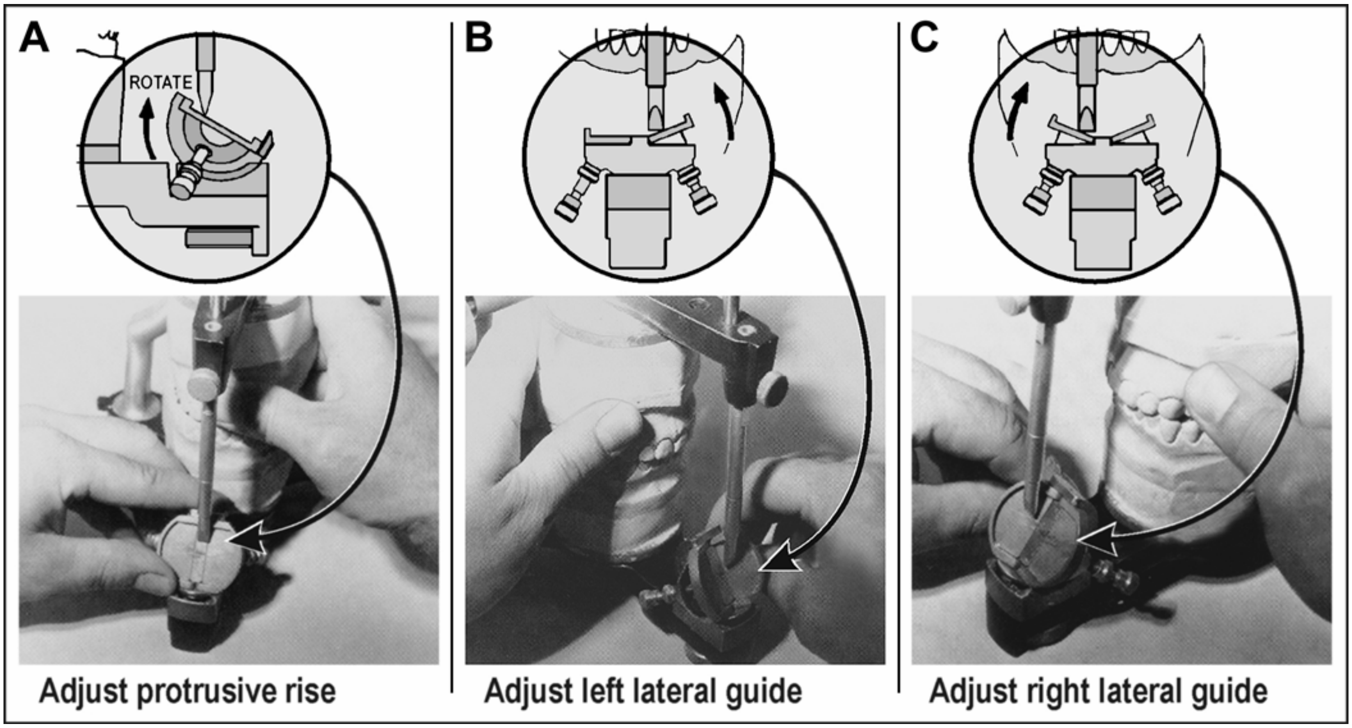
1.38.3.1. **Maximum Intercuspation (MI).** If a patient has a cusp-to-embrasure type of MI and there is an opportunity to switch the prosthesis over to the cusp-to-fossa variety, do so.

1.38.3.2. **Eccentric Occlusion (Example #1).** In this example, a posterior fixed prosthesis has to be made and the guiding surfaces of anterior teeth in eccentric movements are intact.

1.38.3.2.1. **Select an Occlusion.** Barring unusual circumstances, the rule is to make a posterior fixed prosthesis blend into the existing occlusion. For example, after the prosthesis is finished, a cast that showed anterior guidance should show posterior tooth relationships characteristic of anterior guidance.

1.38.3.2.2. **Set the Incisal Guide Table (Figure 1.35).** When casts move by one another in lateral and protrusive excursions, the surfaces of stone teeth wear away rapidly. When the objective is simply to preserve whatever tooth guidance there is between opposing arches, adjust the incisal guide table to minimize the wear on stone surfaces. Place the maxillary and mandibular casts in protrusion and tilt the incisal guide table until it is a hair's breadth short of contact with the pin. Place the casts in right and left lateral excursion relationships and adjust the wings of the incisal guide table in the same way.

Figure 1.35. Setting the Incisal Guide Table.



1.38.3.3. **Eccentric Occlusion (Example #2).** In this example, an anterior fixed prosthesis has to be made and the key eccentric movement guiding surfaces of anterior teeth are involved in the restoration (lingual surface of a maxillary canine, facial surface of a mandibular canine).

1.38.3.3.1. **Select an Occlusion.** The dentist will decide whether the case is going to be rebuilt in anterior guidance or in group function.

1.38.3.3.2. **Set the Incisal Guide Table.** The objective is to make the articulator move laterally as if the guiding surfaces of anterior teeth had already been restored to the type of occlusion the dentist wants. First, slant the incisal guide table to match the patient's actual or programmed rise from MI to anterior tooth contact in protrusion. Next, set the lateral wings to make the case behave like the type of occlusion chosen for the affected side or sides.

1.38.3.3.3. **Build the Anterior Fixed Prosthesis.** Do this to correspond to the movements programmed into the articulator.

1.38.3.4. **Eccentric Occlusion (Example #3).** In this example, a mixture of anterior and posterior fixed units have to be made in the same arch, and key eccentric movement guiding surfaces of anterior teeth must be restored. Directions for selecting an occlusion and setting the incisal guide table are essentially the same as those given in Example #2 (paragraph 1.38.3.3). The anterior restorations are waxed first, and then the posterior units are waxed to conform to the type of occlusion chosen.

1.38.4. **Custom Incisal Guide Tables:**

1.38.4.1. An adjustable incisal guide table looks like a precision adjustment mechanism; but, in reality, it is rather crude. There is a relatively common type of lateral movement where a combination of group function and anterior guidance occurs. As a lateral movement out of MI begins, the posterior teeth on the working side are in group function. As the lateral movement progresses, the anterior teeth on the working side make sufficient contact to separate the posteriors (Volume 1, Chapter 5).

1.38.4.2. In other kinds of cases, the teeth of patients with marked Class II jaw relationships may follow irregular protrusive paths. An adjustable incisal guide table cannot be set to produce these kinds of articulator movements. To deal with the problem, some dentists use a *custom incisal guide table* made from self-curing plastic. Those who use this type of table usually make it before sending the case to the laboratory.

1.38.4.3. To make a custom incisal guide table:

1.38.4.3.1. Set the tilt of an adjustable table and its wings at 0^{o}. Lubricate the top of the table with a thin layer of petrolatum.

1.38.4.3.2. Ensure the *rounded* end of an incisal guide pin rests on the table.

1.38.4.3.3. Remember, an incisal guide table is used to protect dental stone teeth against abrasion and to program the movement of an articulator so a restoration can be made that conforms to the movement. When the latter reason is the justification for making a custom table, wax up the key restorations that take part in the lateral and protrusive guidances first.

1.38.4.3.4. Add a layer of self-curing resin to the top of the adjustable table and crudely form the desired guidance paths in the resin as it cures.

1.38.4.3.5. Carve any final refinements into the cured resin with a bur or other grinding instrument.

1.39. Instruments. There are many kinds of instruments for applying wax to dies and shaping patterns, but the following are typical: (***NOTE:*** If the wax additive [positive waxing, functional waxing] technique is used, a set of Peter K. Thomas's waxing instruments is desirable.)

1.39.1. Beale #7 (spatula, dental wax).

1.39.2. Roach carver (dental carver, wax).

1.39.3. Hollenback #1 (dental carver, amalgam, and wax).

1.39.4. Woodson #1 (plugger, plastic filling, dental).

1.39.5. Electric waxing unit (thermostatically controlled). Many of the same instruments mentioned in paragraphs 1.39.1 through 1.39.4 are available with the electric waxing unit. This tool's advantage is that the temperature for applying wax can be precisely controlled.

1.39.6. Electric wax heater (thermostatically controlled). This heater keeps wax in a molten state at a constant temperature without burning it.

1.39.7. Artist brushes, one stiff and one soft. The stiff brush is used to smooth irregularities on wax occlusal surfaces ; the soft brush is used to dust zinc stearate disclosing powder onto a pattern's occlusal surface for checking its occlusion with opposing teeth.

1.40. Materials. Materials for applying wax to dies and shaping patterns include die lubricant and types A and C inlay wax (the best available).

1.41. Steps in Waxing a Pattern:

1.41.1. Wax expands when heated and contracts when cooled (about 0.02 percent for each degree Fahrenheit of temperature change). Assume that a pattern, waxed under a light bulb near a Bunsen flame, is invested in another part of the room where the temperature might be 10 to 15 ^{o}F cooler. Expect the pattern to shrink. During the subsequent casting procedure, gold contracts about 1.25 to 1.5 percent from the molten to the solid state. Expansion of the investment mold is supposed to compensate for the predictable contractions of solidifying gold and not for unanticipated wax pattern shrinkage.

1.41.2. To obtain a satisfactory fit of a casting to a die, you have to be aware of environmental factors that might affect the stability of inlay wax. Try to wax and invest wax patterns in an area of the room where the temperature is relatively constant. Use room temperature water for the investment mix and invest the pattern as quickly as possible after completion.

1.41.3. Lubricate the die, proximal surfaces of adjacent teeth, and occlusal surfaces of opposing teeth.

1.41.4. Cover the die with a primary layer of wax (wax blank) as a foundation for the rest of the pattern. One method that is adaptable to any type of preparation is to apply molten wax with a #7 wax spatula, completely covering the preparation's surfaces before any part of the wax cools. Once you have laid down a full layer of coverage, you can proceed to build the rest of the pattern at a more leisurely rate.

1.41.5. Another method that is particularly useful when waxing complete crowns is to dip the lubricated die into a pool of molten wax. An electric wax heater is perfect for the job. Use second dip for heavier initial coverage. One of the major objectives in this step is to begin forming an accurately fitting pattern with smooth internal walls. Avoid grossly overextending the wax blank. Carefully remove excess wax from all margins.

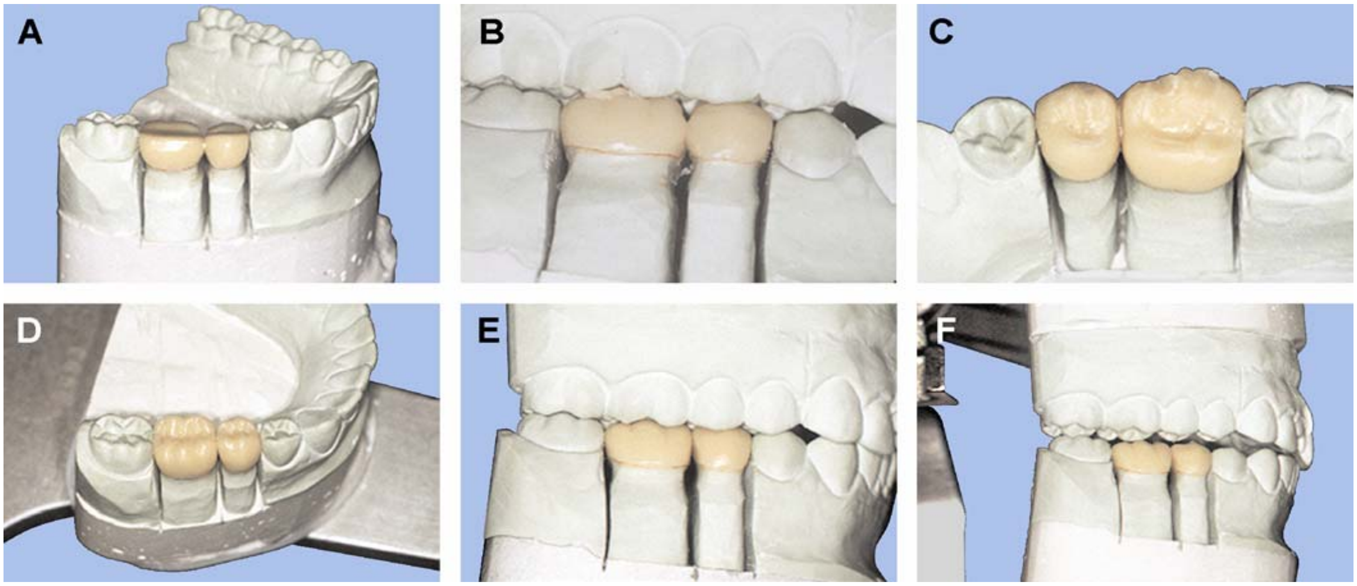
1.41.6. Flow on additional wax with a spatula and contour the pattern. The techniques for occlusal and axial contouring of wax patterns are:

1.41.6.1. Negative waxing, which is the *buildup, smash,* and *carve technique* (Figure 1.36), as follows:

1.41.6.1.1. After laying the foundation layer of wax, overbuild the pattern intentionally with more wax. Soften the occluding surface of the pattern uniformly on the die. Bring the working and opposing casts together (smash) so the teeth opposite the pattern can roughly mold an MI contact in the wax.

1.41.6.1.2. Carve the wax back to proper anatomical and functional contours. When carving wax, hold the instrument in either a palm or pen type of grasp. Use the palm grip to make forceful strokes that remove large amounts of wax without regard for the fine details. You have better control when using *a finger rest.* Brace a finger on the hand that is holding the carving instrument on the die surface or pattern while carving is in progress. To negative wax a pattern, use applicable portions of paragraph 1.42.

Figure 1.36. Negative Waxing of a Pattern.



1.41.6.2. Positive waxing, which consists of adding wax to a wax blank (foundation layer, core layer) in small increments and in highly selected areas to form a three-dimensional skeleton of a crown's final contours. Once the wax framework is complete, all that remains is to fill in the spaces between the various parts of the lattice. The obvious difference between this technique and negative waxing is that wax is being built up to produce a given shape instead of being carved back. To positive wax a pattern, use applicable portions of paragraph 1.42 to shape axial surfaces. Then use the wax-added technique presented in Section 1J for the occlusal surface. ***NOTE:*** In producing an anatomically and functionally shaped pattern, the choice of negative or positive waxing techniques is up to the dentist. If no specific instructions accompany the case, it is up to the technician.

1.41.7. When carving the junction between the wax and the stone die back to where the preparation begins, use blunt carvers instead of sharp instruments. Blunt carvers will produce a clean, well-defined margin without marring the die's surface. ***NOTE:*** If the wax pattern margins are grossly distorted, remove the pattern and carefully cut it back 2 mm off the margin. Apply a fresh coat of die lubricate to the die and reseat the pattern. Quickly flow molten wax into the space created to cover the margin and provide a smooth internal adaptation.

1.41.8. Smooth and polish the pattern. Use the bristle brush to get at occlusal surface irregularities. Use a piece of silk or nylon cloth wrapped around the end of a finger to smooth axial surfaces.

1.41.9. Recheck MI contact and eccentric movement relationships. Test occlusal contacts by dusting powdered wax on the pattern, bringing the working and opposing casts together, and observing where the pattern wax shows through the dust film. ***NOTE:*** Do not use talcum powder in place of zinc stearate for occlusal verification. Talcum powder contains impurities that could cause porosity in the casting.

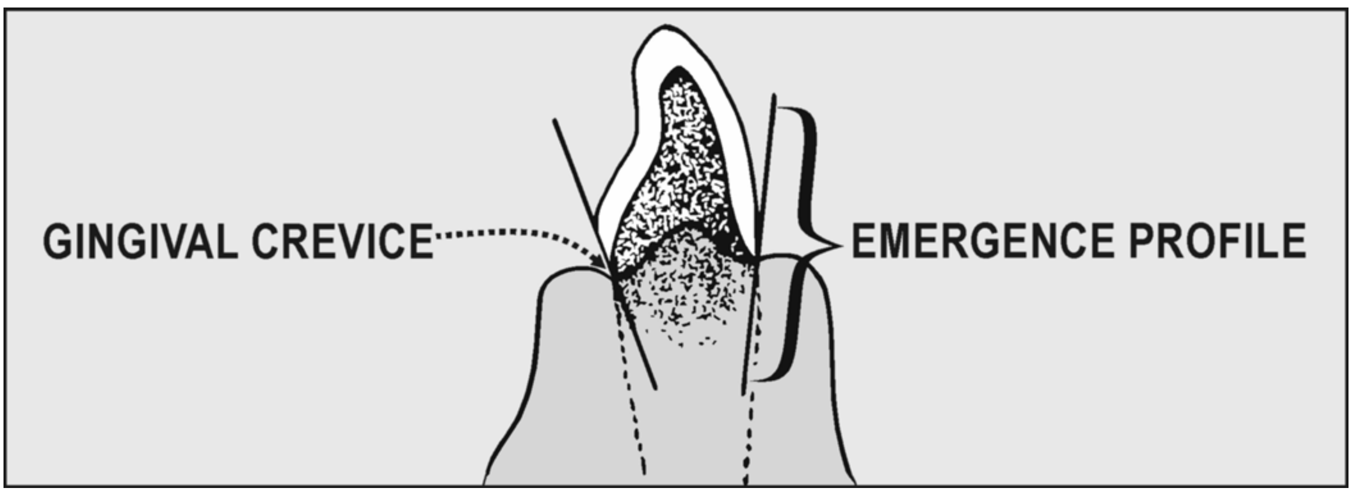
1.42. Anatomic Versus Functional Contouring of Wax Patterns:

1.42.1. When a pattern is *anatomically* contoured, the pattern either looks like a natural tooth or it blends well into a natural tooth's surface. Also, its overall shape and size are proportionally correct in comparison to the teeth around it. Anatomic contouring is done to make prosthesis pleasing to the eye. In contrast, a pattern is *functionally* contoured when it has proper contact relationships with opposing teeth in MI and eccentric relations and when the pattern has a size and shape that helps preserve the health of gingival tissues. Functional contouring is done so a prosthesis will work well without causing damage to remaining teeth and soft tissue.

1.42.2. In some instances, anatomical and functional shaping of patterns amount to the same thing. As an example, when a pattern's anatomic proportions look "right" in comparison to the natural tooth surfaces around it, chances are the resulting casting will help preserve the health of gingival tissues. However, just because the occlusal portion of a pattern looks like the chewing surface of a tooth does not mean it will function without conflict in the patient's mouth.

1.43. Labial and Lingual Contours. The buccal and lingual contours should be "flat, not fat." When the patient eats, the natural contours of the teeth deflect the food. This action stimulates the soft tissues so they will remain healthy. The lip, tongue, and cheek muscles also aid in cleaning the facial and lingual surfaces of teeth. An *overcontoured* restoration keeps these self-cleaning mechanisms from working. One of the clues to *proper* contour can be seen in the emergence profile of natural teeth (Figure 1.37). Natural teeth exhibit a *profile* that is straight and continues to the height of contour as they *emerge* from the gingival sulcus. Overcontouring is extremely hazardous in this area, especially in the interproximal areas.

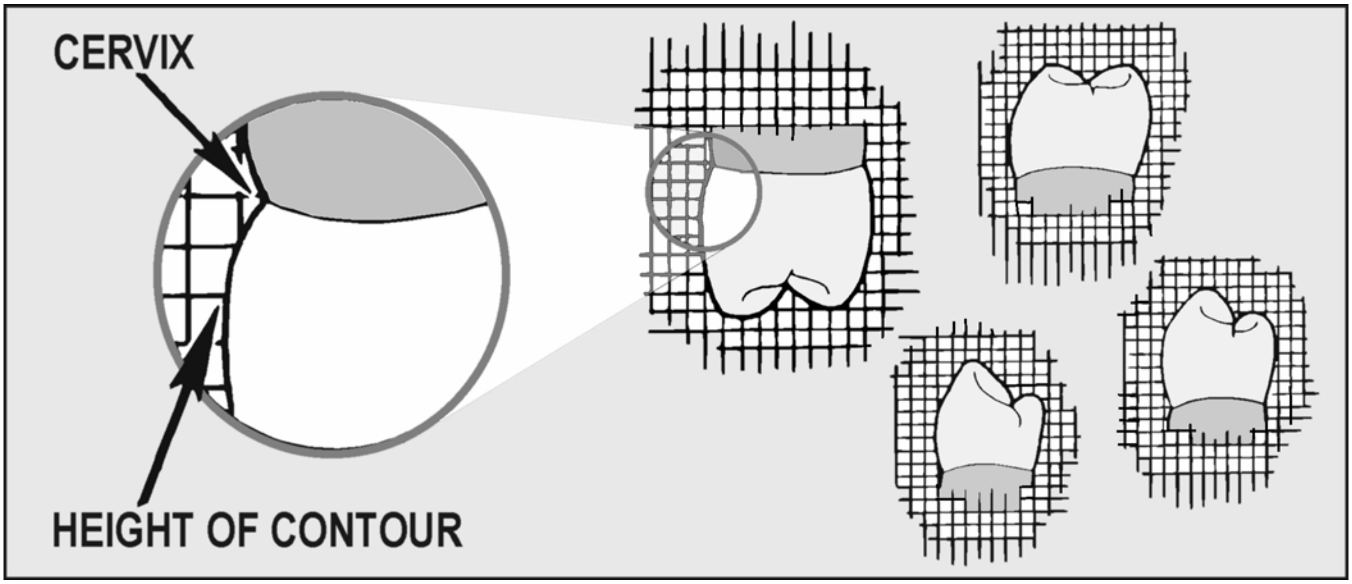
Figure 1.37. Emergence Profile.



1.43.1. **Facial Surface.** The facial height of contour of almost all natural teeth is found in the *gingival third.* These contours rarely exceed 0.5 mm facially beyond the cementoenamel junction (cervix) and are positioned above the gingival margin (Figure 1.38). From the bulge, the contour of the facial surface should be flat or sloping inward as it enters the crevice and reaches the crown margin (subgingival).

1.43.2. **Lingual Surface.** The lingual height of contour on most teeth can be seen in the *gingival third.* Like the facial surface, the height of contour should not project more than 0.5 mm from the cervix. Exceptions to this rule involve the mandibular premolars and molars. Their lingual height of contour is in the *middle third.* The bulge on mandibular premolars and molars may protrude as much as 0.75 to 1 mm, respectively.

Figure 1.38. Facial and Lingual Heights of Contour of Posterior Teeth.



1.44. Contours for Intracoronal Restoration Patterns (Inlays). Negatively wax the pattern. Use the remaining tooth structure, adjacent teeth, and opposing teeth as guides for restoring anatomy, adjacent tooth contact relationships, and occlusion. Remember that inlays are fully beveled preparations and the entire bevel has to be represented in the pattern. For a complete description of contact area placement and embrasure shaping, see paragraphs 1.45 and 1.46 for contouring of anterior and posterior extracoronal patterns.

1.45. Contours for Anterior Extracoronal Restoration Patterns (Partial and Complete Crowns):

1.45.1. **Anatomic Contours.** Typical anatomic contours for anterior teeth are detailed in Volume 1, Figures 4.36 through 4.38 and 4.43 through 4.45.

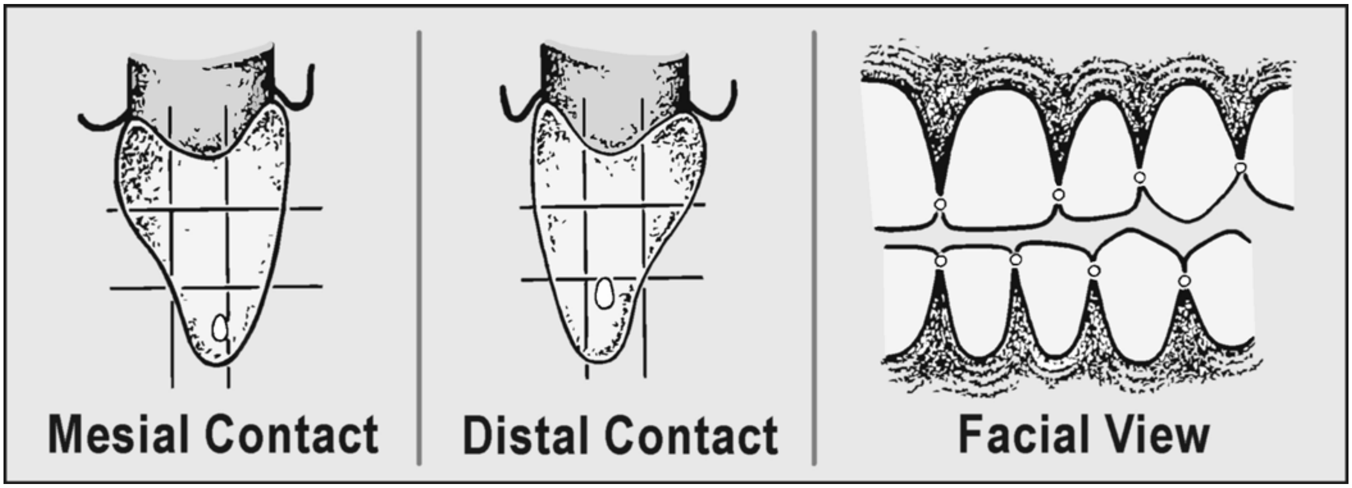
1.45.2. **Functional Contours:**

1.45.2.1. **Facial and Lingual Food Deflection Contours.** Facial and lingual food deflection contours are detailed in Volume 1, Figures 4.36 through 4.38 and 4.43 through 4.45.

1.45.2.2. **Proximal Contact Relationships Among Anterior Teeth.** Contacts between adjacent anterior teeth (Figure 1.39) usually occur within the incisal third, mesially. On the distal surfaces of anterior teeth, the contacts are located closer to the junction of the incisal and middle thirds. Always try to provide a contact with adjacent teeth to keep the teeth from moving out of position. However, there are certain limitations to the mesial-distal width of restorations. Avoid making restorations *so wide* that the patient has difficulty keeping the restorations clean. If a patient has a natural occurring *diastema,* it should be provided for in the pattern. Check with the dentist regarding exceptions to the rule of providing proximal contacts.

1.45.2.3. **Gingival Embrasures.** Accommodate the patient's interdental papillae in the gingival embrasures. To keep the papillae healthy, do not overcontour the proximal surface of patterns or place the contact areas too far gingivally. Esthetics of the restoration will greatly influence the final embrasure form.

Figure 1.39. Proximal Contact Relationships Among Anterior Teeth.



1.45.2.4. **Marginal Ridges.** Proper contour suggests a harmonious relationship among all teeth—a smooth transition from anterior to posterior within the arch. Therefore, all marginal ridges should contact adjacent teeth at the same height to prevent food impaction and food retention.

1.45.3. **Occlusions:**

1.45.3.1. **Maximum Intercuspation (MI).** Imitate the vertical and horizontal overlaps of natural anterior teeth in the vicinity of the preparation. If this guideline is absent, have the dentist determine the proper overlaps.

1.45.3.2. **Working Occlusion.** The patient's overall occlusion has already been evaluated and decisions made whether the restoration will follow the mutually protected concept, the group function scheme, or delayed anterior guidance. The lingual aspect of maxillary anteriors and the facioincisal aspect of mandibular anteriors represent the guiding surfaces of anterior teeth. Wax these surfaces to conform to the scheme of occlusion chosen.

1.45.3.3. **Protrusive Occlusion.** Make the incisal edge of the restoration match the incisal edge contact line formed between the upper and lower anteriors. If this guideline is gone, a rule of thumb for incisor length is that upper and lower posterior teeth should show separation when the anteriors are in protrusive contact. If more specific directions are necessary, check with the dentist.

1.45.4. **Pattern Modification for Resin and Porcelain Veneering of the Casting (Windows, Cutouts).** For information on resin veneers, see Chapter 5 of this volume. For information on metal-ceramic veneers, see Chapter 2 of this volume.

1.46. Contours for Posterior Extracoronal Restoration Patterns (Partial and Complete Crowns, Onlays):

1.46.1. **Anatomic Contours.** Typical anatomic contours for posterior teeth are detailed in Volume 1, Figures 4.39 through 4.42 and 4.46 through 4.49.

1.46.2. **Functional Contours:**

1.46.2.1. **Buccal and Lingual Food Deflection Contours.** Buccal and lingual food deflection contours are in Volume 1, Figures 4.39 through 4.42 and 4.46 through 4.49.

1.46.2.2. **Proximal Contact Relationships Among Posterior Teeth.** Contact areas are generally egg-shaped, with the long axis of the "egg" being oriented buccolingually (Figure 1.40). Occlusogingivally, the contact area is located at the junction of the occlusal and middle thirds of a proximal surface. Buccolingually, the contact area can be found at the junction of the buccal and middle thirds of a posterior tooth's proximal surface except between the maxillary molars, where it is located near the occlusal mesial or distal developmental groove area (Figure 1.41).

Figure 1.40. Posterior Contact Area and Embrasure Characteristics.

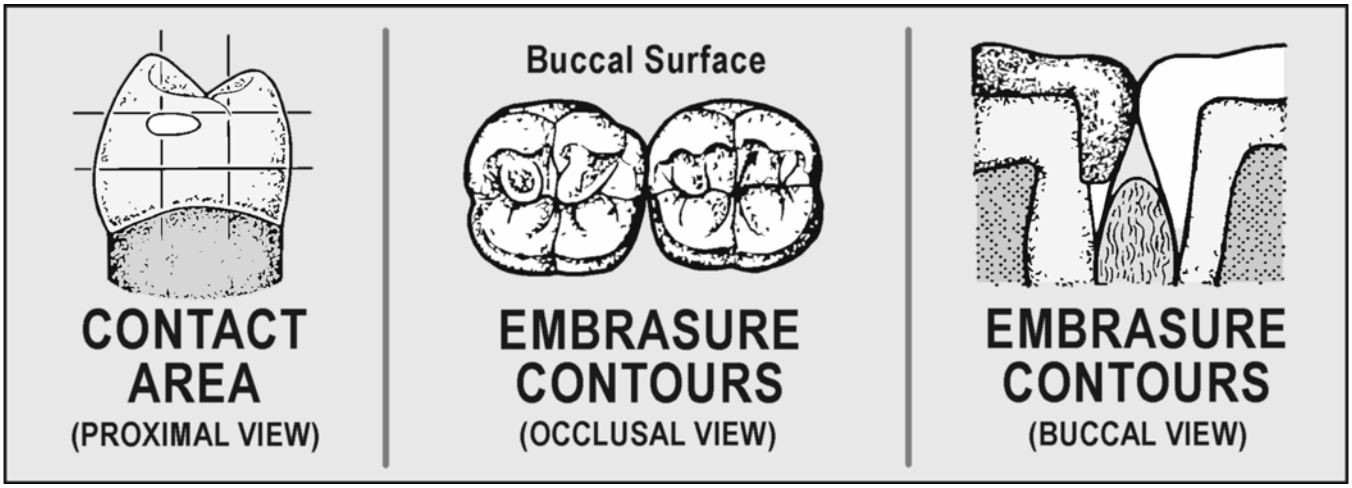
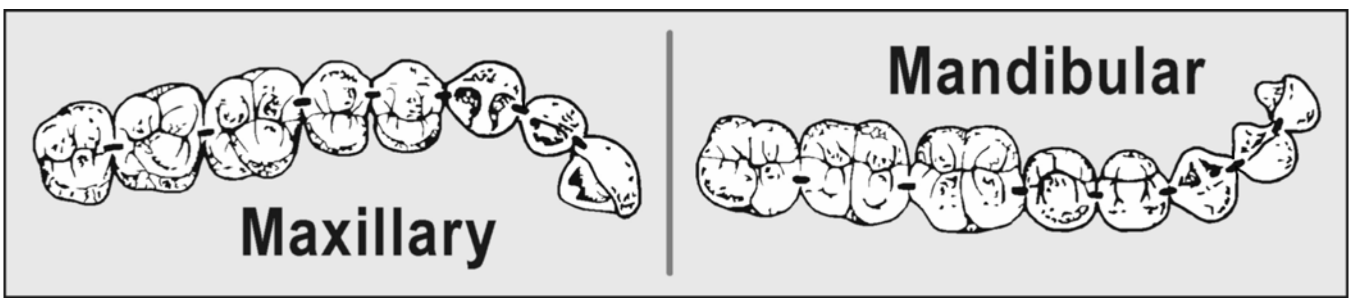


Figure 1.41. Maxillary and Mandibular Contact Areas (Occlusal View).



1.46.2.3. **Marginal Ridges.** The marginal ridges on both sides of an occlusal embrasure should be oriented at about the same height. Also, marginal ridges are supposed to be rounded so the resulting occlusal embrasure looks like a V-shaped crevice. Avoid square, sharply angled marginal ridges on adjacent teeth in contact because they produce crack-like occlusal embrasures and improperly placed contact areas.

1.46.2.4. **Gingival Embrasures.** For interproximal papillae to stay healthy, the natural shape and dimensions of gingival embrasures must still be present after a fixed restoration is cemented in the patient's mouth. The apex of a gingival embrasure is the result of two convex proximal surfaces coming together at the contact area. However, the lower part of the embrasure is formed by diverging, *concave* proximal surfaces. Reduction of embrasure space with subsequent compression of the gingiva happens when the proximogingival surfaces of patterns are overcontoured and when contact areas are located too far gingivally.

1.46.2.5. **Buccal and Lingual Embrasures.** A contact area is located at the junction of the buccal and middle thirds of a posterior tooth's proximal surface. As a result, the lingual embrasure is larger than the buccal embrasure. Because of this relative difference in size, chewing movements will divert most of the food toward the tongue instead of into the buccal vestibule. The tongue moves food back onto the occlusal table for the next chewing stroke more efficiently than the cheek muscle does. Besides the chewing efficiency advantage, proper stimulation of interproximal tissues requires that the lingual embrasure be larger than the buccal.

1.46.2.6. **Maximum Intercuspation (MI).** Decide whether the stamp cusp contact in MI will follow the cusp-fossa or cusp-embrasure type of impact. Cusp-fossa impacts are preferred. Be sure to introduce enough horizontal overlap so the patient does not have a problem with cheek biting. Review Volume 1, Chapter 5.

1.46.2.7. **Working Occlusion.** Besides making a pattern's occlusal aspect look like a chewing surface, the pattern's cusp inclinations along with its ridge and groove direction must be formed in harmony with mandibular movements. A choice among the group function, anterior guidance, and delayed anterior guidance types of occlusion should already have been made. Wax the pattern's working excursion relationships to conform to the chosen scheme of occlusion. Review Section 1B of this chapter and Volume 1, Chapter 5.

1.46.2.8. **Balancing Occlusion.** Fixed prosthetic restorations made to oppose natural teeth *must not* show balancing contacts.

1.46.2.9. **Prostrusive Occlusion.** Posterior teeth are separated bilaterally when the anterior teeth are in protrusive contact.

1.46.3. **Wax Pattern Contour Modifications for Resin or Porcelain Veneering of the Casting (Windows, Cutouts).** For information on resin veneers, see Chapter 5 of this volume; for information on metal-ceramic veneers, see Chapter 2 of this volume.

Section 1J—Wax-Added Technique

1.47. Overview. The wax-added technique is a method of occlusal surface formation through addition of small increments of wax to a wax blank. (***NOTE:*** Review Volume 1, Chapter 4.) Instead of carving grooves to produce ridges, the ridges are built up in wax. As the ridges are being formed, grooves develop between the ridges by contrast. Some carving may be done in association with the wax-added technique, but only to emphasize and smooth the depths of the grooves. This method is popularly regarded as the ideal way to organize a mutually protected occlusion, but there is no reason why the technique cannot be used with similar success to organize other kinds of occlusion schemes (group function, delayed anterior guidance). Axial surface and occlusal anatomy are developed by following the standardized waxing sequence in paragraph 1.48.

1.48. Standardized Waxing Sequence:

1.48.1. The first step in the wax-added technique is to properly shape a wax blank on the die. Wax is applied to the entire die in an even layer to keep distortion to a minimum. Build up the axial surfaces of the blank into their proper facial, lingual, and proximal contours. Leave the occlusal surface out of contact with opposing teeth to allow space for development of the occlusal anatomy.

1.48.2. Place maxillary and mandibular *stamp cusp* wax cones and check them for clearance in lateral excursions.

1.48.3. Place maxillary and mandibular *shearing cusp* wax cones and check them for clearance in lateral excursions.

1.48.4. Build up the buccal, lingual, and proximal marginal ridges.

1.48.5. Place the *stamp cusp* triangular ridges.

1.48.6. Place the *shearing cusp* triangular ridges.

1.48.7. Verify MI contacts.

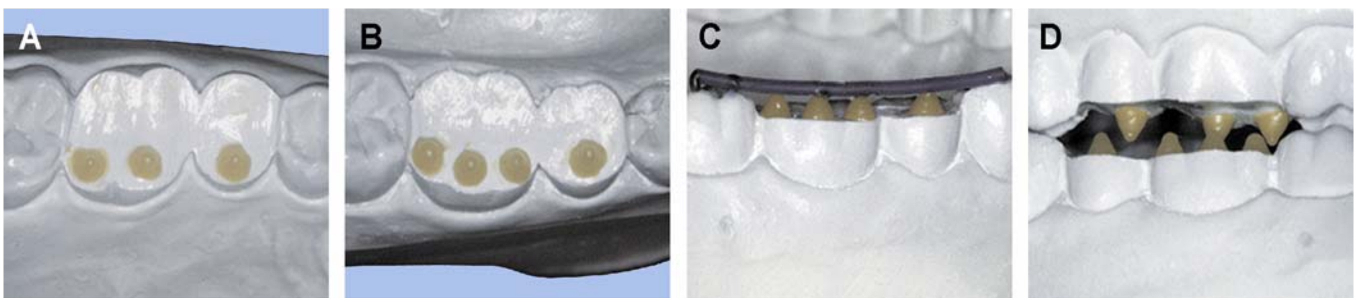
1.48.8. Add supplemental anatomy to fill occlusal voids and to achieve any necessary additional occlusal contacts.

1.48.9. Refine the occlusal surface to emphasize the desirable patterns of MI contact.

1.49. Specific Steps in the Waxing Sequence:

1.49.1. **Placing Maxillary and Mandibular Stamp Cusp Cones.** Place the stamp cusp cones first because they are difficult to see after the shearing cusps and ridges are added (Figure 1.42-A and -B). The stamp cusp cones (lingual of the upper and buccal of the lower) represent the final position and length of the stamp cusps. When complete, the stamp cusp and associated ridges will account for 60 percent of the total occlusal area.

Figure 1.42. Placement of Maxillary and Mandibular Stamp Cusp Cones.



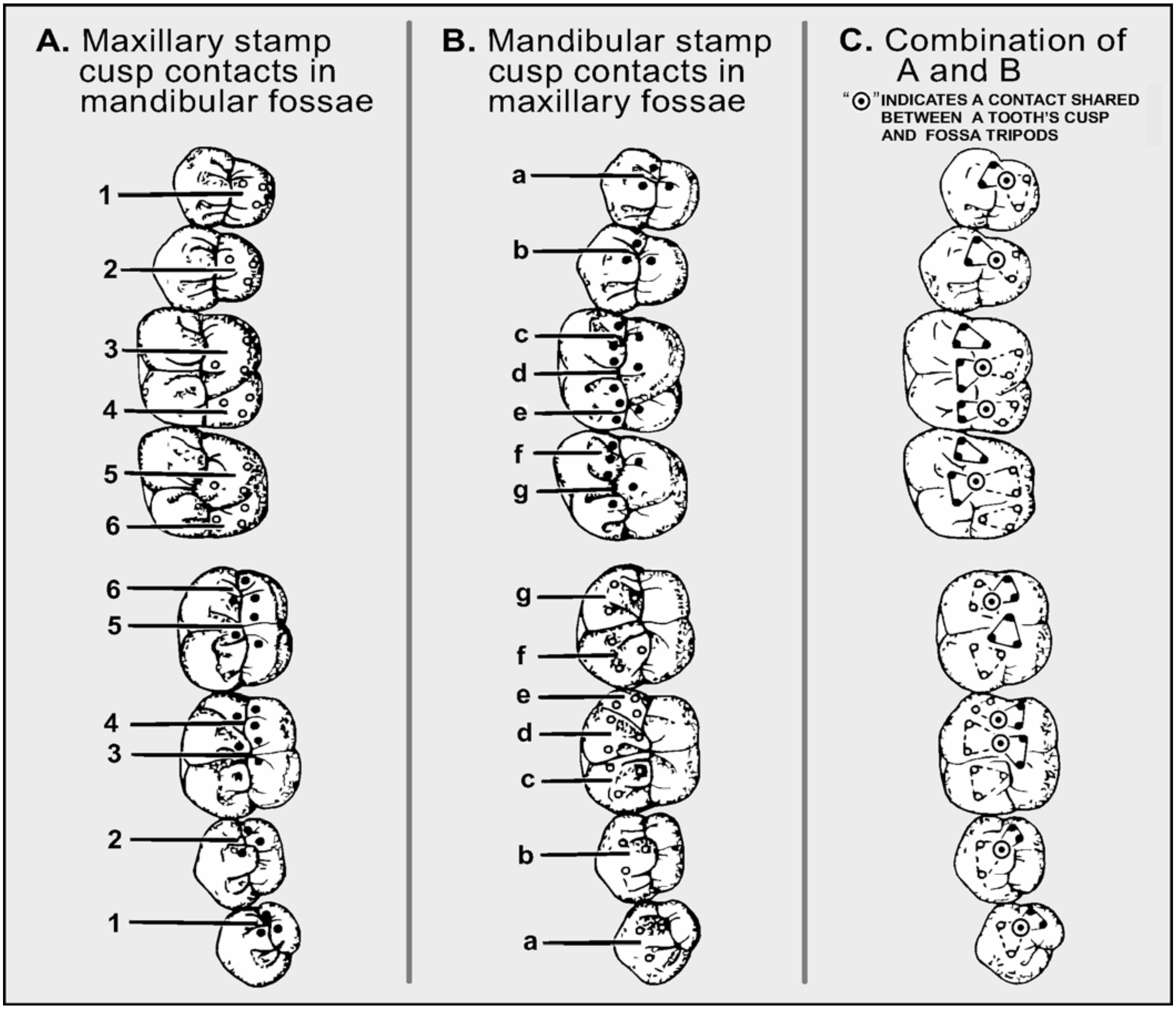
1.49.1.1. **Position.** Center the stamp cusp cones, representing the vertical dimension holding cusps, over the opposing tooth's central sulcus area. This helps orient the forces of occlusion more or less parallel to a tooth's long axis. If a pattern is being waxed against opposing natural teeth, try to make the stamp cusp cone hit in a fossa rather than on the tops of proximal marginal ridges. When waxing one pattern against another, place the stamp cusp cones for one pattern over the anticipated fossa sites on the other. In MI, the ideal is for the tip of a stamp cusp to be supported at three points around an opposing fossa's rim. Such three-point support is known as tripodism (Figure 1.43). Avoid a mortar-and-pestle arrangement in which the cusp tip actually contacts the bottom of the fossa if possible.

1.49.1.2. **Length.** When waxing against *natural* teeth, make the stamp cusp cones long enough to hit the opposing tooth in MI. When waxing *opposing patterns* against one another, make the stamp cusp cones long enough to maintain the anteroposterior curve (Curve of Spee) dictated by the stamp cusps of the unprepared teeth (Figure 1.42-C). Once the length of the cones has been established, build up the sides of the fossae on the opposing patterns to meet them.

1.49.1.3. **Balancing Excursion Stamp Cusp Relations (Figure 1.42-D):**

1.49.1.3.1. **Premolars.** In a balancing excursion, the stamp cusps of the mandibular first and second premolars pass mesially to the maxillary premolar stamp cusps.

Figure 1.43. Cusp-Fossa MI Contacts.



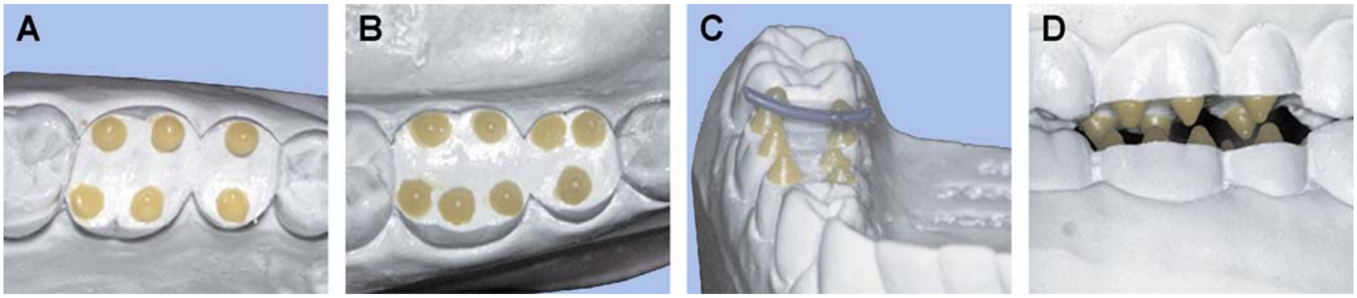
1.49.1.3.2. **First Molars.** The mesiolingual stamp cusp of the upper first molar passes between the distobuccal and the distal stamp cusps of the lower first molar, dividing the space as equally as possible.

1.49.1.3.3. **Second Molars.** The stamp cusps of the lower second molar relate to the maxillary second molar's stamp cusps in the same way as the opposing first molars. The only difference is that the lower second molar pattern might or might not carry a distal cusp.

1.49.2. **Placing Maxillary and Mandibular Shearing Cusp Cones (Buccal of the Upper and Lingual of the Lower) (Figure 1.44-A Through –D):**

1.49.2.1. **Length.** Make shearing cusps shorter than stamp cusps to form a proper mediolateral curve (Curve of Wilson) (Figure 1.44-C). Anteroposteriorly, make shearing cusps conform to the desired Curve of Spee.

Figure 1.44. Placement of Maxillary and Mandibular Shearing Cusp Cones.



1.49.2.2. **Maxillary Shearing Cusp Working Excursion Relations (Figure 1.44-A and -D):**

1.49.2.2.1. **First and Second Premolars.** Make the shearing cusp cones of the upper premolars pass distally to mandibular stamp cusps with ample clearance. In a working excursion, make the shearing cusps of the maxillary premolars travel through opposing embrasures.

1.49.2.2.2. **First Molar.** The mesiobuccal cusp cone of the upper first molar passes between the mesiobuccal and distobuccal cusp cones of the lower first molar, dividing the space evenly.

1.49.2.2.3. **Second Molar.** The shearing cusps of the upper second molar are related to the lower second molar in essentially the same way an upper second molar relates to its opponent.

1.49.2.3. **Mandibular Shearing Cusp Working Excursion Relations (Figure 1.44-B and -D):**

1.49.2.3.1. **First and Second Premolars.** The lingual cusp cones of the upper first premolar passes distal to the lingual cusp cone of the lower first premolar. The lingual cusp cone of the upper second premolar either passes over or travels behind the lingual cusp cones of the lower second premolar.

1.49.2.3.2. **First Molar.** The mesiolingual stamp cusp cone of the upper first molar travels between the two lingual cusp cones of the lower first molar, dividing the distance equally.

1.49.2.3.3. **Second Molar.** The lower second molar shearing cusp cones are placed in the same relation to the upper second molar as the lower first molar is to the upper first molar.

1.49.3. **Waxing the Peripheral Marginal Ridges (Figure 1.45-A Through -D and Figure 1.46).** The peripheral marginal ridges consist of buccal, lingual, and proximal segments. The buccal and lingual marginal ridges are composed of the mesial and distal cusp ridges of a tooth's buccal and lingual cusps, respectively. Each posterior tooth has mesial and distal proximal marginal ridges. A proximal marginal ridge is separated into buccal and lingual parts by a groove or "sluiceway." Sluiceways are escape routes for food during chewing and allow for stimulation of lingual interproximal gingival tissue. Control of buccal and lingual peripheral marginal ridge height is an important influence on the scheme of occlusion you want to develop. If buccal and lingual peripheral marginal ridges are waxed so no contact occurs with opposing cusp ridges or inclines in lateral excursions, the case is anterior guided. If mandibular buccal peripheral marginal ridges are waxed into working side contact with the lingual inclines of maxillary buccal cusps, group function results, as follows:

Figure 1.45. Placement of Marginal Ridge Segments.

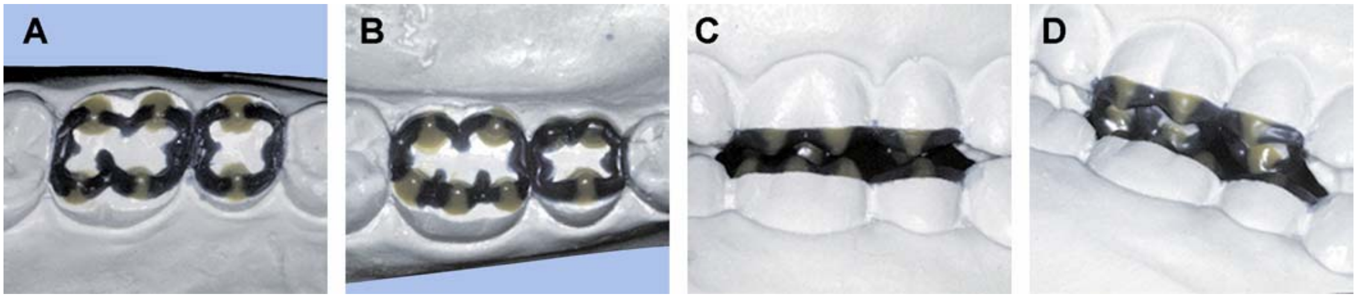
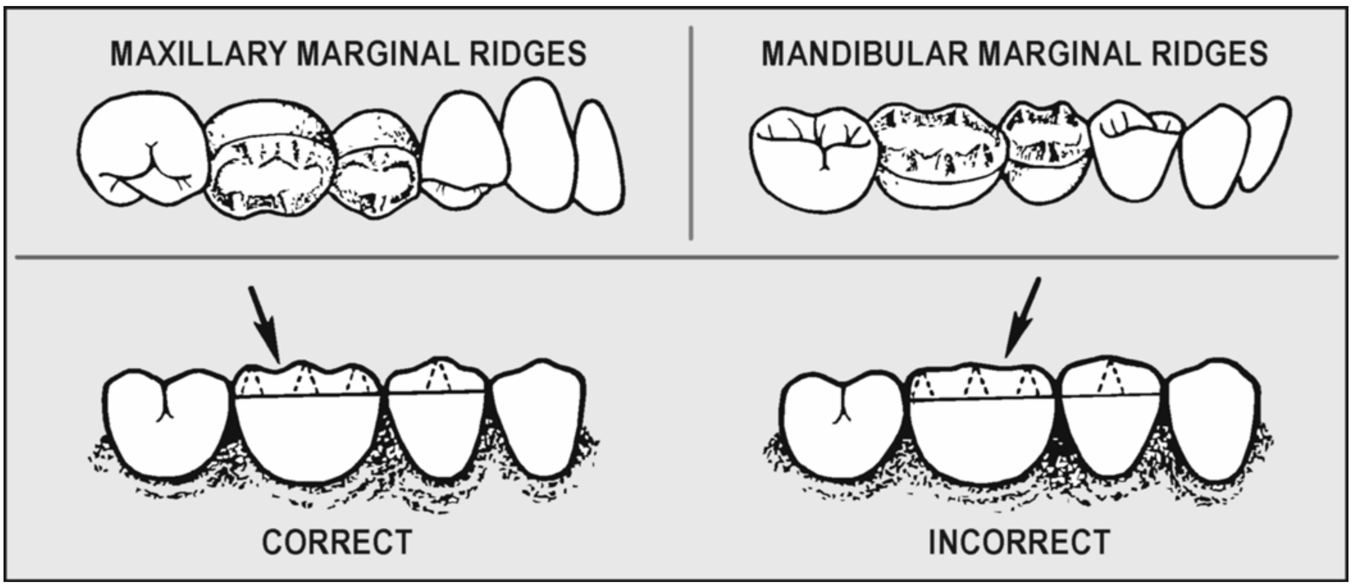


Figure 1.46. Marginal Ridge Contours (Buccal View).



1.49.3.1. **Proximal Surface Peripheral Marginal Ridges and Opposing Cusps (MI):**

1.49.3.1.1. **Cusps to Fossa Stamp Cusp Orientations.** In this type of MI, all stamp cusps occupy fossae and the cusp tips have “tripod” support within the fossae. A proximal marginal ridge forms one wall of a proximal fossa (mesial or distal fossa). When a stamp cusp hits in a proximal fossa, one of the tripod contacts occurs on a proximal marginal ridge (Figure 1.43). The other two tripod contacts occur on stamp and shearing cusp triangular ridges yet to be laid down. ***NOTE:*** When a stamp cusp hits in a central fossa, all three tripod contacts are found on various triangular ridge inclines.

1.49.3.1.2. **Cusp to Embrasure Stamp Orientations.** In the cusp-embrasure concept of MI, most of the mandibular buccal cusps hit across two opposing proximal marginal ridges that form an embrasure. Almost all of the maxillary lingual cusps are in a fossa relationship with mandibular teeth. (See Volume 1, Chapter 5 and Figure 5.4, for details.) Be sure there are no interferences between proximal surface peripheral marginal ridges and opposing cusps during lateral movements.

1.49.3.2. **Maxillary and Mandibular Lingual Peripheral Marginal Ridges (Working Excursion Relationship).** The convention is to wax opposing lingual peripheral marginal ridges and cusp inclines out of contact when the teeth are in a working relationship. This is true for group function and mutually protected occlusions.

1.49.3.3. **Maxillary and Mandibular Buccal Peripheral Marginal Ridges (Working Excursion Relationship):**

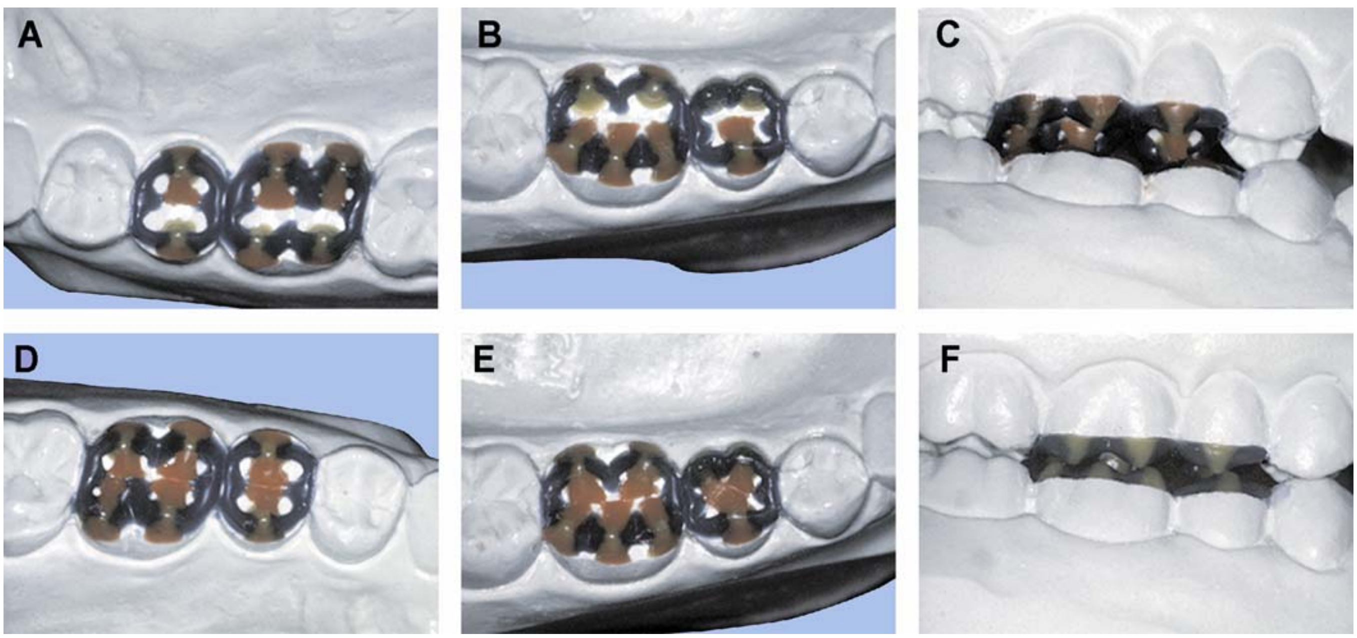
1.49.3.3.1. **Mutually Protected Occlusion.** Mandibular buccal peripheral marginal ridges pass by all parts of the maxillary buccal cusps with clearance.

1.49.3.3.2. **Group Function.** Buccal peripheral marginal ridges of mandibular teeth contact the lingual inclines of buccal cusps and the buccal peripheral marginal ridges of maxillary teeth.

1.49.3.4. **Maxillary Lingual and Mandibular Buccal Peripheral Marginal Ridges (Balancing Excursion Relationship).** There will be no contact of any kind between opposing posterior teeth during the progress of a balancing excursion.

1.49.4. **Positioning Maxillary and Mandibular Stamp Cusp Triangular Ridges (Figure 1.47-A and -B):**

Figure 1.47. Placement of Stamp Cusp and Shearing Cusp Triangular Ridges.



1.49.4.1. **MI Contacts.** The MI fossa contacts that should develop as a result of this step appear in Figure 1.43. The contacts form where the stamp cusp triangular ridges in one arch touch the opposing stamp cusp triangular ridges.

1.49.4.2. **Balancing Excursion Relationships.** There should be no balancing excursion contact between any surface of opposing stamp cusps (Figure 1.47-C). Stamp cusp triangular ridges must be waxed in specific directions to allow escape of the opposing stamp cusps out of the central sulcus area with no interferences during a balancing movement. To achieve this goal, maxillary stamp cusp triangular ridges are angled toward the distal of the tooth as they travel from a cusp tip to the central sulcus. Mandibular stamp cusp triangular ridges angle toward the mesial of mandibular teeth as they travel from cusp tip to central sulcus. Also, on teeth having multiple stamp cusps, the junction of triangular ridge inclines forms a comparatively deep valley of groove to allow escape of an opposing stamp cusp.

1.49.5. **Positioning Shearing Cusp Triangular Ridges (Figure 1.47-D and -E):**

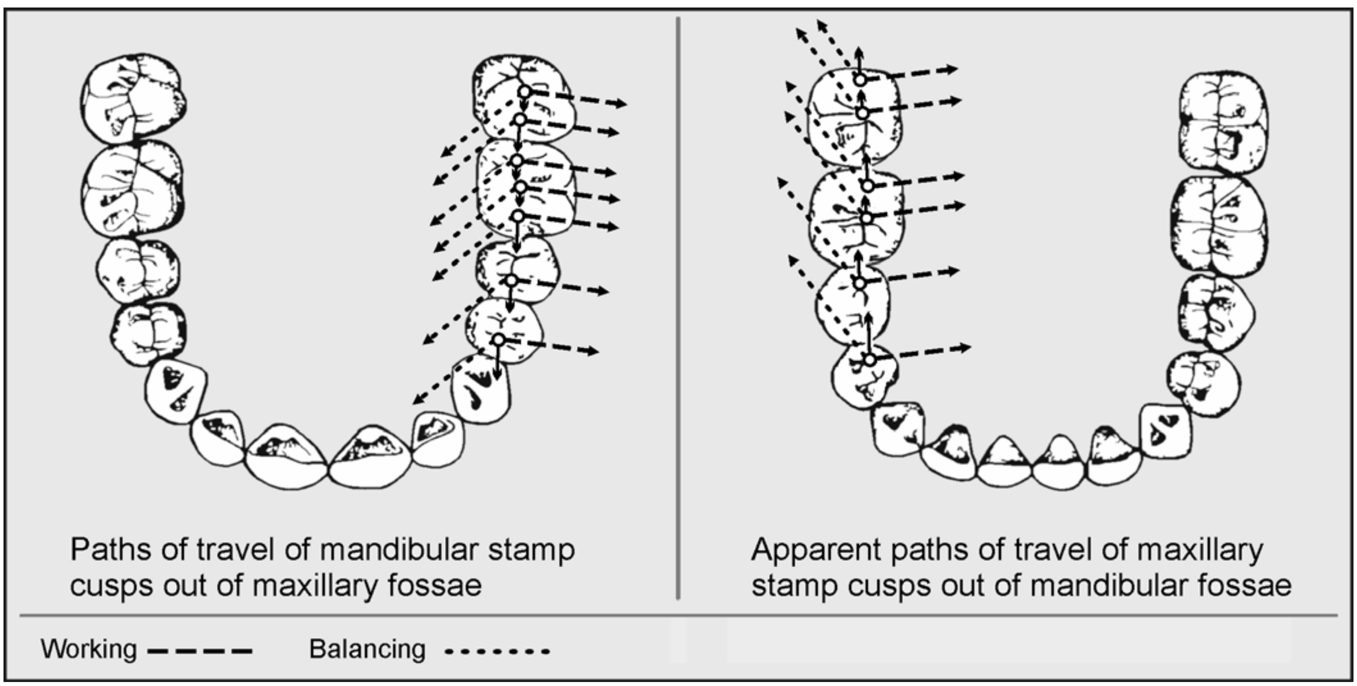
1.49.5.1. **MI Contacts.** The MI fossa contacts that should develop as a result of this step appear in Figure 1.43. The contacts occur because stamp cusp marginal ridges (lingual marginal ridges of the maxillary posteriors and facial marginal ridges of the mandibular posteriors) touch opposing shearing cusp triangular ridges.

1.49.5.2. **Working Excursion Relationships.** In a working excursion, the mandibular shearing cusps are supposed to miss the maxillary stamp cusps (Figure 1.47-F). In the case of a group function occlusion, the maxillary shearing cusp triangular ridges would show working excursion contact with mandibular buccal cusp mesial and distal cusp ridges. When the occlusion is anterior guided, maxillary shearing cusps would miss the mandibular stamp cusps during a working movement. To achieve the recommended working and balancing relations, the following information becomes important:

1.49.5.2.1. Recall how the stamp cusp triangular ridges were angled when they were laid down. Shearing cusp triangular ridges travel at roughly a 90-degree angle from the cusp tip to the central sulcus area.

1.49.5.2.2. The intersection of a stamp cusp triangular ridge and a shearing cusp triangular ridge produces a characteristic Gothic arch or arrow point angle. The apex of this angle is directed toward the distal in the maxillary arch and toward the mesial in the mandibular arch (Figure 1.48).

Figure 1.48. Stamp Cusp Working and Balancing Paths Out of a Fossa MI.



1.49.5.2.3. If stamp cusps are to move laterally out of their respective fossae without interference, triangular ridges must be waxed in arrow point patterns that parallel the working and balancing paths taken by the stamp cusps.

1.49.6. **Verifying MI Contacts.** At this time, all contacts are required for proper tripodism of the stamp cusps and should be present. Figure 1.43-C shows the three-point contact of stamp cusps within fossae (solid lines). It also shows where the three points of contact occur around the rims of individual stamp cusps (dotted lines). A contact is shared where two triangles overlap.

1.49.7. **Waxing Supplemental Anatomy (Figure 1.49).** Supplemental anatomy is used for the following two purposes:

1.49.7.1. To fill any occlusal surface voids that still remain.

1.49.7.2. To provide any additional contacts that might be needed to achieve stamp cusp tripodism. The most common situation for this is when a pattern is waxed against an opposing natural tooth. This is because you have no control over the natural tooth's shape and the wax pattern has to be adapted to existing, unalterable conditions.

Figure 1.49. Placement of Secondary Anatomy and a Cross-Section View of Cusp Placement.

Section 1K—Casting Production

1.50. Overview. This section describes casting, spruing, and finishing procedures for conventional crown and FPD gold alloys. Casting procedures for metal-ceramic substructures are described in Chapter 2 of this volume.

1.51. Rules of Casting. Every casting contains porosity, due to solidification shrinkage. The task is to control the location of that porosity, keeping it out of the casting and in the sprue or reservoir system. To do this, apply the following rules:

1.51.1. Attach the pattern sprue to the thickest cross-sectional area of the wax pattern. The flow of molten alloy from the reservoir to the pattern should be from regions of greater volume to areas of lesser volume.

1.51.2. Position the pattern margins to the right and mark their location with an orientation dot. In centrifugal casting, the wax patterns should be positioned so their margins face to the right to take advantage of the centrifugal, rotational, and gravitational forces on the molten metal.

1.51.3. Position the wax patterns so they will be located in a *cold zone* of the investment mold and the reservoir in the *heat center* (thermal zone) of the ring. That way, the castings will cool first, the sprues will cool next, and, finally, the reservoirs will cool, thereby placing the porosity in the reservoir that cools last.

1.51.4. Provide a reservoir with enough molten alloy to fill the shrinkage that occurs within the casting.

1.51.5. Do not cast a button if you are using a runner bar or other method of indirect spruing. The exposed surface of a button causes the button to cool before the casting, drawing molten metal away from the reservoir and reducing the feed of molten alloy to the castings.

1.51.6. Eliminate sharp turns, restrictions, points, or impingements on flat surfaces that increase turbulence in the sprue. The pathways for the flow of metal must be smooth, gradual, and without impediments. Any restrictions can accelerate the metal's rate of flow and lead to abrasion of the mold (*mold wash*).

1.51.7. Select a casting ring of sufficient diameter and length to accommodate the patterns to be invested. The investment layer surrounding the patterns should be a uniform thickness to ensure proper mold expansion and thick enough to prevent investment breakage.

1.51.8. Apply a wetting agent to the wax patterns to reduce the surface tension of investment. By cleaning the wax surfaces of contaminants and covering the wax patterns with a wetting agent, bubbles on the casting will be less likely to occur.

1.51.9. Measure all investment liquids and weigh all casting investment powder for a precise liquid-powder ratio. Small variations in the liquid-powder ratio greatly affect expansion of the investment.

1.51.10. Eliminate the air in the investment by vacuum mixing and careful pouring of the investment into the casting ring.

1.51.11. Allow the investment to set completely before beginning the burnout procedure. If setting is not complete when the ring is placed in the oven, the mold will be weak and may break during burnout.

1.51.12. Use a burnout technique that is specific for the type of patterns used (wax versus plastic) and suitable for the particular alloy selected. Plastic sprues need to be heated slowly so they soften and do not exert pressure and possibly break the mold. The burnout temperature for each casting alloy varies and must be adjusted to ensure adequate expansion and a complete cast.

1.51.13. Use an adequate heat source to properly melt and cast the alloy selected for use. Inadequately heated alloy does not attain maximum fluidity and may not fill the mold completely. Normally, you will notice blunt margins when the alloy is cast too cool. Too much heat can burn off minor alloying elements through volatilization, oxidation, or both. Symptoms may be brittle or porous castings.

1.51.14. Use the *reducing zone* (middle portion) of the flame to melt the alloy and *not* the *oxidizing zone* (outer portion) when torch casting. The oxidizing portion of the flame can introduce oxygen and carbon into the alloy and adversely affect its properties.

1.51.15. Follow the manufacturer's recommendation on casting procedure and casting force. Whether you use a centrifugal, vacuum, or pressure casting, too much force can be just as detrimental as insufficient force.

1.51.16. Direct alloy flow to your margins. In a centrifugal casting machine, the metal will flow downward and to the right first. Position the casting ring to take advantage of this behavior.

1.51.17. Do not quench the ring immediately after casting. Quenching the casting ring before the metal and investment have completely cooled can result in tensile forces being applied to the casting by the investment. With premature quenching, the metal is still too hot to possess sufficient strength to resist these forces so the casting can *tear*. ***NOTE:*** Many alloy manufacturers do not recommend quenching the casting ring at all. Instead, they recommend allowing the ring to completely bench cool.

1.51.18. Refer to Table 1.1 for the consequences of not obeying the rules of casting.

Table 1.1. Rules of Casting.

ITEM	Probable Cause	Penalty	Solution
1	Spruing to thin areas to reach thicker areas	Cold shuts, short margins, or incomplete castings	Attach sprues to thickest cross-sectional areas of pattern.
2	Pattern or casting ring not oriented to trailing edge of casting arm	Cold shuts, short margins, or incomplete castings	Indicate placement of pattern margins in ring and place ring in casting machine so margins face downward and to the right.
3	Patterns place in thermal zone	Shrinkage porosity	Place patterns in cold zone and locate reservoir in heat center.
4	No reservoir or reservoir too small	Shrinkage porosity or suckback porosity	Use reservoirs that are larger than, or at least equal to, the thickest cross-sectional areas of the pattern.
5	Too much metal used, resulting in a large button	Shrinkage porosity, suckback porosity, or distortion during porcelain firing	Weigh the wax patterns and sprues to calculate amount of metal required. (Technique based on specific gravity of wax versus casting alloy.)
6	Turbulence created by rough sprue network	Voids or surface pitting	Eliminate sharp turns, restrictions, points, or impingements on flat surfaces.
7	Casting ring too small or too many patterns in one ring	Mold fracture, casting fins, or shrinkage porosity	Space patterns 6 mm apart with at least 9 mm of investment between patterns and ring liner. Cover patterns with at least 6 mm of investment.
8	Wetting agent not applied to patterns	Nodules	Brush or spray patterns with wetting agent and let dry. Excess amounts cause rough castings.
9	Investment powder or liquid not measured	Ill-fitting castings	Weigh all casting investment powder and measure investment liquids. Use the proper ratio of each.
10	Investment not vacuum mixed	Weak mold or distorted castings	Vacuum mix and carefully pour investment into rings to ensure a dense, bubble-free mold.
11	Investment not completely set	Mold cracking, blowout, or fins	Allow investment to set completely prior to burnout.
12	Improper burnout techniques used	Cold shuts, short margins, or cold welds	With plastic patterns, use two-stage burnout to soften plastic. Set high temperature according to alloy manufacturer's recommendations.
13	Inadequate heat used to melt and cast alloy or too much heat used	Cold shuts, short margins, cold welds, or rough castings	Use heat source capable of melting the alloy to sufficient fluidity for complete mold fillings.
14	Oxidation zone used instead of reducing zone	Gas porosity or altered coefficient of thermal expansion	Use reducing zone to melt alloy.

ITEM	Probable Cause	Penalty	Solution
15	Not enough casting force or too much force	Cold shuts, short margins, cold welds, mold fracture, or fins	Use casting machine manufacturer's instruction on winding arm or applying vacuum/pressure.
16	Casting ring quenched prematurely	Hot tears	Allow the ring to bench cool completely before quenching.

1.52. Spruing. The *sprue* is a channel through which molten metal will be cast into the mold. The purposes of a sprue channel are to allow an escape for wax during the early stages of the burnout procedure and to direct the molten metal from the crucible into the mold cavity. The channel also provides a reservoir of molten metal on which the casting may draw during solidification. Sprue formers are made of wax, plastic, or metal; and they attach the wax pattern to the sprue base. When the sprue former is burned out, it becomes the sprue through which molten metal will be cast.

1.52.1. **Size of the Sprue Former:**

1.52.1.1. The sprue former should be smooth, short, and thick (6 to 9 mm long and 8 to 10 gauge in diameter). The size of the sprue former will increase with the size of the pattern. Molten metal will first cool and solidify near the walls of the mold and sprue, forming a crust around a molten center.

1.52.1.2. The metal will shrink towards this crust as the molten center cools, leaving a void in the last part of the metal to solidify. This void is called "shrink spot porosity." When using a long, thin sprue former, molten metal will freeze in the sprue channel before it solidifies in the crown portion of the mold. As a result, the casting part of the mold cannot draw on a reservoir of fluid metal in the sprue channel to compensate for cooling shrinkage. Shrinkage porosity will then occur within the crown.

1.52.1.3. When using a sprue former of correct size, molten metal will continue to be drawn into the mold as cooling progresses, and shrink spot porosity will occur in the sprue or reservoir instead.

1.52.2. **Attaching the Sprue Former to the Pattern (Figures 1.50 and 1.51):**

1.52.2.1. To lessen the possibility of distorting the pattern, always attach the sprue former while the pattern is seated on the die. Attach the sprue former to the bulkiest part of the pattern at an angle that will create the least amount of casting turbulence (45 degrees to the axial surfaces of the pattern). Avoid attaching sprue former to anatomical features that are critical to the occlusion you have developed (stamp cusp tips, fossae).

1.52.2.2. When attaching metal or plastic sprue formers, never heat the sprue former and plunge it in to the mass of the pattern because the pattern will warp. Instead, join the sprue former to the pattern with a small bead of sticky wax. Blend the sprue former into the pattern with additional inlay wax. Before taking the sprued pattern off the die, add a small amount of wax to the contact areas to compensate for metal loss during finishing.

1.52.3. **Attaching the Sprued Pattern to the Sprue Base (or Crucible Former) (Figure 1.51-B).** Remove the sprued pattern from the die. Lute the sprue former to the sprue base, building up or reducing the apex of the sprue base until the sprue former's length is 6 to 9 mm and there is 6 mm clearance between the top of the pattern and the rim of the casting ring. This space is the thickness of investment needed to prevent metal from breaking out of the mold while casting is in progress. Yet, it is thin enough to let trapped gases escape ahead of molten metal entering the mold cavity.

Figure 1.50. Examples of Direct Spruing.

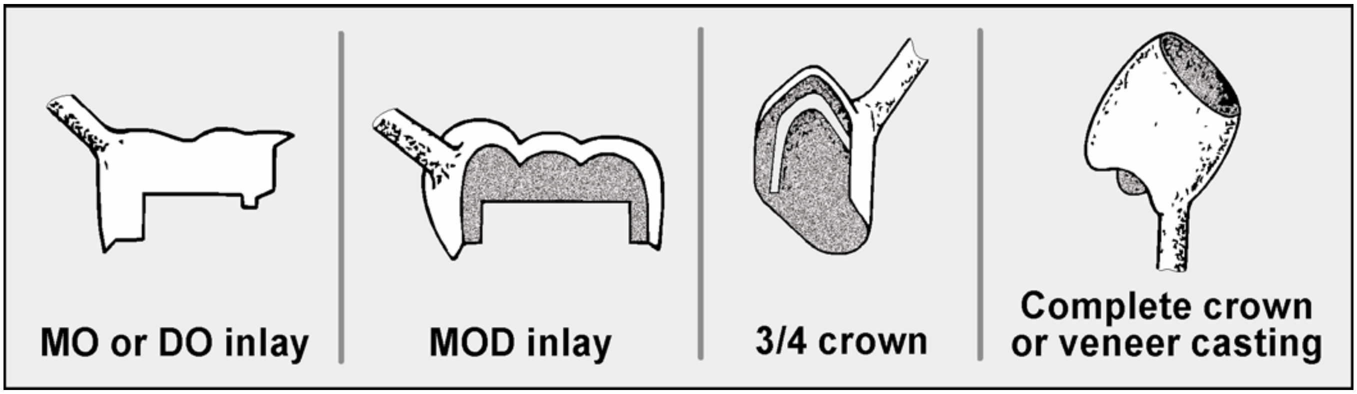
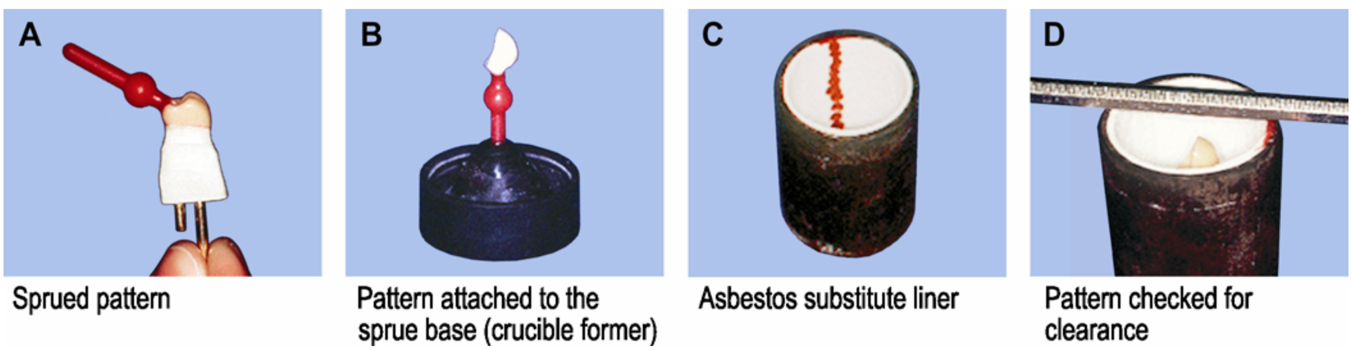


Figure 1.51. Directly Sprued Wax Pattern Attached to a Sprue Base.



1.52.4. **Spruing Options.** Most single unit castings can be made with one direct sprue former—the only spruing option mentioned so far. A straight, uninterrupted sprue channel between the crucible and the mold characterizes direct spruing. However, below are a few more spruing options:

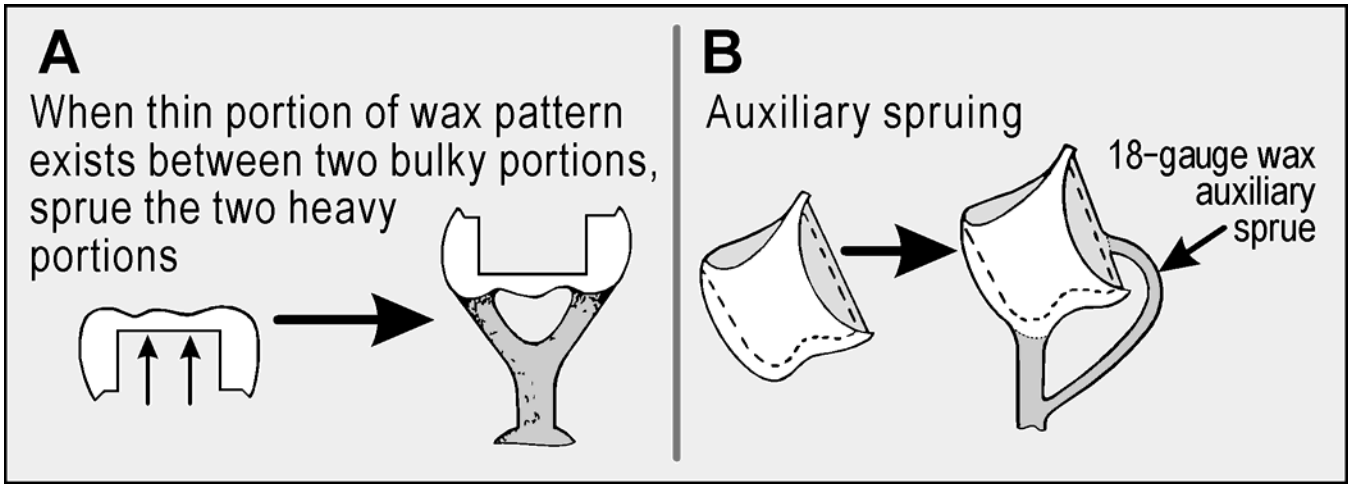
1.52.4.1. **Auxiliary Spruing a Single Pattern (Figure 1.52).** For large patterns or those patterns with two thick areas separated by a thin area, use auxiliary sprue formers (18-gauge wax) to ensure complete casting.

1.52.4.2. **Direct Spruing of Multiple, Independent Patterns.** When two or more patterns are sprued in direct fashion off of the same sprue base, they should fan out from around the apex of the sprue base. Do not make the sprue former's lead off one another. When using prefabricated sprue formers with reservoirs, place the reservoirs so they contact each other and are positioned in the center of the ring (thermal zone). Join the contacts between the reservoirs with inlay wax.

1.52.4.3. **Indirect Spruing of Multiple, Joined Patterns:**

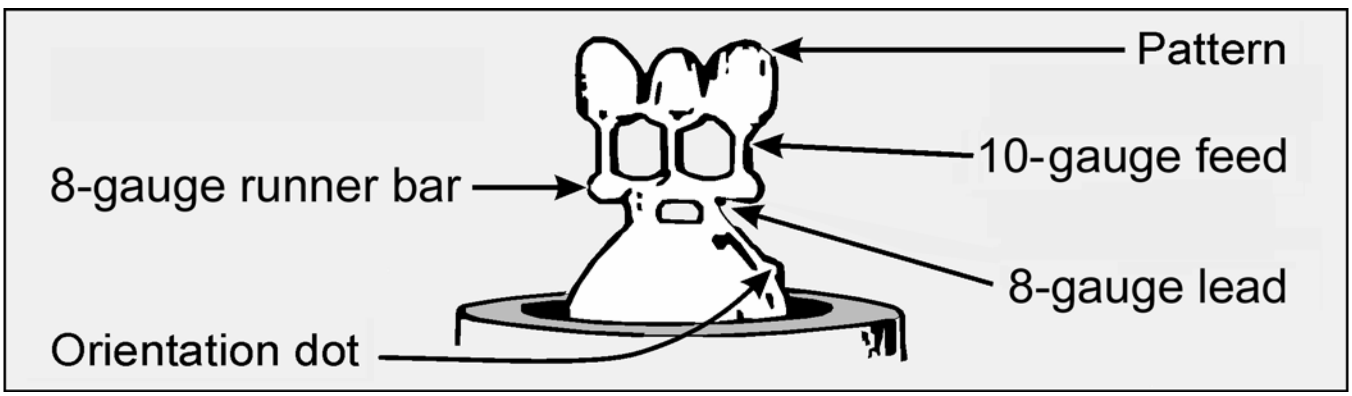
1.52.4.3.1. *Indirect spruing* is commonly used to cast multiple single units or units joined together as a splint or a FPD. In contrast to direct spruing, the sprue channels for indirectly sprued patterns do not lead directly from the crucible to the mold.

Figure 1.52. Auxiliary Spruing of Single Patterns.



1.52.4.3.2. Figure 1.53 illustrates indirect spruing techniques for three unit FPD substructures. Note that the 10-gauge patterned sprue formers from the horizontal runner bar to the pattern are offset from the 8-gauge lead sprue formers that connect the runner bar to the sprue base. The runner bar is also made of 8-gauge round wax.

Figure 1.53. Indirect Spruing of Multiple Joined Patterns.



1.52.4.3.3. This spruing technique allows molten metal to be cast into the mold so it fills the mold uniformly and simultaneously, thus eliminating variations that occur when molten metal hits different areas of the mold at different times. Indirect spruing increases turbulence (over the direct method) and reduces backpressure when the metal is cast into the mold. It helps eliminate shrink spot porosity because the feed of molten metal stays open longer.

1.52.4.4. **Indirect Spruing of Multiple, Independent Patterns (Figure 1.54).** A number of patterns that are not joined together are sprued to a runner bar (as described in the paragraph 1.52.4.3).

1.52.4.5. **Sprued Pattern Orientation Dot.** Investigations have shown that the flow of the molten metal is downward and to the right of the mold (trailing edge) as it rotates in a centrifugal casting machine. Mark the mold so it can be oriented to the arm of the casting machine to take advantage of this flow of molten metal. The two kinds of patterns that receive maximum benefit from selective orientation of the mold in the casting machine are as follows:

Figure 1.54. Indirect Spruing of Multiple Independent Patterns.

1.52.4.5.1. **Single Unit Patterns With a Thin Section.** Place a small round dot of wax on the sprue base. Position the pattern so the thinnest section (or margins) faces the dot of wax. This dot will later appear in the investment and be used to orient the mold to trail as the casting arm spins.

1.52.4.5.2. **Splints and FPDs Being Cast in One Piece.** Place a dot of inlay wax on the sprue base in line with the side of the pattern (Figure 1.53). This leaves a dimple in the investment. Use the dimple to orient the ring in the casting machine. If using a horizontal machine, position the length of the pattern vertically. Also, the facial surfaces of the pattern should trail as the casting arm spins. If using a vertical machine, orient the pattern horizontally.

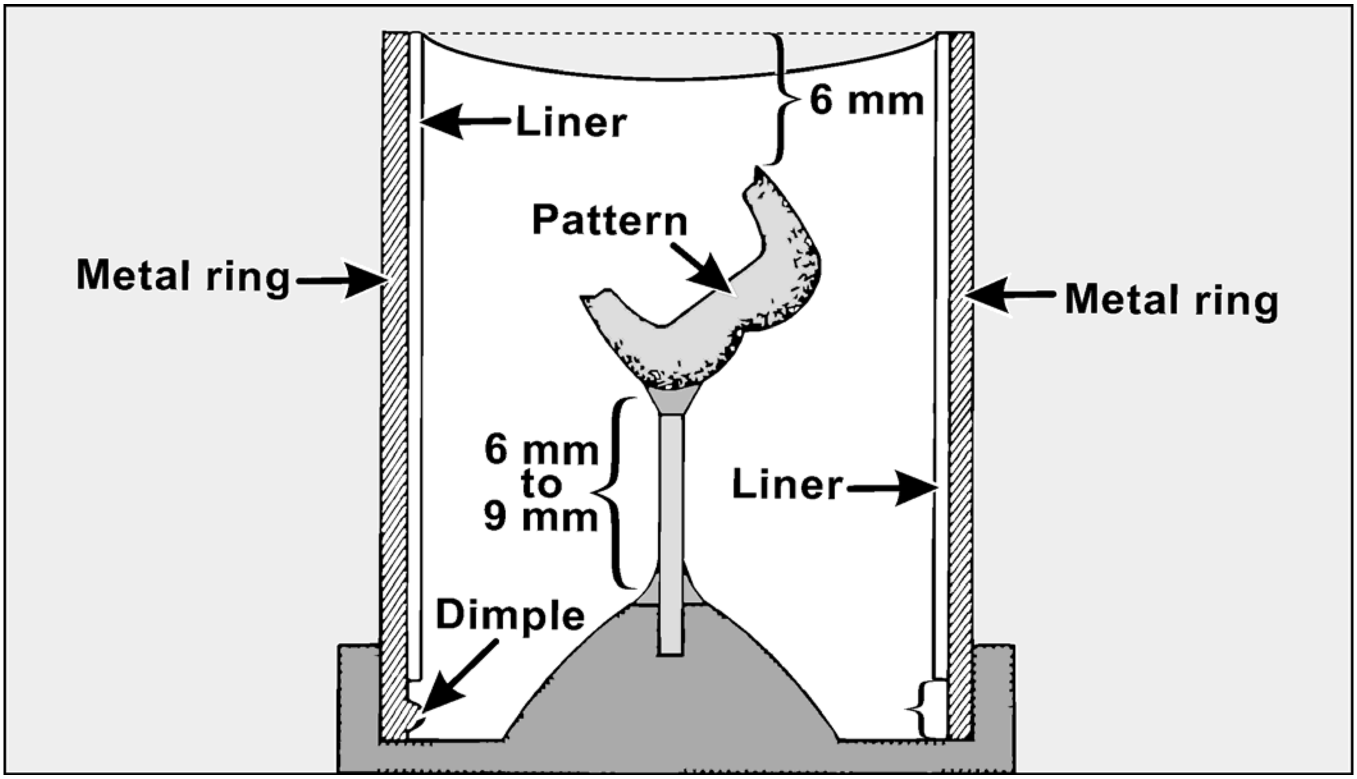
1.52.5. **Prepare the Casting Ring for Investing (Figures 1.51 and 1.55):**

1.52.5.1. Line the casting ring with one layer of dry resilient material (asbestos substitute, trade name Nobestos or Kaoliner), keeping it 3 mm short of the crucible (sprue base) end of the ring with the small locking dimple exposed that prevents shifting of the investment. The ring liner should be flush with the top of the ring so expansion will be even and unrestricted. ***NOTE:*** Commercial ring liner materials are made of either cellulose, which burns out in the oven, or ceramic (kaolin), which remains in the ring after burnout. Ceramic liners are not moistened prior to investing because they will not absorb water.

1.52.5.2. Tack the ring liner in place with a small amount of sticky wax. Moisten the liner so it will not absorb water from the investment and change the investment's expansion characteristics. Some manufacturers recommend you not wet ring liners. The liner acts as a cushion against the different investment expansions that occur, an insulator against the loss of heat during the casting operation, and an aid in removing the investment from the ring after the casting has been made.

1.52.5.3. Paint the pattern with a wetting agent and gently blow away any excess. Seat the dimpled end of the casting ring in the sprue base, being very careful not to disturb the pattern.

Figure 1.55. Schematic View of a Sprued Pattern in a Casting Ring.



1.53. Venting a Sprued Pattern. Venting is a special provision that permits gas to escape rapidly from the mold cavity ahead of incoming molten metal during the casting procedure (Figure 1.56). There are "direct" vents (attached directly to patterns) and "blind" vents (not attached). Current theory states that direct vents act more like *chill sets* and are of lesser importance than "vents" that remove gases. Chill sets are wax projections that radiate heat away from the castings and cause the metal to cool in a desirable way. The term *chill vent* better describes the use of direct venting. In Figure 1.54, two 18-gauge wax rods have been placed on the pontic area of the FPD. Pontic areas are bulky and chill vents should help to control porosity.

Figure 1.56. Vented Pattern.

1.54. Investing. A sprued pattern is invested in a casting ring by pouring investment material into the ring.

1.54.1. **Maintaining Cleanliness.** Keep all equipment and hand instruments used in the investing operation meticulously clean. Keep sprue bases, spatulas, mixing bowls, mechanical mixers, and water baths free of any dried or caked investment. A high percentage of porosity in gold castings can be attributed to investment contamination. Particles may also cause the investment to set improperly, causing it to be soft and crumble when hot molten metal is cast into the mold. Porosity is also caused by investment powder that has absorbed moisture from the environment. It is important to store investment in a tightly covered container. Hermetically sealed bags with individual portion of investment are best.

1.54.2. **Choosing a Compensation System for the Shrinkage of Cooling Gold (Gypsum-Bonded Investments Only).** Cast gold shrinks about 1.4 percent (± 0.2 percent) when it solidifies from the molten state, and investment expansion compensates for this shrinkage. Depending on how they are handled, investments can expand in a number of ways:

1.54.2.1. **Kinds of Investment Expansions:**

1.54.2.1.1. **Semihygroscopic or Effective Setting Expansion.** This setting expansion (about 0.35 percent) occurs in air when the casting ring contains a wet ring liner.

1.54.2.1.2. **Hygroscopic Expansion.** This setting expansion (about 0.75 percent) occurs when the invested pattern is completely immersed in a warm water bath.

1.54.2.1.3. **Thermal Expansion.** Thermal expansion of the investment and mold occurs when it is heated in a burnout oven. Higher heat results in more thermal expansion.

1.54.2.2. **Two Popular Systems of Compensating for Cast Gold Shrinkage:**

1.54.2.2.1. **High Heat Technique.** In this system, most of the investment expansion is heat induced. The investment bench sets in air for 45 minutes during which semihygroscopic expansion of 0.35 percent occurs. The pattern wax is then burned out at 1250 ^{o}F, during which thermal expansion of 1.2 percent occurs. Total expansion for high heat technique is 1.55 percent.

1.54.2.2.2. **Hygroscopic Technique:** (***NOTE:*** Most of an investment's expansion is hygroscopic.)

1.54.2.2.2.1. First, the investment sets under 100 ^{o}F water for 30 to 45 minutes, during which hygroscopic expansion of 0.75 percent occurs. Pattern wax expansion from room temperature (72 ^{o}F) to 100 ^{o}F is 0.3 percent. Then, the pattern is burned out at 900 ^{o}F, during which thermal expansion of 0.55 percent takes place. Total expansion of the hygroscopic technique is 1.60 percent.

1.54.2.2.2.2. Advantages claimed for the hygroscopic compensation method over the high heat technique are that the method gives smoother castings, prolongs the life of furnaces and casting rings, and gives finer grain structure to the solidified gold.

1.54.2.2.2.3. Some brands of investment are specially compounded for use in the hygroscopic method while others work best in the high heat technique. Always read the manufacturer's directions.

1.54.3. **Preparing the Water and Investment Powder.** Use the water-to-powder ratio recommended by the manufacturer. Recommended ratios will fall within a narrow range. When selecting from this range, keep in mind that less water in the mix will give greater mold expansion.

1.54.3.1. **Distilled Water.** The water should be carefully measured. Using *only* distilled water, pre-wet the bowl. (***NOTE:*** A significant percentage of the water can be consumed in wetting the mixing bowl and not become incorporated into the mixed mass.) Do not leave excess water on the surface of the bowl, but be sure it is damp. Water temperature should be about 70 °F. Room temperature water can vary according to the area within the laboratory and the season of the year. Water that is too warm or too cool is one of the greatest contributing factors to the distortion of the wax pattern during the investing process. Use only distilled water.

1.54.3.2. **Investment Powder.** If not using a prepackaged investment, be sure to weigh the investment powder accurately.

1.54.4. **Investing a Pattern.** There are two basic ways to invest a pattern—mechanical mixing the investment under vacuum and hand-mixing (investing). No matter which method you use, the first step is to pour water into the mixing bowl and then slowly add the powder. Incorporate the powder and water with a hand spatula so no dry powder or large lumps are visible.

1.54.4.1. **Mechanical Mixing Under Vacuum (Figure 1.57):**

1.54.4.1.1. After incorporating the powder and water with a hand spatula, place the lid on the bowl and ensure it is tightly closed.

1.54.4.1.2. Connect the vacuum tubing. Slip the metal trap cap at the end of the tubing into its opening on the top of the lid.

1.54.4.1.3. Position the vacuum spatulator so the agitator's drive nut engages the motor's drive chuck. Start the unit. Spatulate for the length of time recommended by the manufacturer (Figure 1.57-A). Then disengage the spatulator.

Figure 1.57. Investing With a Vacuum Spatulator.

1.54.4.1.4. Release the vacuum, but let the unit run for 1 more minute to flush water vapor from the pump and re-oil the motor.

1.54.4.1.5. Use a brush or instrument and mild vibration to flow a mix of investment over all the pattern's surfaces and into the cavity of the pattern (Figure 1.57-B). Take care not to incorporate air bubbles. Do not touch the pattern with the brush or instrument. Instead, vibrate a brush load of investment ahead of the brush's bristles until the pattern is covered. When done properly, precoating a pattern in this way helps ensure a bubble-free casting.

1.54.4.1.6. Place the ring carefully on the sprue base and pour the investment around the pattern (Figure 1.57-C). This is done by pouring investment down the side of the ring and allowing it to rise around the pattern. While the ring is being filled, hold it in the hand that is rested on the vibrator plate. The vibrations cause the ring to fill evenly without trapping air. If the hygroscopic technique is being used, submerge the ring in a water bath (Figure 1.58). If not, let the investment bench set.

1.54.4.1.7. Wash mixer parts, lid, bowl, and hand spatula thoroughly under running water before the investment has a chance to set.

Figure 1.58. Hygroscopic Expansion Water Bath.

1.54.4.2. **Hand-Investing.** If powered mechanical spatulators and vacuum equipment are not available, a pattern can be hand-invested as follows:

1.54.4.2.1. Place the mixing bowl on a vibrator and spatulate the contents with a hand spatula. The vibration causes the mix to stay in the bottom of the bowl and facilitates thorough mixing. Mild vibration will also act to remove most air bubbles.

1.54.4.2.2. At the very least, most laboratories have a hand-driven mechanical spatulator. If using one of these devices, start the mix with a hand spatula and finish it with the hand-cranked unit. The number of turns of the handle is important. Follow the manufacturer’s directions because differences in the amount of spatulation cause variations in setting expansion. Gently vibrate the mix to liberate trapped air.

1.54.4.2.3. The investment can now be added to the ring as described in paragraphs 1.54.4.1.5 and 1.54.4.1.6.

1.54.5. **Investment Setting Time:**

1.54.5.1. **Investment Destined for High Heat Pattern Burnout.** A minimum setting time of 45 minutes (1 to 1.5 hours is best) is critical to developing sufficient semihygroscopic setting expansion and ensuring adequate strength. Be sure the invested pattern is allowed to stand on a bench where there is no vibration. If the investment is subjected to vibration during the initial setting period, a cracked mold or rough casting can result.

1.54.5.2. **Hygroscopic Investment Expansion.** After investing (and while the investment is still wet), submerge the ring in 100 ^{o}F water for 45 minutes. It *may* remain in water up to 3 hours. Do not subject the investment to vibration while it is setting.

1.54.6. **Removing the Sprue Base and Sprue Former:**

1.54.6.1. Once the investment has set for the recommended length of time, carefully twist off the sprue base in a single motion and free it from the investment and sprue former. Remove any excess investment from the ends and side of the ring so it will fit properly in the casting machine.

1.54.6.2. Break the glaze at the top of the ring so gases generated by pattern burnout can escape readily (Figure 1.59). Ensure the crucible portion of the mold is clean and free of loose investment particles.

Figure 1.59. Breaking the Top Surface Glaze of the Set Investment.

1.54.6.3. Metal sprues formers must be removed before wax pattern burnout; wax and plastic sprue formers do not. To remove a metal sprue former, warm it through contact with a hot pair of pliers, invert the casting ring with the crucible downward, and rotate the sprue former out of the mold with the pliers. From this point until the casting is made, keep the ring inverted to prevent particles of investment or other debris from falling into the sprue hole. Debris in the mold causes gross casting defects.

1.54.7. **Storing Invested Patterns:**

1.54.7.1. Invested patterns usually go directly into the burnout oven after the investment sets. Occasionally, though, invested patterns cannot be burned out immediately so they must be stored overnight or longer.

1.54.7.2. Do not let set investments dry out. Water must be present in the investment to conduct heat evenly throughout a mold. When a mold is dry, the outer edges nearest the heated furnace walls can become much hotter than the mold's inner core. The investment may crack under these conditions.

1.54.7.3. Store invested patterns in a humid atmosphere. Wrap them in a damp towel and keep them in a plastic bag that contains a few drops of water. If a ring dries out, soak it in water for 10 or 15 minutes before placing it in a burnout furnace.

1.55. Wax Elimination (Burnout):

1.55.1. **Overview.** Wax elimination (burnout) is used to eliminate all moisture from the invested ring. It is also used to eliminate the wax or plastic used to form the pattern from the mold cavity. The heat expands the mold cavity to compensate for alloy shrinkage during solidification and cooling and raises the mold to the proper temperature to receive molten alloy. Controlled burnout prevents damage to the investment from overheating. Uncontrolled burnout causes breakdown of the mold's walls and possible sulfur contamination of the alloy. Sulfur contamination renders the alloy weak and brittle.

1.55.2. **Calibrating the Burnout Furnace's Temperature Indicator:**

1.55.2.1. Every burnout furnace should have a good pyrometer and indicator. The pyrometer (or thermocouple) consists of a pair of dissimilar wires welded together at the couple tip. The wires project into the furnace's burnout chamber (muffle). Contamination of the wires by gases released in the muffle and exposure to continued high temperatures changes the thermocouple's behavior characteristics.

1.55.2.2. Because the thermocouple is directly responsible for the readings on the temperature indicator, the readings tend to lose their accuracy. Therefore, temperature readings should be checked monthly. One method is to use a commercially prepared pellet made from metal oxides. The pellet fuses and flows when its melting point is reached. The accuracy of these pellets is within 1 percent of their rated melting temperatures. Pellets may be obtained that melt at almost any temperature up to 2400 ^{o}F. The pellets come from the manufacturer with full directions for use.

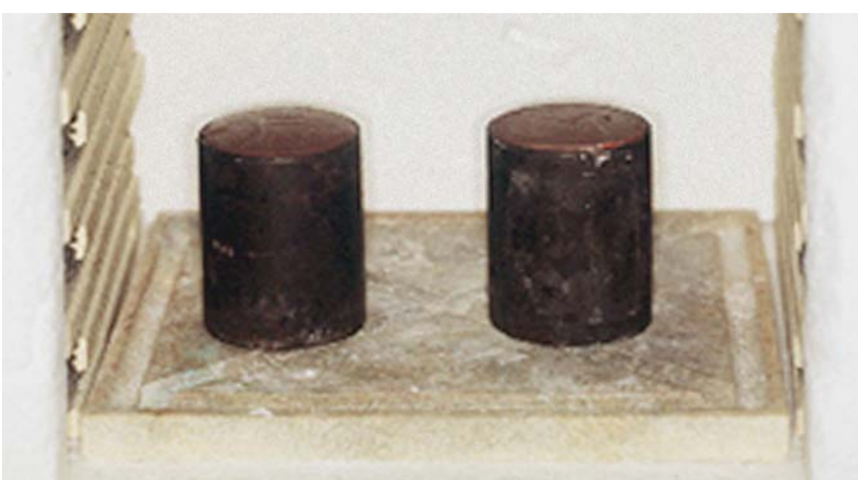
1.55.3. **Placing Rings in the Furnace:**

1.55.3.1. Make sure the ring is damp when placing it in the furnace to minimize the possibility of cracking. Soak rings that have dried overnight (or longer) in water for 15 minutes before placing them in the furnace.

1.55.3.2. Place a tray in the bottom of the muffle for the rings to sit on. The tray will retain the molten wax that flows out of the mold cavity and keep it from soaking through the muffle floor where it could damage the heating element. An alternative is to line the floor of the muffle with asbestos-substitute strips.

1.55.3.3. Place the rings in the center of the furnace toward the back wall when possible (Figure 1.60). The temperature in different parts of the oven may vary and this placement ensures that the furnace atmosphere surrounding the ring is the same as that recorded by the pyrometer indicator.

Figure 1.60. Placement of Rings in the Burnout Furnace.



1.55.3.4. Place the mold in the oven with the sprue hole down. Elevate one edge of the ring upward by resting it on a small piece of ceramic material. (This is not necessary if the burnout furnace has a firing platform with channels in it.) Molten wax will flow out of the mold as it melts and air will pass more freely into the mold cavity to ensure complete burnout of all residual carbon.

1.55.4. **Controlling Burnout Time and Temperature:**

1.55.4.1. **High Heat Technique.** Use the high heat technique with investments that have bench set in air and semihygroscopically expanded. The burnout temperature is 1250 to 1275 ^{o}F. Starting with a cool oven, the furnace takes about 1 hour to reach burnout temperature. After reaching burnout temperature, heat soak the mold for another hour. Total time in the oven is about 2 hours. Do not raise the temperature above 1300 ^{o}F because it will cause the investment material to break down, which causes rough castings. Excessive burnout temperatures also produce sulfur gases that mix with gold alloys and make castings brittle. Do not use the oven to burn out new molds until its temperature has dropped to at least 900 ^{o}F.

1.55.4.2. **Low Heat Technique.** Low heat burnout is used in combination with investments that have been hygroscopically expanded in a water bath. The burnout temperature is 900 ^{o}F. Heat the mold from room temperature to 900 ^{o}F or place it directly in the furnace at 900 ^{o}F. After reaching burnout temperature, heat soak the mold for 1 hour. Total time in the oven is about 2 hours when starting with a room temperature furnace. However, only half the time is needed with a preheated furnace. Some claim low heat burnout produces finer grained, stronger castings than the high heat technique. Using equipment at lower temperatures generally prolongs its life.

1.55.4.3. **Factors Influencing Burnout Time and Temperature.** Do not rush burnout. If an error is made in burnout time, be sure it is on the long side rather than on the short side, as follows:

1.55.4.3.1. **Temperature Rise Time.** The time from room temperature to the desired burnout temperature should not be less than 1 hour.

1.55.4.3.2. **Number and Size of the Molds.** Allow an additional 10 minutes for each additional mold. (Use an additional 20 minutes for larger molds.) Calculate burnout time from the time the last mold is placed in the oven.

1.55.4.3.3. **Preheated Oven.** Using a preheated oven does not significantly decrease burnout time. At the start of the burnout cycle, the temperature of the investment is much lower than the atmosphere of the furnace. The time it would take the mold to reach the preheated temperature is about the same as the time it would take a room temperature oven and mold to rise simultaneously to the preheated temperature. Therefore, burnout time stays about the same whether the ring is initially placed in a room temperature furnace or in a preheated oven.

1.55.4.3.4. **Plastic Patterns.** Molds containing plastic patterns must burn out slower and longer. The initial burnout temperature should not exceed 600 ^{o}F for the first 30 minutes.

1.56. Casting With a Gas-Air Torch and Centrifugal Casting Machine. (***NOTE:*** There are more sophisticated, electrical methods of melting and casting gold alloys. If you are going to use an electrical device in the casting process, be sure to follow the manufacturer's directions for operating the equipment.) This method uses direct application of heat with a blowtorch to melt an alloy before casting as follows:

1.56.1. **Balance the Machine.** Keep a "dummy" casting ring available to balance the casting machine.

1.56.2. **Prepare the Crucible.** There are three types of available casting crucibles; clay, quartz, and aluminum oxide. Clay crucibles must be glazed by sprinkling powdered flux inside them and heat with a casting torch. The alternative approach would be to simply use a quartz or aluminum oxide crucible. These crucibles are self-glazing if they are sufficiently heated with a torch.

1.56.3. **Determine the Amount of Alloy Needed.** The amount of alloy required for a casting is dictated by the pattern's weight. Ideally, you should not cast a button when using a reservoir. A button is any additional cast alloy beyond the sprue. To determine the amount of alloy needed, weigh the patterns with attached sprue former. Then multiply that weight times the specific gravity of the alloy being used. The product is the amount of alloy needed to cast. For example, .6 grams (weight of patterns and sprue former) times 15.5 (specific gravity of the alloy) equals 9.3 grams. Thus, you would cast 9.3 grams of alloy.

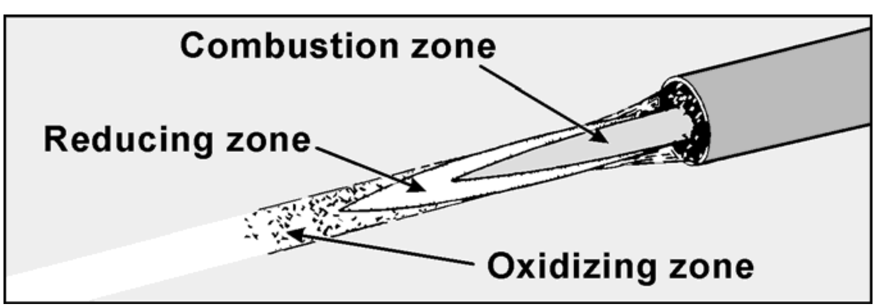
1.56.4. **Select the Metal Needed.** Use either new alloy or a combination of new alloy and previously cast alloy for a casting. Do not mix brands or types of alloy because the physical properties of such blends are unpredictable. When using previously cast alloy, combine it with at least 50 percent new gold alloy. Thoroughly microblast previously cast alloy before reusing it. When necessary to combine small pieces of alloy or remove impurities from a button, melt the alloy in a depression on a charcoal block with the reducing part of a blowtorch flame. Sprinkle a reducing flux over the molten metal to remove the oxides and impurities. Prevent reoxidation by shutting off the air to the torch and playing the gas flame over the alloy to exclude air until the alloy solidifies.

1.56.5. **Wind the Casting Machine.** Allow three to four turns to generate enough casting force. Use more turns for small masses of metal and a lower number for large masses. Raise the stop rod from the base of the machine and rest the main arm against it. The pressure of the arm holds the rod in an elevated position. The arm will not rotate as long as the stop rod is up.

1.56.6. **Adjust the Torch Flame:**

1.56.6.1. Good casting torches usually have two control valves, one for air and the other for gas (natural gas or propane). Be sure the hoses supplying the torch are connected to the correct gas sources. Light the torch with only gas flowing. Incorporate progressively more air into the gaseous mix until a pointed flame showing two "cones" develops (Figure 1.61). The outer cone, called the reducing zone, is the part of the flame that consists of burning gas. The inner cone, called the combustion zone, is unburned gas of a low temperature.

Figure 1.61. Parts of a Gas-Air Torch Flame.



1.56.6.2. Melting must be done in the reducing zone of the flame lying between the tips of the inner and outer cones. This portion should be large enough to cover the button of gold alloy used.

1.56.6.3. Taken as a whole, the flame should always have a reducing nature. This means the flame has a supply of gas somewhat larger than the available air can completely burn. If the flame does not have this reducing character, excess oxygen will oxidize base metals in the alloy and raise the alloy's melting temperature to a point where it is impossible to melt it satisfactorily.

1.56.7. **Preheat the Crucible.** Preheat the crucible with the torch. This ensures a cold spot does not develop at the base of the alloy as it is being melted.

1.56.8. **Melt the Gold and Apply Flux.** Place the required amount of alloy in the preheated crucible. Melt the alloy with the reducing zone of the flame. If a significant oxide film forms, sprinkle a small amount of casting flux onto the surface of the alloy. If the metal is clean and uncontaminated, this should be the only time you use flux. Never add flux once the ring has been positioned in the casting machine. The rush of gas out of the torch could blow the flux into the mold and cause it to become part of the casting.

1.56.9. **Position the Ring in the Casting Machine (Figure 1.62).** Maintain the alloy in as molten a state as possible. Remove the burned out mold from the oven. Insert the ring into the machine with the sprue hole toward the crucible and ensure the orientation dot is positioned toward the trailing edge of the rotation of the casting machine. Move the crucible into contact with the ring.

1.56.10. **Heat the Alloy to Casting Condition.** The exact time of casting the alloy into the mold cavity is determined by appearance. The gold alloy is ready to cast when it exhibits a mobile, bright, mirror-like surface.

1.56.11. **Make the Casting.** Grasp the arm of the machine firmly, move it away from the stop rod, and let the rod drop back into the base. Release the arm and make the cast, holding the flame on the gold until the crucible starts to rotate. Release the casting arm smoothly. Do not allow it to jerk because molten metal spills can result.

1.56.12. **Recover the Casting From the Mold.** When the machine stops spinning, remove the mold and place it on a bench top. Allow it to bench cool completely before divesting. Push the investment out of the ring and break away the bulk of investment surrounding the castings.

1.57. Cleaning and Pickling (Deoxidizing) the Casting:

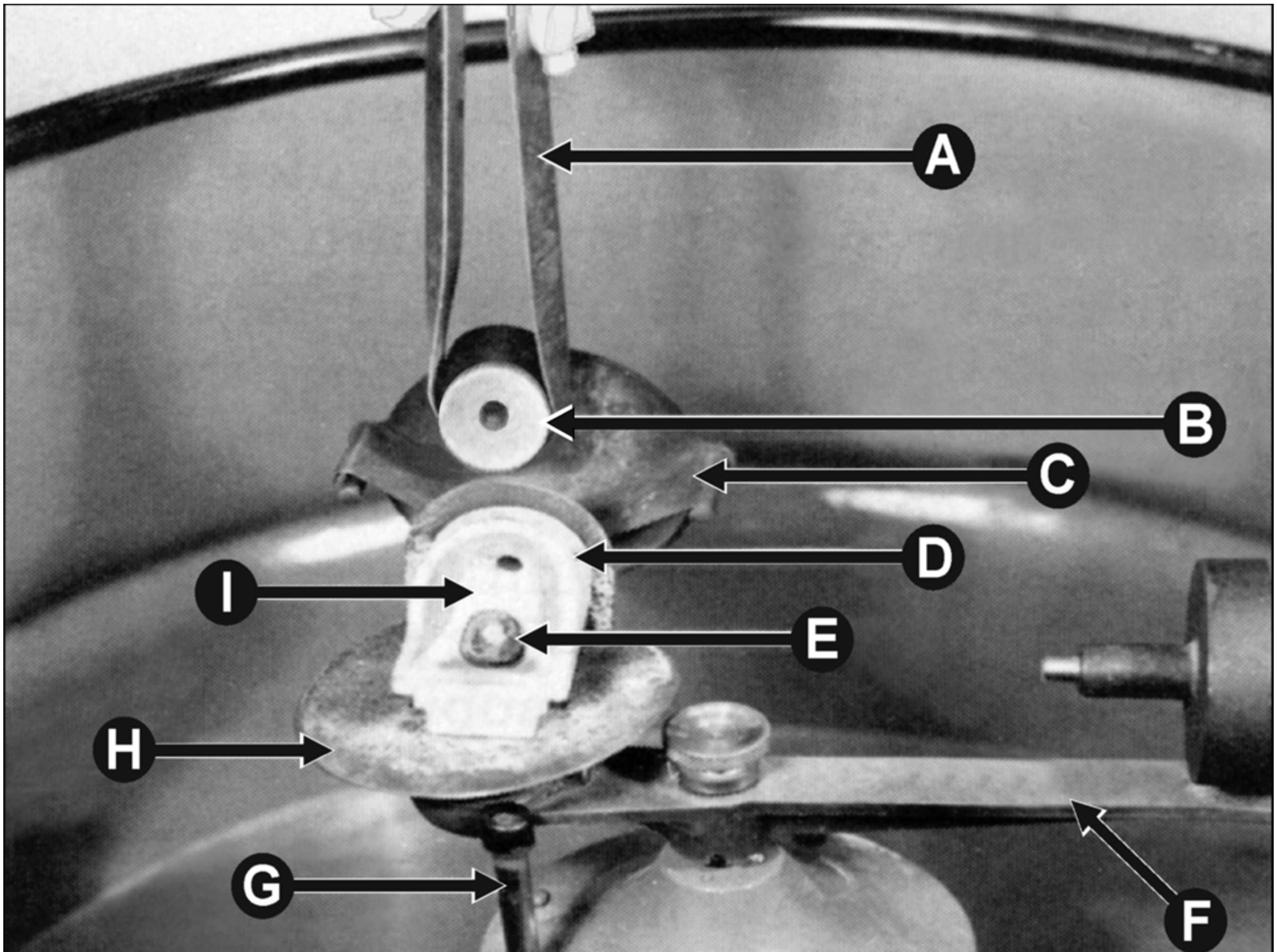
1.57.1. **Cleaning.** Use a stiff brush under running water to remove adhering investment. A microblaster with glass beads under low pressure may also be used to remove investment from the outer casting surface, while aluminum oxide may be used to remove investment from the inner casting surface. Use caution not to use too much air pressure or abrade the margins of the casting with the microblasting process (Figure 1.63).

1.57.2. **Pickling (Figure 1.64):**

1.57.2.1. Pickling consists of chemically removing oxides from a casting. A 50-percent solution of hydrochloric acid is frequently used for pickling. Also, there are various kinds of commercial pickling preparations available. Because these commercial preparations are generally safer than hydrochloric acid solution, their use is recommended.

1.57.2.2. Place the pickling solution in a porcelain pickling dish. Using plastic-coated tongs, submerge the casting. Heat the solution, but do not let it boil.

Figure 1.62. Melting the Gold Alloy and Positioning the Ring in the Casting Machine.



A. Tongs	D. Crucible	G. Stop rod
B. Casting ring	E. Molten gold	H. Crucible carriage
C. Cradle	F. Casting arm	I. Asbestos liner

1.57.2.3. After the casting brightens, take it out of the pickling agent with the plastic-coated tongs. ***NOTE:*** Using inert plastic or plastic-coated tongs is important because the plastic material has no effect on the casting. When using ordinary metal tongs or forceps, an undesirable copper deposit forms on the casting's surface.

1.57.2.4. Wash the casting with a solution of sodium bicarbonate, liberally rinse in clear water, and dry. Because undesirable deposits form on a casting if the pickling solution is dirty, be sure to change the solution often in relation to the usage rate.

1.57.2.5. An alternative method of pickling involves placing the casting in a plastic bag filled with solution and then in an ultrasonic cleaner for about 10 minutes. This will remove remaining investment particles and lightly clean the casting of surface oxides.

Figure 1.63. Microblasting Process.

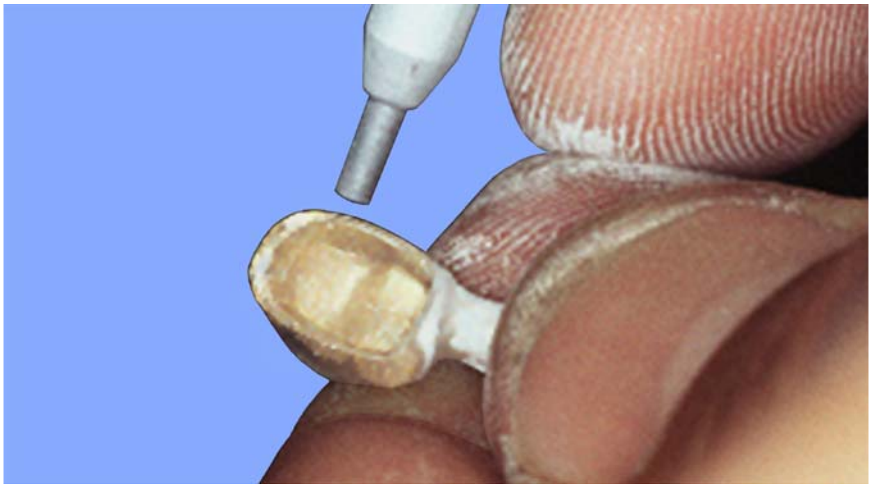


Figure 1.64. Pickling a Casting.

1.57.3. **Safety Hazards Associated With Pickling:**

1.57.3.1. Almost all pickling solutions are potentially dangerous. They burn skin, ruin clothes, and corrode equipment. Keep all pickling solutions in clearly labeled, plastic bottles with plastic caps.

1.57.3.2. When making an acid pickling solution, *ALWAYS* pour the acid into the water. *NEVER* pour the water into the acid because the chemical reaction is violent and the acid will splatter. The antidote for an acid burn is to apply baking soda to the affected area immediately after contact. In the absence of a specific chemical neutralizer for a pickling agent, the best course of action is to liberally flush the affected area with water.

1.57.3.3. One of the first rules of safety during the pickling procedure is to wear protective eyeglasses. Do not boil pickling agents; they tend to foam and splatter unexpectedly when boiled. A thermostatically controlled electric heater will eliminate this hazard. Leave the lid on the pickling dish as much as possible and work under a power exhaust hood because the vapors generated by a pickling solution are toxic.

1.58. Finishing and Polishing the Casting. The finishing of a casting consists of inspecting the casting for defects, removing the sprue, test-fitting the casting on the die, rough-finishing the casting's surface, checking the contact areas, adjusting the occlusion, and polishing (Figure 1.65-A through 1.65-L):

1.58.1. **Inspecting the Casting for Defects.** If possible, use magnification to check the casting's surfaces. The casting should be smooth, dense, and complete. There are two major kinds of defects to look for, positive and negative. Bubbles of metal or fins that protrude from a casting's surface are called *positive defects.* Porosity, holes, and incomplete castings are classified as *negative defects.* Holes can sometimes be soldered closed. Porosity and incomplete castings usually means starting over. Before a casting can be test-fitted on its die, free the internal surface of the casting of all positive defects. It is highly recommended that a microscope is used in this process. Remove nodules and fins with a round carbide bur of adequate size in relation to the defect. Never grind or polish a casting's internal surface.

1.58.2. **Removing the Sprue.** Remove sprues with a separating disk (Figure 1.65-A). Be careful to avoid cutting into the body of the casting or damaging the fine margins. Leave a little of the sprue on the casting to permit proper recontouring of the area.

1.58.3. **Test-Fitting the Casting on the Die.** Examine the internal surface of the casting for positive defects under microscopic view and eliminate any defects (Figure 1.65-B). After all internal surface positive defects have been removed, carefully place the casting on the die (Figure 1.65-C). There is serious potential for die damage when a casting is test fitted. If a casting does not fit, don't force it because the pattern cannot be remade if the die is damaged. The casting should seat completely without undue pressure. It should be stable on the die and the margin of the casting should conform perfectly to the margin of the die. If the casting does not seat, try to determine the cause and check for positive defects that might remain. If the casting is warped or otherwise distorted, reject it and start over. Once the casting is accurately seated on the die, go to the next step.

1.58.4. **Rough-Finishing the Casting's Surface:**

1.58.4.1. Finishing and polishing can be done rapidly and effectively only by well-organized use of progressively finer abrasive and polishing agents. Be careful not to damage the casting.

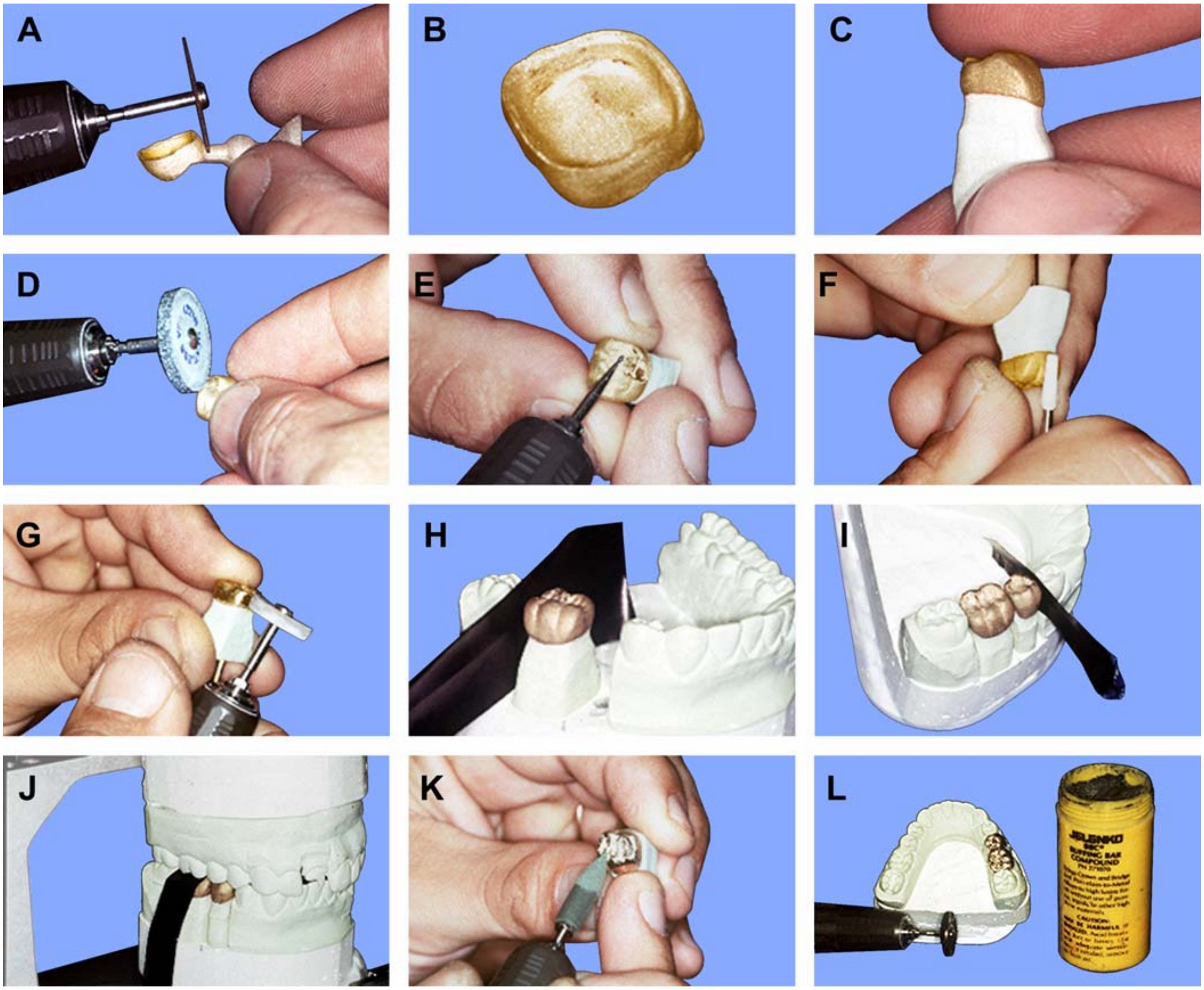
1.58.4.2. Shape the sprue stump into the general contour of the casting with a heatless stone (Figure 1.65-D) followed by a #203 stone.

1.58.4.3. Sharpen the occlusal anatomy by using a small, dulled round bur (Figure 1.65-E).

1.58.4.4. Go over the entire casting with fine stones (Figure 1.65-F) and rubber abrasive wheels (Figure 1.65-G) and points (in that order). Depending on the roughness of the casting, start with the finest abrasive that does the job. Smooth and contour all axial surfaces, from the tips of the cusps to within 1 mm of the margins. Be careful not to grind away proximal contours in contact areas. This could cause loss of contact with *adjacent* teeth and/or loss of contact with *opposing* teeth.

1.58.5. **Adjusting Proximal Contacts.** When a casting has mesial and distal proximal contacts, adjust them one at a time. At the time the working cast was made, the natural teeth adjacent to a preparation site were also made removable with dowel pins. Place the die in the working cast, remove one of the teeth next to the die, try to seat the casting on its die, and carefully remove contact excess with a rubber abrasive wheel. Use a piece of articulating film between the crown and adjacent teeth to disclose excessive contact areas (Figure 1.65-H). After the casting seats, follow the same procedure for the other contact. Finally, check the proximal contacts with both adjacent dies in place to ensure proper contact (Figure 1.65-I).

Figure 1.65. Finishing and Polishing a Casting for Try-In.



1.58.6. **Adjusting the Occlusion.** Place each working cast in position in the articulator. Seat the casting on the die. Restore the vertical dimension of occlusion first. Use articulating film to disclose high spots on the casting (Figure 1.65-J). Preserve the occlusal anatomy when grinding these spots. After restoring the vertical dimension of occlusion, check the casting's eccentric relations with opposing teeth. The casting should conform to the occlusion scheme chosen for the wax pattern (anterior guidance, group function, etc.). Maxillary stamp cusps should not contact between upper and lower teeth on the balancing side. Perform a final smoothing of the casting with rubber wheels and points (Figure 1.65-K). Remember to stay about 1 mm away from the margins.

1.58.7. **Polishing the Casting.** The materials used for final polishing are buffing bar compound (BBC), rouge, soft bristle brushes, and (sometimes) mandrel mounted felt wheels and a chamois. The BBC and rouge are polishing agents used together with an appropriate wheel or brush to shine a casting. BBC is the coarser of the two. Polishing starts with BBC on a soft bristle brush or felt wheel and continues with rouge on a soft bristle brush or felt wheel (Figure 1.65-L). An extremely high luster results when rouge is applied to a casting with a chamois wheel.

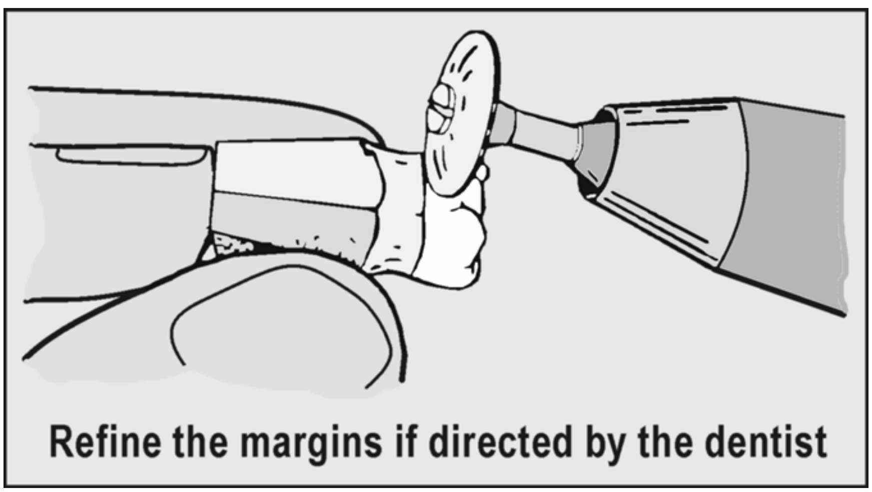
1.58.7.1. **Preliminary Polish.** The dentist will try the casting in the patient's mouth after the occlusion has been corrected in the articulator and will probabley modify the proximal contacts and adjust the occlusion. In effect, a casting is finished and polished twice—once before and once after the try-in. The casting's occlusal surface is the portion most likely to be modified. It makes sense to anticipate this and not carry polishing of the occlusal surface to completion before try-in. For a pre-try-in polish, high shine all axial surfaces and leave a satin finish on the occlusal. Some dentists prefer a matte-finished occlusal surface because it is easier to see interferences on a casting in the patient's mouth against a dull background than a shiny one. The matte finish is produced with a mini-sandblaster.

1.58.7.2. **Final Polish (Figure 1.66):**

1.58.7.2.1. Remove any gross scratches the dentist might have produced and give the casting its final polish. If the dentist did not finish the margins during try-in, the technician will do so now.

1.58.7.2.2. Some technicians finish the margins with the casting seated on the die; others prefer to finish them off the die. Neither method completely assures the margins will not be abraded, so use extreme care. WHEN FINISHING AND POLISHING MARGIN AREAS, ALL ROTARY INSTRUMENTS USED MUST REVOLVE PARALLEL TO THE MARGINS (Figure 1.66).

Figure 1.66. Final Polish.



1.58.7.2.3. If the casting is finished on the die, the die will probably be ruined. The dentist should be prepared to accept this.

1.58.7.2.4. Apply BBC and rouge to all external surfaces of the casting as the last steps in the polishing procedure. Clean off all polishing compounds with soap and water or by immersion in an ultrasonic cleaning device.

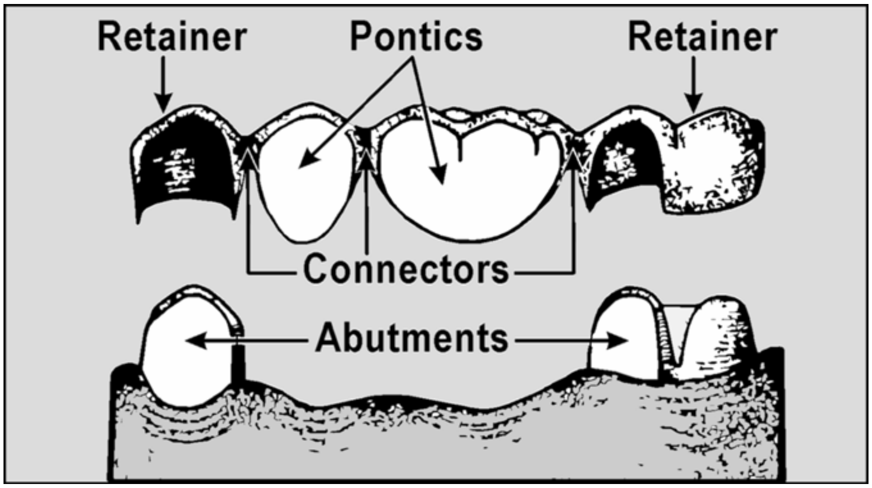
Section 1L—FPDs (Retainers, Pontics, and Connectors)

1.59. Overview:

1.59.1. An FPD is a replacement for missing natural teeth that is cemented to existing teeth in the patient's mouth. Once cemented, an FPD cannot be removed without a great deal of difficulty.

1.59.2. An FPD is composed of two kinds of units, *retainers and pontics*, and the unit castings are jointed together by *connectors* (Figure 1.67).

Figure 1.67. Parts of an FPD.



1.59.3. The dentist prepares (reduces the tooth structure) an adequate number of natural teeth adjacent to an edentulous space to provide enough support and retention for the FPD. The natural teeth the dentist prepares are *abutments.* Metal castings (onlays, complete crowns) are made to replace what the dentist reduces on the abutment teeth. These castings are *retainers.*

1.59.4. A *pontic* is an artificial tooth suspended from the retainer castings. A pontic occupies the space formerly occupied by a natural tooth and is attached to a retainer by a *connector.*

1.59.5. Connectors can be rigid or nonrigid. There are two types of rigid connectors—solder joints and cast joints (multiple wax patterns joined with wax at their proximal surfaces and cast as one piece). Nonrigid connectors take the form of key and keyway interlocking parts (patrix and matrix interlocking parts, respectively).

1.60. FPD Designs:

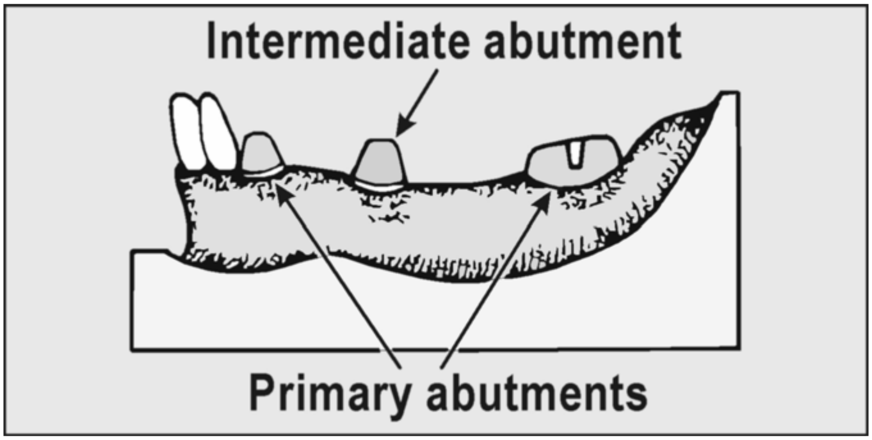
1.60.1. The typical FPD consists of one or more pontics rigidly suspended between two retainers, one on each side of the edentulous space. Normally, an abutment at both ends will support an FPD, but there are special situations where this requirement is waived. When a pontic is suspended from only one retainer, it is *cantilevered.*

1.60.2. The best example of a cantilever FPD involves replacement of the maxillary lateral incisor, when the adjacent central incisor and canine are still present. In some cases, the dentist chooses to preserve the central incisor and does not prepare it as an abutment. The prosthesis will then consist of a canine retainer and a lateral incisor pontic. The reasoning behind this compromise is that the maxillary canine is very strong and can bear chewing loads for itself and for a small, relatively nonfunctional lateral incisor pontic.

1.60.3. The dentist is obligated to prepare enough teeth to provide adequate support for an FPD, usually at least two. For long span FPDs (four units or more) or in cases where potential abutment teeth are somewhat mobile, the dentist might prepare more than two teeth as abutments. When a pontic is attached to two adjacent, jointed retainers, the prosthesis is said to have *double abutments.* It is possible to have double abutments on both ends of the prosthesis.

1.60.4. There are patterns of natural tooth loss where two edentulous spaces are separated by an intervening tooth, and at least one tooth remains distal to the posterior edentulous space (Figure 1.68). When an FPD is made to bridge the two edentulous spaces, the intervening tooth will be prepared as an abutment. On this kind of FPD, the most mesial and the most distal abutments are called *primary abutments and* the intervening tooth is called an *intermediate abutment or pier.*

Figure 1.68. Intermediate Abutment.



1.60.5. Rigid connection between all units of an FPD is recommended most of the time. However, a key to keyway, nonrigid connector, placed between one retainer and pontic, is an acceptable alteration in design for special situations.

1.60.6. For example, rigid connectors cannot be used between all units of a case where the dentist is unable to prepare the abutment teeth with a path of insertion common to all of the abutments. In another example, maxillary FPDs with canine intermediate abutments tend to break loose from their abutments when all of the connectors are rigid. (This kind of prosthesis "turns the corner" of the maxillary arch and the abutments are subjected to unusual stresses.) To "break" or reduce stress, a dentist might decide to prescribe a nonrigid connector distal to the canine.

1.61. Steps in FPD Construction. For steps in FPD construction, see Figure 1.69 and as follows:

1.61.1. Make working casts with removable dies.

1.61.2. Mount the casts and trim the dies.

1.61.3. Wax the retainer and pontic patterns.

1.61.4. Sprue, invest, and cast the patterns.

1.61.5. Seat the casting, desprue, and solder the FPD, if necessary.

1.61.6. Satin finish the castings and adjust the occlusion.

1.61.7. Veneer the castings with applications of porcelain or acrylic resin, if prescribed.

1.61.8. Polish the completed restoration.

1.62. Materials Used in Making FPDs. The units of an FPD may be made entirely from metal, a combination of metal and acrylic resin, or a combination of metal and porcelain. To satisfy esthetic requirements, use appropriate laboratory equipment to veneer retainers and pontics with porcelain fused to metal or with acrylic resin processed to metal.

1.63. Retainer Construction. The dentist determines the type of retainers needed and prepares abutment teeth accordingly. The most commonly used retainers are complete crowns, partial crowns, and onlays. Retainers, regardless of their finished composition, start out as wax patterns. The only exception is some all-ceramic systems that do not use the lost wax technique. Section 1I addresses construction of wax patterns for individual restorations. Use Section 1I to construct the retainers because the directions for retainer patterns are essentially the same as single unit construction. Basic patterns must be modified when retainers are programmed for acrylic resin or porcelain application. (See Chapter 2 of this volume for ceramic veneers and Chapter 5 of this volume for acrylic resin veneers.)

Figure 1.69. Fabricating a Posterior FPD.

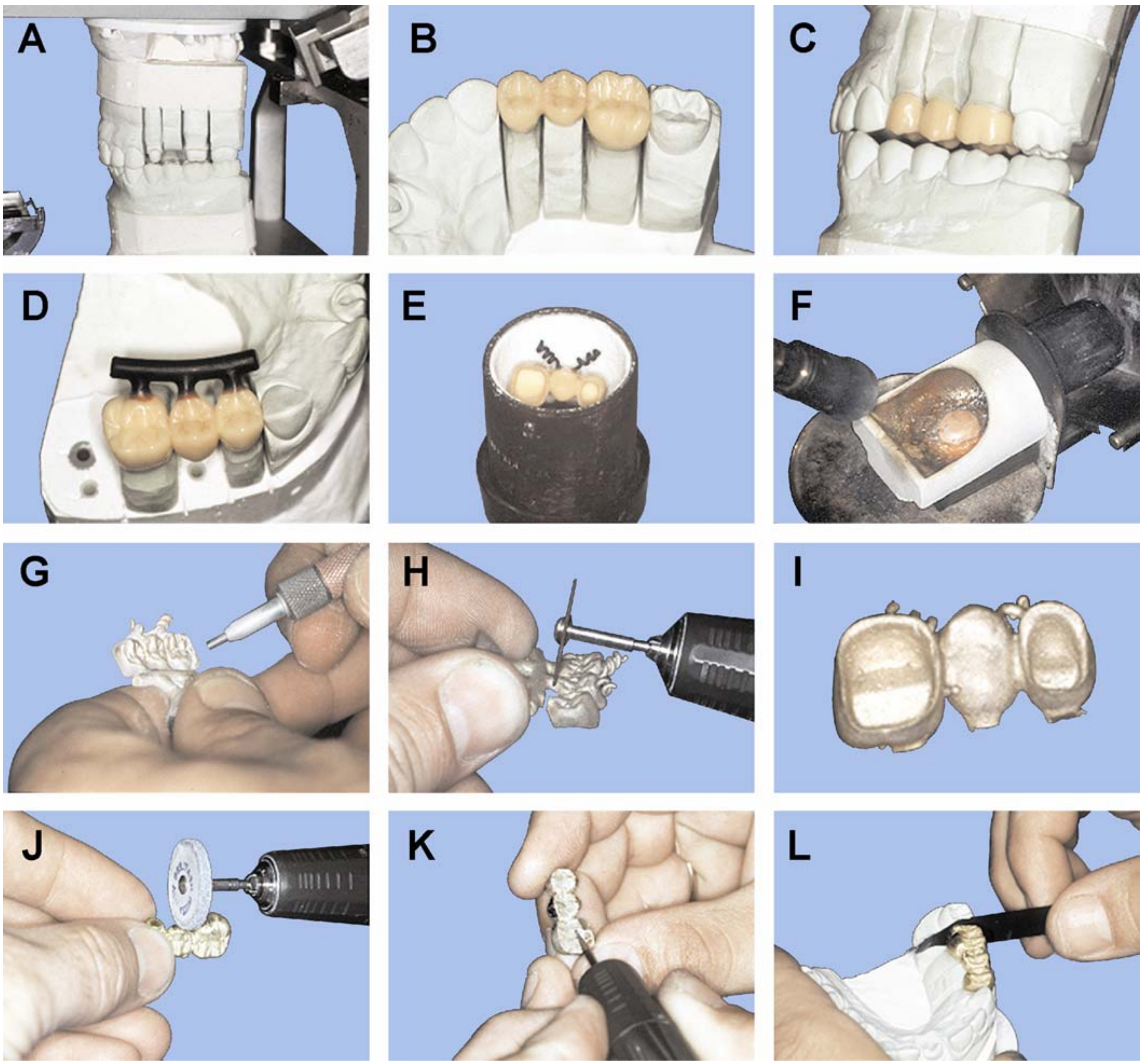
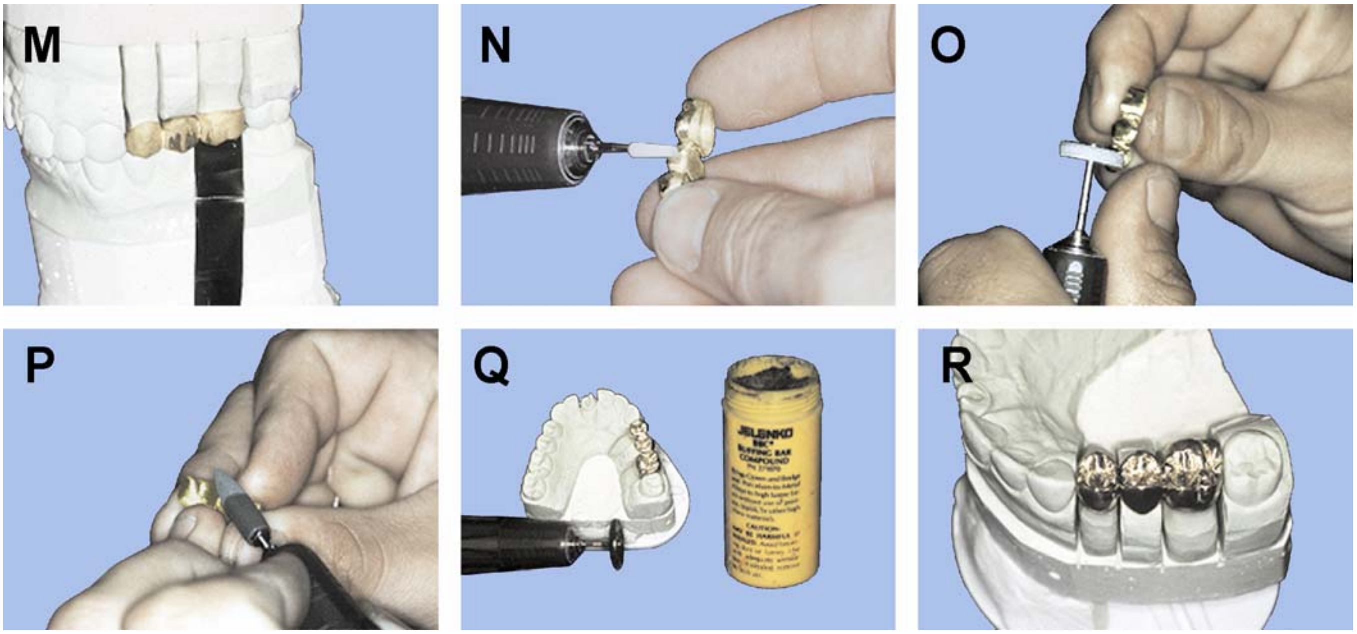


Figure 1.69. (Continued).



1.64. Pontic Designs. Although most of a typical pontic conforms to the shape of the tooth it is replacing, the linguogingival one-third to one-half has to deviate from a crown's natural shape for hygenic reasons. A pontic that duplicates a crown's natural shape exactly would lap over (saddle) the residual ridge from facial to lingual, and this kind of broad coverage is very unhealthy. It fosters food debris retention and gingival tissue inflammation. As much as possible, construct pontics with rounded contours, avoiding sharp angles, which are harder to floss and promote debris retention. The following three types of pontic design are generally used:

1.64.1. **Modified Ridgelap.** The style of gingival adaptation most universally used is the *modified ridgelap* (Figure 1.70). The modified ridgelap closely resembles the shape of a natural tooth from the facial view. It is the shape of choice for maxillary anterior, maxillary posterior, and mandibular anterior pontics. It is also used for mandibular posterior pontics when there is sufficient buccal sulcus depth. Contact with the residual ridge should extend no farther lingually than the crest of the ridge. (An ideal area of contact between a modified ridgelap pontic and the residual ridge is illustrated in Figure 1.71.)

Figure 1.70. Modified Ridgelap Pontic Forms.

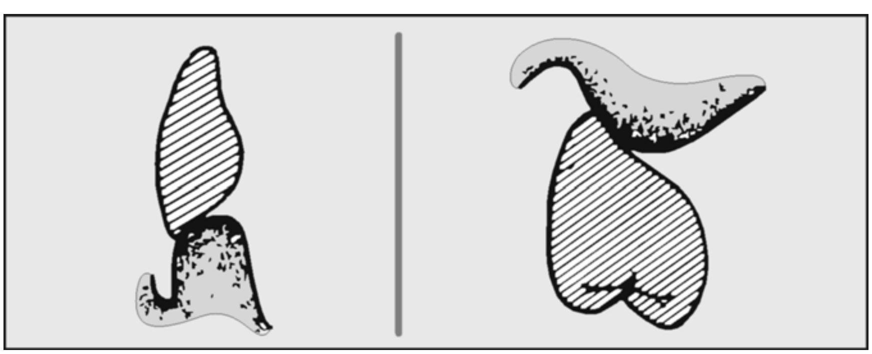
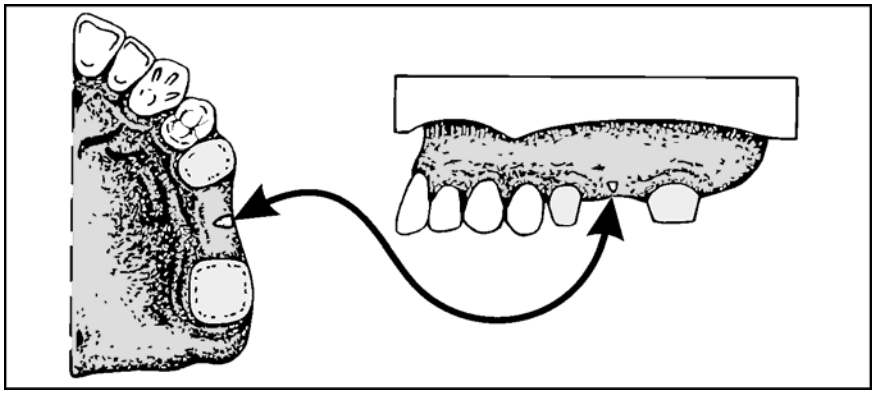
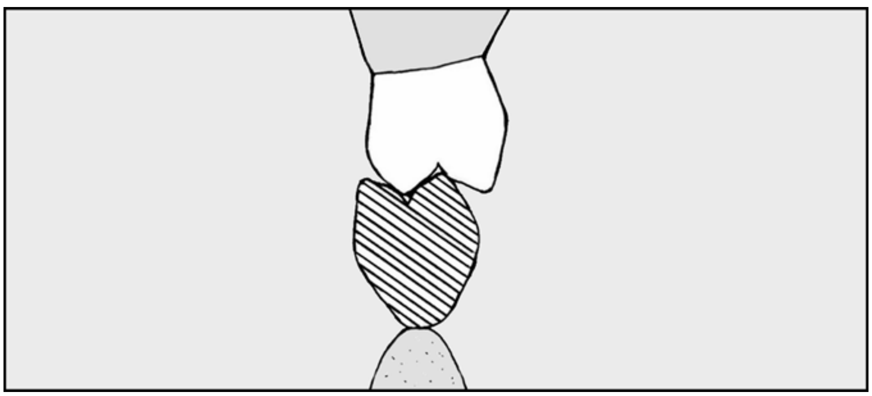


Figure 1.71. Modified Ridgelap Pontic Gingival Contact Area.



1.64.2. **Conical (Figure 1.72).** If ridge resorption is slight to moderate and the buccal sulcus is shallow, the conical pontic is substituted for the modified ridgelap form. The concern is that a pontic with a facial lap might impinge on an active, shallow sulcus. The gingival half of the conical pontic is formed into an "egg" shape, both mesiodistally and buccolingually with a ridge contact area localized to a small spot on the crest of the ridge.

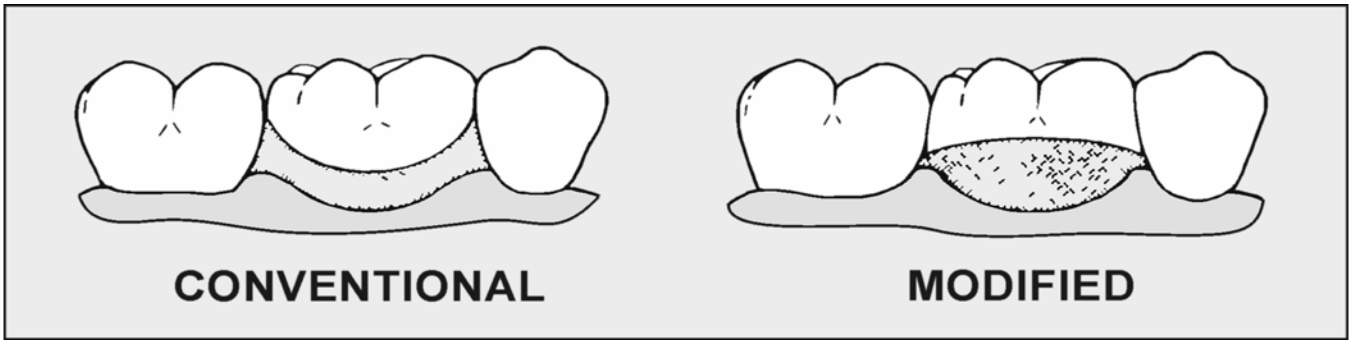
Figure 1.72. Conical Pontic Design.



1.64.3. **Hygienic (Figure 1.73).** When ridge resorption is very far advanced the hygienic pontic is used. The hygienic pontic has no contact with the ridge and is suspended a minimum of 2 mm (and not more than 4 mm) over the crest of the ridge. An alternative design of the hygienic pontic also appears in Figure 1.73 and is called the archway (modified) pontic. Proponents claim that because of this pontic's shape, it is easier to clean and has more strength in the connector areas.

1.65. Pontic Construction (Figure 1.69). As a general guideline, first fabricate the pontic's full axial and gingival contours in wax. Rigid (wax) connector areas may be formed at this time. (Connectors are discussed in depth in paragraph 1.68). Next, wax the occlusal surface and establish occlusal contacts. If the dentist prescribes a veneered surface, modify the pattern for the veneered surface at this time. (See Chapter 2 of this volume for ceramic veneers and Chapter 5 of this volume for acrylic resin veneers.) Use one of several pontic designs discussed in paragraph 1.64 while fabricating an FPD.

Figure 1.73. Hygienic Pontic Design.



1.65.1. **Overview.** The facial and lingual shape of a pontic should imitate the corresponding contours of the natural tooth it is replacing as much as possible. The long axis alignment and faciolingual position of the pontic should fall within limits that are normal for the crown of a natural tooth. Besides looking good in the patient's mouth, a well formed pontic positioned to harmonize with adjacent natural teeth will help maintain gingival health by shunting food properly.

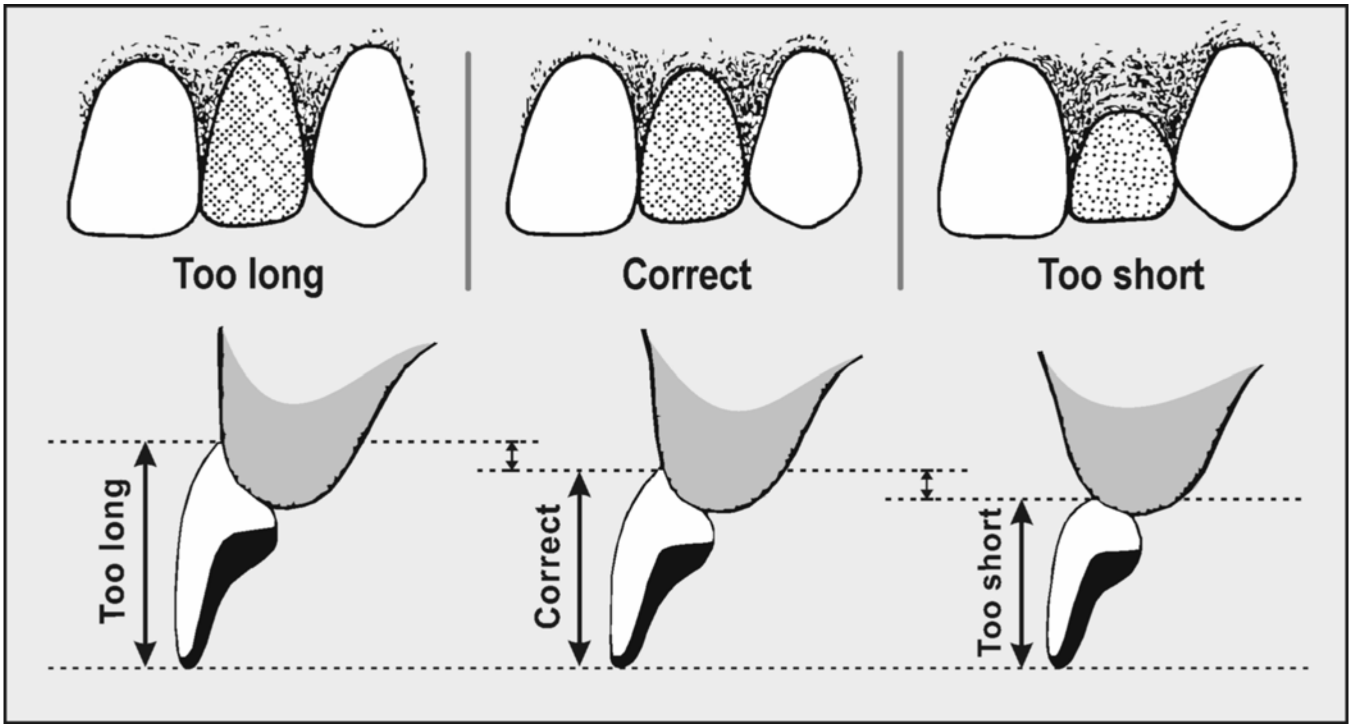
1.65.2. **Facial Surface (Figure 1.74):**

1.65.2.1. One of the more important considerations affecting a pontic's appearance is its facial surface length. Pontics that are too long or too short do not blend well with natural dentition. It is not enough to make a pontic just as long as the natural tooth it is replacing. For an observer to get an acceptable visual impression of facial surface length, the pontic's cervical line as well as the facio-occlusal or incisal edge will have to fall in the right places relative to adjacent teeth.

1.65.2.2. There are two methods of developing an acceptable visual impression of a pontic's cervical position as ridge resorption increases. One is to make the gingival half of a facial surface more convex than usual. The other is to deviate from the normal long axis alignment by depressing the neck of the pontic. Frequently, both of these methods are used at the same time. When ridge resorption is slight to moderate, depend more on depressing the neck than changing gingivofacial convexity to achieve the desired cervical line effect. If a ridge is substantially resorbed, there is little choice but to do both. Given that resorption is far advanced, a conventional FPD may not be indicated.

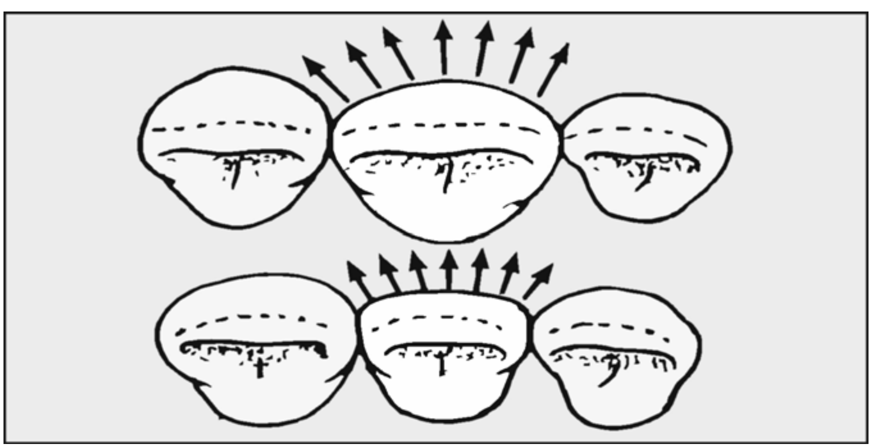
1.65.2.3. When possible, working and protrusive movement contacts should be borne by the natural teeth, not a pontic. This is one control over a pontic's facio-occlusal or facio-incisal length. Another control is how the facial edge lines up with the remaining teeth. Extend the facial cusp ridges of a posterior pontic or the incisal edge of an anterior pontic as far as these controls allow. Many frustrating situations will arise where a pontic's facio-occlusal or incisal edge is oriented at just the right level to look good in a patient's mouth, but the pontic's vertical overlap causes it to have contacts in working and protrusive excursions. Decreasing the vertical overlap or increasing horizontal overlap will reduce or eliminate the force of the excursive contacts, but it also compromises the pontic's appearance. It is up to the dentist to give specific advice in these cases.

Figure 1.74. Positioning the Cervical Line of an Anterior Pontic.



1.65.2.4. A pontic's facial surface convexity as viewed from mesial to distal affects its appearance significantly (Figure 1.75). When the mesiodistal width of an edentulous space is greater than the tooth extracted from the spot, the facial aspect of an oversized pontic is shaped to produce a mesiodistally convex surface that scatters reflected light rays and gives the illusion of being a narrower pontic than it is. When teeth adjacent to a space have drifted to make the space narrower than the natural tooth was, the facial surface of the pontic is flattened to reflect more light straight back into the viewer's eyes and create an illusion of a wider pontic.

Figure 1.75. Mesiodistal Convexity.



1.65.3. **Lingual Surface:**

1.65.3.1. **Anterior Pontics.** An anterior pontic's lingual contours, down to the junction between its middle and gingival thirds, should more or less imitate adjacent natural teeth. As a general rule, anterior pontics do not have working and protrusive contacts; it is better that natural teeth bear such loading. This means vertical and horizontal overlap must be controlled, often to the detriment of the pontic's appearance. The lingual height of contour is roughly located at the junction of the pontic's gingival and middle thirds. The lingual surface below the height of contour tapers in toward the crest of the ridge where initial contact with the ridge is made.

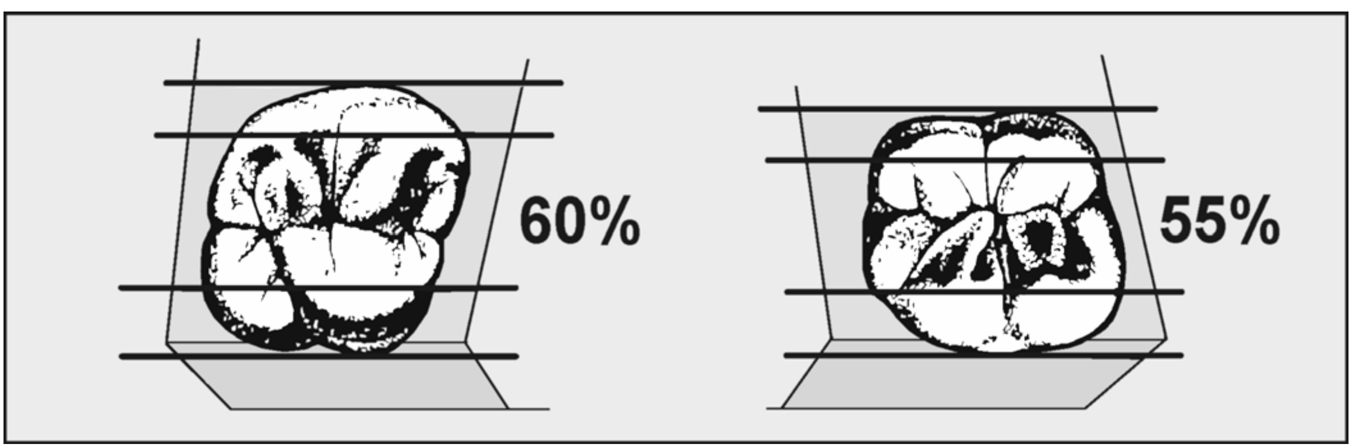
1.65.3.2. **Posterior Pontics.** The shape of the occlusal half of a posterior pontic's lingual surface should conform to accepted food-shunting standards for retainers. The height of contour is located at the junction between the pontic's occlusal and gingival halves. The lingual surface below the height of contour tapers in toward the crest of the ridge where initial contact with the ridge is made.

1.65.4. **Proximal Surfaces.** Mesiodistally, a pontic is constructed to fill the edentulous space. However, embrasures between pontic and retainer units of an FPD should be sufficiently open to allow effective cleaning. If the embrasures are too open, they become obvious to the casual observer and represent gross food traps.

1.66. Pontic Occlusion. Pontics must function or occlude against opposing teeth according to the same rules as individual cast restorations with one significant exception—pontics should clear opposing teeth in working and protrusive excursions no matter what kind of occlusion scheme is involved. The limit of acceptability in this regard is *light contact.* An extension of this principle is that no pontic should bear the burden of anterior guidance. To the extent possible, working and protrusive excursion contacts should be borne by well supported natural teeth. When not possible, consult the dentist.

1.67. Pontic Occlusal Surface Area. The occlusal surface area of pontics should be the same as or slightly narrower than the adjacent teeth. (Pontics should not be arbitrarily narrowed by a set percentage as was taught in the past.) A narrowed occlusal surface is sometimes compared to a malposed tooth that cannot shunt food properly. It is considered a poor practice, which results in soft tissue damage in the edentulous space. One method of checking the facial-lingual width is to measure the corresponding natural teeth using a Boley gauge. Remember, the occlusal table width (buccal cusp tip to lingual cusp tip) represents just a fraction of the total buccal-lingual width of teeth (Figure 1.76). The mistake made most often is to unknowingly widen the occlusal table by placing the cusps too far apart.

Figure 1.76. Occlusal Table Width Compared to Overall Buccal-Lingual Width.

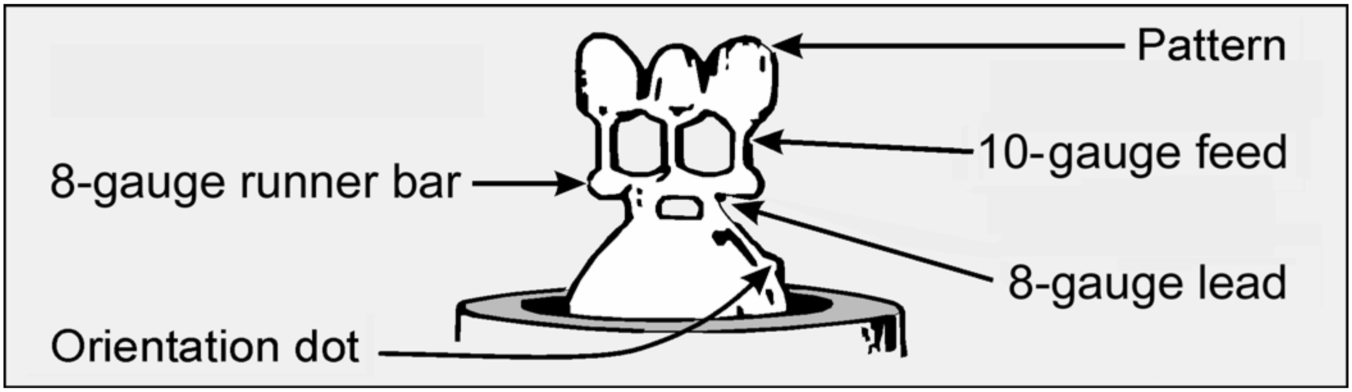


1.68. FPD Connectors. The various means used to join fixed prosthodontic units are single-piece casting, nonrigid (stress breaker) connectors, and soldering, as follows:

1.68.1. **Single-Piece Casting (Figure 1.77):**

1.68.1.1. One way to fabricate an FPD is to connect all units during the wax-up and cast it into a single piece. This method is widely used, but requires the technician to pay close attention to the fit of the wax-up on the stone dies prior to spruing and casting in order to achieve a solid fit (no rocking) of the casting.

Figure 1.77. Single-Piece Casting of an FPD.



1.68.1.2. A single-piece die (see Figure 1.19) is very useful in achieving a solid fit of the casting. A good guideline is to cast in two pieces and solder any FPD larger than three units. The accuracy of the casting declines as the number of units increases. As an example, a five-unit FPD can be cast as separate two and three-unit segments and later joined by soldering. Note that the choice of materials for preparing multiple unit patterns can vary.

1.68.1.3. Wax patterns made by conventional techniques with regular inlay wax work well. Patterns that are a combination of resin and wax are equally acceptable. When the patterns for individual units have been satisfactorily positioned on a working cast, join them together with a drop of inlay wax to form a multiple unit pattern. Contact areas are generally egg-shaped, with the long axis of the "egg" being oriented buccolingually.

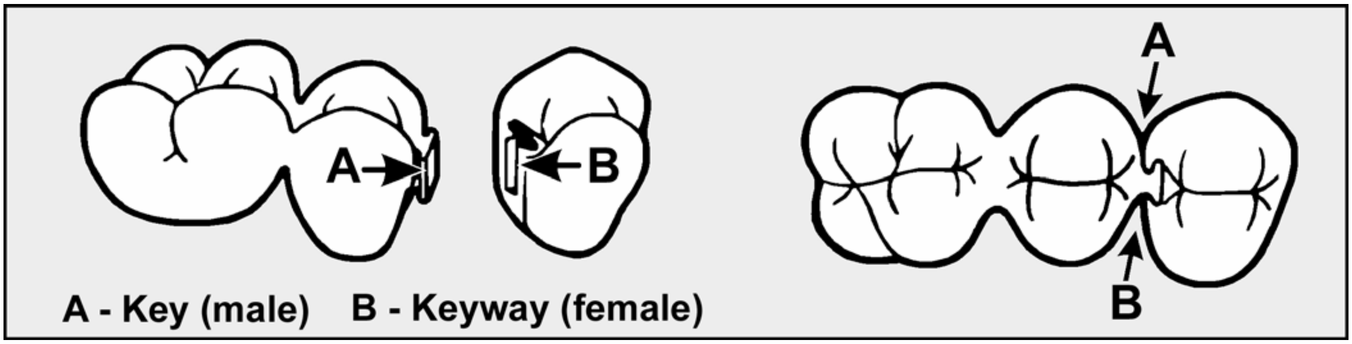
1.68.1.4. Occlusogingivally, the contact area is located at the junction of the occlusal and middle thirds of a proximal surface. Buccolingually, the contact area can be found at the junction of the buccal and middle thirds of a posterior tooth's proximal surface; except between the maxillary molars, where it is located near the occlusal mesial/distal developmental groove area (Figure 1.41). The minimum width of a connector is 2 mm and the minimum depth is 2.5 mm. Use extreme care when working with the wax patterns to minimize distortion.

1.68.2. **Semiprecision (Stress Breaker) Attachment:**

1.68.2.1. A *stress breaker* is a mechanical type of connector that depends on the dovetail retention principle to unite FPD units (Figure 1.78). It consists of two interlocking parts, a *key* (or male) element and a *keyway* (or female) portion.

1.68.2.2. When used, the stress breaker connector usually joins the distal proximal surface of the anterior retainer to the mesial proximal surface of the adjacent pontic. The pontic carries the key, and the retainer houses the keyway. As far as relative dimensions are concerned, a keyway should be at least twice as deep, occlusogingivally as it is wide buccolingually. The key portion of a stress breaker connector is not ordinarily made to fit the keyway with absolute precision. *Limited* buccolingual movement between the connector parts is desirable.

Figure 1.78. Semiprecision Attachment.



1.68.2.3. One of the major advantages of a broken stress connector is that an FPD can be made for a case where the abutment preparations are not parallel to each other or when an FPD includes a pier abutment. A serious disadvantage is that its use is restricted to short span segments replacing only one tooth.

1.68.2.4. Semiprecision attachments are commercially available in various sizes. An adequate stress breaker connector can be made from materials found in most dental facilities. The following paragraphs described two types of attachments:

1.68.2.4.1. **Commercial Attachment (Ney Mini-Rest).** The Ney mini-rest has a slightly tapered, dovetail design. To help position this attachment, a surveyor mandrel is molded as an integral part of the key portion. The key and keyway parts are made of acrylic resin and are completely eliminated during burnout. Procedures for making FPDs with a Ney Mini-Rest are in Figure 1.78 and as follows:

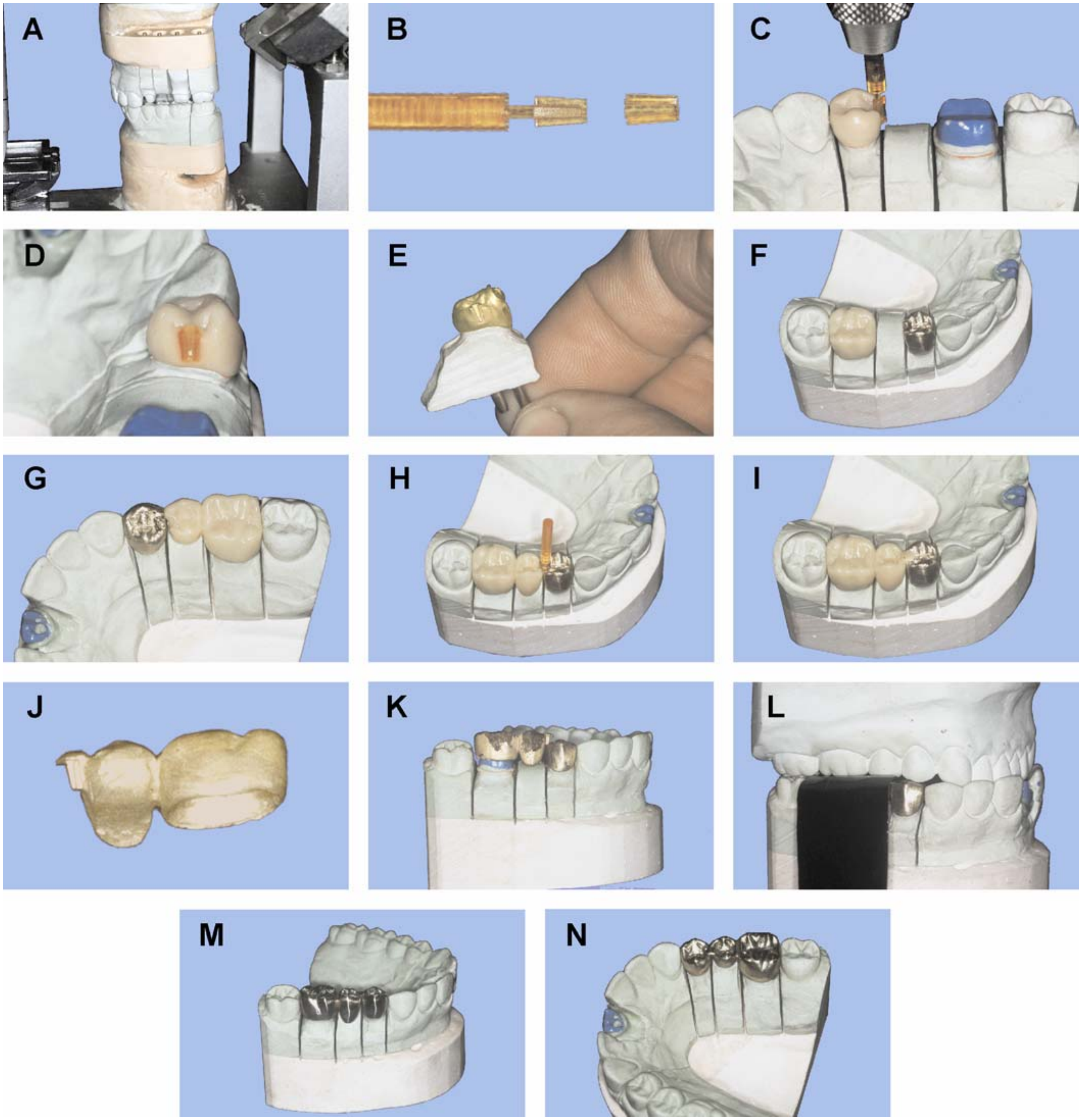
1.68.2.4.1.1. Mount the casts (Figure 1.79-A). Seat the key (male) portion of the attachment in the keyway (female) part (Figure 1.79-B). Determine the position of the mini-rest by placing the mandrel (on the key portion) in a surveyor and relating the attachment to the dies on the working cast. Although the keyway part of the attachment will probably be placed in the FPD's anterior retainer, the key's path of insertion into the keyway has to line up with the long axis or the distal abutment preparation. Mount the working cast on a surveying table and establish the attachment's best orientation to the distal abutment die. Lock the survey table at the selected tilt (Figure 1.79-C).

1.68.2.4.1.2. Complete the wax patterns and carve a recess in the pattern destined to receive the keyway. While mounted on a surveyor, move the attachment into this recess and seal the keyway portion in position (Figure 1.79-D). Remove the mandrel-mounted key from the keyway and take the mandrel out of the surveyor's spindle. The surveyor is no longer needed.

1.68.2.4.1.3. Cast the pattern that contains the keyway portion of the attachment. Satin finish the casting's exterior surfaces and test fit it on the die (Figure 1.79-E). Adjust the proximal contact if necessary. Be certain the casting is fully seated on the die in the working cast (Figure 1.79-F).

1.68.2.4.1.4. Wax the pontic and distal retainer (Figure 1.79-G). Carve enough wax away from the proximal surface of the adjacent pontic to accommodate the key part of the attachment. Align the pontic on the working cast in proper relation to the edentulous ridge and opposing teeth. Seat the key portion of the attachment in the keyway and join the key to the pontic pattern (Figure 1.79-H). Cut the mandrel off the key with a hot spatula (Figure 1.79-I) and sprue the patterns. Sprue and cast the distal retainer, pontic, and key in one piece (Figure 1.79-J).

Figure 1.79. Fabricating an FPD With a Semiprecision Attachment.

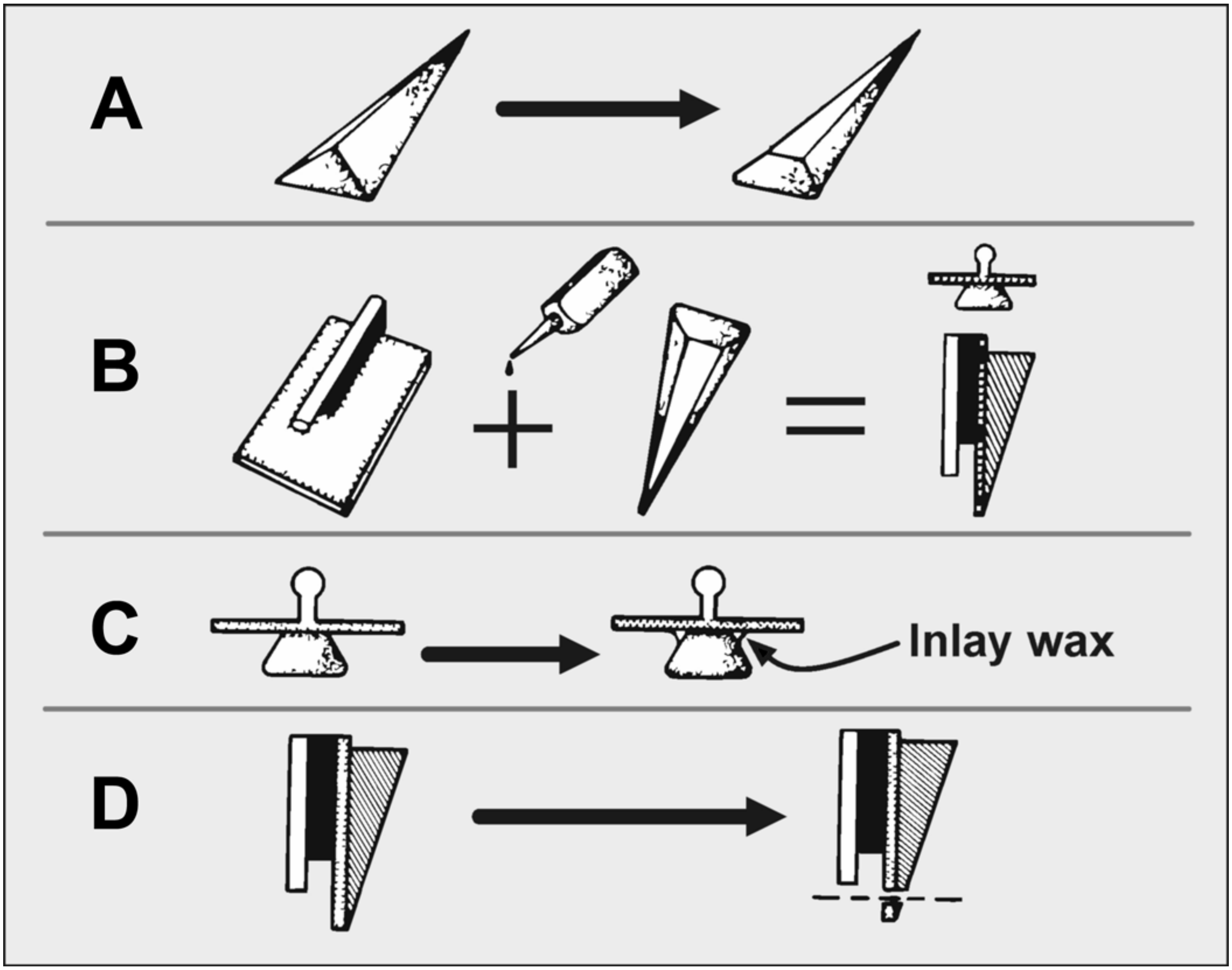


1.68.2.4.1.5. Finish, adjust, and polish the castings (Figure 1.79-K through -N). The mini-rest does not provide for unlimited movement between segments of the FPD, but it does allow normal tooth movement.

1.68.2.4.2. **Technician-Fabricated Key and Keyway (Figure 1.80):**

1.68.2.4.2.1. Flatten off one long edge of a wooden or plastic dental matrix wedge and round the other two long edges slightly (Figure 1.80-A). Use cyanoacrylate glue to attach the flattened edge of the wedge to the smooth side of a plastic backing (Figure 1.80-B). Round off the junction between the wedge and the backing by applying a minimal amount of molten inlay wax to the two lines of union (Figure 1.80-C). Trim the backing and the pointed end of the wedge to provide a definite seat for the key in the keyway (Figure 1.80-D).

Figure 1.80. Technician-Fabricated Key and Keyway.



1.68.2.4.2.2. Make a rubber impression of the backing and wedge side of the assembly. Using the sprinkle-on technique, fill the impression with acrylic resin to form a plastic pattern. Many such patterns can readily be made from the same impression. Grinding can easily modify the resultant keys if necessary. Use large patterns for molars and small patterns for premolars and anterior teeth.

1.68.2.4.2.3. Use sticky wax to mount the plastic pattern of the key on an analyzing rod. The long axis of the pattern should parallel the rod. Place the working cast on a surveying table and determine the best orientation of the dies to the key as previously described for the Ney mini-rest. Lock the table at the selected tilt.

1.68.2.4.2.4. Now that all patterns are completed, cut a recess into the retainer pattern destined to contain the keyway. The recess should be large enough to accommodate the plastic pattern of the key.

1.68.2.4.2.5. Lubricate the key. Place the working cast on the surveying table and position the key in the retainer pattern's recess. Flow melted inlay wax over the resin key and incorporate it into the contour of the retainer. Complete the key from the wax. Invest, cast, and finish the retainer, taking particular care to preserve the accuracy of the keyway.

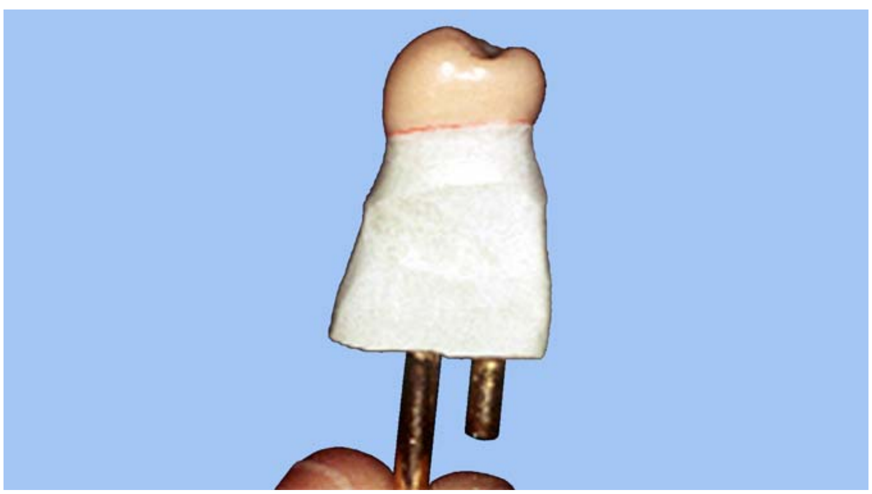
1.68.2.4.2.6. Position the finished retainer on the die and replace the plastic pattern in the keyway. Make wax patterns for a one-piece casting of the posterior retainer and pontic, incorporating the key pattern into the pontic pattern. Sprue, invest, and complete the one-piece casting.

1.68.2.4.2.7. Finish, adjust, veneer, and polish the FPD.

1.68.3. **Solder Connectors.** A two-piece casting can also be used to construct an FPD. When using a solder connector, first completely wax the retainers and pontic in one piece as previously described in paragraphs 1.63 and 1.65. Cut through the connector area to be soldered, using a wax saw or suture silk. The pontic should remain attached to the smaller retainer. The wax-up is now ready to be completed and cast. After casting, the FPD can be soldered. Procedures for the soldering process are detailed in paragraph 1.75.

1.69. Completing the Wax-Up. Figure 1.81 and the following procedures apply to this process:

Figure 1.81. Refine the Margins and Smooth the Wax Patterns.



1.69.1. Refine the margins. When carving the junction between the wax and the stone die back to where the preparation begins, use blunt carvers instead of sharp instruments. Blunt carvers will produce a clean, well-defined margin without marring the die's surface. ***NOTE:*** If the wax pattern margins are grossly distorted, remove the pattern and carefully cut it back 2 mm off the margin. Apply a fresh coat of die lubricate to the die and reseat the pattern. Quickly flow molten wax into the space created to cover the margin and provide a smooth internal adaptation.

1.69.2. Smooth and polish the patterns. Use the soft bristle brush to get at occlusal surface irregularities. Use a piece of silk or nylon cloth wrapped around the end of a finger to smooth axial surfaces.

1.70. Spruing:

1.70.1. Attach a 10-gauge wax sprue former (pattern sprue) to each unit as if it were an individual pattern (Figure 1.82). Reduce the sprue formers to a uniform height of 4 to 6 mm from the patterns. Place an 8-gauge wax rod (runner bar) over them and seal them with molten wax. Depending on the number of units being cast, attach two or three 8- to 10-gauge wax sprue formers (lead sprues) opposite the pattern sprue formers on the runner bar.

Figure 1.82. Spruing an FPD.

1.70.2. The lead and pattern sprue formers should be on the same plane, but not in direct line with one another. Cut off the lead sprue formers to a length that will position the patterns outside the thermal zone. Normally, this position places the pattern 6 mm from the end of the casting ring. Be sure to leave at least 6 mm of investment covering the pattern for strength.

1.70.3. Remove the sprued wax pattern from the working cast by carefully withdrawing it parallel to the long axes of the dies. Attach the lead sprue formers to the sprue base at a common point of attachment. Use the wax orientation dot method to record the position of the pattern in the ring (paragraph 1.52.4.5). Indirect spruing is described in detail in paragraph 1.52.4.3.

1.71. Investing. Invest the pattern according to an acceptable method of choice. (See Figure 1.57 and paragraph 1.54.4.)

1.72. Burnout. Follow burnout procedures described in paragraph 1.55.

1.73. Casting. Use the reference dot on the investment's crucible surface to precisely position the ring in the casting machine. If a horizontal casting machine is used, orient the pattern vertically with the pattern's thin areas trailing while the machine is spinning. For additional guidance on casting see paragraph 1.56.

1.74. Finishing the FPD. Finishing an FPD is essentially the same as finishing a single unit (Figure 1.65). Additional care must be taken not to reduce the size of the connectors. A detailed description of the finishing process is given in paragraph 1.58.

1.75. Soldering. Soldering consists of applying heat to pieces of metal that are next to each other, flowing a lower fusing metal (solder) on to the surfaces of the adjoining pieces, and filling the intervening space at the same time. After the solder cools, the metal pieces are rigidly connected.

1.75.1. **Requirements of a Solder Connector:**

1.75.1.1. A solder joint has to be free of oxide and voids for maximum strength. Dental gold alloys contain base metals, particularly copper, that readily oxidize in the presence of oxygen. Satisfactory union between units will not take place unless the surfaces to be soldered are free from debris and oxide. Besides mechanical cleaning of the parts to be joined, a good soldering flux is essential.

1.75.1.2. The physiologic and mechanical success of the soldered connection also depends on the design or shape of the connection. The solder joint must be centered on the proximal contact area, triangular in shape with rounded corners, and have concave peripheral borders (Figure 1.83). The gingivo-occlusal or incisal length of the connection is critical. The soldered area must not encroach on the interdental tissue or allow a food pocket to be created (Figure 1.84). The joint has to be wide enough, faciolingually, for strength, but not so wide as to be visible and unsightly (Figure 1.83).

1.75.1.3. A solder joint has to unite the units of an FPD or splint precisely.

Figure 1.83. Solder Joint Between Two Posterior Castings (Proximal View).

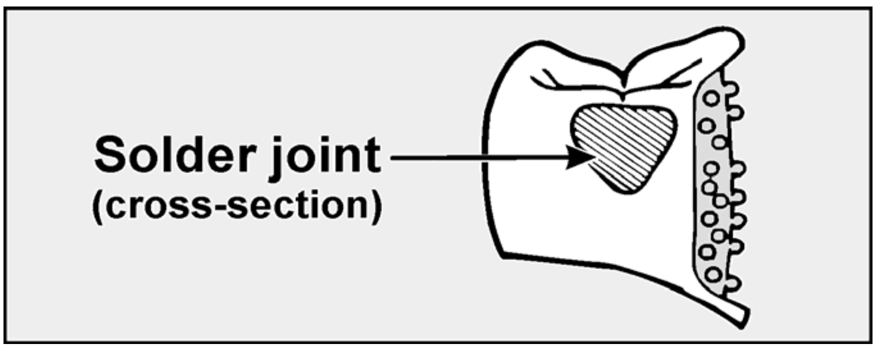
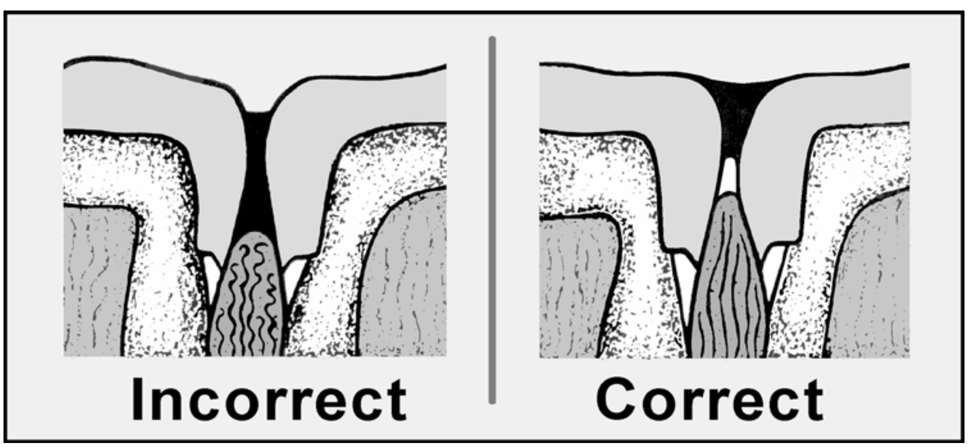


Figure 1.84. Solder Joint Between Two Posterior Castings (Buccal View).



1.75.2. **Procedures Associated With Soldering Type III Golds:** (***NOTE:*** Procedures for soldering porcelain fused to metal systems are in Chapter 2 of this volume.)

1.75.2.1. **Aligning the Units on the Working Cast and Evaluating the Width of the Solder Gaps (Figure 1.85):**

1.75.2.1.1. Remove all oxide from the proximal surfaces to be joined with a rubber wheel. Do not polish the surfaces. The solder bond is stronger on a satin finish.

Figure 1.85. Testing the Width of the Solder Gap.

1.75.2.1.2. Place the retainers and pontics on the cast. Seat the retainers on the dies as solidly as possible.

1.75.2.1.3. When assembling the FPD or fixed splint on the cast before soldering, the proper width of the solder gap between units is a very important consideration. Factors that affect the width of the solder gap are the setting expansion of the soldering investment, the thermal expansion of the investment, and the thermal expansion of the metal units.

1.75.2.1.4. The setting and thermal expansions of the soldering investment tend to increase the solder gap over what has been established on the cast. On the other hand, thermal expansions of the gold parts tend to close the gap. When the investment and metal units are heated, the overall effect is to close the solder gap. The width of the solder gap at its closest point should be about 0.15 to 0.30 mm (0.005 to 0.010 inch). This distance, represented by two to three thicknesses of letter paper, may be judged by slipping letter paper through the gap while the units are assembled on the cast.

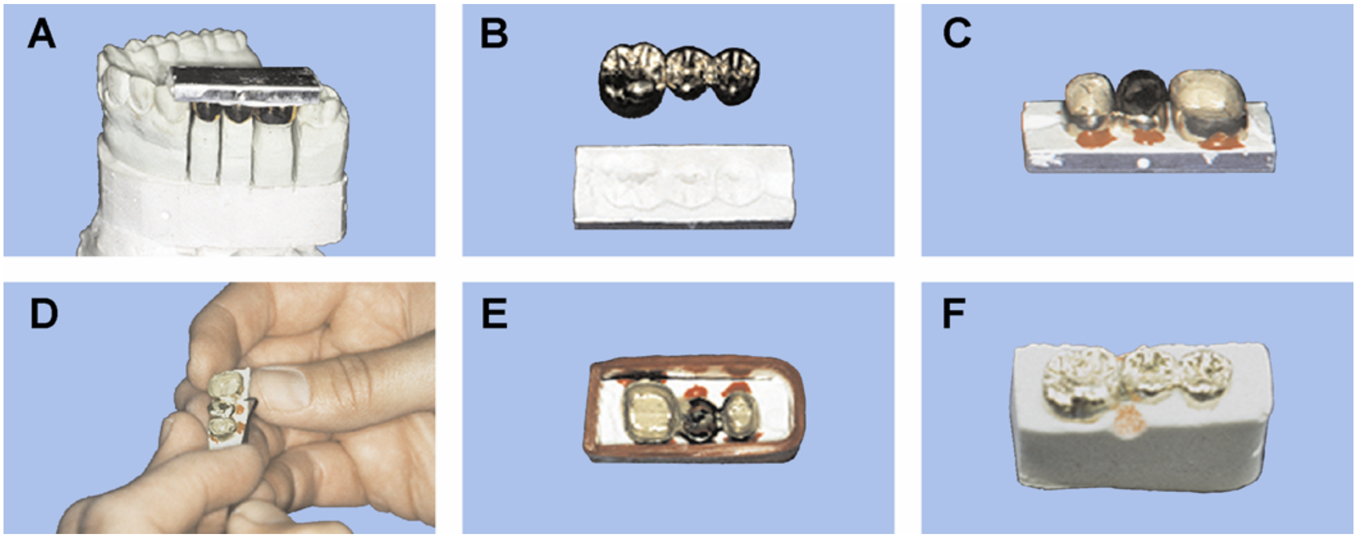
1.75.2.1.5. If the gap is too small, metal-to-metal contact of the units might occur during heating. Such contact could cause shifting of the units, warping of the metal, and possibly cracking of the investment. On the other hand, if the gap is too wide, the solder joint will be porous and the likelihood for distortion will be greater.

1.75.2.2. **Relating Units to Each Other and Investing the Assembly.** Units can be related to each other for soldering in either of two ways, the stone index method or the resin method, as follows:

1.75.2.2.1. **Stone Index Method (Figure 1.86).** The purpose of a stone index is to hold the castings in position while the solder investment is being poured:

1.75.2.2.1.1. First, paint a separating medium for dental stone onto the surfaces of the teeth adjacent to the fixed prosthesis. To form an index for a posterior FPD or splint, fill a segment of a used metal denture tooth card with low-expansion stone and place it over the occlusal surfaces of the castings (Figure 1.86-A). Include about half a stone tooth on each side of the prosthesis. The section of denture tooth card acts as a tray. Make a soldering index for an anterior FPD or splint on the lingual aspect of the arch. Cut and bend the denture tooth card to conform to the curvature or make a carrier out of baseplate wax.

Figure 1.86. Stone Index Method of Fabricating a Solder Investment Patty.



1.75.2.2.1.2. After the stone has set, remove the index. The index should include the cusp tips of posterior castings or the entire lingual surfaces of anteriors. Anything more is unnecessary and should be trimmed away. Trim the index to 3 mm (1/8 inch) around the perimeter of the castings (Figure 1.86-B).

1.75.2.2.1.3. Remove the retainer castings from their dies. Reposition the castings in the index. Lute the castings in position by applying sticky wax (Figure 1.86-C). Do not use sticky wax in the joint areas because the wax contraction during cooling might make the castings move out of position.

1.75.2.2.1.4. Fill the embrasures in the joint areas with inlay wax. Carve the precise shapes of the solder connectors into the wax. This prevents solder investment from entering the solder joint gap (Figure 1.86-D).

1.75.2.2.1.5. Paint the exposed stone surfaces of the index with a separating medium.

1.75.2.2.1.6. Wrap a 15 to 20 mm wide strip of boxing wax around the index to form the solder investment patty (Figure 1.86-E).

1.75.2.2.1.7. Mix the solder investment according to the manufacturer's instructions and paint it onto and around the castings with a soft brush. Fill the boxed index with investment material.

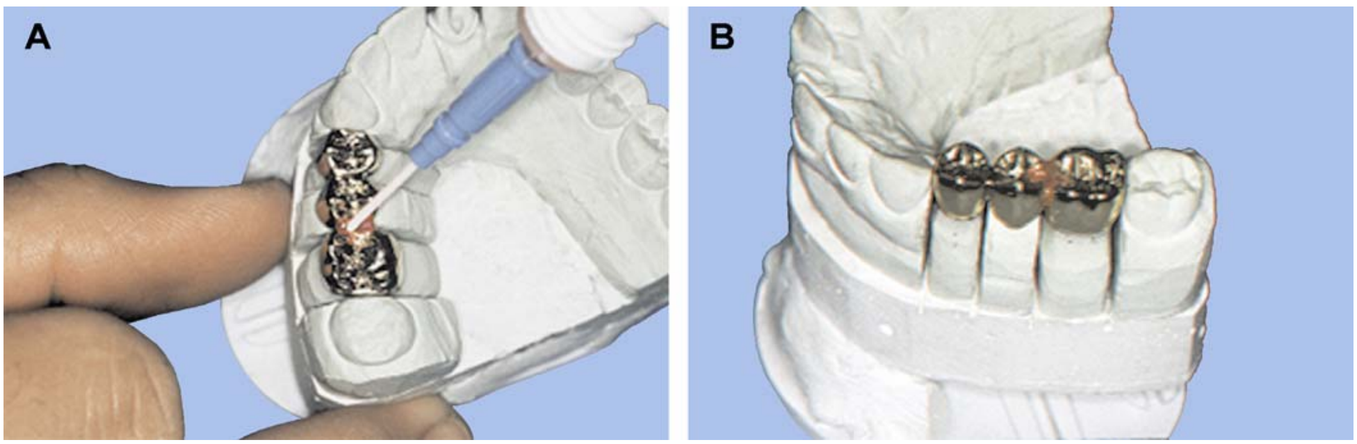
1.75.2.2.1.8. When the investment has set, separate the assembly from the index by immersing the assembly in boiling water, melting the sticky wax. Trim the investment to 15 to 20 mm thick and 3 mm (1/8 inch) around the perimeter.

1.75.2.2.1.9. Thoroughly flush away all wax residues from the investment with boiling water. Cut V-shaped channels leading from the edge of the investment to the metal parts to be soldered (Figure 1.86-F). These channels give the soldering flame access to the joint. Ensure no loose investment particles remain in the spaces between the units.

1.75.2.2.1.10. While the assembly is still warm from boiling, use an explorer dipped in flux to place a small amount of soldering flux onto the metal areas to be joined. (***CAUTION:*** An excess of flux will cause pits and weaken solder joints.) The flow of solder has to be controlled. It cannot be allowed to ruin margins or run onto carved occlusal surfaces. Areas on which solder is not wanted may be covered with an antiflux, applied after the soldering flux application. A good antiflux is made by moistening rouge with chloroform and painting it on the areas where solder is not desired. Use a small, soft brush to sparingly apply this mixture.

1.75.2.2.2. **Resin Method (Figure 1.87).** Use a high-quality, fast-setting material such as Dura Lay® or Zap-It® to unite the castings. Ensure the castings are seated properly on the stone dies. Apply resin, using the brush-on technique or tube type dispenser into the solder joint area. Continue to do this until the resin has enough strength to allow handling of the prosthesis during subsequent steps. Once the resin has set and the prosthesis removed from the cast, check the tissue side of the joint for voids. If voids are present, add more resin. (Let the resin polymerize while the prosthesis is seated on the working cast.)

Figure 1.87. Resin Method.



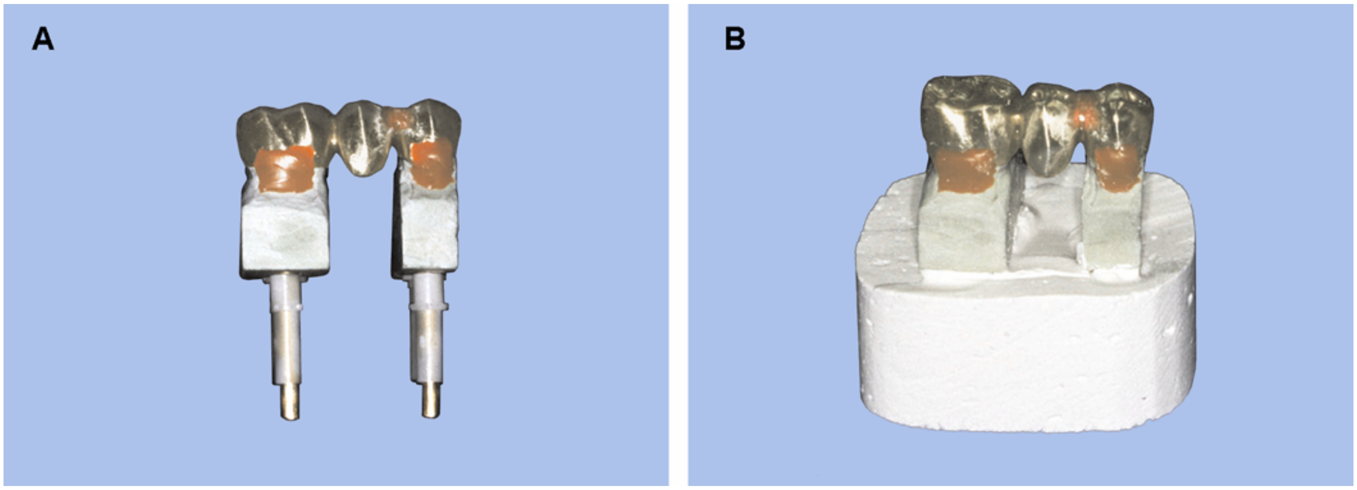
1.75.2.2.2.1. Place properly measured and mixed investment on a suitable work surface and build up to a height of 25 mm (1 inch). Use small increments of investments to fill the inside of individual castings. Float the prosthesis on the mound of investment material. Stand the assembly upright and take care not to bury it. Leave as much metal exposed as possible, but be sure that the margins are covered. Maintain a sufficient bulk of investment beneath the castings (15 to 20 mm) to provide strength during the soldering operation.

1.75.2.2.2.2. After the investment has set, trim it to these following dimensions: 15 to 20 mm thick and 3 mm beyond the perimeter of the castings. Cut a V-shaped groove from the edge of the investment to the joint areas. Paint around the periphery of all joints with antiflux if desirable (paragraph 1.75.2.2.1.10).

1.75.2.2.2.3. It is not necessary to go through the boilout procedure associated with the stone index method. All of the resin will vaporize during the preheating operation in the burnout oven.

1.75.2.3. **Secondary Laboratory Solder Relationship Index (Figure 1.88).** If a resin index has come directly form the patient's mouth, it is a good idea to fabricate a secondary laboratory index to check the prosthesis for accuracy after soldering has been completed as follows:

Figure 1.88. Secondary Laboratory Solder Relationship Index.



1.75.2.3.1. First, place the stone dies from the working cast into the castings and use sticky wax to hold them in place (Figure 1.88-A).

1.75.2.3.2. If pindex pins were used, slide new sleeves over the die pins. Mix the stone and place a mound on the bench thicker than the length of the longer die pins. Gently place the dies with castings into the stone until the pins are fully covered. Do not bury the dies into the stone.

1.75.2.3.3. After the stone has set trim the stone patty leaving a 3 to 5 mm border around the perimeter of the dies (Figure 1.88-B).

1.75.2.3.4. Remove the castings and complete the soldering procedures. After soldering, return the FPD to the dies on the stone index and check for accuracy.

1.75.2.4. **Selecting a Solder and Cutting the Strip Into Pieces.** Select solder with a melting range at least 100 ^{o}F below the melting range of the castings. The solder's color must match the castings. There are two ways of getting solder to a joint area during the soldering procedure:

1.75.2.4.1. Feed the strip of solder into a cherry-red embrasure until a joint of satisfactory size develops.

1.75.2.4.2. Place a piece of solder of suitable size in the embrasure before the soldering. In the strip feed method, solder flow is fast and heavy and its spread is sometimes difficult to control even with antiflux. Solder may run onto delicate margins or onto occlusal surfaces to destroy carefully established occlusal relationships. The size and shape of the joint can better be controled when the solder has been cut into pieces and placed with appropriate forceps.

1.75.2.5. **Preheating the Assembly.** Place the invested castings in a burnout furnace. Heat soak the assembly at 900 ^{o}F for 30 minutes. Do not preheat the assembly over a bunsen burner flame. Because the part of the investment closest to the flame expands more rapidly than portions further removed, this causes distorted assembly relationships and occasional investment cracking.

1.75.2.6. **Soldering:**

1.75.2.6.1. Adjust the torch flame so the reducing part of the flame is large enough to cover the connector area being soldered, but no larger. The reducing atmosphere prevents troublesome oxide formation. A larger flame only increases the chances of releasing sulfur contaminants from the surrounding investment.

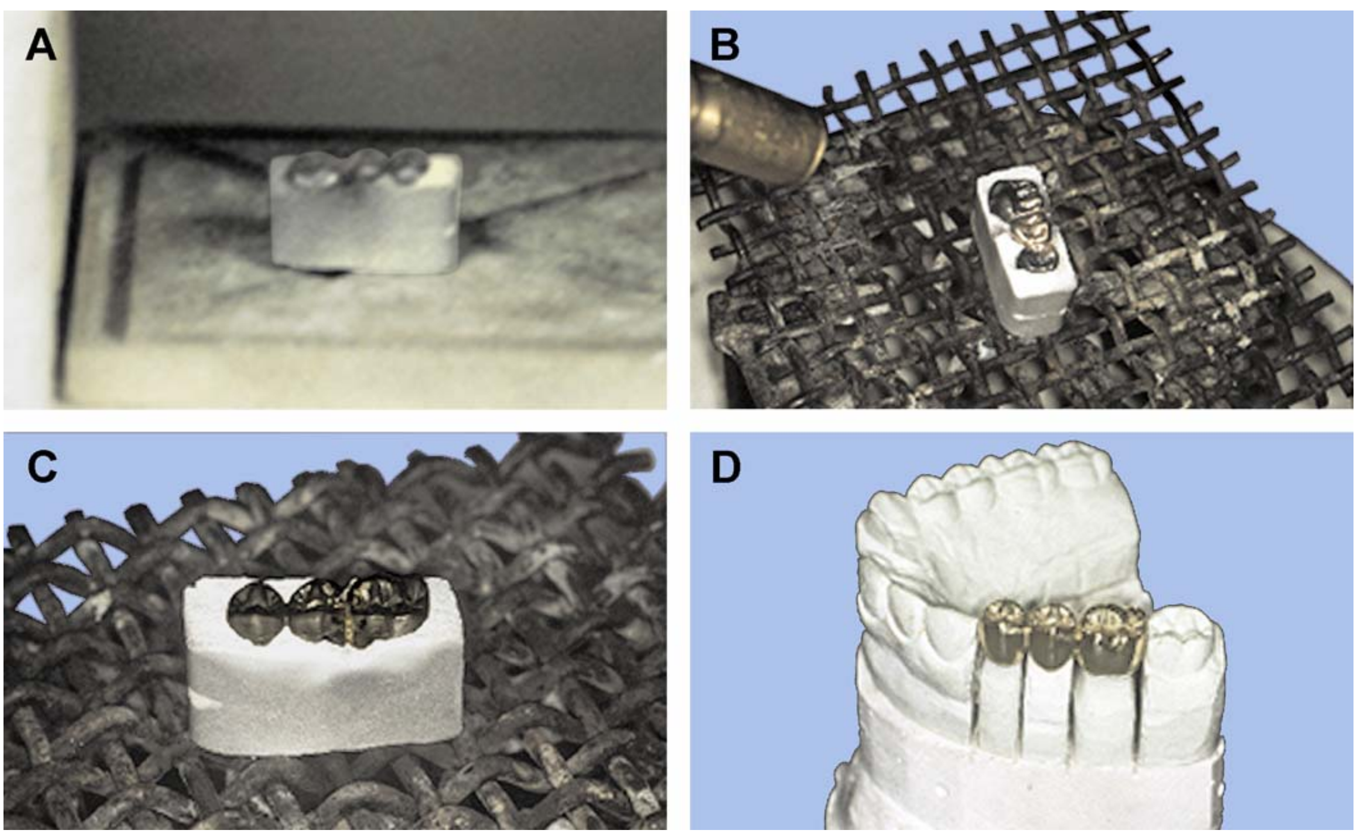
1.75.2.6.2. Remove the preheated assembly from the burnout oven and place it on a hot soldering frame. If not previously done, place a small amount of flux in the joint area. Coat a small square of solder with flux and place it in the linguo-occlusal embrasure of the joint area (Figure 1.89).

1.75.2.6.3. Using the reducing part of the flame, gradually heat up the units adjacent to the joint area. Avoid applying the heat of the torch directly to the solder. When the castings become dull red in color, they are approaching soldering temperature. Switch from gradual heating of a relatively large area to concentrating the flame's movement around the connector site. The units will become bright red, and the solder should flow. As soon as the solder flows, remove the flame.

1.75.2.7. **Bench Cooling and Removing the Investment.** Allow the soldered assembly to bench cool completely. Rapid quenching from a high temperature induces distortion. Slow cooling heat hardens the restoration. Cleanse the soldered castings of investment particles and pickle them to remove oxides.

1.75.2.8. **Finishing.** Proper control of the amount of solder used to make the connection will minimize the effort needed to finish the soldered area. Use a separating disc or a small tapered fissure bur (#669 or #700) to develop the final shape of the joint. A knife-edged rubber wheel will further smooth the area. Use guidelines for finishing in paragraph 1.58 for completion and polishing.

Figure 1.89. Soldering an FPD.



1.76. Repairing Metal Castings:

1.76.1. **Adding Proximal Contacts (Figure 1.90).** Normally, restorations have proximal contacts with adjacent teeth. When this contact is removed, it must be restored and the proximal surface must be recontoured. Adding a proximal contact to a single crown can be done with or without first investing the case, while FPD castings must be invested. The *freehand* method is by far the fastest and easiest way. But, for those cases that must be invested, be sure to place the restoration in the investment patty so the area to be repaired is accessible and in a horizontal plane. Let gravity work for you. Also, invested cases must be preheated in a furnace as described in paragraph 1.75.2.5. The following procedures describe the *freehand* method of soldering:

1.76.1.1. As always, rubber smooth the surface to be soldered. Outline the boundaries of solder flow with an antiflux such as a graphite pencil.

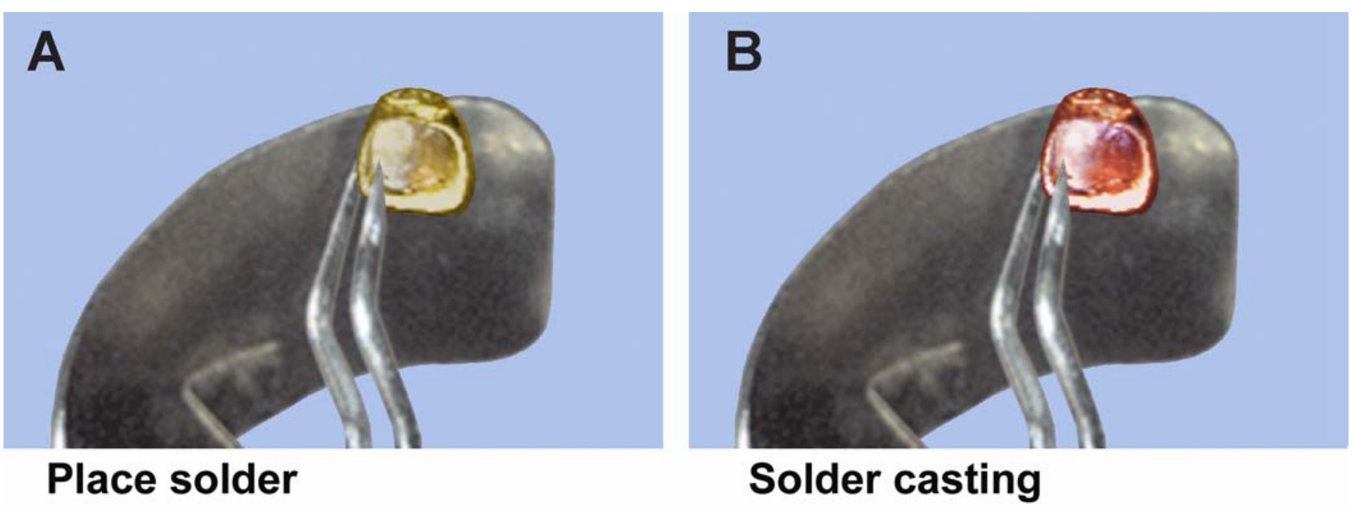
1.76.1.2. Pick up the crown with a pair of locking tweezers, hemostats, or cotton pliers. Make sure you don't accidentally damage the margin. ***NOTE:*** To make a pair of soldering tweezers, bend one tip of a pair of locking tweezers. Place the bent tip on the inside of the crown to avoid crimping the margin.

1.76.1.3. Select the solder and cut a piece larger than actually needed. (The added bulk will help in recontouring the proximal surface.)

1.76.1.4. Warm the casting slightly over a bunsen burner flame and apply flux on the surface to keep oxides from forming. Dip the piece of solder into the flux and place it on the crown (Figure 1.90-A).

1.76.1.5. Place the casting in the reducing zone of the flame and keep it there until the casting glows *a bright red.* The solder should soon melt and adapt itself to the surface. Deoxidize the casting and finish it to proper contour (Figure 1.90-B).

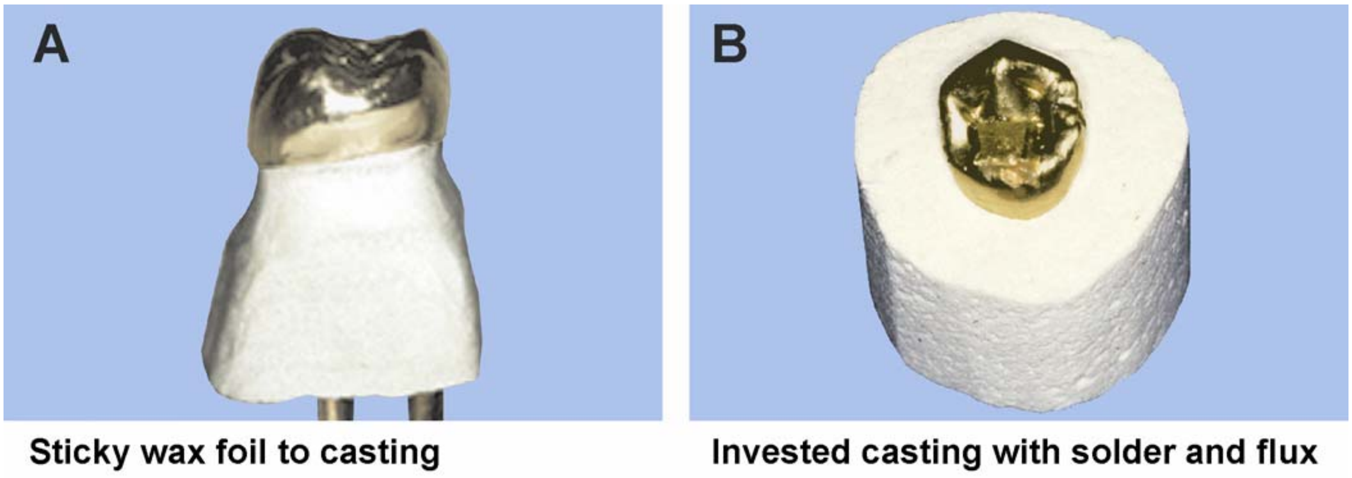
Figure 1.90. Adding a Proximal Contact.



1.76.2. **Repairing Casting Voids (Figure 1.91).** Some casting defects can be repaired by soldering, but not all. Small voids such as pits can be soldered freehand. Larger voids that extend all the way through a casting must first be invested. Also, a backing of platinum foil is used underneath the hole to aid in solder flow. Holes on the occlusal surface can be successfully repaired, but you risk covering the entire surface with solder. Do not try to repair deficient margins because it is improbable that adding solder will result in an acceptable margin.

1.76.2.1. Start by adapting a small piece of platinum foil onto the die and in the area under the hole. Seat the casting on the die and sticky wax the foil to the casting through the hole (Figure 1.91-A). Remove the casting and check to see that the foil stays in place inside the casting. Fill the casting with solder investment and set it down in a small investment patty.

Figure 1.91. Repairing Casting Voids.



1.76.2.2. After the investment has set, remove the sticky wax. Outline the area to be soldered with a graphite pencil. Apply a small amount of flux to the hole and preheat the assembly in a furnace at 900 ^{o}F for 30 minutes.

1.76.2.3. Remove the preheated assembly and position it on a soldering frame. Place a square of solder (slightly larger than the hole) over the hole (Figure 1.91-B) or touch a strip of solder to the casting as the soldering procedure nears completion. Heat the casting with the reducing zone of a gas or air torch. Do not direct the flame onto the solder. When the solder flows, remove the torch.

1.76.2.4. Divest the casting. Remove the platinum foil from inside by grinding it away with a small round bur. Finish and polish the casting in the usual manner.

Section 1M—Remounting Casts With Low-Fusing Metal

1.77. Overview:

1.77.1. Most times, the technician's adjusting of the occlusion of a fixed prosthesis in an articulator before try-in and the dentist's refining of the occlusion in the patient's mouth are enough to ensure the prosthesis will function satisfactorily. However, the truth of this statement decreases as the number of units being placed in the patient's mouth at one time increases.

1.77.2. In a situation where a complete mouth rehabilitation is being done and many units have been made for both arches, most dentists will order a remount of all castings in the articulator after try-in. To do this, the dentist must try the castings in the patient's mouth and make sure they fit the preparations, perform gross occlusal adjustments on the castings, seat all of the castings on the preparations and make maxillary and mandibular pickup impressions; make a new facebow transfer, and make a new jaw relationship record. Given the pickup impressions, castings, a facebow transfer, and a jaw relationship record, pour the impressions and remount the castings.

1.78. Remount Procedures:

1.78.1. Prepare the pickup impression. The pickup impression usually consists of a combination acrylic resin and zinc oxide-eugenol matrix embedded in an alginate impression. Paint the interior of the casting with a white, liquid shoe polish and let the film dry. Position the castings in the impression, seating each casting firmly and positively in the matrix. Protect the margins of the castings by flowing a thin layer of rubber base impression material onto them.

1.78.2. Pour the pickup impression. Melt the low-fusing metal of choice as suggested in Volume 1, Chapter 2. Syringe the melted metal into the castings. Add enough additional metal to create an arch form at least 6 mm thick. After the metal cools, incorporate some form of mechanical retention into its base. For example, heat paper clip loops or small brass screws and partially embed them in a number of places. Pour the rest of the impression in dental stone. Be sure to form a few retention nodules on the base of the stone.

1.78.3. Use the facebow transfer to mount the maxillary cast (paragraph 1.29.2).

1.78.4. Use the interocclusal jaw relationship record to mount the lower cast (paragraph 1.30.2).

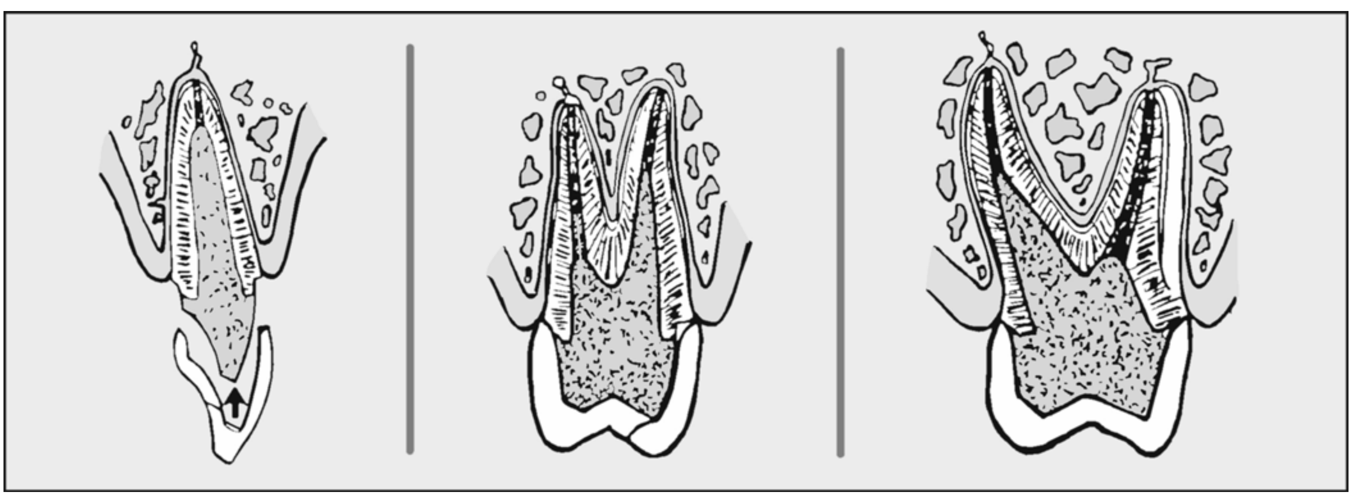
1.78.5. Adjust the occlusion (paragraph 1.58.6).

1.78.6. Final polish as directed by the dentist. In complete mouth rehabilitation cases, this will probably mean applying a mandrel-mounted wire brush to the occlusal surfaces of posterior teeth and high shining the lingual surfaces and incisal edges of anterior teeth with jeweler's rouge.

Section 1N—Post and Core Castings

1.79. Construction Procedures. Most teeth that have been endodontically treated have been so destroyed by caries or previous restorations that there is very little clinical crown left. Often, only the root portion is left to retain the crown. A casting, called a post and core, must then be constructed for retention. This device anchors in the root and replaces the supragingival axial walls similar to the standard crown preparation. Post and core castings are most often associated with endodontically treated anterior teeth, but they may be used on posterior teeth as well (Figure 1.92). Patterns for post and core construction can be made of wax, self-curing acrylic, or metal and acrylic, using either the direct technique or indirect technique.

Figure 1.92. Post and Core Castings for Anterior and Posterior Teeth.



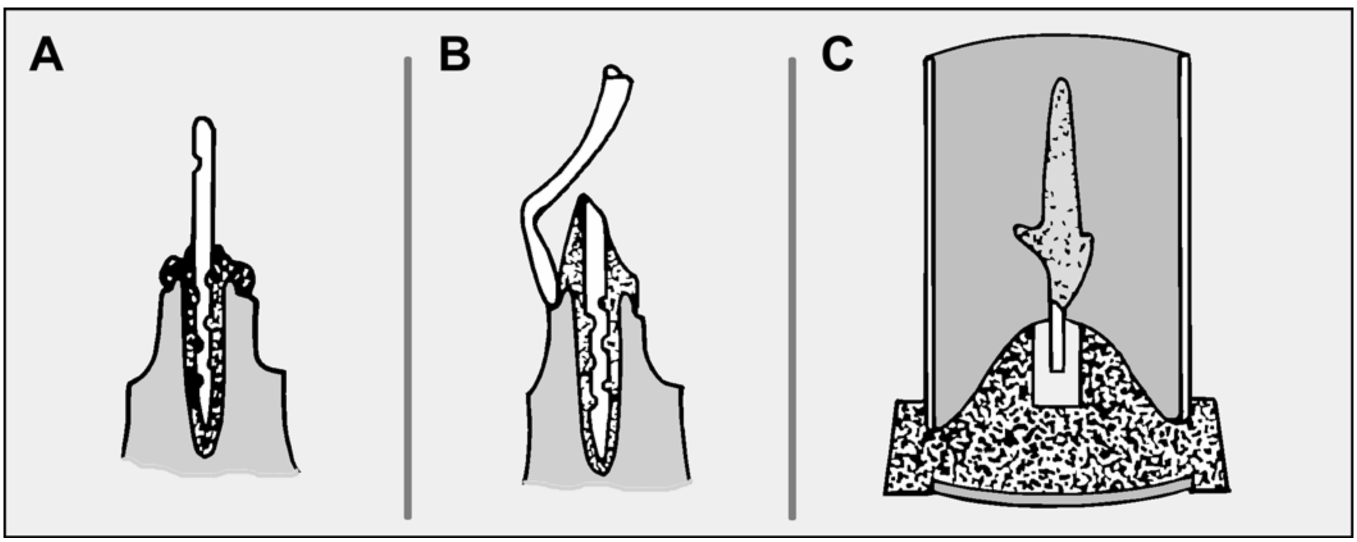
1.79.1. **Waxing.** Using the indirect technique, patterns are more easily made of wax. A device is needed to strengthen the wax post portion of the pattern and to ensure wax completely fills the root canal. A sprue between the tip of the post and the gutta-percha used to fill the root tip would not be acceptable. To prevent this from happening, use a 14-gauge solid plastic sprue former or paper clip inside the canal (Figure 1.93).

1.79.1.1. Trim the tip of the plastic sprue former so it will exactly fit into the canal and reach the apical end of the preparation. Also, cut small notches into the sprue to aid in retention of the wax.

1.79.1.2. Liberally apply die separator to the inside of the preparation. Using an explorer or PKT No. 2, fill the apical end of the canal with dead soft wax (sprue wax, utility wax). Warm the sprue slightly and insert it into the wax completely (Figure 1.93-A). Wait until the wax cools and test the wax post for removal. Be sure each time the pattern is removed it is returned to the same place. Rewax the pattern if it has voids or if it breaks.

1.79.1.3. Add enough inlay wax to the coronal portion of the pattern to overbuild the core. Carve away the excess wax and refine the core pattern until it imitates the contours of an ideal crown preparation (Figure 1.93-B). Ensure the margin of the core is continuous with the canal preparation. ***NOTE:*** The final restoration will probably be a metal-ceramic crown. See Chapter 2 of this volume for details on amount of reduction needed for a metal-ceramic crown.

Figure 1.93. Post and Core Construction.



1.79.2. **Spruing.** Sprue the pattern on the incisal or occlusal surface (Figure 1.93-C).

1.79.3. **Investing.** Add 1 or 2 cc more water per package of investment to lessen the amount of mold expansion and thereby produce a smaller post and core that will have less tendency to bind in the canal.

1.79.4. **Burnout and Casting.** Follow the conventional routine used with Type III gold alloys.

1.79.5. **Finishing.** Finish the casting as you would an inlay. Check the casting's fit by gently seating it in the preparation. If it binds in the canal or will not seat completely, coat the post with disclosing medium and relieve any shiny spots on the casting that are disclosed by the medium. Once the casting completely seats in the preparation, desprue the post and core. Recontour the sprue attachment area and finish the casting with mounted stones or sandpaper discs. Give the core part of the casting a final satin finish with a rubber wheel.

Chapter 2

METAL-CERAMIC RESTORATIONS

Section 2A—Metal-Ceramic System

2.1. Overview. The information presented in this section applies to the noble-metal alloy systems and does not necessarily reflect the characteristics of base metal alloy systems. A metal-ceramic restoration is one in which veneer porcelain is bonded to an underlying metal substructure. This type of restoration enables the dentist to provide the patient the esthetic and biological advantages of porcelain plus the fit, strength, and durability of a ceramic alloy. Also, porcelain is impervious to mouth fluids, color stable, resistant to abrasion, and causes minimal tissue reaction.

2.2. Physical Characteristics of the Metal-Ceramic System:

2.2.1. **Strength of the Bond.** The role of each bonding mechanism between porcelain and metal is not clearly defined. Three factors influence the bonding of porcelain to metal:

2.2.1.1. A *chemical bond* occurs when oxides, primarily tin oxide, on the metal surface fuse with the porcelain during firing.

2.2.1.2. A *compression bond* exists when the cooling metal shrinks, drawing the porcelain together and placing the veneer in a state of compression. The metal substructure should be designed to take full advantage of the compressive nature of porcelain.

2.2.1.3. A *mechanical bond* results from the gripping action of the porcelain that has solidified in the microscopic grooves and undercuts of the metal surface. The bond strength of porcelain fused to metal is greater than the tensile strength of the porcelain itself. A break would occur through the porcelain before the porcelain and metal pull apart.

2.2.2. **Coefficients of Thermal Expansion:**

2.2.2.1. The success of using one manufacturer's porcelain system with another's ceramic alloy may be measured in terms of their coefficients of thermal expansion. The coefficients of thermal expansion of the porcelain and the metal must be relatively close if the porcelain is to remain firmly bonded after the completed restoration has cooled.

2.2.2.2. Although the expansion coefficients of the porcelain and metal are similar, they are not the same. Porcelain is strongest when it is compressed. Manufacturers deliberately lower the coefficient of expansion of the porcelain slightly in relation to the metal. (The porcelain expands, or similarly shrinks, less than the metal.) After firing and subsequent cooling, the porcelain is bonded to the metal in a state of compression. If the opposite condition exists, the porcelain, after cooling, would be in a state of tension and the veneer would likely crack. It is for this reason that the porcelain and alloy chosen should be a compatible system.

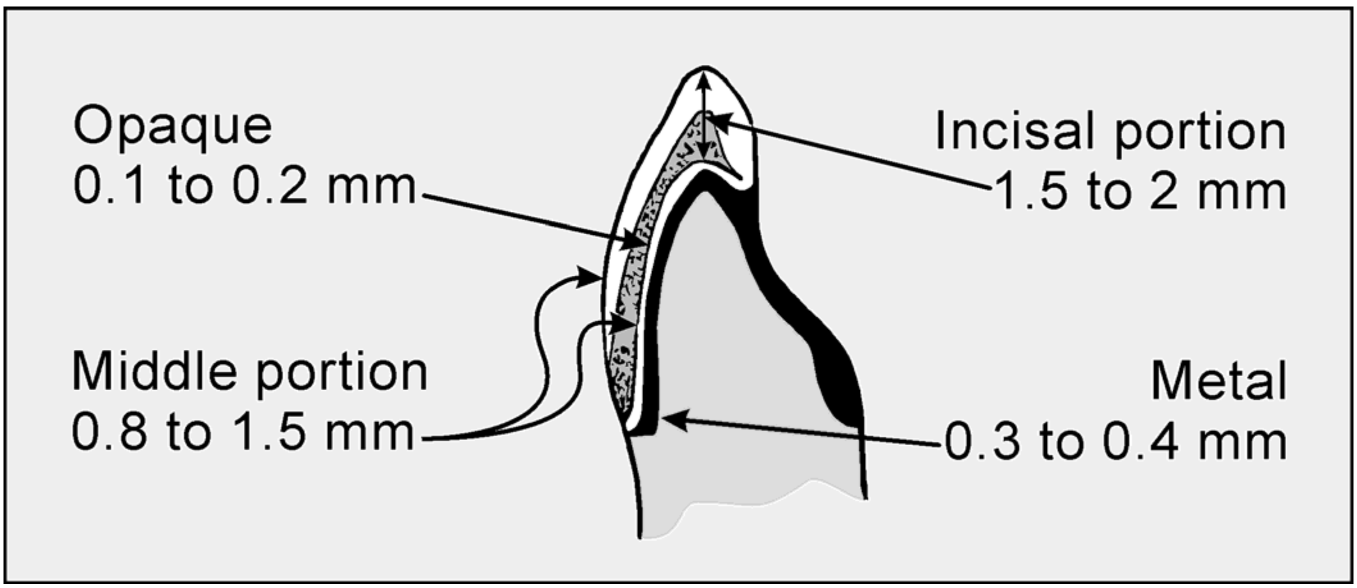
2.2.3. **Strength of the Substructure.** When a porcelain veneer is bonded to metal, any deformation of the metal may cause the brittle porcelain to fracture. Metal frameworks must be strong enough to resist any deformation under an occlusal load. An alloy's strength does not depend solely on how its molecules are put together. *Strength* also depends on the bulk and design of the metal frame. As the length of the span increases, an FPD must have a thicker cross-section and the thickness increase must be in line with occlusal loading. In designing posterior FPDs with veneered pontics, one reason for covering the occlusal and tissue contacting surfaces with metal is that the correspondingly greater bulk of metal will increase resistance to deformation and decrease the possibility of porcelain fracture.

2.2.4. **Melting Range of Ceramic Alloys.** Most low-fusing porcelains mature between 870 to 1065 °C. Because the melting range of the conventional golds used in dentistry is approximately the same temperature, it is necessary to have an alloy with a higher melting range to withstand the firing temperature of dental porcelain without deforming. Several ceramic alloys are formulated with a casting range from 1150 to 1360 °C. The technician can *bond* low-fusing porcelain to these ceramic alloys without any deformation of the framework.

2.2.5. **Thickness of the Veneer:**

2.2.5.1. The combined thickness of metal and porcelain on the facial surface of metal-ceramic crowns should be at least 1.2 to 1.5 mm thick to meet minimum strength and shade requirements (Figure 2.1). There should be at least 0.3 mm metal thickness in the porcelain-veneer areas to keep the substructure from flexing during seating or occlusal load, thus fracturing the applied porcelain. The opaque layer needs to be 0.1 to 0.2 mm thick to perform its masking function. The dentin and enamel porcelain should be a minimum of 0.8 mm thick with 1 mm being ideal to reproduce the desired shade. More porcelain may be needed in the incisal portion because of added translucency necessary in this area.

Figure 2.1. Veneer and Metal Thickness.



2.2.5.2. The technician can place the required metal and porcelain thickness on a stone die regardless of the amount of tooth reduction done by the dentist. However, if the tooth's *normal* contour is to be restored, the dentist is obligated to reduce the facial surface of the tooth at least 1.2 mm to ensure there is room for the minimal thickness of metal and porcelain.

2.2.5.3. Pontics should be made so the bulk of the pontic is composed of metal evenly veneered with 1 to 1.5 mm of porcelain. Metal-ceramic frameworks should be made so porcelain can be uniformly applied in a thickness that does not exceed 1.5 mm on the facial or 2 mm on the incisal. Try to keep the porcelain to a minimum thickness without sacrificing esthetics. A *thin, uniform* thickness of porcelain supported by a rigid substructure offers the most strength.

2.2.5.4. The relative thickness of the metal substructure, opaque, dentin and enamel porcelains depend on the type of ceramic alloy and porcelain used. For example, metal substructures made from high-gold content alloys need to be at least 0.5 mm thick to adequately support the porcelain. The minimum thicknesses listed above are not absolute and will not apply in every given situation. Strength requirements also depend on the design and extent of the restoration.

Section 2B—Color and Shade Selection

2.3. Color. Visible light is the range of the electromagnetic spectrum that is visible to the human eye. The visible light range includes violet, blue, green, yellow, orange, and red wavelengths (spectrums). Color is defined as the physical modifications of light by colorants, observed by the human eye and interpreted by the brain. The many variables involved in producing color will be discussed in this section.

2.3.1. **Dimensions of Color:**

2.3.1.1. Just as an object can be described by its dimensions (length, width, and depth), color can be described by its dimensions (hue, chroma, and value).

2.3.1.2. *Hue* denotes the name or type of color. For example, red, orange, and blue are all names for colors.

2.3.1.3. *Chroma* is the amount of saturation of a hue. For example, an object that is intensely red is higher in chroma than pale pink.

2.3.1.4. *Value,* sometimes referred to as brightness or reflectivity, can be defined as the relative whiteness or blackness of a hue. High value is more white or reflective. When relating to a black and white photograph to describing value, a light blue object next to a tan colored object may appear as identical levels of gray. Value is probably the most important dimension of color to the dentist and technician. If the value of a restoration and the teeth match, small differences in the hue and chroma will not usually be noticed, but a crown of higher value will be more reflective and readily visible.

2.3.2. **Subtractive Color System.** This system is used with pigmented objects and is useful in characterizing fixed prosthodontic restorations. When light reflects from a pigmented object, some wavelengths are absorbed or *subtracted.* The color you see is the wavelength reflected from the object. The red from a stop sign subtracts all wavelengths except red. The three primary hues are *red, yellow,* and *blue.* They are the basis of the subtractive color system and cannot be reproduced by mixing other hues. As their names imply, secondary hues are produced by mixing primary hues. They are *orange, green,* and *violet.*

2.3.3. **Complementary Colors:**

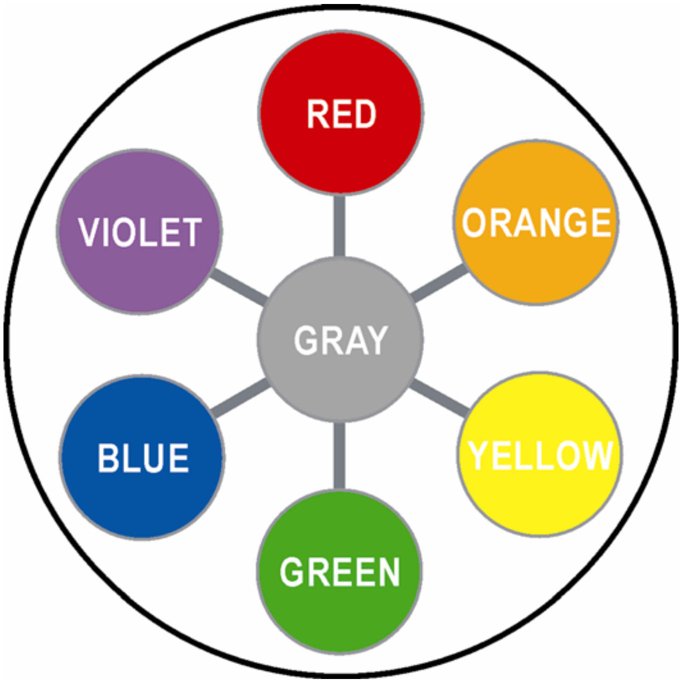
2.3.3.1. Any hue that is opposite another hue on the color wheel (Figure 2.2) is called a complementary hue. Orange and blue and yellow and violet are the two most common complementary color relationships used in reference to fixed restorations.

2.3.3.2. Adjusting the shade is rarely as simple as adding a hue that is lacking. More often it also involves reducing an apparent excess of chroma in a given hue or making an adjustment in value as well. Complementary hues become an important part of this process.

2.3.3.3. When two complementary hues of equal chroma are mixed together, they produce a neutral gray. This can be a very effective way to reduce chroma or lower value.

2.3.3.4. Complementary hues can also be used to intensify the chroma of the dominant hue present. When two complementary hues are placed side by side, each intensifies the other's chroma. For instance, placing blue stain along the cervical, mesial, and distal boundaries of a predominantly yellow tooth may make the tooth appear *more yellow.*

Figure 2.2. Color Wheel.



2.3.4. **Color Variables.** Many factors come into play when observing, recording, and reproducing a selected tooth shade. Be aware of the following environmental influences when evaluating the color of a tooth:

2.3.4.1. **Object Variables.** When looking at an object such as a crown, the color of the object may contrast with the surroundings. A green object placed on a yellow background will appear *blue*. The same green object placed on a blue background will appear *yellow*. Because blue and yellow together produce green, placement of a green object on *one* of these colors contrasts the remaining color. This same effect can also be applied to the value of an object. For example, a gray object on a black background will appear *lighter;* on a white background, the same object would appear *darker*.

2.3.4.2. **Light Source Variables.** Without light, color cannot exist. Each light source, whether it is daylight, fluorescent light, or color-corrected light, emits wavelengths of varying color, temperature, and intensity. Cool white fluorescent or normal office fluorescent bulbs usually emit light high in blue and green. Incandescent bulbs are high in yellow and red. Daylight is considered by many to be the best light source for comparing colors. However, daylight varies in intensity and quality depending on atmospheric conditions and time of day. The light that produces consistent illumination and negates using daylight is the *color-corrected* light or a commercially available, hand-held light for taking shades. These lights are made to emit a broader spectrum of light for better color comparisons.

2.3.4.3. **Metamerism.** This phenomenon occurs when stimuli reaching the eye causes two objects to match in color *under certain lighting conditions*. To avoid metamerism, compare objects in the same or similar light sources and build color modifications internally.

2.3.4.4. **Cone Fatigue.** Avoid staring at the teeth or a shade guide for long periods of time. After staring at a particular color, the retinal cones in your eyes become desensitized to that color. If you stare at a blue card, blue will deplete the retinal chemical balance for blue, and orange will be easily seen. An opposite reaction will occur if you stared at a yellow-orange card. Varying your gaze and looking at a variety of colors is less likely to desensitize any one color. Do not use the blue card as a background for comparing shades. White is the best background for extraoral comparisons.

2.4. Selecting a Shade. As a minimum, the dentist will select the shade for the restoration and include this information on the prescription form. The technician will then interpret the prescription and make the restoration, duplicating the shade selected. Shade selection is a dentist's responsibility; but, when possible, the individual who will make the restoration should be involved in the shade selection process. Whether selecting a shade or comparing the restoration to a shade tab, the following principles apply:

2.4.1. Take the shade in a neutrally colored room, the porcelain room, or a room with some outside light available. If possible, use a color-corrected light as the primary light source. Cover bright or high chroma clothing with a patient napkin and have lipstick removed. Choose a shade guide compatible to your porcelain system and if possible arrange guides by value. Choose a shade with a similar value regardless of shade. Choosing value is difficult for many people, reducing the amount of light entering the eye by squinting can help discern reflectivity.

2.4.2. Once satisfied that the value is correct, try to determine the dominant hue of the tooth. Natural teeth have dominant hues in the yellow to yellow-orange range. With the Vita Lumin® shade guide, the A range is yellow-red, the B range is predominately yellow, the C range is a gray-yellow, and the D range is gray yellow-red in color. Other shade guide systems may have varying hues and organization. If choosing the hue is difficult, compare areas thin in enamel such as the lingual, proximal, or cervical regions of a tooth.

2.4.3. For the last comparison, determine the chroma. The selected chroma level should closely correspond to the previous value selection. For example, a value selection of D3 with a hue and chroma selection of A3 is almost ideal. These two shade tabs are adjacent to each other on the value scale. Use of either shade would probably work fine, so choose the closest match.

2.4.4. If no satisfactory shade match is available, select a shade tab that is higher in value and lower in chroma. A higher value shade can be lowered (adjusted) more easily without loss of translucency. Any deviation in the *final restoration* should be toward a lower value because a darker crown will be less noticeable over a lighter crown.

2.4.5. The shade selection process improves with practice. Develop a habit of viewing the shade selection at various distances—close up and then far away. If there are any color defects or abnormalities, be sure to include these on the prescription along with any characteristics such as glaze level and surface texture.

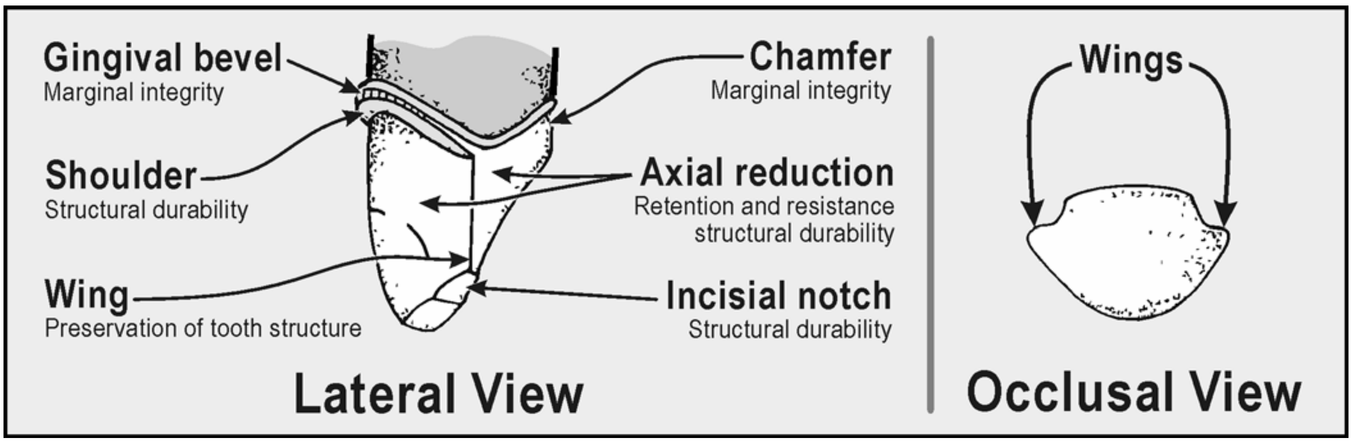
Section 2C—Substructure Design and Fabrication

2.5. Factors in Substructure Design. To a great extent, the shape of the metal substructure seriously affects the stresses that develop in the porcelain. As it is being fired, porcelain tries to become a sphere. This results in the porcelain drawing to the metal structure; and when the restoration has cooled, the porcelain is in a compressive state. If the metal's surface is sharp or uneven, tensile stresses are created in the porcelain as it cools and may cause the veneer to fail.

2.5.1. **Surface Form.** The primary bond between porcelain and metal is chemical in nature, but mechanical bonding also plays an important role. Bond strength overall seems best when the porcelain-bearing metal surfaces are gently rounded. Avoid producing corners, angles, points, or deep concavities on the porcelain-bearing surfaces. Sharp angles and points will create stresses in the porcelain, causing it to fracture. Deep concavities are a problem because the porcelain is likely to shrink away from these areas during firing towards its greatest bulk. Due to the tenacious bond strength between porcelain and metal, mechanical retention in the form of beads, lugs, or peripheral boxing (acrylic resin veneer) is not required and, if present, would make the porcelain more susceptible to fracture.

2.5.1.1. **Tooth Preparation.** A typical tooth preparation for anterior restorations combines a facial shoulder margin style with a lingual chamfer or knife-edge margin (Figure 2.3). The amount of tooth surface removed from the facial surface is about 1.5 to 2.0 mm, and only about half this thickness is removed from the lingual portion. An elevated ridge, called a wing, results from the differences in these depths and is usually located lingual to the proximal contact area. This preparation form significantly affects the design of the preparation.

Figure 2.3. Typical Tooth Preparation for Anterior Metal-Ceramic Restorations.



2.5.1.2. **Full Contour Wax-Up.** The porcelain-bearing surfaces of substructures should closely parallel the finished contours of the porcelain veneers. Remember, porcelain is strongest when it is applied in a thin uniform thickness. To do this, wax the restorations to full contour and uniformly cut back the wax patterns. Then (and only then) can you be sure of a uniform thickness of porcelain and know where to place the metal-ceramic junction (commonly referred to as porcelain-to-metal junction or finish line). If the porcelain is left unsupported, two results will likely happen—the porcelain may fracture due to stress or thermal shock or subsurface porosity may increase in the thicker sections, weakening the porcelain.

2.5.1.3. **Finish Lines.** When wax patterns are made, finish lines should be placed in a position to take full advantage of the compressive strength (paragraph 2.2) of the porcelain. Designs that do not let the porcelain wrap around the structure are not recommended because the porcelain does not have anything to grasp or hold on to. With this design, the risk of fracture is much greater than when the finish line is kept as low as possible (Figure 2.4). All junctions between porcelain and metal on the external surface of a restoration should be as close to a 90-degree angle as possible (Figure 2.5). The porcelain must not be feathered at the porcelain-to-metal junction because the porcelain would be more likely to chip in function or "flake off" during seating.

2.5.1.4. **Cervical Collar.** A cervical collar of metal is recommended for strength and support of the porcelain in the shoulder area. With beveled shoulder preparations, the width of the facial bevel determines the width of the cervical collar. A 1 mm wide bevel requires a 1 mm wide cervical collar. At a minimum, provide a 0.5 mm cervical collar as a routine practice.

Figure 2.4. Balancing the Compressive Strength of Porcelain.

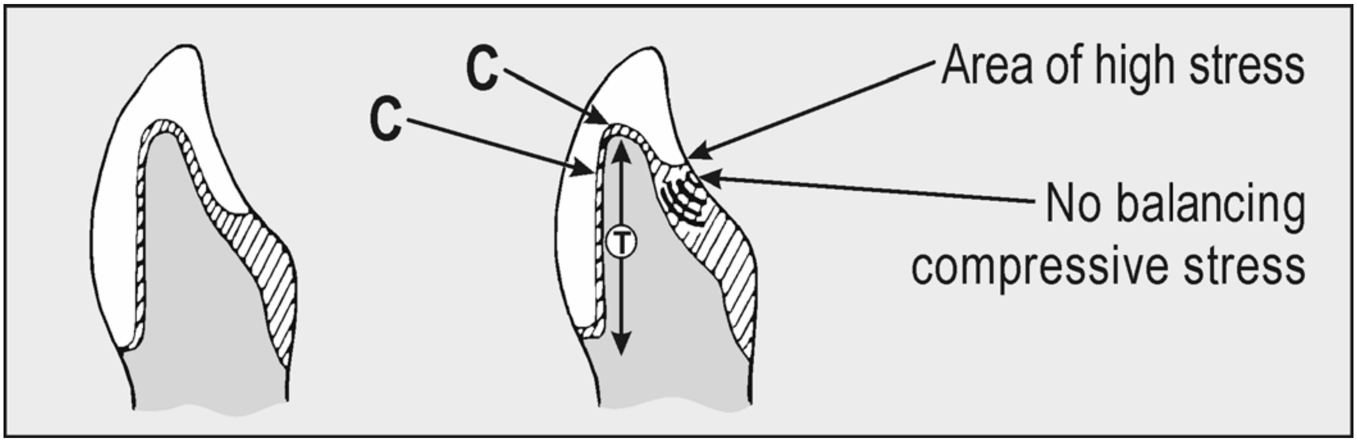
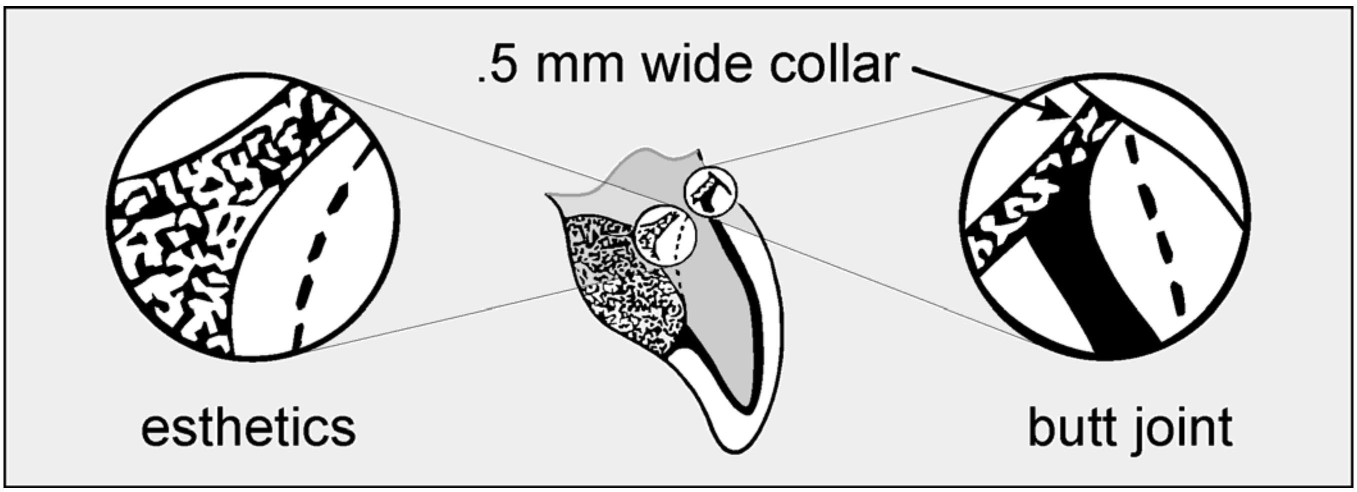


Figure 2.5. Creating a 90-Degree Angle Butt Joint for Porcelain.



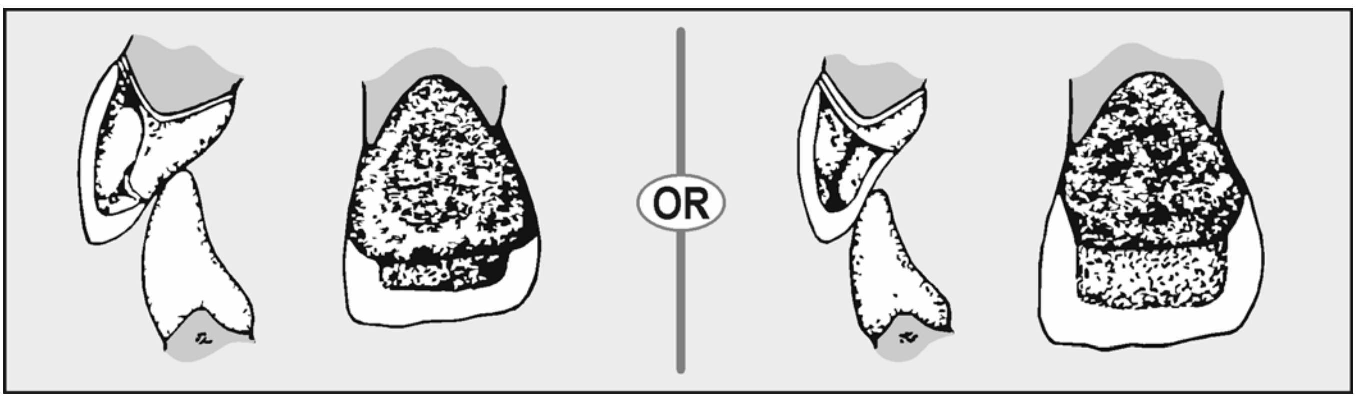
2.5.1.5. **Porcelain Margins.** Sometimes, the placement of facial metal margins subgingivally creates problems. If the patient has thin translucent tissue, a dark shadow may be visible at the gum line. This dark shadow reflected at the cervical collar is considered unattractive. One way to prevent this problem is to make crowns without metal collars (collarless) (Figure 2.6). The dentist cuts a shoulder preparation for the porcelain margin technique. An alternative to this design requires the metal and porcelain to be finished to a knife edge at the margin (known as a disappearing margin). However, this design is not recommended because the porcelain could fracture while the crown is being seated. Do not try to apply porcelain over a long beveled shoulder that was originally prepared for a cervical collar.

2.5.2. **Occlusal Contacts.** As a rule, *never* place the metal-ceramic junction at an MI contact point or area because porcelain fracture would be inevitable. In fact, do not place the junction where the opposing tooth would ride across it during an excursion. This situation may also cause the porcelain to flake, especially if the substructure is poorly designed.

2.5.2.1. **Anterior Design.** Because occlusal contacts should not occur at the metal-ceramic junction, the contact must occur either on the metal framework or on the porcelain (Figure 2.7). Keep the metal-ceramic junction well away (2 mm) from the MI contact point. If you don't, the metal may flex and cause the porcelain to fracture.

Figure 2.6. Porcelain Shoulder Margin.

Figure 2.7. Metal-Ceramic Design for Anterior Crowns.

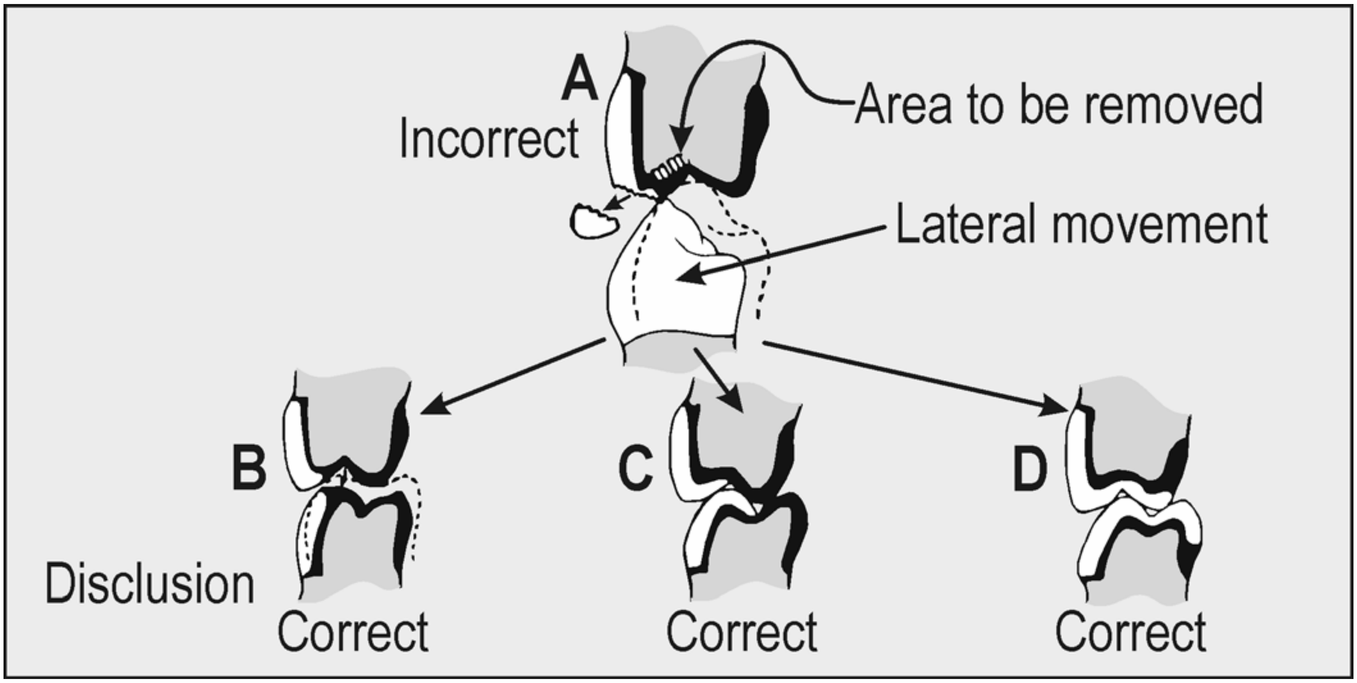


2.5.2.2. **Posterior Design (Figure 2.8):**

2.5.2.2.1. In the m axillary arch, the posterior d esign is fairly sim ple because the s hearing cusps do not occlude in MI nor should they function during an excursion. On a premolar, the metal-ceramic junc tion is located ac ross the buc cal triangu lar ridge. If the m etal-ceramic junction is placed too close to the fossa, the porcelain w ill fracture (Figuare 2.8 -A). The pattern sho uld be wax ed with eno ugh space f or porcelain or adequate m etal con tact to support porcelain.

2.5.2.2.2. W ith the mandibular arch, the problem of where to place the m etal-ceramic junction becomes more difficult depending on the situation. In Figure 2.8-B, the mandibular buccal cusps are made of metal to lessen the ris k of porcelain fracturing . This design is not very esthetic; it should be used only when th e patient's exhibits group function occlusion in lateral m ovements. If mutually p rotected or anterior guidance occlusion is provided, the design shown in Figure 2.8-C or -D is recomm ended. Also notice that like m aterials, metal-to-metal and porcelain-to-porcelain, are made to contact one another in occlusion.

Figure 2.8. Placement of the Metal-Ceramic Junction on Posterior Occlusals.



2.5.3. **Proximal Contacts.** The proximal contacts of anterior restorations should be in porcelain. This is the most esthetic design, and it offers the most latitude in contouring the veneer. Do not place the metal-ceramic junction lingually as far as the proximal wing of the preparation because this would result in a thin area and thereby weaken the framework (see Figure 2.9). For premolars, place the mesial contact in porcelain for esthetic reasons. The distal contact may be in metal. Generally, molar contacts are made in metal.

2.5.4. **FPD Design:**

2.5.4.1. All the principles of framework design that apply to single units would also apply to FPDs. In addition, FPD frameworks require more strength because of connectors. Frameworks must not flex or bend, causing the porcelain to fracture. There must be a large enough mass of metal to ensure rigidity, plus uniform thickness of porcelain to prevent uneven stress concentrations in the porcelain.

2.5.4.2. The typical design for an anterior FPD is in Figure 2.10. Notice the continuous width of metal across the lingual surfaces. The lingual finish line may also be scalloped to add length and bulk in the connectors. If needed, this connector design is also easier to solder. Also, be sure to make the connectors wide enough buccal-lingually for adequate strength.

2.5.4.3. Porcelain coverage of the pontics is basically the same as for retainers. ***EXCEPTIONS:*** Porcelain is applied to ridge areas for better esthetics and to prevent possible tissue irritation, and the porcelain veneers of pontics should be continuous with the veneers of retainers.

2.5.4.4. From a mesial or distal view, the contour of the metal surface must appear to closely follow the contour of the porcelain veneer (Figure 2.11). At least 1 mm of porcelain should cover the facial surface, while an absolute minimum of 0.5 mm of coverage is needed on the pontic's tissue side. Possible irritation of the gingival tissues could result from contact with a rough metal-ceramic junction. Therefore, the pontic's lingual finish line is placed lingually and incisally to the crest of the ridge.

Figure 2.9. Improper Placement of the Metal-Ceramic Junction.

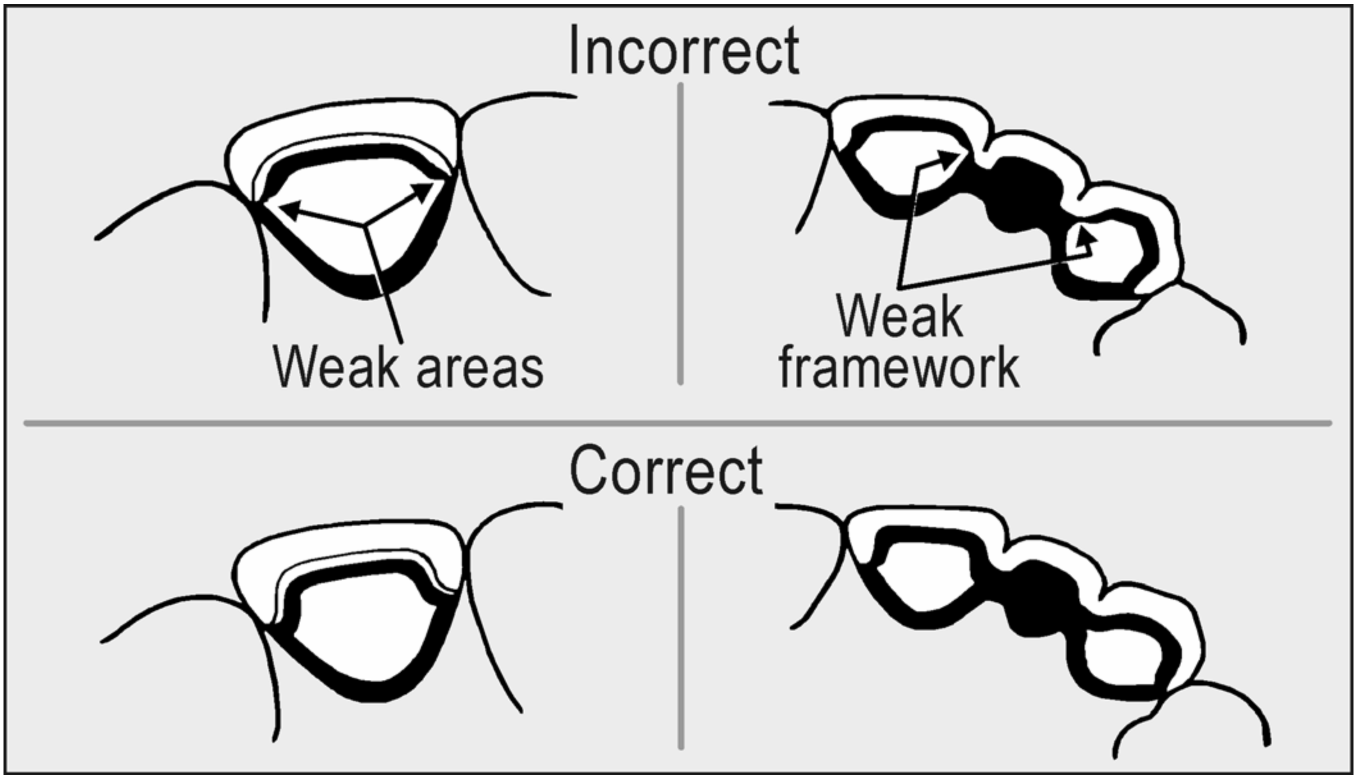
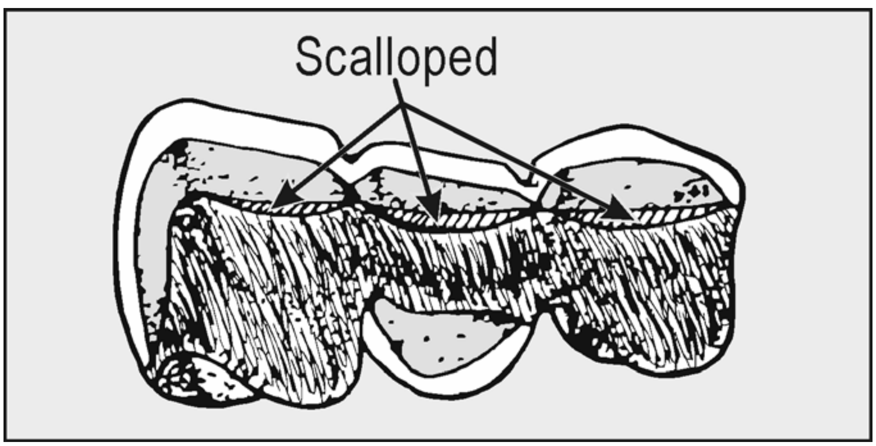


Figure 2.10. Typical Metal-Ceramic Substructure for Anterior FPDs.

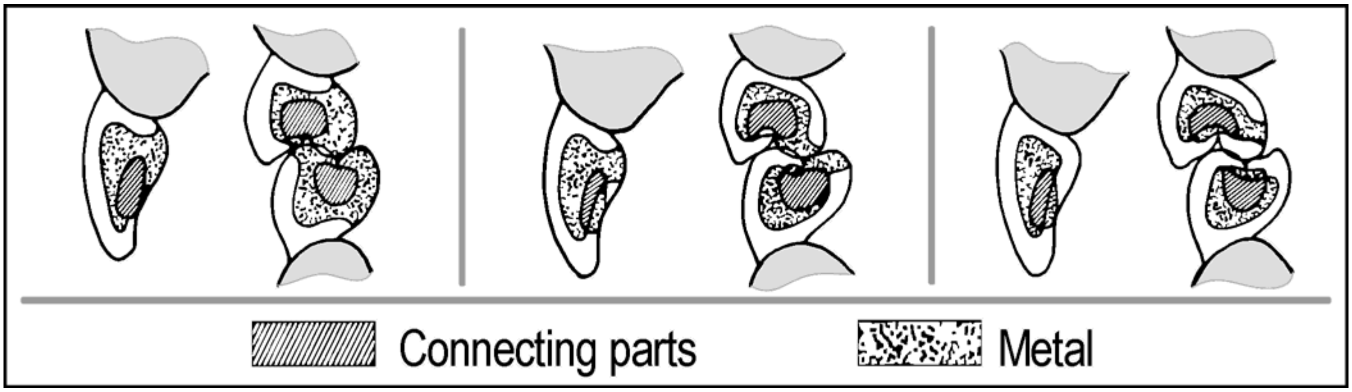


2.6. Waxing. Patterns should follow the designs described in paragraph 2.5. Wax all single complete crown and multiple complete crown retainer patterns to a minimum thickness of 0.4 mm in the veneer areas. This thickness is needed to strengthen the wax pattern and provide enough bulk to ensure a complete casting. The wax has to have uniform thickness and be wrinkle free if the pattern is to cast without holes or voids.

2.6.1. **Coping Preparation:**

2.6.1.1. One of the many ways to lay down a well-adapted coping for this kind of pattern is to dip the die into molten wax until the wax completely covers the cervical margin. Use a wax specifically made for wax dipping. Dip the die as many times as it takes to get the desired thickness. Adjust your technique so one coat of wax will equal 0.4 mm.

Figure 2.11. Metal-Ceramic Design for Pontics.



2.6.1.2. Wax the margins and cervical area, using regular inlay wax or follow the dual wax technique, using a harder inlay wax (type A). Use the dual wax technique because the harder inlay wax used for the marginal area resists distortion. You can also wax copings free hand, but use care to prevent internal wrinkles and voids in the pattern.

2.6.1.3. After making the coping, remove it to ensure that undercuts do not prevent removal of the *completed* pattern. Complete the full contour wax-up, using the wax-added technique mentioned in Section 1J.

2.6.2. **Cutback Technique.** Study the full contour wax-up carefully. Make mental notes about the occlusion and overall appearance of the waxup. Better still, make an impression of the wax-up to serve as a guide during the porcelain application procedures. An ideal method is to make a facial index of the full contour wax-up with a silicone putty impression material. Pour this index with stone to make a permanent record of the wax-up and the opposing teeth. Cut the index in half below the incisal (occlusal) edge to expose the impression from an occlusal view. Then, use it to check the amount of cutback on the wax substructure (Figure 2.12). However, you will not be able to use this index during the porcelain application step so be sure to mark the width and length of the restorations on the opposing cast for future reference.

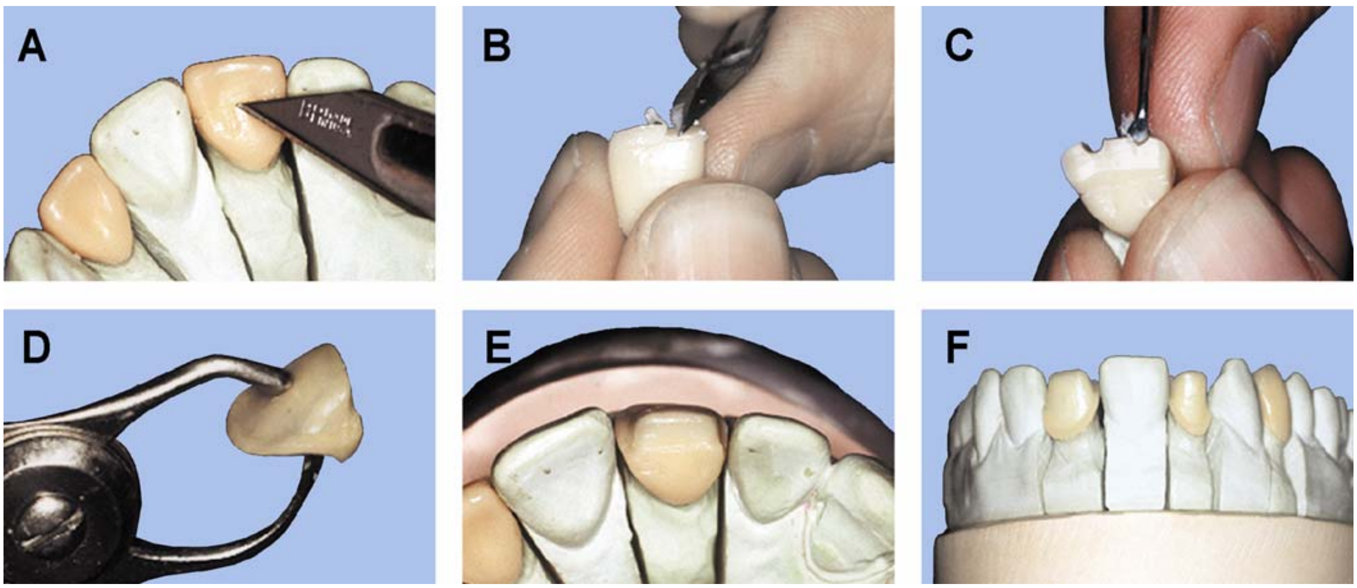
Figure 2.12. Facial Core Used To Check Cutback.

2.6.3. **Single Crown Cutback (Figure 2.13):**

2.6.3.1. The first step in performing the veneer cutback area is to scribe the outline of that area on the pattern using a No. 25 blade (Figure 2.13-A). Place the proximal metal-ceramic junction of anterior units as far lingual as possible.

2.6.3.2. Using a sharp instrument, carve away 1.5 mm from the incisal edge of the pattern (Figure 2.13-B). Then use a discoid carver to provide a nice, smooth butt joint between the metal and the porcelain and to also place vertical grooves (depth cuts) in the center of the labial surface (Figure 2.13-C). Use these grooves to measure the depth of wax in the veneer area, which should be at least 1 mm deep.

Figure 2.13. Cutback Technique for Crown Patterns.



2.6.3.3. Remove the remaining wax with a #25 blade or similar instrument, leaving a smooth veneer surface with a sharp clean metal ceramic junction. If the crown is to have a metal collar, leave a .5 mm cervical collar on the facial one-half of the pattern. This width helps to ensure strength of the pattern and complete casting of the facial marginal area. Later, reduce the width of the collar in metal to the minimum 0.3 mm thickness (a bulk that resists distortion when the porcelain cools from its firing temperature).

2.6.3.4. If a porcelain margin is prescribed remove the wax from the facial margin area to the junction of the facial axial wall of the wax pattern and the shoulder, leaving the shoulder margin exposed.

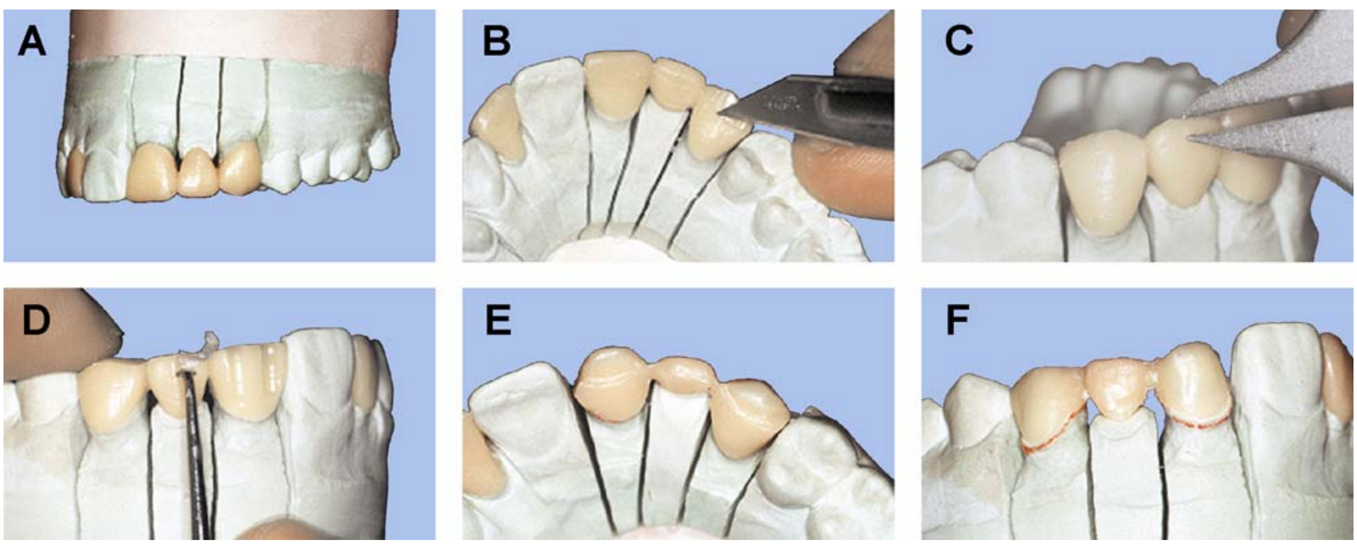
2.6.3.5. Use a wax gauge to check the thickness of the facial cutback (Figure 2.13-D). The wax should measure at least 0.4 mm. If not, add wax to provide enough bulk. Also inspect the inside of the pattern for thin areas of wax that might cause an incomplete casting. Smooth the completed pattern, being careful not to destroy the nice, crisp finish lines or intricate anatomy.

2.6.3.6. Replace the die and pattern on the working cast and check the occlusion and placement of finish lines. From various angles (mesial, distal, and occlusal profiles), inspect the cutback for amount of reduction (Figure 2.13-E and -F). Remember, the metal surface should parallel the contour of the finished restoration. There are usually two areas of concern, the mesiodistal curvature and the occlusogingival curvature of the facial surfaces of teeth. Almost always, the wax pattern should be "rolled in" on these surfaces, especially anterior units. The tendency is for novice technicians to make their substructures "box-like" without allowing for the natural esthetic curvature of all teeth.

2.6.3.7. The final step is to adapt the margins before spruing and investing. Carefully remove the wax pattern and check for defects such as broken or frayed margins, overextended margins, and short margins. Use a microscope to check the margin while the wax-up is on the die. Some technicians also prefer to attach a small wax knob to the lingual collar. They use this knob for removing the crown during the try-in and, in some instances, as a holder while building porcelain layers.

2.6.4. **FPD Patterns.** Waxing multiple unit wax substructures is much like waxing single units. Each retainer is reduced the same way an individual unit is (Figure 2.14). The difficulty lies in the cutback of the pontics. Either carefully cut back the pontic while it is attached to one of the retainers or section the pontic from its retainers and cut back the pontic individually. Bear in mind that once you remove the pontic, you must reposition it precisely so you do not destroy the occlusal relationships originally established. Review paragraph 2.5.4 for a description of FPD substructure design.

Figure 2.14. Cutback Technique for FPD Patterns.



2.7. Spruing. For the most part, metal-ceramic substructure patterns can be sprued the same as conventional alloys, but lower density and increased melting range make the metal-ceramic alloys more susceptible to casting porosity. This porosity, whether deep inside the metal or on the surface, can create subsurface bubbles in the porcelain, which will weaken the veneer. Due to the sensitive nature of these alloys, it would be better to adapt the standard spruing, investing, and casting techniques to coincide with the particular metal-ceramic alloy being used.

2.7.1. **General Observations.** To make the best possible castings, follow these principles: (1) make sure the sprue former's diameter corresponds to the volume of the pattern (larger patterns need thicker sprues); (2) when using direct spruing, avoid constrictions in the sprue; and (3) position patterns in the investment mold so they are 3 to 6 mm from the top and their reservoirs are within the thermal zone.

2.7.2. **Sprue Former Attachment:**

2.7.2.1. **Single Units:**

2.7.2.1.1. Sprue single anterior units on the incisal edge (Figure 2.15). This way, you can place the sprue former at an angle that will direct molten metal into the thinnest areas of the casting as well as the thick areas. If the wax is thin in an area, add a small ridge of wax to that surface to act as an auxiliary sprue. Normally, copings are thick enough to allow for a complete casting. Spruing to the veneer area positions the sprue away from the margins and makes finishing a lot easier. Sprue posterior wax patterns on the lingual cusp because of their large bulk. ***NOTE:*** This method may distort previously established occlusal relationships. To preserve occlusal contacts on maxillary waxups, sprue to the facial cutback area, taking care to direct the flow of metal across the occlusal table, toward the thicker areas.

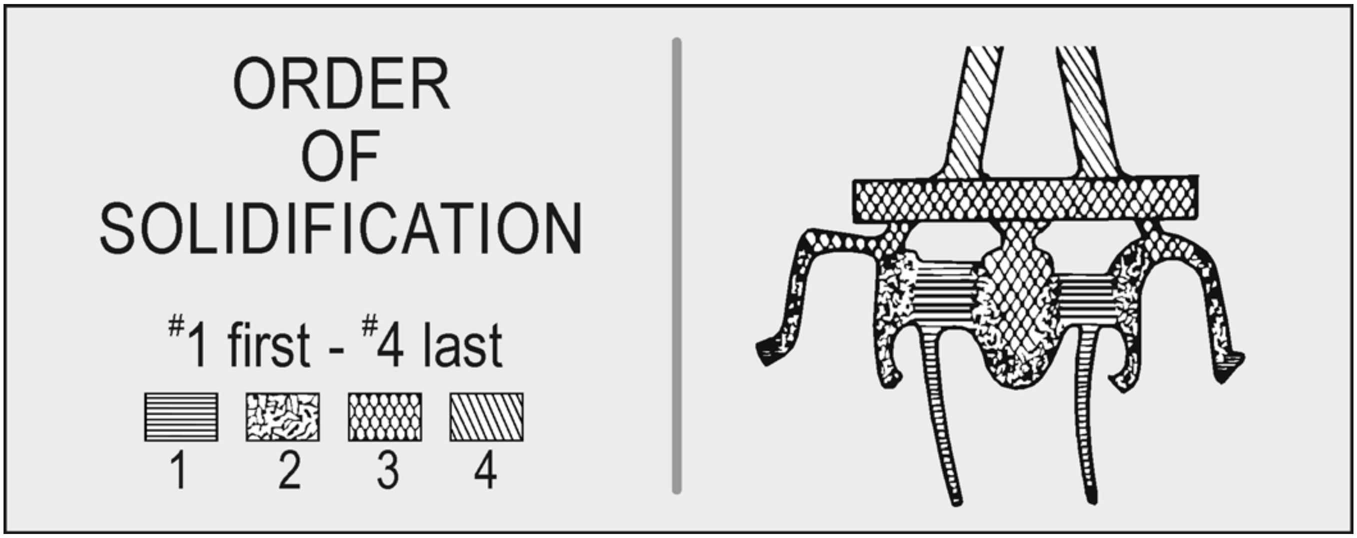
Figure 2.15. Direct Spruing of Wax Substructure Patterns.

2.7.2.1.2. Most single unit castings can be made from a single sprue. *Rarely* will a wax pattern require an auxiliary sprue former. Judge each case on its individual merits. Remember the following rule: sprue size and sprue placement depends on the volume of the wax pattern. Normally, the sprue former is made of wax and is at least 10 gauge in diameter.

2.7.2.2. **FPD Patterns.** The most common ways of spruing FPDs and multiple single units involve the indirect and direct methods. For best results, use the indirect spruing method described in paragraph 1.52.4.3. Placement of pattern sprues is the same as paragraph 2.7.2.1.

2.7.3. **Chill Vents.** Use chill vents to remove gases from the mold and to transfer heat away from the casting. The logical placement of chill vents is on the bulkiest areas of the wax patterns—the connectors (Figure 2.16). To construct a chill vent, attach an 18-gauge round wax wire about 6 mm long to each connector. This chill vent will draw heat away from the pontic and connector, preventing porosity in those areas.

Figure 2.16. Placement of Chill Vents on a Substructure Pattern.

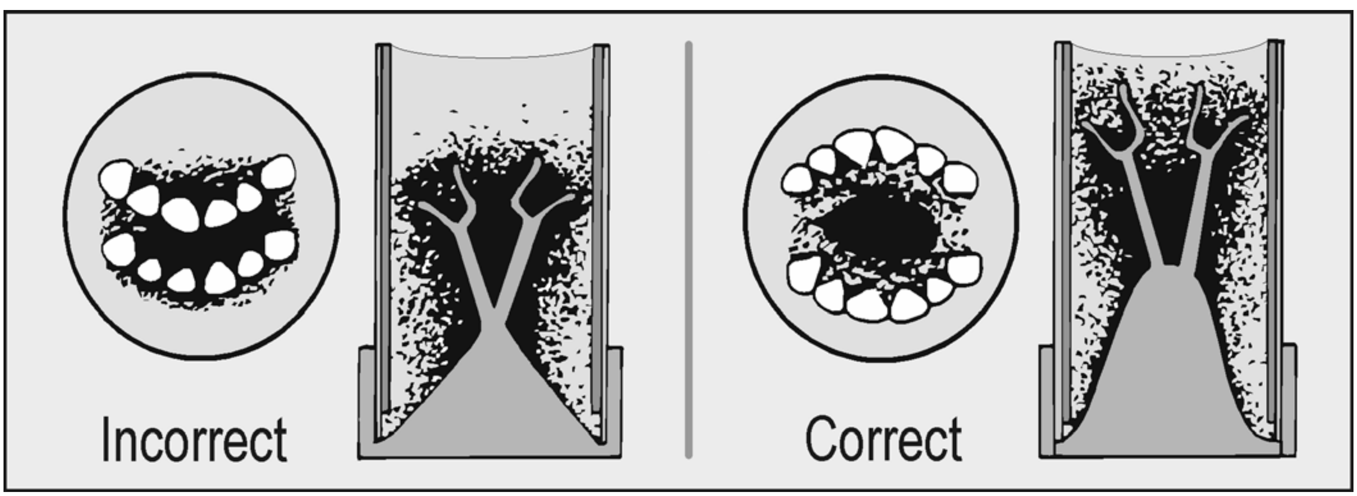


2.7.4. **Pattern Position:**

2.7.4.1. Wax patterns should be 3 to 6 mm from the end of the ring so gases can escape through the porous investment as the rushing metal enters the mold. The chance of back-pressure porosity or an incomplete casting increases if this gas is not eliminated. Because phosphate-bonded investments are stronger than gypsum-bonded investments, the danger of the mold cracking is not as great and strength is not a problem.

2.7.4.2. Another factor involves placement of patterns outside the *thermal zone* (Figure 2.17). After the molten metal enters the mold, heat is transferred to the investment and concentrated in the center of the ring. The molten metal in this area (thermal center or *thermal zone)* will solidify last due to the hotter investment temperature. If the pattern is in the thermal zone, the feeder sprues could freeze before the pattern does. Place the pattern above or to one side of the thermal zone so that the casting will cool first and then the sprues.

Figure 2.17. Placement of Metal-Ceramic Patterns Outside the Thermal Zone.



2.7.5. **Orientation Dot.** Besides depending on the force generated by a spring-wound casting arm to fill a burned-out mold, it is critical that the mold gets maximum benefit from the natural flow of molten metal during the casting procedure. Use the orientation dot method to indicate the relative position of the invested pattern inside a ring (paragraph 1.52.4.5).

2.8. Investing. The procedures used for investing metal-ceramic substructures are like those used with conventional gold castings. Phosphate-bonded investments must be used with ceramic alloys because of their high heat capabilities. Gypsum-bonded investments tend to break down when heated to temperatures greater than 1300 ^{o}F, giving off a sulfur gas. Not only is the strength and accuracy of the mold reduced by this breakdown, but sulfur gas can contaminate the alloy. Phosphate-bonded investments generally use a special liquid to control part of the expansion. This liquid is a colloidal silicate that can be diluted with water to provide various amounts of investment setting expansion. Undiluted liquid provides maximum setting expansion.

2.8.1. **Mold Expansion:**

2.8.1.1 When using phosphate-bonded investments, mold expansion is affected by:

2.8.1.1.1. Using more layers of asbestos substitute to line the casting ring.

2.8.1.1.2. Increasing the ratio of special liquid to water (more special liquid, more expansion).

2.8.1.1.3. Placing the investment in contact with water during setting (hygroscopic technique).

2.8.1.1.4. Burning out the mold at a higher temperature. If your castings are too large and you want to decrease the amount of expansion, try the opposite approach with any or all of the above methods.

2.8.1.2. The size of the casting ring affects the seating of castings. If too many patterns are crammed into one casting ring, expansion of the mold cavity will be uneven. Also, the castings will not be as precise nor will they fit their preparations. Therefore, be sure to use the larger oval or round rings to produce FPDs that will seat more completely.

2.8.1.3. "Ringless" casting systems may also be used to gain added expansion. These systems do not use solid metal casting rings, and they vary in design from disposable wax forms to reusable plastic cylinders. The similarity all ringless casting systems share is unrestricted expansion during burnout.

2.8.2. **Investment Procedures:**

2.8.2.1. Use a separate mixing bowl for each type of investment (one for phosphate-bonded and one for gypsum-bonded investments). Particles of other investment types can alter the chemical and physical properties of the mix. After mechanically mixing the ingredients together (manufacturer's powder-to-liquid ratio and mixing times), continue to vibrate the mix under vacuum for an additional 15 seconds to remove ammonia gas that escapes as part of the chemical reaction taking place. Small metal nodules on the underside of the casting are a direct result of this gas escaping.

2.8.2.2. It may also be necessary to change the mixing times because some mixing bowls become worn and will generate heat, causing the mix to suddenly harden. Either inspect the equipment and replace it or spatulate the mix for a shorter period of time. After investing the pattern, let the ring bench set for at least 60 minutes before burning out.

2.9. Burnout:

2.9.1. Follow manufacturer's directions for burnout temperature, rate of temperature climb, and hold time. Large rings will need more time according to their size. In any case, keep the investment at the recommended temperature until the color of the investment has completely whitened. A dark shadow in the center of the investment indicates carbon residue still left in the investment mold. The physical properties of some metal-ceramic alloys, especially high palladium content alloys, is greatly affected by carbon, making the use of a *carbon-free* investment desirable.

2.9.2. When using preformed plastic sprue formers, you should begin the burnout sequence gradually, before increasing the temperature to 1300 °F. Usually 30 minutes at 600 °F is sufficient to soften the plastic and allow the wax to run out. All burnout times and temperature should follow exactly the instructions of the investment's manufacturer and of the particular alloy being used.

2.10. Casting. Ceramic metals are melted in a quartz or zircon-alumina crucible (made to withstand higher temperatures) and cast at 2300 to 2500 °F. Because of their lower densities and critical casting temperatures, they need more casting force. Instead of winding the casting arm only 3 1/2 to 4 times, wind it 4 1/2 to 5 times. Also, do not use casting flux during the melt because it can remove some of the trace elements in the alloy. Use a separate crucible to melt different types of alloys, thereby preventing alloy contamination.

2.10.1. **Adjusting the Torch.** Use a gas-oxygen casting torch with a multiorifice tip. Regulate the oxygen pressure to 8 pounds per square inch (psi), with the propane gas between 6 to 8 psi. ***NOTE:*** Bottled propane under constant pressure produces a cleaner, hotter flame than natural gas. Use caution in lighting the torch. Always add oxygen to the gas flame and always remove oxygen from the gas flame in shutting off the torch. A correctly adjusted torch will produce a fairly soft, shower flame with the small blue reducing cones about 5 mm in length. The reducing nature of the flame indicates a slight excess in propane gas left unoxidized. Too much oxygen added to the flame causes oxygen gas absorption by the gold, and resulting in minute porosity throughout the casting. Hydrogen gas absorption by palladium is also a problem, especially in the higher content palladium alloys.

2.10.2. **Melting the Alloy:**

2.10.2.1. Preheat the crucible to a dull red to drive off moisture and prevent a cold spot at the base of the crucible. Alumina or quartz crucibles are self-glazing and do not need a liner. Ceramic alloys are usually superheated (white hot—about 100 °F above their upper limit) before they are cast. Wear dark colored glasses to prevent an eye injury from the bright light of the hot metal.

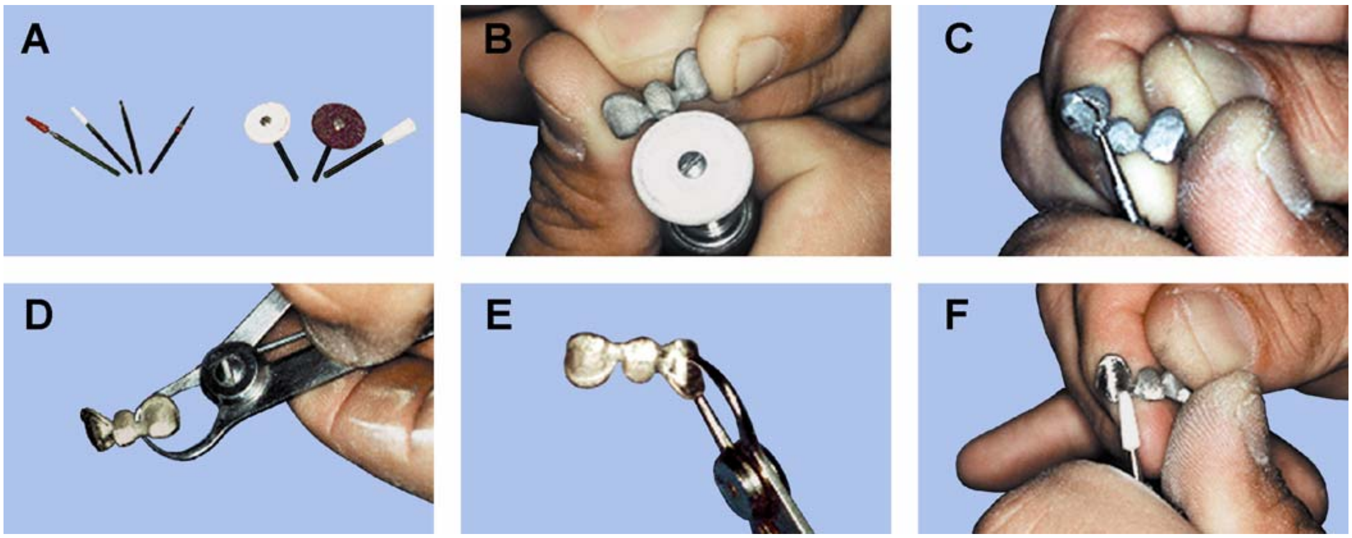
2.10.2.2. Place the alloy in the crucible's center and start the melt with the tip about 3 or 4 cm from the alloy. Continue heating the alloy, watching it change color from red, to orange, to dull white, to a mirror-like white. When the alloy is orange, transfer the ring from the furnace to the cradle. When the alloy is white hot and mirror-like, release the casting arm and let spin until the casting arm comes to a complete stop. Then remove the casting ring and let it bench cool.

2.10.2.3. When the ring is cool enough to handle, remove the casting and pick off most of the investment. Carefully air abrade the casting with aluminum oxide to remove any remaining investment.

2.10.3. **Alternative Casting Method.** Another casting method uses electric means of induction melting. Induction casting machines, similar to the Ticomatic, can be used to cast all types of ceramic alloys, but they are especially helpful when using base metal alloys. More information on induction casting is in Chapter 3, paragraph 3.8.2.

2.11. Finishing. See Figure 2.18-A through -F. Overall, the three objectives in finishing the porcelain-bearing areas of castings for metal-ceramic restorations are to: (1) provide clean surfaces for the chemical bonding of porcelain and metal, (2) provide the ideal surface texture that will increase the wetting action between the porcelain and metal, and (3) return the metal substructure to previously established contours, taking full advantage of the porcelain's physical characteristics (preparation of a porcelain-to-metal junction, placement of the junction, and overall design of the framework). While the goal is to make a wax pattern that only requires minimal finishing, chances are some recontouring may be needed as follows:

Figure 2.18. Surface Preparation of a Metal-Ceramic FPD.



2.11.1. **Precautions:**

2.11.1.1. Only use new finishing stones and burs or those used exclusively on a particular ceramic alloy to prepare porcelain-bearing surfaces (Figure 2.18-A). Indiscriminate use of finishing equipment can cause contamination by copper, silver, zinc, or chromium alloys. If the surface is unusually rough or is contaminated by using "dirty" stones, the result may be severe blistering of the opaque layer.

2.11.1.2. Furthermore, only use abrasives that are fused together with a ceramic binder. Do not use rubber wheels or abrasives held together with epoxy resins or silica binders. If you are unsure about using an abrasive stone or point, place a sample of it in a porcelain furnace and fire to 1000 ^{o}C. If the abrasive does not turn to powder, it has a ceramic binder. Ceramic points either have carborundum or aluminum oxide as an abrasive particle; the latter abrasive is better.

2.11.1.3. Single-cut carbide burs make the best finishing instruments. They sharply cut the metal surface, producing lower roughness and very few undercuts or concavities. Try to grind on the castings in one direction only since criss-cross strokes may cause folding of the metal surface and impurities could become trapped.

2.11.2. **Seating the Casting and Restoring Occlusion.** Before despruing the casting, check to see that it fits the die and the margins are complete. Use a disc or abrasive wheel to recontour the sprue attachment area (Figure 2.18-B) and remove gross amounts of metal from the proximal contacts. Do not use "heatless" stones because they can contaminate the metal. Rubber the contacts smooth into light contact with the adjacent teeth. If the occlusion is high, reduce it to bring the restoration back into MI. Check the amount of clearance available for porcelain coverage in centric as well as through working, balancing, and protrusive excursions. If there is not enough space, reduce the metal substructure. ***NOTE:*** If the framework is to be presoldered (paragraph 2.27), do it at this time and before reducing the bulk metal.

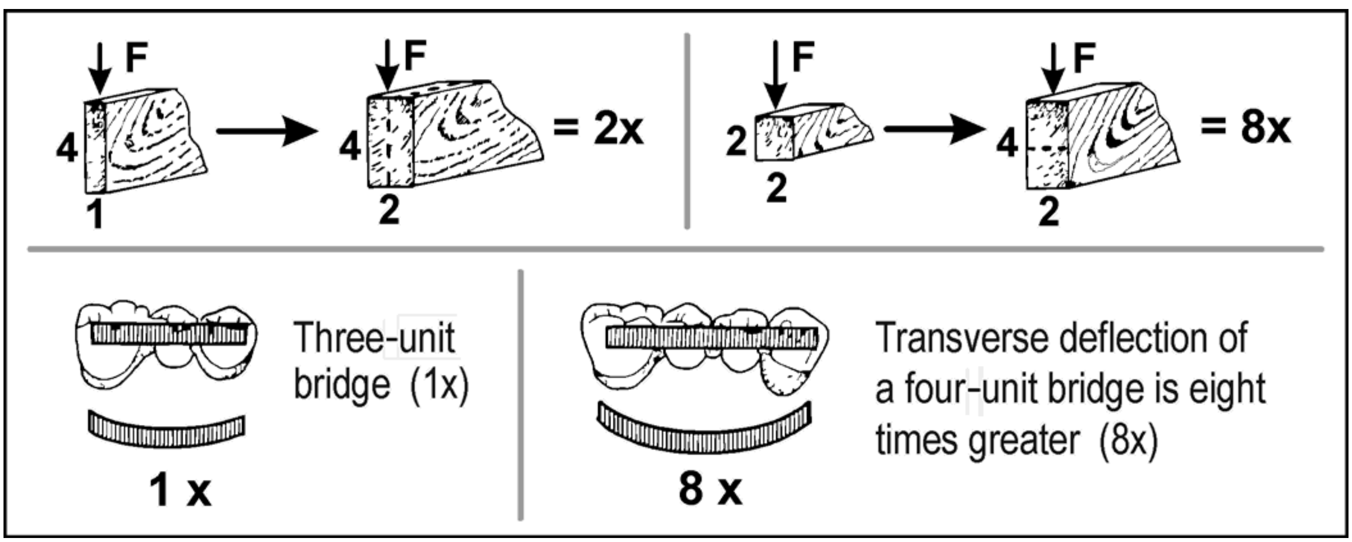
2.11.3. **Reducing Bulky Areas:** (***NOTE:*** Areas that normally require attention are adjacent to the metal-ceramic junction and connector areas.)

2.11.3.1. Use a fresh #8 carbide bur to prepare the metal-ceramic junction. Retrace the metal-ceramic junction, making a 90-degree angle preparation (Figure 2.18-C). The resulting finish line should be sharp and continuous. Everywhere porcelain is applied, it must end abruptly *without feathering* onto the metal and the shallow concavity created must encircle the metal support *evenly and smoothly,* reducing all traces of sharp angles or points.

2.11.3.2. Make sure the connectors are strong enough to resist flexing of the metal, yet positioned where they will not compromise esthetics. Should the metal flex, the porcelain will fracture and the veneer will break off. Doubling the connectors width makes it twice as strong, but doubling its depth increases the strength by a factor of eight. If a force (F) of 1 is applied to a *three-unit* FPD, flexing of the metal will only be minimal (Figure 2.19). However, if the same force (F) is applied to a *four-unit* FPD, the amount the metal flexes will be eight times greater. The minimum width of a connector for a three-unit FPD is 2.5 mm; the minimum depth is also 2.5 mm.

2.11.3.3. You can verify these dimensions by measuring the thickness with a metal gauge (Figure 2.18-D). If the connectors are too thick faciolingually, they will make contouring of the embrasures more difficult. You may accidentally expose the metal framework while trying to shape the interproximals with an ultra thin disc. If the connectors are too thick occlusogingivally, they may impinge on the gingival tissues. The bulk of the connector should be as high as possible and towards the lingual.

Figure 2.19. Law of Beams.



2.11.3.4. Dentists are often conservative in the amount of tooth structure removed for a metal-ceramic restoration. If this is the case, reduce the entire facial surface of the metal framework to the minimum 0.3 mm noble metal thickness (0.2 mm for base metal alloys). However, if you reduce the thickness to these dimensions, the risk of the framework flexing and porcelain fracturing is much greater. Using a metal gauge, measure the thickness of the metal at different spots (Figure 2.18-E). Areas of importance are towards the facioincisal, which may cause the opaque porcelain to be visible, and the entire lingual surface, due to close bite conditions.

2.11.3.5. Avoid thin areas of metal, as you might accidentally make a hole in the casting. If a casting has a *large thin area,* it must definitely be remade. Also check to see if there is at least 0.5 mm of clearance under the pontic for porcelain coverage. To reduce large areas of metal, use a double separating disc or Busch Silent® wheel. Sandpaper discs are also effective in smoothing large areas and gently rounding the metal's surface. Always go over the entire porcelain-bearing surface with a #203 stone as the last step before moving on to treating the metal surface (Figure 2.18-F). Move the #203 stone in one direction to create satin finish that will enhance the mechanical bond of the porcelain to the metal.

2.11.3.6. Remember that undercontoured metal can create thick porcelain areas that cause support and shade control problems. Porcelain that is not properly supported (more than 2 mm) is prone to fracture. If the porcelain is too thick in an area, it will affect the shade, largely because the shade is controlled by the presence of *opaque, dentin,* and *enamel porcelains.* Too much of one and not enough of the other alters the shade. If the opaqued framework does not extend far enough (either incisally or gingivally) light will simply pass directly through. In this instance, the pontic will appear grayer than the retainers due to increased translucency.

2.11.4. **Nonporcelain-Bearing Areas.** Confine finishing of these areas to *light finishing only,* not to polishing. Rubbering metal adjacent to the porcelain-bearing areas could contaminate the prepared surface. The only exceptions include rubbering metal contact areas to finalize the proximal contact or the margins if you doubt their completeness. All other nonporcelain-bearing areas can be lightly finished with a fine abrasive to recontour areas and to remove wrinkles and pits.

2.11.5. **Removing Contamination.** If a high-gold content alloy framework has been finished on a metal die (copper, silver, or amalgam), boil it in nitric acid 1 minute and then pickle it in hydrochloric acid. This procedure eliminates any possibility of contamination from the metal die. If using a white ceramic alloy, consult the manufacturer's instructions for its behavior in acids.

Section 2D—Porcelain Application and Firing

2.12. Pretreatment of the Metal Surface. Treatment of the metal surface prior to porcelain application varies with the base-metal elements, such as *tin, indium,* and *iron,* to precipitate on the surface and produce an oxide film. Alloys that contain greater amounts of base-metal elements (notably nonprecious alloys) produce thicker oxide layers. In contrast, high-gold content alloys with far lesser amounts of base elements produce fewer surface oxides. For this reason, bond strength varies greatly depending on the types of alloy and surface pretreatments. Strictly adhere to the manufacturer's instruction on preparing the metal surface. (The use of metal conditioners is discussed in paragraph 2.12.7.)

2.12.1. **Overview.** Use any or all of the following procedures (listed in sequential order) to pretreat the metal surface:

2.12.1.1. Surface grinding.

2.12.1.2. Ultrasonic cleaning with distilled water or steam cleaning.

2.12.1.3. Heating under vacuum at 1040 ^{o}C for 2 minutes.

2.12.1.4. Deoxidizing with acids or air abrading with aluminum oxide.

2.12.1.5. Heating at atmospheric pressure at 1040 °C for 2 minutes.

2.12.2. **Surface Grinding.** Normally considered the last step in the metal finishing process, surface grinding is done to remove defects and make final adjustments. It is also expected to increase the mechanical bond between the porcelain and metal. This finishing procedure is best accomplished by using a carbide bur and grinding in only one direction. If you leave the surface *rough,* it can create stresses within the porcelain veneer. From this point on, handle the castings with forceps or the like to prevent contaminating the porcelain-bearing surfaces with oil and dirt from your fingers.

2.12.3. **Ultrasonic Cleaning.** The purpose of using an ultrasonic at this time is to clean the metal surface. Abrasive particles, dirt, and oils that may have attached to the surface during grinding can be removed by using distilled water in a ultrasonic. If oily residue remains on the ground surface, it will bake on the metal surface as a contaminant. Steam cleaning is also effective for this purpose.

2.12.4. **Heating Under Vacuum.** The term "oxidation" describes the heating process used to produce a controlled oxide layer on the metal's surface and to dispel gases absorbed by the metal during casting. If these gases aren't released before porcelain is applied, they could cause the opaque to bubble at the interface between metal and porcelain. These gas bubbles will eventually migrate to the surface where they become visible. The resultant holes can be repaired; but each time the porcelain is fired under vacuum, the risk of escaping gas increases. Heating the framework under vacuum to 1040 °C for 2 minutes will drastically decrease bubbling.

2.12.5. **Deoxidizing.** Some metal-ceramic alloys produce excess amount of oxides that decrease bond strength and darken the metal surface. Air abrading the metal surface will deoxidize the castings and, to some extent, expose "fresh" metal for reoxidation. ***NOTE:*** Do not deoxidize castings made from high-gold content alloys. These alloys produce fewer surface oxides and deoxidation could strip the metal surface of its base-metal atoms.

2.12.6. **Heating at Atmospheric Pressure.** A second oxidation finish may be indicated to improve the oxide film's quality and color. Each metal-ceramic alloy, when properly oxidized, will have a characteristic appearance. Precious metal alloys containing tin should have an optimal oxide film composed of dense tin oxide (SnO_2), which appears grayish-white in color. The appearance of nonprecious alloys after oxidation varies so much that it would be impractical to discuss here. Instead, refer to the manufacturer's instructions. Repeat heating as needed, but take care not to overtreat the metal surface and disturb the fragile oxide film. When you observe interfacial bubbling of the porcelain, it is best to strip the framework and lightly refinish the metal surface with a carbide bur before proceeding again.

2.12.7. **Metal Conditioning Agents.** Use metal conditioning agents to enhance the metal-ceramic bond or, when using silver-bearing alloys, to prevent staining of the porcelain veneer:

2.12.7.1. **Gold Metal Conditioners:**

2.12.7.1.1. The 24K gold metal conditioners reduce the apparent silver content on the surface of the alloy when properly fired. Theory predicts that the silver content at the surface drops sharply to about 15 percent due to the addition of the gold. As the percentage of silver decreases, so does the probability of discoloration. Because gold metal conditioners do not form oxides, the bond strength between porcelain and metal may diminish using this technique.

2.12.7.1.2. One manufacturer adds small platinum beads to its metal conditioner for mechanical retention of porcelain, claiming it dramatically strengthens metal and porcelain bonding. Gold metal conditioners, having a characteristic color compliment with natural teeth, are also indirectly responsible for lightening the shade of the veneer porcelain.

2.12.7.2. **Ceramic Metal Conditioners.** These materials act as a barrier layer between the metal and porcelain, preventing the porcelain from contacting the metal surface.

2.12.7.3. **How To Use Metal Conditioners.** To use metal conditioners, prepare a thin mix of powder and liquid. Apply a thin coat of conditioner to the metal surface to be conditioned. Dry the coat of conditioner and then fire it to a slight sheen. Remove the frame and cool it before applying the opaque porcelain. When using a metal conditioner, follow the manufacturer's instructions regarding porcelain application.

2.13. Opaque Porcelain. Opaque porcelain serves a three-fold purpose; it masks or hides the color of the underlying metal, it simulates the dentin of a natural tooth and complements the dentine shade porcelain, and it combines with the metal surface oxide to form a powerful bond.

2.13.1. **Applying:**

2.13.1.1. Measure out the correct amount of opaque powder onto a flat glass slab or ceramic dish. Using a glass mixing rod or nylon spatula, mix the powder with modeling fluid (or opaquing liquid) to a creamy consistency. Modeling fluid is a combination of glycerin and distilled water that prevents the porcelain from drying out. Before applying the first masking coat of opaque, apply an initial, thin "wash coat" of opaque porcelain. This initial application increases the wetting action of the opaque to the metal.

2.13.1.2. Using a #6 sable hair brush, slightly moisten the casting with fluid and apply a *thin slurry* of opaque. Place the casting on the firing platform (predrying is not necessary) and fire the casting 600 to 960 ^{o}C at 32 ^{o}C per minute in a vacuum.

2.13.1.3. To apply the first coat of opaque, pick up a ball of porcelain on the brush and let it lightly contact the metal surface (Figure 2.20 -A). Move the brush down the metal and the opaque will follow it in a thin film. Continue to repeat this procedure until the entire porcelain-bearing area is covered. It is important to work quickly so the opaque stays wet before it is condensed. Gently vibrate the opaque porcelain to smooth and condense the surface. ***NOTE:*** Allow the casting to completely cool between porcelain applications. Also, rewet the surface with distilled water before making subsequent additions.

2.13.2. **Drying.** Dry the opaque in front of an open furnace door or draw the moisture away with the tip of a facial tissue. Remove any opaque porcelain from the inside of the casting or on the nonporcelain-bearing areas.

2.13.3. **Firing.** Place the casting on the firing platform. Insert the crown into the furnace and start the vacuum pump. Set the temperature at 960 ^{o}C and the rate of temperature rise to 32 ^{o}C per minute. When the furnace reaches the right temperature, immediately remove the casting and let it bench cool. (***IMPORTANT:*** Firing times and temperatures presented in this section are for VMK 68® porcelain used with Olympia® metal. They do not necessarily apply to other porcelain or ceramic alloys.)

2.13.3.1. Properly calibrate the furnace. If you have done so correctly, the fired opaque should have a matte finish or possibly a slight sheen similar to an eggshell surface. If the opaque has a glazed appearance, it was fired too high. *An expert ceramist always fires porcelain to maturity, as identified by its appearance.*

2.13.3.2. Apply the second opaque layer in a thin, even covering, eliminating all metal shadows. (Simply patching the gray areas would show through the veneer as a defect.) Fire the second layer the same as the first. The casting and opaque should now measure at least 0.5 mm in thickness, allowing 0.2 mm for the opaque layer.

2.13.4. **Opaque Effects:**

2.13.4.1. Intrinsic staining on fired opaque can help provide a basic color background to crowns. It should *not* be used to simulate special effects such as check lines or decalcification marks. These special effects are better placed in the dentin and enamel porcelains. Most porcelain manufacturers supply special opaque powders to create opaque effects. Some of these colored opaques are:

2.13.4.1.1. White—for lightening the standard opaque or adjusting the color at the incisal edge.

2.13.4.1.2. Gray—for gray shading both in the body and incisal areas.

2.13.4.1.3. Lilac Gray—same as paragraph 2.13.4.1.2.

2.13.4.1.4. Pink—for reddish discoloration spots and to produce a warmer tone in the standard opaques.

2.13.4.1.5. Brown—for increasing the brown color at the cervical area of opaque.

2.13.4.2. If the special opaque powders above are not available, try using other standard opaque powders or porcelain stains. The most practical use for opaque staining is at the cervical and incisal areas. Depending on the age of the patient, some cervical staining may be necessary. The effect may range in color from light brown to dark brown with varying amounts of other modifiers (orange and pink) mixed in.

2.13.4.3. For crowns that combine a body shade and a separate incisal shade, prepare two separate mixes of opaque porcelain and apply them as necessary (Figure 2.20-B). To lighten the incisal, mix white opaque with the chosen opaque shade or use lighter shade of opaque porcelain. To create more translucency at the incisal, mix blue, violet, or gray opaque with the chosen opaque porcelain.

2.14. Porcelain Application:

2.14.1. **Condensing Porcelain.** The process of packing the particles together and removing the water is known as condensing. The *methods* used to condense the raw porcelain mass and your *experience* as a ceramist will determine the quality and the amount of shrinkage of the processed veneer:

2.14.1.1. **Porcelain Shrinkage:**

2.14.1.1.1. The amount of shrinkage is related to the porcelain powder's particle size and shape. Porcelain powders contain several sizes of particles to reduce the amount of shrinkage. On the average, the volume shrinkage of porcelains is between 30 and 40 percent. This can be misleading, though, because the amount of linear shrinkage is only about 14 percent. Usually, you would only be concerned with the linear shrinkage because most of the shrinkage occurs in overall *length.*

2.14.1.1.2. Some porcelain powders are coarse grained, while others are fine grained. Fine grained porcelain has improved handling characteristics and lower volume shrinkage. *How does the beginner judge shrinkage?* Porcelain will always shrink toward the greatest bulk;

that is, toward the incisal and interproximal and at the suprabulge area (Figure 2.20-C). Pay careful attention to the line and point angles of the bulk porcelain buildup because they shrink the most.

Figure 2.20. Layering Technique for Porcelain Application.

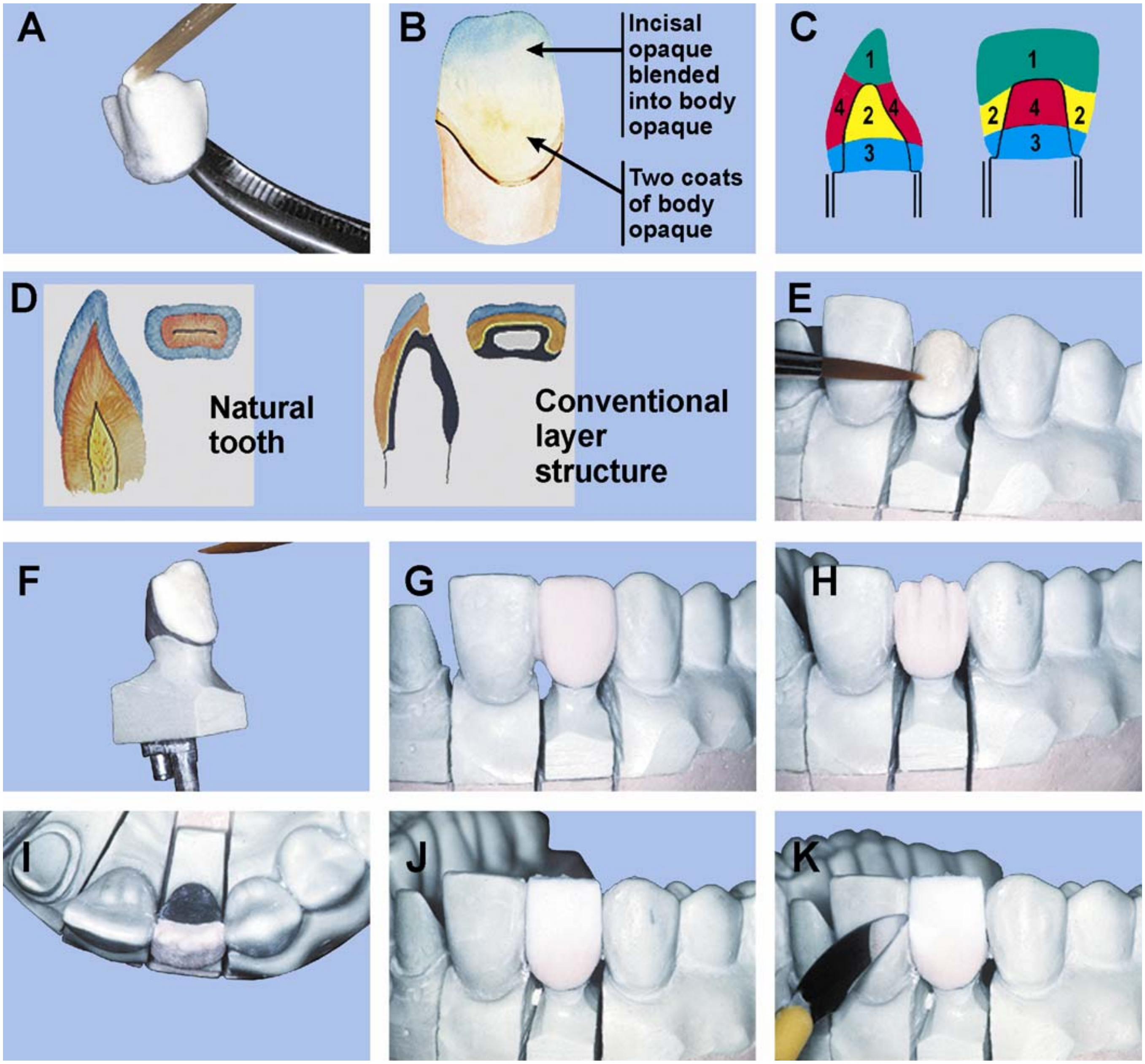
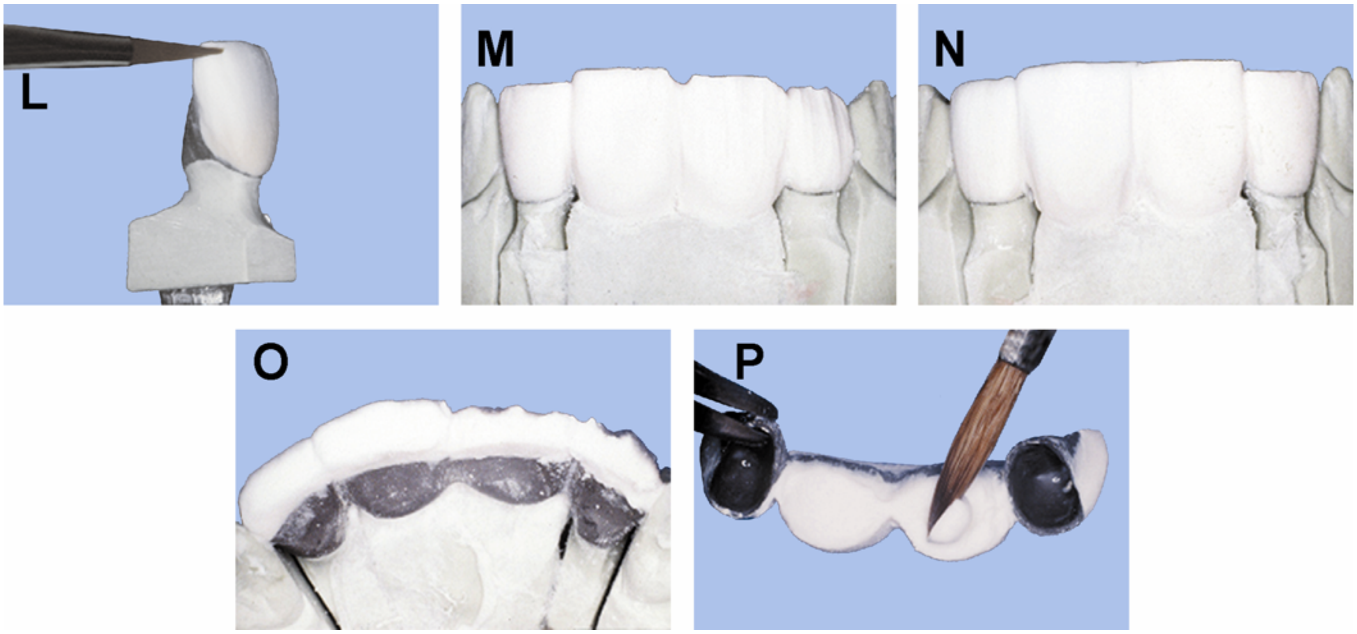


Figure 2.20. Continued.



2.14.1.2. **Methods of Condensing Porcelain:**

2.14.1.2.1. Your ability to condense the porcelain will affect the amount of shrinkage and color of the fired porcelain. If the porcelain is not condensed enough, extra air spaces between particles will make the buildup shrink more and appear grayer. In contrast, porcelain that is well condensed will shrink very little, be exceptionally hard, and appear saturated with color. It is not correct, however, to say that if a little condensation is good, a lot must be better. Hypothetically, if all the air spaces were removed, the porcelain would lose a great deal of its translucency, making the veneer look less vital.

2.14.1.2.2. Be sure to compare the shade of the restoration against its shade tab each time a buildup is fired. This will let you know how well your techniques are working. *NEVER let the porcelain mass dry out during application.* This is because dry porcelain can't be condensed and it is hard to rewet the buildup once it dries out. Use the following four methods to condense porcelain:

2.14.1.2.2.1. Apply *vibration* by serrating or tapping with an instrument. This will eliminate large air bubbles or spaces. However, it is hard to control, and cracks may unintentionally be created in the buildup.

2.14.1.2.2.2. Perform *capillary action* by blotting from the lingual surface. In this way, the flow of moisture from the facial to the lingual will draw the particles closer together.

2.14.1.2.2.3. Perform *pressure packing* by smoothing with a spatula or pressing with a clean tissue.

2.14.1.2.2.4. Continue by *whipping* or brushing the surface with a large soft brush to fill in the surface voids and remove loose particles.

2.14.1.2.3. The net effect of these four methods increases the amount of surface tension within the buildup. Surface tension is the actual *driving force* that tightly binds the mass together. The entire condensation process can be described as being more *molecular* than *mechanical*.

2.14.2. **Preparation.** Make sure the cast is clean. Seal the surface contact areas with clear finger nail polish or cyanoacrylate glue to prevent moisture absorption and contamination of the porcelain. Using a wet brush, adapt a clean piece of tissue or rice paper over the ridge area. This will help keep porcelain from adhering to the cast and consequently aid in later removal of the buildup. Accurately seat the opaqued casting on its die.

2.14.3. **Ready Materials.** Measure out the dentin and enamel porcelains onto a glass slab or ceramic dish. Using a nylon mixing spatula or glass rod, mix the dentin powder with distilled water to a thick consistency. If the mix is too wet, blot the excess moisture away from the powder bed with a clean tissue. The condition of the powder bed is important because the air bubbles that remain in the mixture are a major cause of porcelain failure. Also, you should be able to pick up small increments of the mix with an instrument or brush. The mix should not be so thin that it would drip off the end of an instrument. If using color modifiers in the buildup, simplify their placement by dyeing the separate mixes with food coloring.

2.14.4. **Layering Technique.** There are as many different methods of porcelain application as there are ceramic authorities, and each one has an approach to reproducing natural teeth. Some authorities believe concessions have to be made for the optical differences between dental porcelain and natural enamel and dentin. Others contend dental porcelain should be layered the same as natural teeth. Either approach will yield acceptable results if oral conditions are favorable and the techniques are properly executed. Figure 2.20-D shows one approach used in building porcelain.

2.14.4.1. **Applying Cervical Porcelain.** Using a #6 sable hair brush, pick up a bead of cervical shade porcelain from the edge of the mix. Start at the cervical collar and flow the mix onto the opaque (Figure 2.20-E). Place each increment of porcelain with a *gentle pushing and tapping action* and absorb the excess water with a clean, dry tissue. Less cervical porcelain is used to simulate youth; more is used for middle-aged or elderly dentition.

2.14.4.2. **Applying Opacious Dentin (Figure 2.20-F).** This material was developed with greater opacity for use in special shading situations. Opacious dentin is an intermediate shade porcelain, falling between the cervical and dentin shade porcelains. Use opacious dentin in place of cervical porcelain around the necks of teeth to slow light penetration to the opaque layer. In the darkened and shadowed interdental areas, use it to create color and brightness. Opacious dentin is especially helpful in correcting the shade difference between the pontic's gingival portion with that of the retainer's. This difference is due to the absence of opaque porcelain on the pontic's internal surface layer and the dark reflection of the gingiva. Also use opacious dentin to create dentin effects, and, in very thin areas, to prevent opaque show-through.

2.14.4.3. **Applying Dentin Porcelain (Figure 2.20-G):**

2.14.4.3.1. Build the dentin porcelain drop by drop, using a brush or apply a greater amount of material using a spatula. Do not let the porcelain dry out, leaving large voids in the buildup. Gentle vibration of the cast will bring water to the surface where it can be blotted away. Avoid heavy vibration because it tends to make the porcelain slump; and it may also displace internal color modifiers.

2.14.4.3.2. Control slumping by pressing with a tissue on the lingual surface to draw the moisture through the porcelain. As water is withdrawn, the particles pack closer together due to surface tension. Slightly overbuild the porcelain mass to allow for shrinkage. At this point, the porcelain should be compact and moist.

2.14.4.3.3. A brush additive technique is suitable when placing porcelain modifiers and stains in the buildup as it progresses. On the other hand, the spatula technique is quicker and molding of the porcelain buildup is easier.

2.14.4.4. **Cutback:**

2.14.4.4.1. Note that not only does the cutback create space for the enamel porcelain, but it also forms the shape of the natural dentin with the dentin porcelain. The amount of dentin porcelain remaining depends on the shade selected and the firing shrinkage of the porcelain mass. There is also a relationship between the amount of dentin, enamel, and age. Young teeth have larger pulp chambers, more dentin, and less enamel than middle-aged teeth. The older the patient, the thicker the enamel layer becomes.

2.14.4.4.2. Using a bladed instrument, cut back the incisal third and proximal surfaces (Figure 2.20-H and -I). Make two small grooves in the labial surface to simulate mamelons. Check the thickness of dentin porcelain covering the opaque with an instrument.

2.14.4.5. **Applying Enamel Porcelain:**

2.14.4.5.1. Mix the enamel porcelain a little thinner than the dentin porcelain. If the buildup is too dry, moisten it slightly before applying the enamel. Trying to add wet porcelain to an already dry buildup will cause entrapment of *large air bubbles* and *areas of blotchy opacity*.

2.14.4.5.2. Pick up a bead of enamel porcelain and apply it to the buildup. Continue to build up the incisal area until the original contour is established. The final buildup should extend 1 to 1.5 mm past the desired length (Figure 2.20-J). The enamel porcelain should blend well into the middle third or, for some shades, into the gingival third of the tooth. This enamel overlay prevents a *visible line* of demarcation and creates an illusion of depth.

2.14.4.6. **Completion.** Using a thin blade, remove any porcelain from below the proximal contact area that might be in an undercut (Figure 2.20-K). Carefully remove the built up restoration from the cast. Remove any dirt particles that might be present because they will be visible through the porcelain. Moisten the mesial and distal contact areas of the buildup and apply clear porcelain to these areas (Figure 2.20-L). Smooth the completed buildup with a large soft brush to remove any loose particles. Clean excess porcelain away from the metal-ceramic junction, as well as porcelain particles inside the crown. Check the overall outline, contour, and detail of the buildup. Place the restoration to be fired on a sagger tray.

2.14.5. **Building FPDs:**

2.14.5.1. **Applying Porcelain.** Follow the procedures in paragraphs 2.14.4.1 through 2.14.4.3 when applying porcelain.

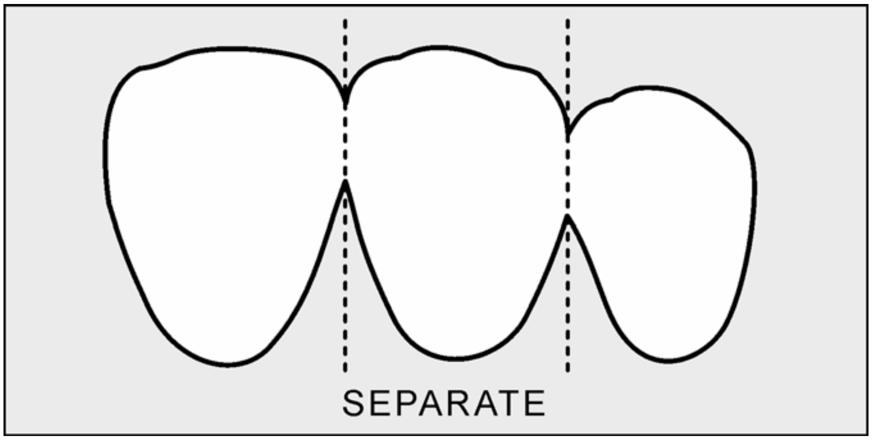
2.14.5.2. **Cutback.** One technician might prefer to build each unit separately and cut back each one separately, trying to be as uniform as possible. Another technician will build the entire FPD in dentin porcelain, cut back the entire buildup, and then complete it with the application of enamel porcelain. Someone else would prefer to apply dentin porcelain and only cut back half of the buildup (Figure 2.20-M through -O). In this way, the enamel porcelain can be added to the cutback, using the adjoining buildup as a guide.

2.14.5.3. **Contact Areas.** Start by removing any porcelain that may be in an undercut. Remove the buildup by gently pushing up on the retainers. If any porcelain should break off, add it back or rebuild it. Now add clear porcelain to the mesial and distal contacts and dentin porcelain to the ridge area (Figure 2.20-P). Be careful in vibrating to avoid making the porcelain slump.

2.14.5.4. **Firing Shrinkage:**

2.14.5.4.1. Firing shrinkage varies with the type of restoration. The porcelain on single unit crowns shrinks towards the center of the buildup. In the case of FPDs, firing shrinkage causes stress in the porcelain in the interproximal areas as it is drawn toward the center of each unit. Some porcelain manufacturers recommend that each unit be separated by cutting through to the opaque, using a sharp instrument such as a razor blade (Figure 2.21). Do this to relieve stress and prevent cracking in the *conventional* buildup technique. The resulting gap between the units is later filled in during the correction step.

Figure 2.21. Separating the Units.



2.14.5.4.2. An *alternative* method to separating the units is to thoroughly precondense those areas where cracking is likely to occur. Using this method, first apply porcelain to the cervical and proximal areas and condense. Then, place the restoration on the working cast, and complete the porcelain buildup.

2.14.6. **Building Porcelain Cusps (Figure 2.22).** There are two ways of controlling firing shrinkage. Either porcelain can be built in two or three bakes to full occlusion with the articulator closed or the porcelain can be built in one bake with the incisal pin opened one to two millimeters. Using the latter method, occlusion is restored and then refined during the contouring step (paragraph 2.15). Because the second method is simpler, its description is presented below:

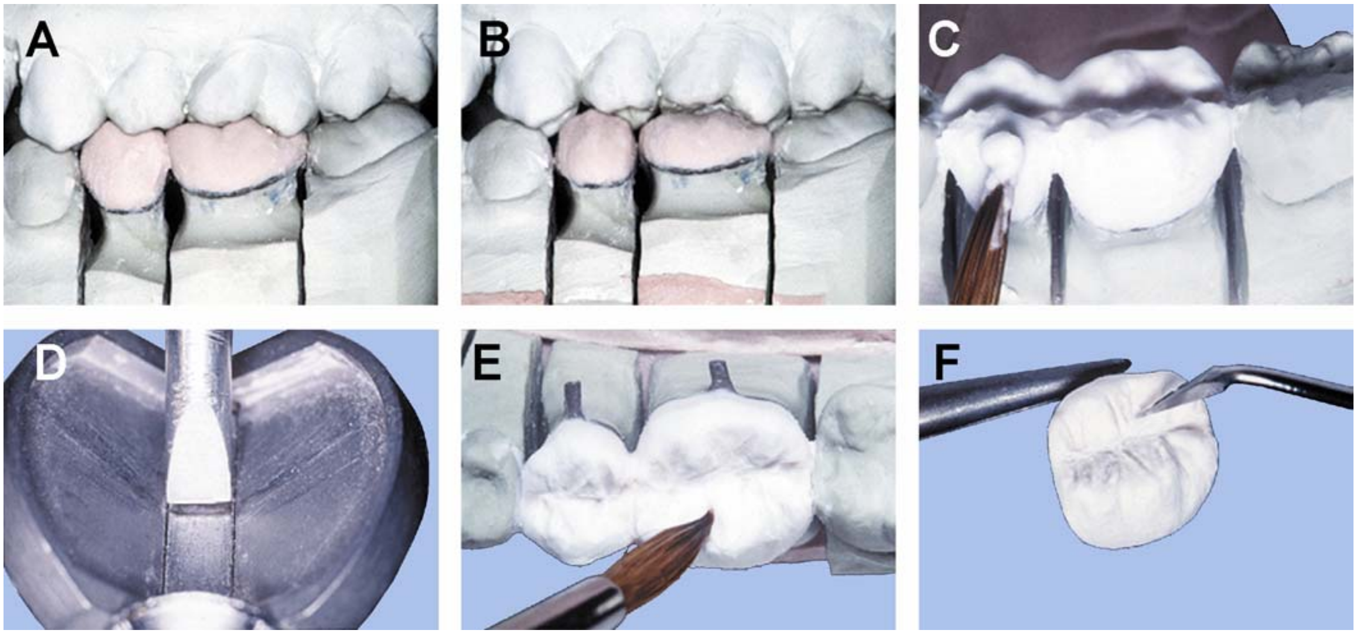
2.14.6.1. Follow procedures in paragraphs 2.14.4.1 and 2.14.4.2 for applying cervical or opacious dentin porcelain.

2.14.6.2. Before building the dentin porcelain, apply a thin layer of cervical porcelain or orange-brown modifier near the occlusal fossae. Doing this will provide increased chroma in the depths of the occlusal grooves and fossae.

2.14.6.3. Apply dentin porcelain establishing cusp height and contour with the articulator completely closed (Figure 2.22-A).

2.14.6.4. To cut back the dentin porcelain, first remove 1 mm of porcelain from the occlusal table (Figure 2.22-B). Reduce the buccal, lingual, and proximal surfaces by 1 mm and inspect the amount of cutback.

Figure 2.22. Building Porcelain Cusps.



2.14.6.5. Apply the enamel porcelain to the buildup in wax-added fashion—first the functioning cusps and then the nonfunctioning ones. Apply enamel porcelain to the external surfaces of the buildup before establishing the internal inclinations of the cusps (Figure 2.22-C). Next add the marginal ridges and fill remaining occlusal voids. Condense the buildup at each stage. The completed enamel buildup should elevate the incisal pin 1 mm to compensate for shrinkage when fired (Figure 2.22-D).

2.14.6.6. After building with the restoration in occlusion, carve the primary grooves in the occlusal surface with a brush tip (Figure 2.22-E).

2.14.6.7. Remove the buildup and add to the proximal contacts. Thoroughly condense the buildup.

2.14.6.8. Because firing shrinkage can be predicted fairly accurately, carve the delicate secondary anatomy into the occlusal surface using a small bladed instrument (Figure 2.22-F).

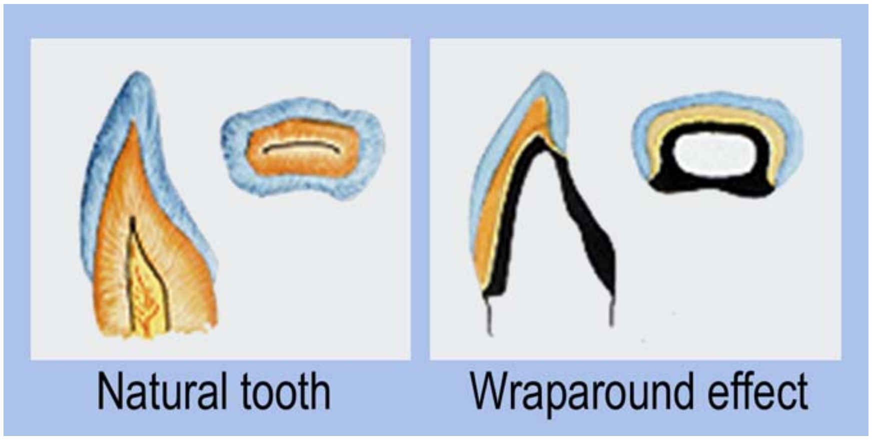
2.14.7. **Modified Layering Technique.** The clinical crown of a natural tooth is covered with enamel, creating a transition and depth of natural color. The conventional layering technique does not provide this "wraparound" effect of enamel. Use the modified layering technique as shown in Figure 2.23. It nearly copies natural dentition as follows:

2.14.7.1. Follow the basic technique for building porcelain layers as in paragraph 2.14.4.1 through 2.14.4.3.

2.14.7.2. Cut back the incisal third, proximal, and interproximal surfaces of the dentine layer. Remove about 1 mm of porcelain from each surface. Be sure to draw accurate guidelines on the surface before cutback. The amount of cutback on the proximal and interproximal surfaces is especially difficult to determine.

2.14.7.3. Apply enamel porcelain to the dentin layer. The enamel layer should be built up to resemble the contour of dentin porcelain prior to cutback. The enamel porcelain should extend slightly beyond the incisal edge to cover the dentin porcelain.

Figure 2.23. Wraparound Effect of Enamel.

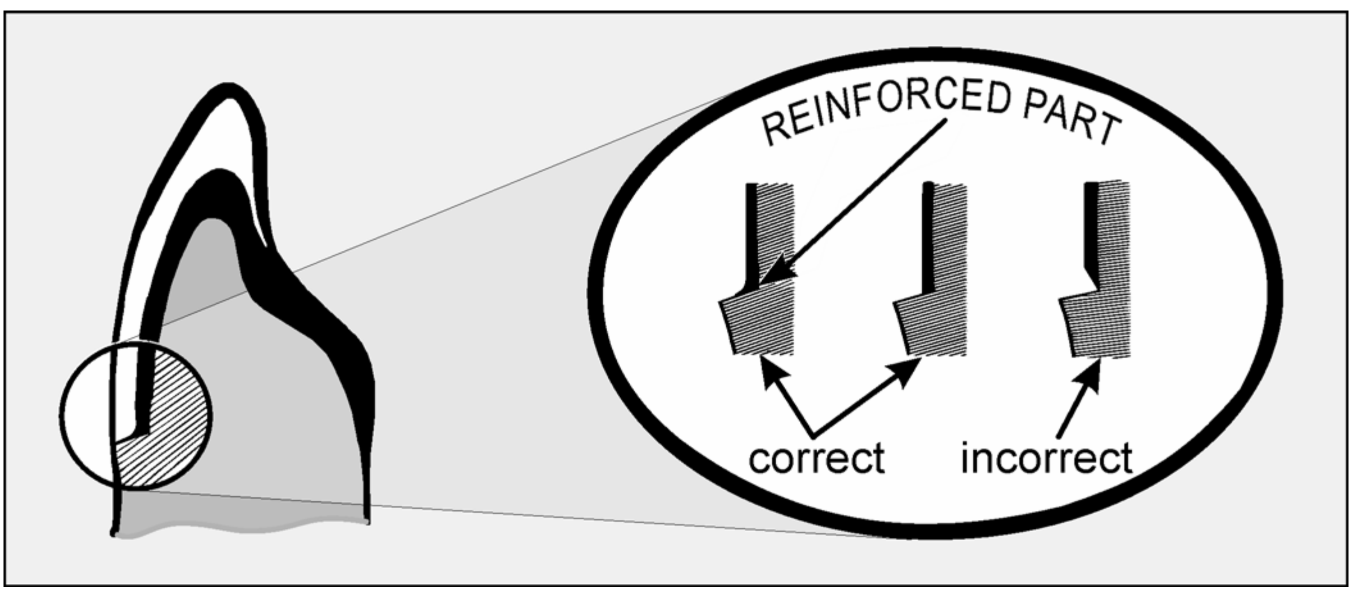


2.14.7.4. Apply clear porcelain to the entire facial surface. This will provide depth of color within the fired restoration. The completed buildup should be 15 to 20 percent larger than the finished restoration. Because a clear porcelain layer that is too thick makes the crown appear dark and gray, exercise care when constructing the dentin and enamel layer.

2.14.7.5. Once the facial surface is complete, cut back the lingual surface to make room for the next porcelain addition. Apply clear porcelain to the prepared lingual surface to complete the wraparound effect. Completion of the buildup is the same as the basic layering technique.

2.14.8. **Porcelain Margin Technique.** The ideal preparation for a collarless crown is a 90-degree shoulder preparation on the facial extending from one proximal surface to the other. This type of labial margin preparation allows you to butt the porcelain directly to the shoulder area. Alternate styles of margin preparation and casting design appear in Figure 2.24.

Figure 2.24. Margin Designs for Collarless Crowns.



2.14.8.1. **Materials.** In addition to the conventional materials, you will need:

2.14.8.1.1. *Cyanoacrylate glue* for sealing the surface of the die.

2.14.8.1.2. *Porcelain separating medium* (or mineral oil) to use as a release agent for the raw porcelain.

2.14.8.1.3. *Shoulder porcelain* for building the porcelain margin. Shoulder porcelain is gingival-shaded porcelain specially prepared to have a higher sintering temperature than other metal bonding porcelains. Many porcelain manufacturers have shoulder porcelain available for use with their systems.

2.14.8.1.4. *Medium* for mixing the shoulder porcelain. Distilled water is preferred, but it is sometimes difficult to remove the casting and wet porcelain without fracturing the buildup. Some technicians prefer to mix the shoulder porcelain with the special liquid provided with phosphate bound investments. This special liquid reacts with the porcelain, causing it to stiffen. Specially prepared waxes have also been developed to mix with porcelain. Mix 8 parts porcelain to 1 part wax by weight. Proponents of the wax technique say it works well in extremely difficult margin situations.

2.14.8.2. **Procedures.** It is difficult to achieve marginal accuracy with porcelain, due to firing shrinkage. Therefore, porcelain margins must be built up two or three times until an acceptable fit is achieved.

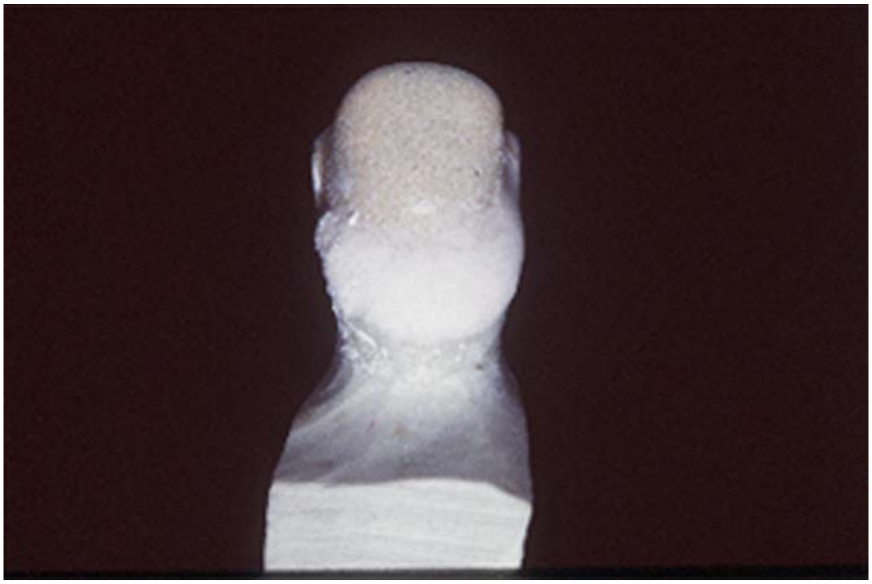
2.14.8.2.1. Start by waxing the substructure as designed in Figure 2.25. Invest and complete the substructure in the usual manner. When finishing the casting, do not thin the metal at the labial shoulder because this could weaken the porcelain margin. Also ensure the proximal metal-ceramic junction meets the cervical margin abruptly at a 90-degree angle to reduce the chance of metal creep during firing. Opaque the casting.

Figure 2.25. Wax Patterns for Porcelain Margin Technique.

2.14.8.2.2. Apply a thin coat of cyanoacrylate glue to the facial shoulder area. After the glue has dried, apply a light coat of separating medium.

2.14.8.2.3. Make the buildup in two steps. First apply a bulk of shoulder porcelain to the shoulder area. Carefully remove the casting and dry the buildup (Figure 2.26). As the porcelain is drying, you may notice small dark areas on the surface. These dark areas are small amounts of organic matter in the porcelain. In this instance, the entire cervical margin will appear black because of the separator. Don't fire the porcelain until this area has completely dried or porosity will result in the processed porcelain.

Figure 2.26. Applying Shoulder Porcelain in the Porcelain Margin Technique.



2.14.8.2.4. Once the porcelain has been fired, add more shoulder porcelain to the marginal area to fill the gap and repeat the firing process. When the crown is again cool, contour the processed porcelain to finalize the facial margin. The remainder of the construction sequence follows the normal metal-ceramic technique.

2.14.9. **Dentin Effects (Figure 2.27).** You can create a multitude of dentin effects in the dentin porcelain with porcelain powders called *effect powders* or *modifiers*. Porcelain stains may also be used, but their intensity is hard to control.

2.14.9.1. **Altered Shades.** Basic hue and chroma changes can be made to a small area of the dentin porcelain or to the entire facial surface area of the veneer.

2.14.9.1.1. To increase chroma in a small area, start by building the porcelain to full contour and then carve away the porcelain in the affected area (Figure 2.27-A). Next, apply the effect powder to that area, tapering the porcelain onto the sides (Figures 2.27-B and -C). The dentist may request that the entire gingival shade be altered, changing the hue of the veneer.

2.14.9.1.2. To make a predominantly gray shade appear yellower, first cover the opaque with a layer of porcelain that has a yellow hue (Figure 2.27-D and -E). Follow this layer with a layer of porcelain that has a gray hue. You can decipher the dominant hue for a given shade porcelain by looking at the shade guide. Whatever the desired effect, you can make it by combining different porcelain shades.

2.14.9.2. **Dentin Mamelons:**

2.14.9.2.1. In many cases, dentin mamelons (Figure 2.27-F) originate during the development of the teeth, appearing as three finger-like extensions of the dentine separating the incisal edge.

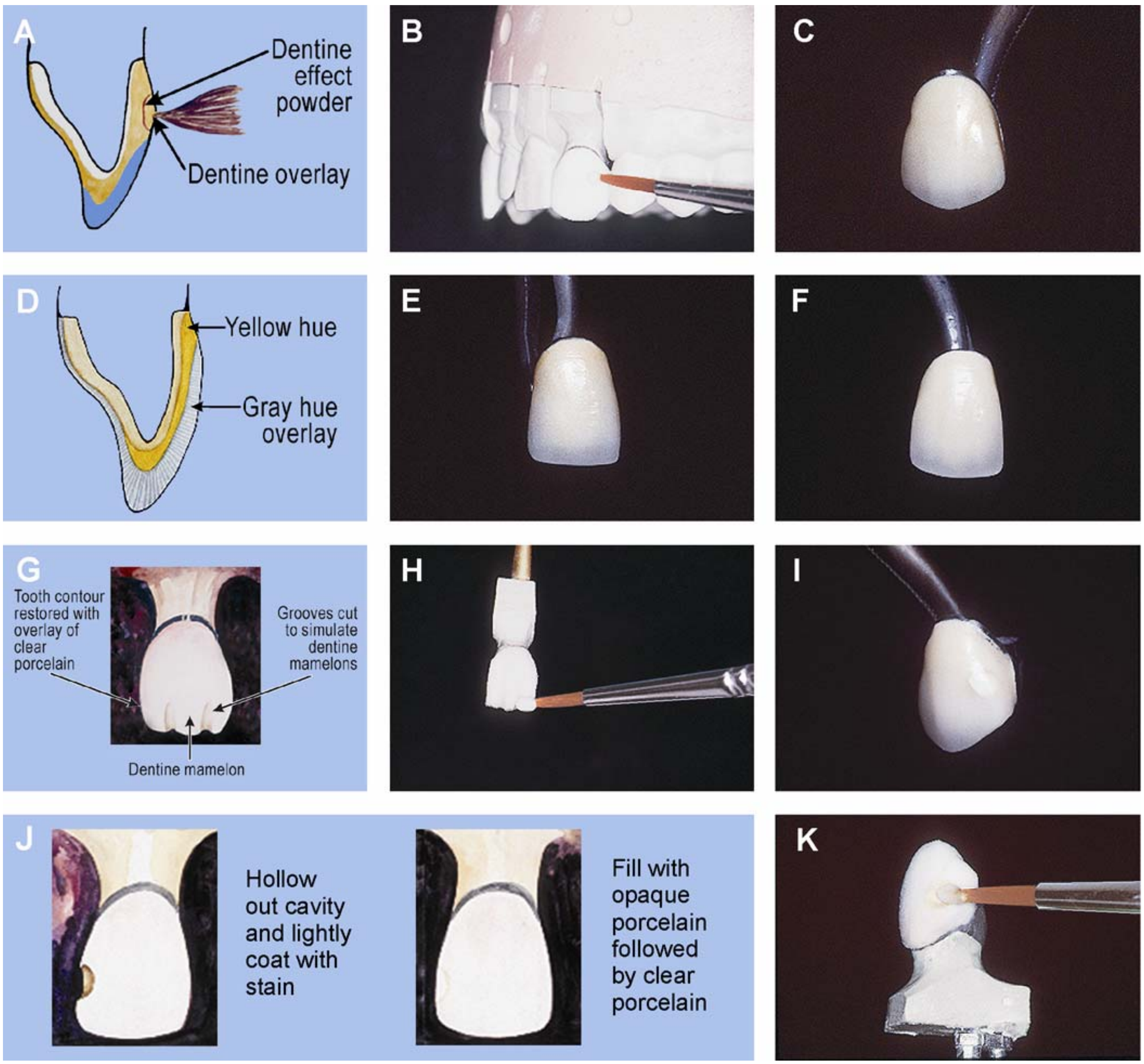
2.14.9.2.2. To simulate this effect. the porcelain is built to full contour and two grooves are cut into the incisal third (Figure 2.27-G). Then a small amount of colorless porcelain is placed in each groove (Figure 2.27-H). The net effect will be to increase the translucency in these areas.

2.14.9.3. **Discolored Fillings:**

2.14.9.3.1. Discolored fillings (Figure 2.27-I) are composite or plastic restorative materials that have discolored. They usually appear opaque like and have brown discoloration marking their boundaries.

2.14.9.3.2. Build the porcelain to full contour and hollow out the area to be filled (Figure 2.27-J). Lightly coat the walls of the cavity with yellow-brown stain. Then fill the cavity with a core of opaque porcelain followed by clear porcelain (Figure 2.27-K).

Figure 2.27. Dentin Effects in Dental Porcelain.

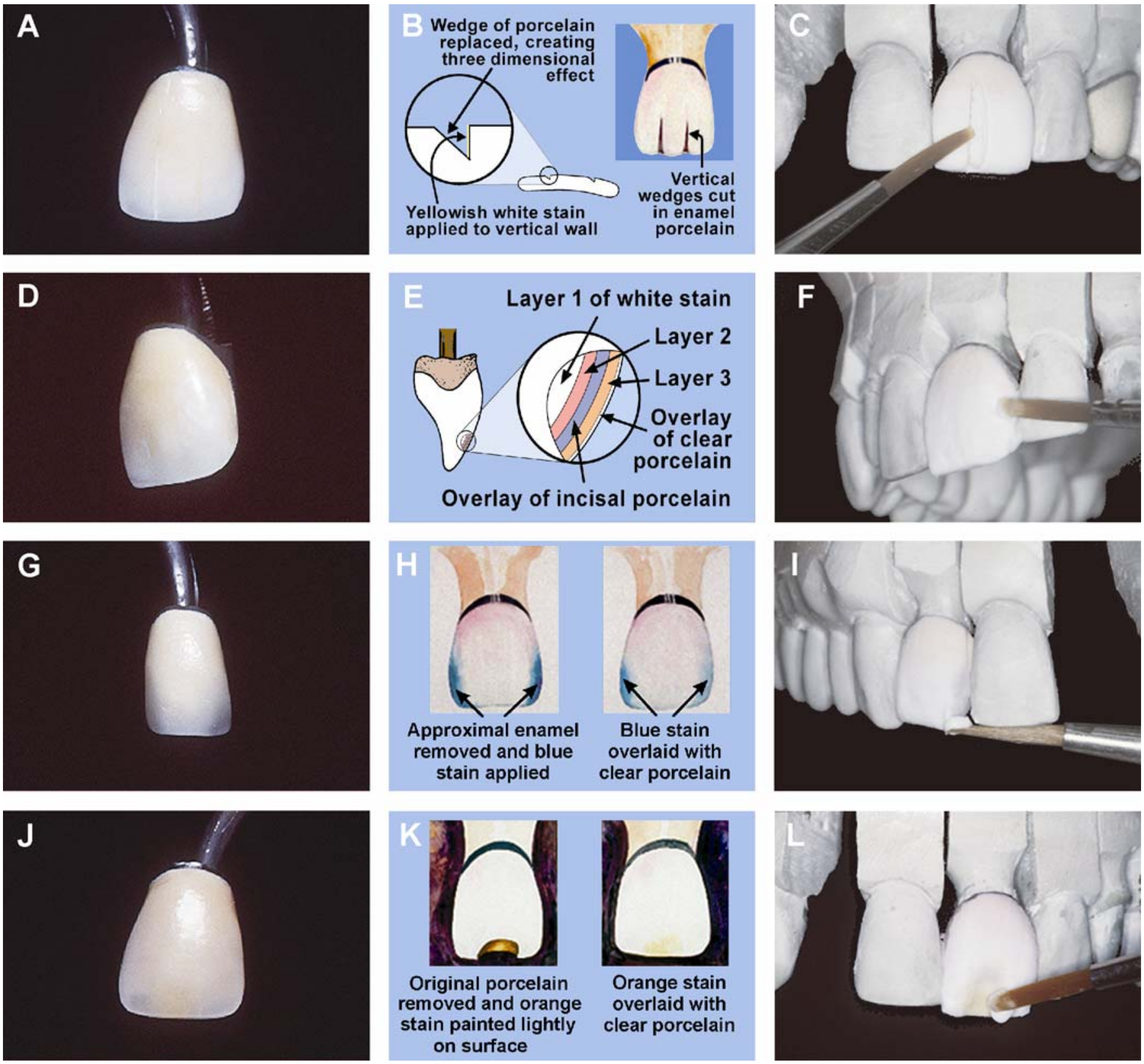


2.14.10. **Incisal Effects (Figure 2.28).** These effects range from fine check lines to strong orange hues. The effect of subtle shading of the incisal will drastically affect the appearance of the veneer.

2.14.10.1. **Enamel Check Lines (Figure 2.28-A):**

2.14.10.1.1. To adequately simulate a natural check line or crack, reproduce it in depth. The reason for this is these defects in the enamel are difficult to reproduce with surface stains.

Figure 2.28. Incisal Effects in Dental Porcelain.



2.14.10.1.2. Build up the entire crown, including enamel porcelain. Cut a V-shape wedge in the incisal third and put it aside to be replaced later (Figure 2.28-B). Now, with one light stroke, apply yellow-white stain to the vertical wall and remove any excess from the facial surface with a clean brush. Do not work the stain into the porcelain. Gently replace the wedge slice you saved earlier and seal the cut by lightly tapping the cast on the bench top (Figure 2.28-C). Failure to seal the cut could lead to fissure cracks during firing.

2.14.10.1.3. This effect is also accomplished by creating and staining a vertical wall during initial layering of the incisal porcelain. This eliminates difficulties associated with replacing and sealing the V-shaped wedge. However, great care must be taken to ensure the stains are not disturbed while completing the incisal buildup.

2.14.10.2. **Hypocalcification:**

2.14.10.2.1. Note that white hypocalcified areas are also hard to reproduce with surface stains. They often appear as a series of white dots that do not look like natural hypocalcification (Figure 2.28-D). This effect is better treated using white modifiers or effect powders in the porcelain buildup. White effects are better created if they are applied in two or three layers (Figure 2.28-E).

2.14.10.2.2. Use a fine brush tip to pick up just the right quantity of white powder and gently rub it into place. Then cover the white powder with enamel porcelain and repeat the process (Figure 2-27-F).

2.14.10.3. **Blue Translucency:**

2.14.10.3.1. Remember, natural teeth often appear more translucent (Figure 2.28-G) at the mesial and distal incisal edges.

2.14.10.3.2. To create this effect, remove a small amount of incisal porcelain from the mesial and distal proximal surfaces (Figure 2.28-H). Apply blue stain to these areas with a light stroke and overlay them with clear porcelain (Figure 2.28-I). Be careful not to remove too much incisal porcelain because this will cause the blue effect to be lost in the graying of incisal by the clear porcelain.

2.14.10.4. **Incisal Orange Hue:**

2.14.10.4.1. Notice how this effect appears as an orange hue at the incisal, just short of the incisal edge (Figure 2.28-J). The enamel outlines the orange effect like a halo.

2.14.10.4.2. To reproduce this effect, first scoop out a section of enamel porcelain from the facial surface of the incisal edge (Figure 2.28-K). Next, apply orange stain to the prepared area. Follow that with an application of clear porcelain (Figure 2.28-L).

2.15. First Dentin-Enamel Firing:

2.15.1. **Drying.** Let the buildup dry fully to keep from releasing steam and causing large sections of the veneer to crack. The amount of drying time depends on the amount of moisture, which can be judged by the density of the mass and elapsed time from initial application. Also, setting the entrance temperature too high will fracture the porcelain. Dry and preheat gradually by moving the restoration closer to the hot zone of the furnance muffle in stages. The entire drying, preheating, and inserting process usually takes 3 to 6 minutes, depending on the number of units to be fired. The entrance temperature should stay at 600 ^{o}C during this entire process.

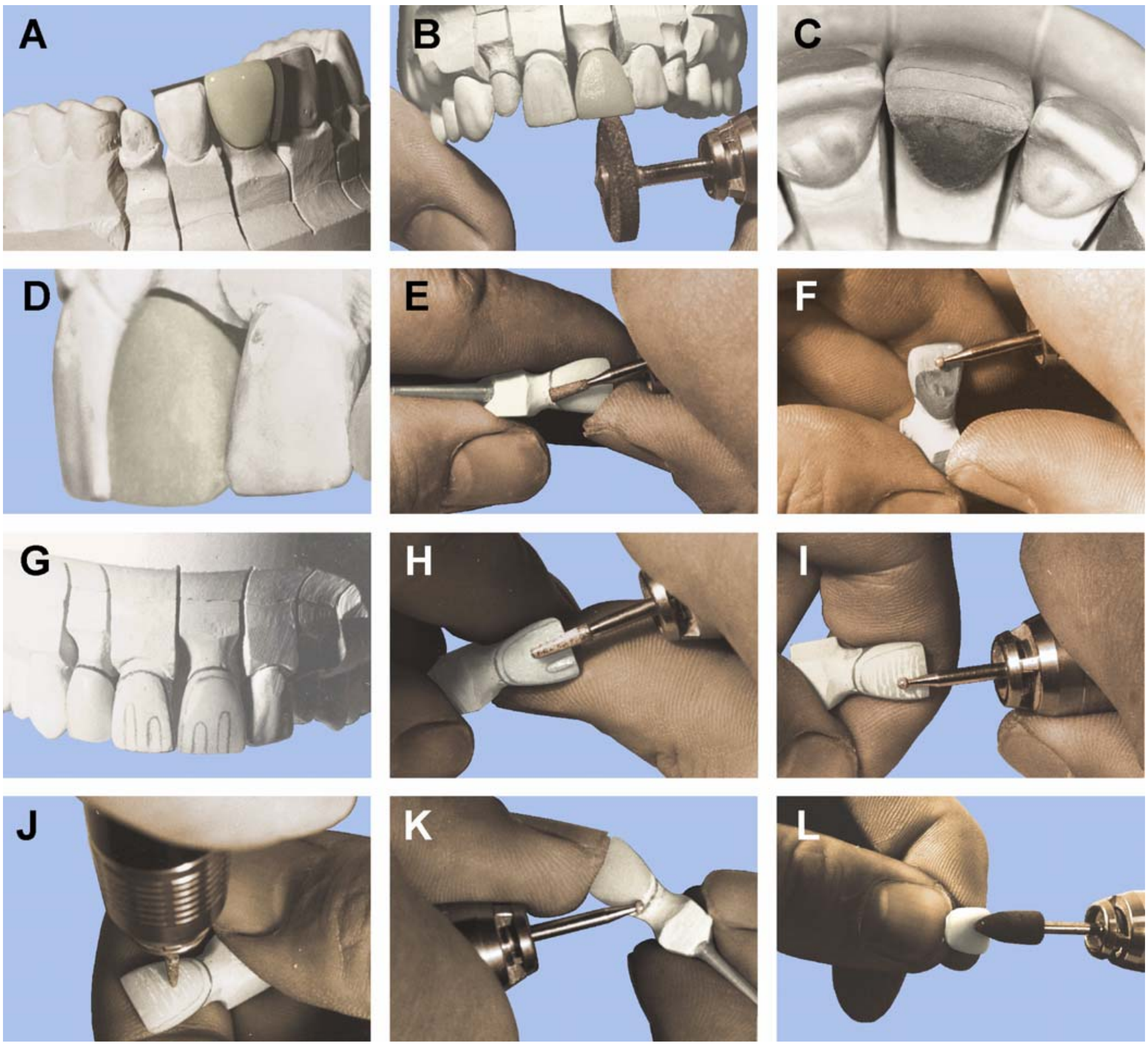
2.15.2. **Firing Sequence.** Center the restoration in the muffle or on the firing platform and close the muffle door. Seal the vacuum chamber and start the vacuum pump. Do not increase the temperature until you get a full vacuum of 26 to 29 inches of mercury. Set the amperage control for a rate of rise of 32 ^{o}C per minute and set the temperature control for the maturing point of the porcelain at 940 ^{o}C. When the restoration reaches 940 ^{o}C, release the vacuum and remove the fired porcelain immediately. Let the restoration cool completely before handling it. Most porcelain furnaces in use today can be pre-programmed to follow the porcelain manufacturer's recommendations for firing their porcelain.

Section 2E—Anatomical Contouring

2.16. Shaping the Sintered Porcelain Veneer:

2.16.1. Use abrasives designed for finishing and polishing porcelain surfaces to shape the veneer. Each type abrasive has a specific function (Figure 2.29). Certain rubber wheels and points are used to smooth and polish. Bulk-reducing wheels can be used for most of the overall contour. These abrasive wheels remove porcelain quickly and wear at about the same rate as the porcelain, making them ideal for "roughing out" the restoration's form.

Figure 2.29. Contouring Metal-Ceramic Restorations.



2.16.2. Various shaped diamond-cutting instruments can also be used for shaping and characterizing the surface. When they are new, these devices cut very quickly and should be used cautiously. An alternative to the "diamonds" would be mounted stones and points.

2.16.3. Avoid using abrasives that have been used on other materials. Each time you must refire the restoration, be sure to remove the porcelain's glaze first by lightly air abrading the surface with aluminum oxide and then clean the restoration using an ultrasonic and distilled water. (Review Chapter 1, Section 1H, Esthetics, before continuing.)

2.17. Establishing the Overall Contour:

2.17.1. Initially, inspect the inside of the crown for sintered (fired) porcelain particles or other interferences that might keep the crown from seating. Seat the crown on its die and verify its marginal accuracy. Sometimes the metal may distort upon sintering, lifting away from the preparation's shoulder (known as metal creep). If possible, adjust each proximal contact separately until the crown is completely seated on the cast (Figure 2.29-A). When through making adjustments, the crown should be in light contact and smooth. The proximal surface can either be rubbered smooth or lightly finished with a sandpaper disc.

2.17.2. Next, restore the functional occlusion of the crown according to the dentist's prescription (that is, unilateral balance or mutually protected occlusion). Restore MI first; then adjust the restoration in working, balancing, and protrusive excursions. When adjusting the crown in excursive movements, be careful not to remove too much of the crown's length. When the occlusion is correct, you can then adjust the length of the incisal edge until it matches the adjacent tooth (Figure 2.29-B). Also consider the linguoincisal line angle of the incisal edge. This angle may be steep or shallow, showing visible signs of wear (wear facets). *Precision grinding* of the incisal edge and embrasure form is an absolute must.

2.17.3. Using a bulk-reducing wheel, grind away enough porcelain from the facial surface until the curvature matches the teeth being duplicated. The mesiodistal and distofacial line angles are especially important because almost all anterior teeth exhibit a "rounding in" effect at their distofacial surface. From incisal and proximal views (Figures 2.29-C and -D), inspect the facial contour and alignment of the incisal edge.

2.17.4. Frequently check the thickness of the veneer with a metal gauge, especially in the incisal third area. If the thickness measures less than 1.2 mm, chances are the opaque may be noticeable through the enamel porcelain. This " light spot" of opaque is hard to hide, using extrinsic stains. An alternative to this approach is to shape the restoration in a protruded fashion, but esthetics of the restoration might be compromised.

2.17.5. Shape the cervical third of the veneer so the contour is continuous with the cervical collar (Figure 2.29-E). If the crown is collarless, also refine the porcelain shoulder margin at this time. Normally, the height of contour of the crown (suprabulge area) will correspond to the adjacent teeth.

2.17.6. Smooth the entire facial surface while ensuring all the line angles are correctly positioned. Inspect the shape of the labial surface by viewing it from several aspects. You should be able to line up the facial surface of the restoration with the adjacent tooth. This exact symmetry is not always the goal, but use it as a guide.

2.17.7. Once you have defined the overall facial contour, start shaping the lingual surfaces with a small diamond wheel or ball diamond (Figure 2.29-F). The crown should have a definite lingual fossa with incisal edges corresponding to the adjacent teeth. Check again to ensure the crown functions properly with the movements of the articulator in excursive positions.

2.18. Charactering the Veneer Surface:

2.18.1. Study the working cast or diagnostic aid for surface details. Most teeth have a satin finish, and only the high spots, such as ridge and point angles, will be shiny. Often signs of wear or abrasion may change the character of older teeth. These teeth may appear smoother, and some facial anatomy (horizontal grooves, development lobes) may be absent. Only a close inspection of the adjacent teeth of a diagnostic cast will determine the exact method of characterization.

2.18.2. With a sharp pencil, trace out the ridge and point angles (Figure 2.29-G) and make a final check of the facial contour. Use a small diamond point or diamond wheel to make the developmental grooves. Scribe a fine groove. Then, if necessary, widen and deepen it by gently moving the diamond from side to side (Figure 2.29-H).

2.18.3. Observe how numerous small transverse lines may sometimes cover the facial surface of teeth. The surface may vary greatly from having deep irregular grooves to appearing almost smooth. Use a small diamond ball to create these striations (Figure 2. 29-I). Finer lines can be drawn across the surface as shown in Figure 2.29-J.

2.18.4. Note that the patient's tissue will often recede, exposing the cervix of the tooth. Reproduce this cervix on the veneer's surface or the crown will look too long. Overcontour in the cervical area can also lead to chronic gingivitis. Use a small round diamond to simulate the cervix of the crown (Figure 2.29-K). Your goal in this critical area is to reproduce the original contours or to match the adjacent teeth. Lightly touch and polish all high spots with a rubber wheel to simulate natural wear in the mouth.

2.19. Establishing Occlusal Surfaces. It is difficult to establish occlusal contact in porcelain as successfully as with metal. The optimum type of occlusion for a porcelain occlusal is mutually protected occlusion because the forces of mastication are mostly vertical. Also, when possible, cusp-to-fossa tooth orientations are preferred.

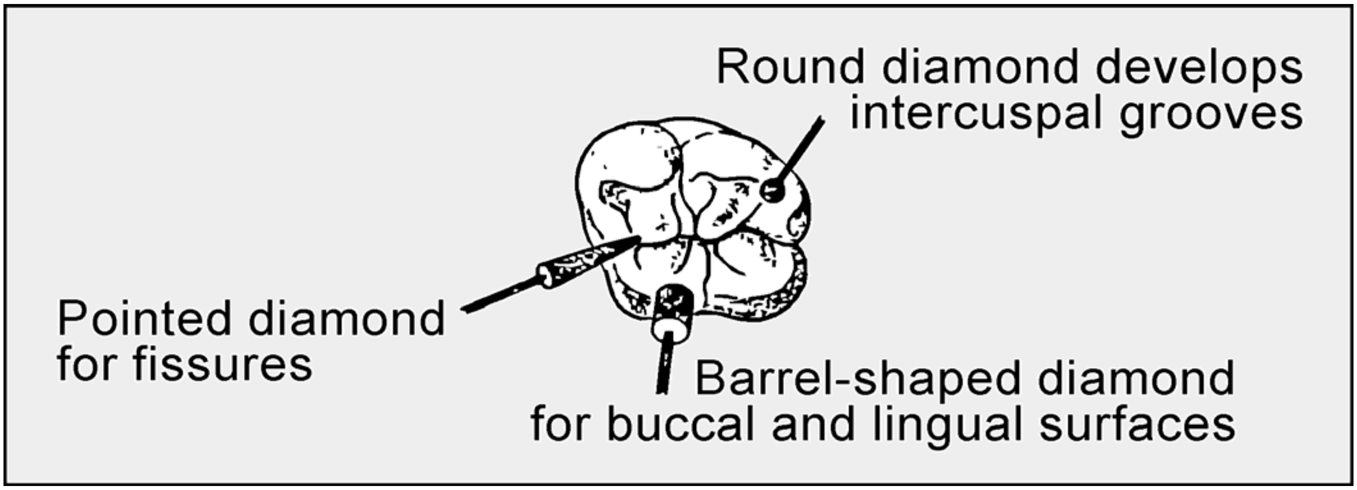
2.19.1. **Contacts.** Avoid contact on marginal ridges where porcelain is easily fractured. Do not widen occlusal tables or leave sharp edges on porcelain cusps because breakage is more likely.

2.19.2. **Redefine Occlusal Anatomy.** Grinding posterior occlusal surfaces requires great skill. The objective is to *highlight* detailed anatomy made when the porcelain was first applied, not create it. The grinding stones and diamonds should, therefore, be used with a very light action. Some suggested finishing devices and their uses can be seen in Figure 2.30. Fissures should be finished with points, and supplemental grooves and fossae with small round diamonds. Be sure to remove all porcelain that overlaps the metal before glazing. During final polishing, any fired porcelain left on the metal will be very hard to remove.

2.20. Shaping FPDs. As the number of units increases, so does the level of difficulty. Finishing an FPD will require more time and patience. Before you actually start, *think about* and *plan* your approach to contouring each restoration. It may be helpful to scribe a pencil line showing the boundaries of each individual unit.

2.20.1. The initial steps of seating the restoration are the same as for a single unit. Adjusting the contact areas will be easier if you can remove one of the adjacent teeth or ridge area from the cast. The process of functionally contouring begins by restoring MI, then working and balancing excursions, and finally the protrusive excursion. A diagnostic cast is almost a necessity in determining the length of a larger anterior FPD. Without it, estimate the length according to the anterior guidance present and the proportionate length of the remaining anterior teeth.

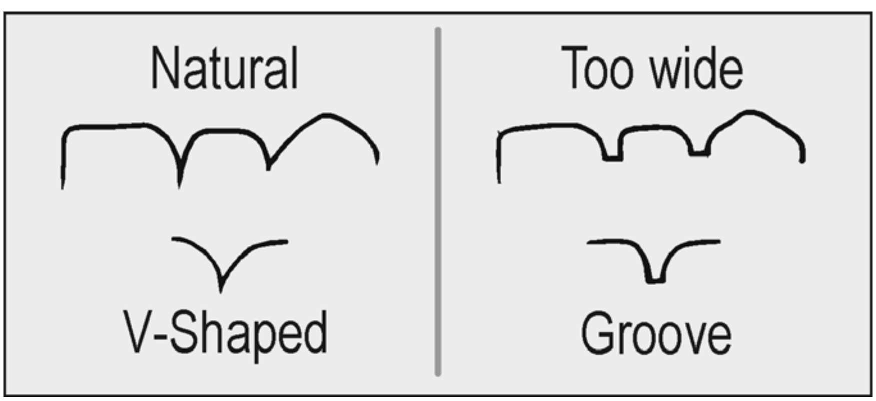
Figure 2.30. Types of Diamonds Used To Carve Porcelain Occlusals.



2.20.2. One of the more difficult steps involves shaping the interproximals. During the porcelain application step, many ceramists cut through the porcelain to the opaque, separating the teeth. When the restoration is processed, the porcelain shrinks away from these areas. The task now is to remove all sharp edges by light grinding with a diamond-coated disc and then later adding porcelain to the interproximal areas and refiring the restoration. But first, its best to shape the remaining bulk of porcelain to establish the overall contour and prevent needless repeated porcelain additions. Then, lightly air-abrade and clean the restoration in an ultrasonic before adding porcelain in the interproximals and other deficient areas. ***NOTE:*** Ensure interproximal spaces are precisely positioned and contoured to allow only minimal finishing.

2.20.3. Separation between the units must be *finely* divided and deep enough so the teeth will appear natural (Figure 2.31). This division should appear V-shaped and not like a groove separating the individual units. It takes patience to shape teeth to look natural and not like “cutouts” bonded to a metal backing. Use a diamond-coated ultra-thin separating disc to divide the units. Exercise care not to grind through the porcelain, exposing the opaque layer or underlying metal.

Figure 2.31. Separation Between Units of Anterior FPDs.



2.21. Second or Corrective Dentin-Enamel Firing. To add porcelain, first remove the glaze and clean the restoration. Then apply the same porcelain powders originally used during the initial application to make the addition. Be sure to add enough porcelain to allow for recontouring. Process the porcelain addition under vacuum and at a slightly lower temperature.

2.22. Repairing Porcelain (Low-Fusing, Air-Fired):

2.22.1. Another way to correct post-completion contour or repair porcelain veneers is with repair porcelain (for example, correction powder). These porcelains will bond to glazed or unglazed surfaces, but, an unglazed surface is preferred. Repair porcelain fusing temperatures are considerably below that of the standard veneer porcelains. Consequently, they are sometimes mixed with standard powders to lower the fusing temperature of the mix.

2.22.2. Uses for repair porcelain include filling imperfections such as bubbles or cracks, adding onto the occlusal where it does not contact the opposing bite properly, adding to interproximal contact areas, adding to pontics that are short of contacting the tissue, and correcting crown contour near the gingiva. These additions can be carried out at the glaze step without risking the vacuum cycle and possibly causing the veneer porcelain to bubble.

2.22.3. While some repair porcelains such as *Ceramco® 1600 Add-On Porcelain* are supplied in as many shades as standard porcelains, others are designed to be mixed with the regular dentine and enamel powders. Because materials are widely different and repair situations vary, consult the manufacturer's directions when using repair porcelains.

Section 2F—Staining

2.23. Shade Modification and Characterization. Extrinsic staining involves applying porcelain stains to the surface of a porcelain restoration and then processing the stains, usually during the glazing sequence. When the stains are fired, they actually become part of the porcelain, covered by a thin, transparent glaze layer. Surface stains are highly pigmented objects that absorb some wavelengths of light and reflect others. As such, when they're used in heavy concentrations, they tend to mask the surface of the porcelain, reducing the translucency and vitality of the product. The stains should be mixed to a consistency that is neither too dry nor too wet. They should flow on easily (evenly and smoothly), but stay in place and not run. The surface on which the stains are placed should be clean and dry and, of course, the glaze must be removed. Review Section 2B on color and shade.

2.23.1. **Shade Alteration.** Any changes in shade should be minor and, if possible, limited only to corrections between adjacent shade tabs. It would be better to remake the veneer rather than make a major correction to the shade.

2.23.1.1. **Surface Glaze.** Apply a liquid glaze medium to the porcelain surface to simulate a glazed surface. The *liquid medium* will restore the surface luster and allow a good appraisal of color. Do not use saliva or water for this purpose. Compare the crown and shade tab, using principles discussed in paragraph 2.4. Evaluate the color of the restoration to determine where the change is needed—hue, chroma, or value.

2.23.1.2. **Chroma Adjustments.** To increase the chroma, simply add the stain of the same dominant hue as the crown until the intensity is correct. To decrease the chroma, add the compliment of the dominant hue. If the shade is bright yellow, adding violet will neutralize it. This also lowers the value but, hopefully, it will not be so drastic as to cause a mismatch. ***NOTE:*** Usually, the processed porcelain veneer is of higher value than required (depending on the ceramist's ability to apply porcelain). If the processed porcelain veneer always appears darker, it is because the porcelain is not being condensed properly.

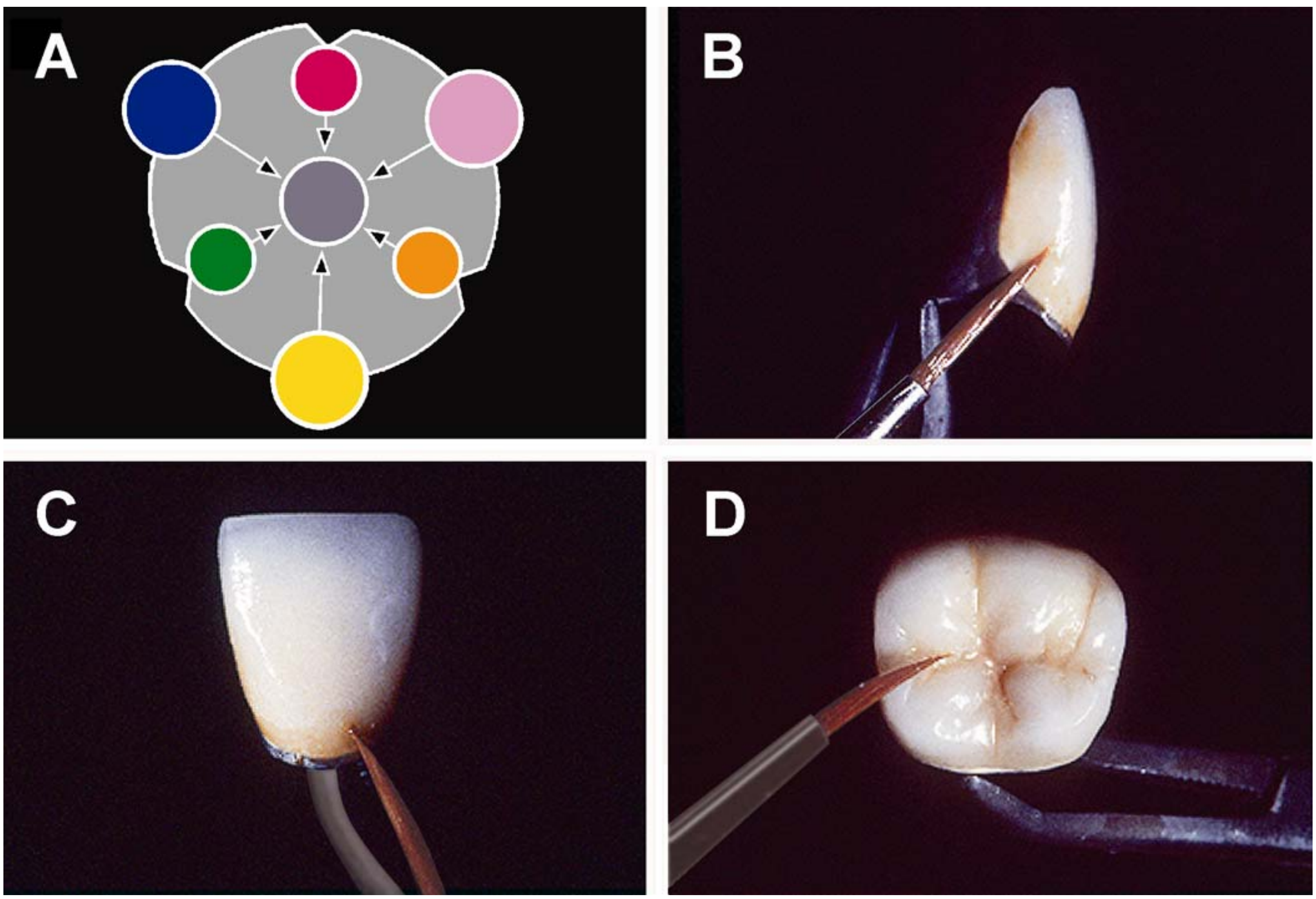
2.23.1.3. **Hue Adjustments.** To change the hue of a restoration, refer to the color wheel (Figure 2.32-A). Only two hue modifications are necessary because natural teeth are located in the yellow to orange range. To move a yellow hue to an orange hue, add a pink stain. (The stain represented by red on the color wheel is actually a pink.) To change a orange hue to yellow, add a yellow stain.

2.23.1.4. **Value Adjustment:**

2.23.1.4.1. Lowering the value can be done very easily by adding the complementary color. If the dominant hue is orange, add blue. If the dominant hue is yellow, add violet. Because most teeth have a yellow hue, the violet stain is used more often, especially in the incisal third. Adding violet to the incisal area has the effect of apparent translucency. If the crown being modified has a dominant hue of orange, use a blue stain instead.

2.23.1.4.2. Another very powerful modifier used to lower value is brown stain. Brown is a low value shade of red, orange, or yellow. A small amount of brown applied to the surface will increase chroma and lower value.

Figure 2.32. Extrinsic Staining of Metal-Ceramic Crowns.



2.23.1.4.3. Raising the value of a restoration is next to impossible. The only successful way to raise value is by adding a stain of higher value, which may change the hue, increase chroma, and *also raise* the value. Sometimes a small amount of white stain can increase the value, but it is not a good choice of modifiers, because it is *very opaque*. ***NOTE:*** If at any time, the actual hue of the stain can be seen rather than the neutral gray desired, remove the stain with a tissue and repeat the procedure.

2.23.2. **Characterization (Figures 2.32-B through -D).** The desired effect of external characterization is similar to the placement of internal modifiers. However, with internal modifiers, the characterization can be seen in depth. The goal of every ceramist is *to produce a restoration so natural it prevents detection when seated in the patient's mouth.* Therefore, any characterization should not be the focal point, but it should blend into the entire composition with balance and harmony:

2.23.2.1. **Proximal Staining:**

2.23.2.1.1. Every tooth will appear to have some degree of proximal staining. The intensity and color of the staining may vary with the age and lifestyles of the patient. A young patient may have very little proximal staining compared to an older patient. The same comparison can be made between a coffee drinker and nondrinker.

2.23.2.1.2. To simulate proximal stain, apply a mixture of orange and brown stain that compliments the patient's age and tooth color to this area, extending facially just beyond the contact area, but not covering the facial surface itself (Figure 2.32-B). You can also apply this orange-brown mixture to the interproximal connector areas of an FPD to enhance the apparent separation of the units. Be sure to remove any excess stain from the facial surface. For a fairly young patient, use a gray mixture instead. For the most part, the mesial and distal surfaces of a FPD unit should be treated the same way as an individual crown.

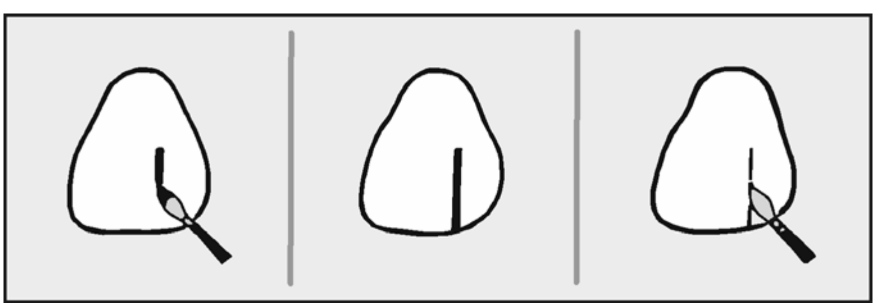
2.23.2.2. **Cervical Staining.** The cervical areas of a tooth reflect the pink coloration of the gingiva and may also be stained. This effect may vary from a light pinkish-orange color to an orange-brown color. Cervical staining is present on most shade guide tabs and will have a bearing on the overall shade of the restoration. Cervical staining is often used to simulate the root portion of a tooth. This is especially true of periodontally involved teeth and exceptionally long pontic. To remedy the problem, an orange-brown mixture its applied to the prepared area to accentuate the cementoenamel junction and make the restoration look shorter (Figure 2.32-C).

2.23.2.3. **Enamel Cracks:**

2.23.2.3.1. The enamel crack is hard to simulate with surface stains. To give an appearance of depth, the enamel crack simulation should have both a *highlight* and a *shadow*. This can be done by applying a mixture of white and yellow stain (4 to 1 ratio) in a thin line.

2.23.2.3.2. The excess stain is removed by a method called painting off (Figure 2.33). Use a clean brush to narrow the width of the line and to apply a second gray stain line distally to the first, simulating the shadow. Narrow this second line until just a hint of shadow remains. The combination of these two should give the illusion of a fracture (Figure 2.28-A).

Figure 2.33. Painting-Off Technique.



2.23.2.3.3. Sometimes the enamel crack lines become discolored with food, tobacco, or other stains. If this happens, replace the white-yellow mixture with one of orange-brown and apply with a small amount of orange stain along either side of the first line to create the shadow.

2.23.2.4. **Hypocalcifications.** These areas result from the removal of calcium from the enamel and appear as white blotches or even white lines (Figure 2.28-D). To create this effect, use white stain mixed with liquid medium to a fairly heavy consistency. Although this stain is quite opaque, it is sometimes difficult to apply in the opacity desired. If the stain applied is too thick it will actually create lumps on the surface. The desired effect should appear much the same after firing as it does when the stain is applied.

2.23.2.5. **Resin Restorations (Figure 2.27-I).** Sometimes it is necessary to place a metal-ceramic crown in the mouth of a patient who has many anterior composite restorations. A flawless restoration would look out of place in such an environment. To simulate a resin filling, the proper color of an orange-brown mixture (also white, if needed) is selected and applied to the desired area. Then, the first application is outlined with a slight bit of brown stain. The outline should be narrowed to a thin marginal line.

2.23.2.6. **Anatomy.** The occlusal anatomy of posterior teeth and lingual anatomy of anteriors should also show degrees of characterization to define surface detail and break up the monotony of the basic shade. The concern, however, is to avoid the overuse of stains. Different ratios of orange and brown are used, depending on the anatomy. A darker stain would normally be applied to a defect (such as a pit) rather than to a groove or fissure. On occlusal surfaces, the stain is randomly applied with a fine-tipped brush (Figure 2.32-D). The lines should appear as mere suggestions of grooves, rather than being heavily accented. Marginal ridges can be made to seem more translucent by adding violet stain. Cusp tips are highlighted with white stain. Lingual anatomy may also be accentuated in much the same way.

Section 2G—Glazing

2.24. Overview. Glazed porcelain surfaces have been described as being impervious to mouth fluids and biologically compatible with oral tissues. The glaze itself is a formation of a thin transparent glass. The amount of glaze on the surface determines its appearance. A *low glaze* appears as a slight sheen with no loss of surface detail. A *medium glaze* appears with some rounding of fine detail. A *high glaze* appears glossy (highly reflective, smooth) with a greater loss of surface detail and form. A medium glaze is usually preferred for its beauty and long-lasting quality. Also, in the patient's mouth, some of the surface detail may become filled with saliva and, therefore, go unnoticed.

2.25. Autogenous Method:

2.25.1. This method is usually done in conjunction with extrinsic staining and is preferred by many for its durability, simplicity, and beauty. After the restoration is processed, the stains become a part of the thin transparent glass that covers the restoration.

2.25.2. Two factors that are used to control the formation of the glass are *time* and *temperature*. Either variable can be increased or decreased to obtain the desired amount of glaze. For example, a crown sintered to 920 ^{o}C may require holding at that temperature for a period of 2 or 3 minutes. The same crown fired to 940 ^{o}C may only require holding 1 or 2 minutes. It is always easier and safer to increase the holding time than to increase the temperature. You might accidentally cause the porcelain to coalesce or devitrify. If the porcelain coalesces, it will need to be recontoured. If the porcelain devitrifies, it may not glaze, in which case you must start over.

2.25.3. After the extrinsic staining is complete, place the restoration on a firing tray and then on the firing table to dry. Set the firing temperature at the lowest end of the manufacturer's recommendation or 20 °C below the last known firing temperature for that restoration. A typical setting would be 920 °C for 2 to 3 minutes. Air-fire the restoration, using the proper time and temperature controls. Remove the restoration and *visually* inspect the glaze. If the restoration is underfired, immediately replace it in the furnace and raise the temperature another 10 °C and hold the restoration at that temperature for 30 seconds to 1 minute. When you observe the desired amount of glaze, remove the restoration immediately and let it completely cool.

2.26. Overglaze Method:

2.26.1. Some uses of this technique are to reglaze denture teeth, facings, or prefabricated pontics after they have been adjusted; reglaze a ceramic restoration that has been adjusted; and ensure a glazed surface covers a ceramic restoration that may have been difficult to glaze. An autogenous glaze is superior to an overglaze so avoid the routine use of an overglaze.

2.26.2. Mix the overglaze powder with the liquid medium until it will *string* from the spatula when lifted from the mix. Apply the mixture in one direction, using a small brush. Keep the mix even and remove any excess or puddling. Dry the overglaze in front of an open furnace as if it were a stain. Correctly applied glaze material will appear as an even white layer after drying. Air fire the restoration to a temperature of approximately 860 °C. Immediately remove the restoration and let cool.

Section 2H—Soldering

2.27. Presolder. This technique joins the units of a metal-ceramic FPD before porcelain is applied (Figure 2.34). Presoldering metal-ceramic units requires a solder with a much higher fusion temperature (about 1090 °C) than Type III gold solders. The solder joint must be able to withstand the porcelain firing temperatures. Be sure the presolder you are using is matched to the ceramic alloy in its composition and color.

2.27.1. **Preparing the Units:**

2.27.1.1. The principles and theories of presoldering differ somewhat from those used for conventional soldering. The *strongest* presolder joints are those that have been prepared so they need the least amount of solder. Trying to bridge a large gap, especially if the presolder has been overheated, will result in a weak joint. The proper amount of solder gap width for presoldering is 0.1 mm. The area of the solder joint must also be rubbered smooth before making the matrix.

2.27.1.2. One method of separating the units of a FPD is to make a diagonal cut through the pontic. The cut can be made with a separating disc through the casting or by making a diagonal cut with a warm razor blade through the wax pontic (Figure 2.34-A). This way, the solder joint will be long and thin, resulting in a much stronger joint. Ideally, the connectors should be cast metal (for strength) so they are not as good a location for a presolder joint.

2.27.2. **Soldering Matrix.** Seat the units on the cast and secure them with sticky wax. Join the units together with a high quality fast-setting material such as *Dura Lay®* or *Zapit®* (Figure 2.34-B). Once the material has set and the units are removed from the cast, check the tissue side of the joint for voids. Fill any voids with more material.

2.27.3. **Investing the Assembly:**

2.27.3.1. Use a special high-heat solder investment or phosphate-bonded casting investment. If casting investment is used, mix with *distilled water* instead of the special liquid to limit expansion to an absolute minimum. Mix the investment thick; a thin mix can weaken the investment, causing it to crack at high temperatures.

2.27.3.2. Place the mix inside each retainer, using a bladed instrument (Figure 2.34-C). Next, place a patty of the mix on a paper towel and invert the assembly onto the patty (Figure 2.34-D). The towel absorbs moisture, which helps to control slumping. Make sure the margins are covered and the metal is supported. However, do not bury the castings because it would make soldering more difficult because of poor heat transfer to the castings.

2.27.3.3. The assembly should rest gently on the investment mound with as much metal exposed as possible so the heat can be applied quickly and evenly without overheating the assembly. Let the investment bench set for at least 45 minutes and then trim the investment base to these dimensions: 10 to 15 mm thick, and 3 mm beyond the castings (Figure 2.34-E).

2.27.4. **Preheating the Assembly.** Burn off the *Dura Lay*® or *Zapit*® and preheat the solder assembly before applying the soldering flame. One burnout method suggests placing the assembly in a cold furnace, raising the temperature to 1300 ^{o}F, and then letting it heat soak for about 5 to 10 minutes.

2.27.5. **Soldering the Units:**

2.27.5.1. Use a gas-oxygen torch with a special soldering tip to melt the solder. Adjust the oxygen pressure to 6 pounds and set the gas pressure between 6 and 8 pounds. Light the torch and check the flame. Adjust the flame until the inner cone is about 15 mm long. If the torch is adjusted right, there should be little or no hissing.

2.27.5.2. Remove the assembly from the oven and place it on a tripod. Immediately direct the flame around the base of the investment to raise the temperature. Then direct the flame to the castings until they show a slight orange color. Holding the torch in one hand and the presolder in the other, place the end of the strip onto the joint. Now, as you direct the flame onto the joint area, the solder will melt and flow down into the joint (Figure 2.34-F).

2.27.5.3. Remove the solder strip, but keep a brush flame on the assembly. Move the flame to the reverse side of the assembly and draw the solder through the joint. Solder will always flow to the hottest areas.

2.27.5.4. Let the investment bench cool completely before you remove the castings (Figure 2.34-G). On multiple units, never solder more than two joints at a time.

2.28. Postsolder Technique. This technique involves furnace soldering metal-ceramic restorations that have already had porcelain applied to them (Figure 2.35). Occasionally, a Type III gold alloy retainer must be soldered to the remaining part of a metal-ceramic FPD. Another use includes splinting two metal-ceramic crowns to strengthen weak abutment teeth. Finally, this technique may be used to repair the metal part of a metal-ceramic restoration.

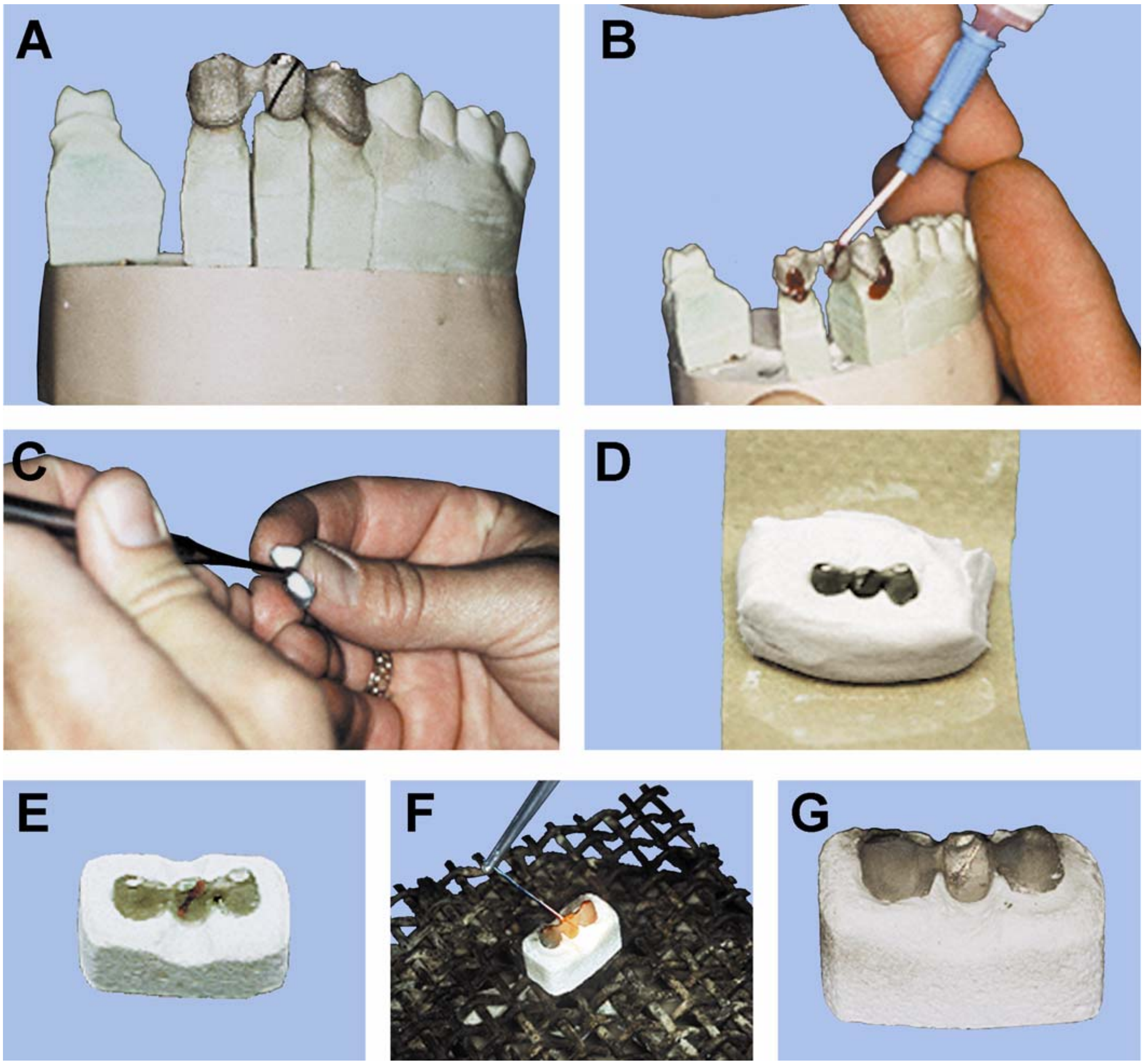
2.28.1. **Preparing the Units:**

2.28.1.1. Assembling the units is much the same as for Type III gold alloy. Because you will use low-fusing solder, you can make the solder assembly with any solder investment. A solder gap width of 0.250 mm between the metal surfaces is suggested, but the porcelain veneers should be as close to each other as possible without contacting.

2.28.1.2. Lightly rubber all surfaces to be soldered, seat the units on the abutment teeth, and flow wax into the prepared area. Use a steel bur and sticky wax to hold the units together.

Remove the solder relation and flow ivory wax over any porcelain surface that would contact investment (Figure 2.35-A). This will keep the solder investment from contacting and fusing with the veneer (Figure 2.36).

Figure 2.34. Presolder Technique.



2.28.2. **Investing the Assembly.** Mix a small amount of soldering investment and construct the assembly as described in paragraph 1.75.2.2. Carve a V-shaped notch on the lingual to ensure adequate access to the solder joint. Flush out the wax with boiling water. Place the invested units on the firing table of a porcelain furnace to warm slowly for 10 minutes. Then move closer to the muffle and warm it for 5 more minutes.

Figure 2.35. Postsolder Technique.

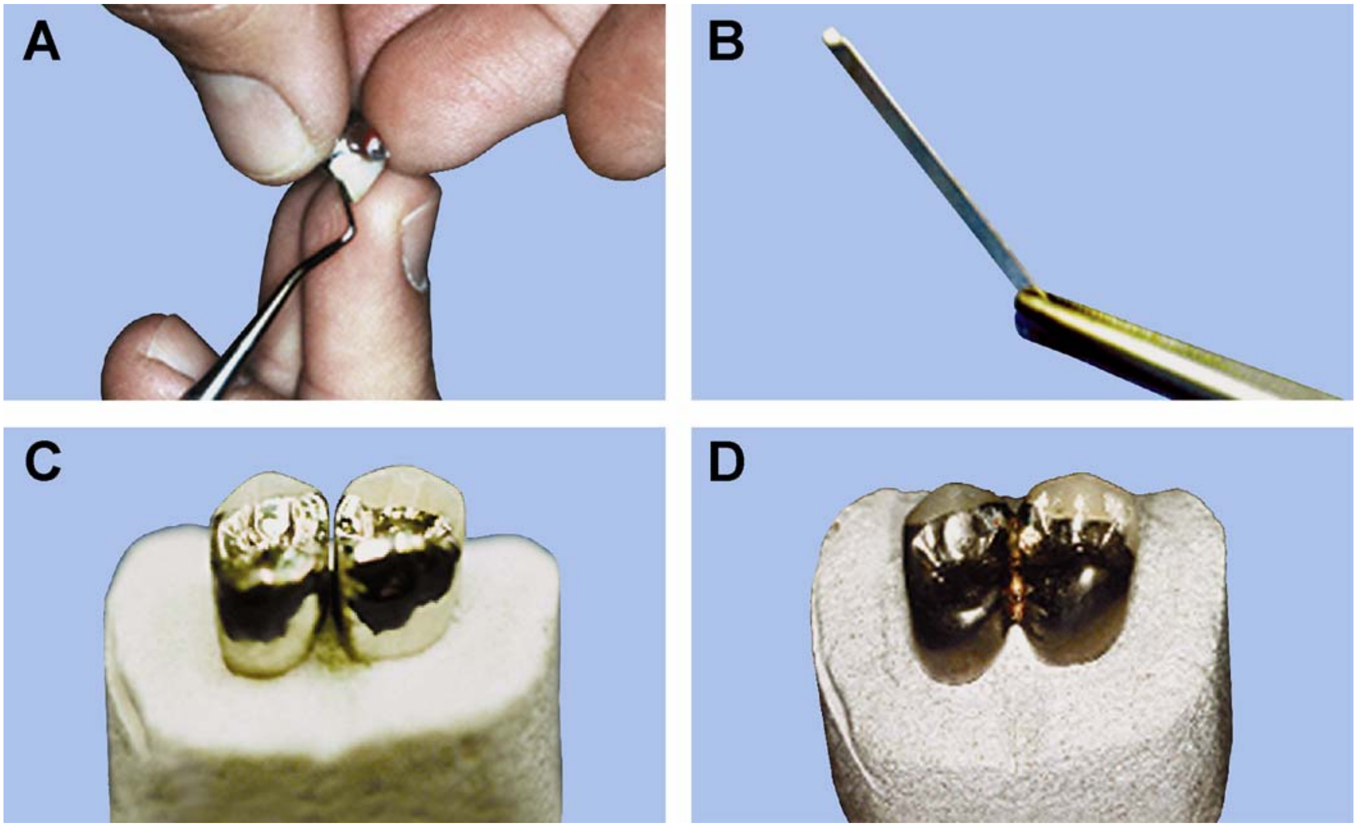
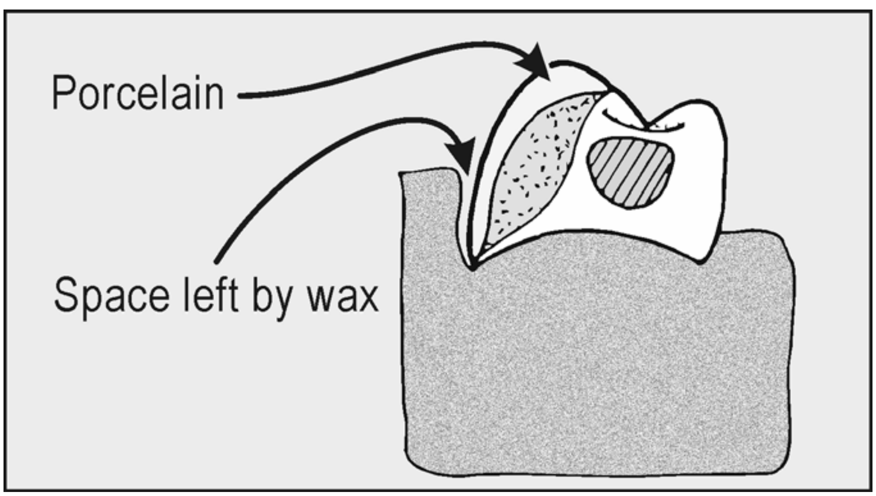


Figure 2.36. Investing a Metal-Ceramic Restoration (Cross-Section).



2.28.3. **Soldering the Units:**

2.28.3.1. Hold a strip of low-fusing solder over a bunsen burner until a small ball of solder forms (Figure 2.35-B). Cut off the ball of solder, leaving a small tail long enough to touch the investment patty. Apply flux to the solder joint. Apply antiflux to the occlusal surface to confine the solder flow. Position the ball of solder with the tail extending down (Figure 2.35-C).

2.28.3.2. Place the assembly in the furnace and start the vacuum pump to reduce the amount of oxide that would normally form in the solder joint. (A porcelain furnace with *a viewing glass* is best because you can watch the solder melt.)

2.28.3.3. Set the furnace to 870 °C (slightly above the fusing temperature of the solder) and wait for the solder to melt. The actual temperature the solder flows may vary with the solder used. Start to check for solder flow when the oven temperature reaches 815 °C. Release the vacuum and remove the assembly as soon as the solder wets the joint (Figure 2.35-D). If the solder is overheated, you'll have porosity and an embrittled joint. The solder joint should extend far enough gingivally to recontour and still maintain adequate strength.

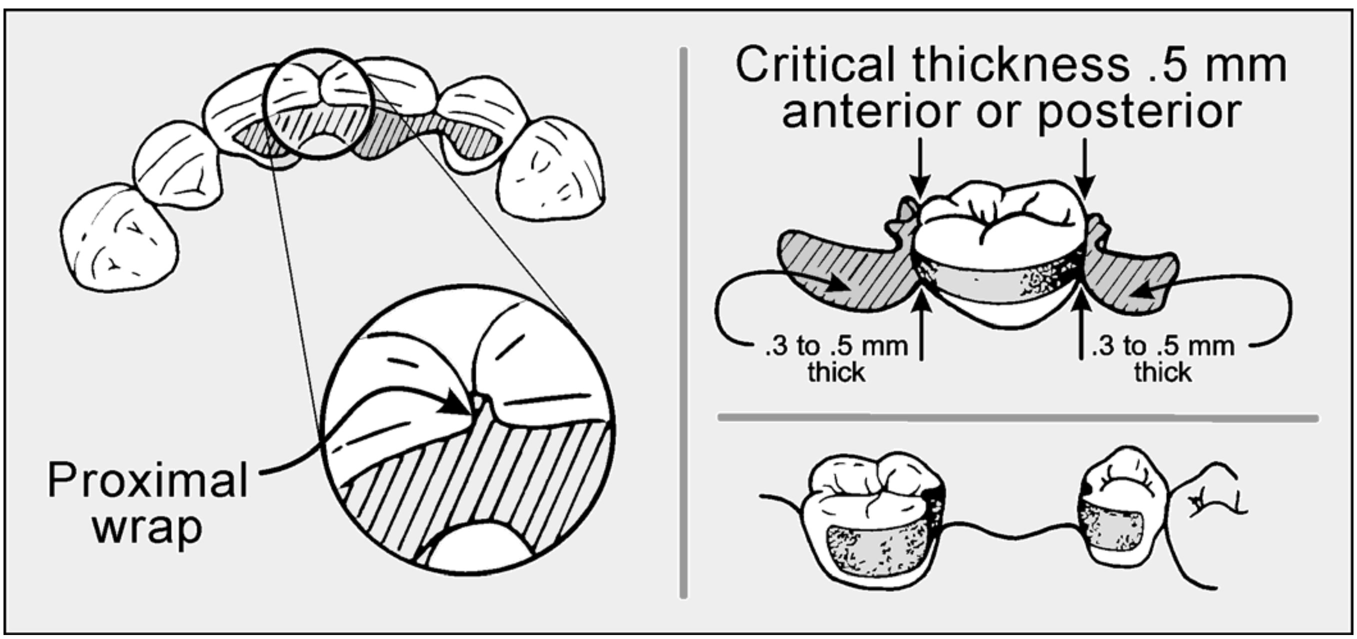
2.28.4. **Repairing Exposed Metal Surfaces.** After the porcelain has been applied, make any metal repairs by the postsolder technique, using the rules for low-fusing alloys. *Furnace soldering* is preferred over torch soldering for this purpose because it is more controlled and does not subject the porcelain to drastically changing temperatures. Remember to position the restoration in the solder investment to take full advantage of solder flow. This would be the case in soldering a hole or contact area.

Section 2I—Resin-Bonded FPDs (Maryland Bridge)

2.29. Design Factors. The two primary considerations are to establish a distinct path of insertion to allow for proper seating and resistance to dislodgment and to maximize the bonding surface of the retainers for strength and retention. The design of the retainers consists of four parts:

2.29.1. **Proximal Segment.** The dentist prepares the abutment teeth by removing enamel from the proximal suprabulge and undercut areas to increase the bonding surface. This enamel shaping extends just past the proximal line angle, allowing the retainer to grasp the abutment and provide bracing for the framework (Figure 2.37). The proximal wrap limits facial-lingual movement of the retainer during function. The dentist may also cut small subtle grooves in the interproximal parallel to the path of insertion to resist displacement.

Figure 2.37. Resin-Bonded FPD Design.

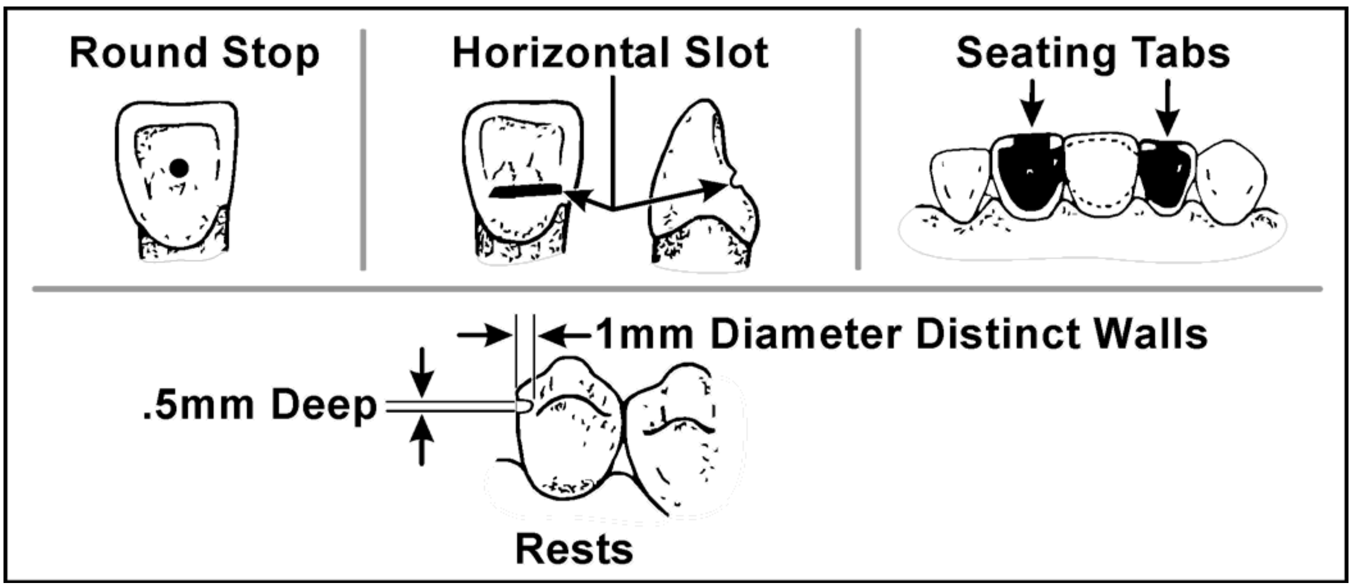


2.29.2. **Lingual Segment.** The design goal in the lingual segment is to create as large a bonding surface as possible without creating periodontal problems, excursion problems, or plaque traps. Therefore, it is necessary that the framework ends 1 mm away from the gingival tissue and has a knife-edge finish. The metal thickness of the framework should range from 0.3 mm to 0.6 mm. The minimum thickness passing over a marginal ridge is 0.6 mm. This thickness increases with the transition into the connector areas.

2.29.3. **Occlusal Rests.** Preparations for occlusal rest seats for resin-bonded retainers are shallower, narrower, and have straighter "locking" walls than occlusal rest seats for RPDs. Rest seats are usually about 1.5 to 2.0 mm in diameter and 1.0 mm in depth.

2.29.4. **Seating Stops.** The design may include incisal seating tabs to provide positive orientation of the restoration during cementation or to stabilize mobile teeth (Figure 2.38). These stops greatly enhance positive seating during the short time period available for bonding. Afterward, the tabs are cut off and smoothed. Many dentists object to the tabs because, in some instances, they interfere with making occlusal adjustments. An alternative method involves the use of dimples or delicate horizontal slots prepared in the lingual enamel of anterior teeth.

Figure 2.38. Seating Stops for Resin-Bonded FPDs.



2.30. Framework Fabrication. There are two methods of producing frameworks for resin-bonded FPDs. The first involves the use of a refractory cast, where the pattern is waxed directly to the refractory cast, sprued and invested, and cast to the refractory cast. In the second method, the pattern is waxed directly on the master cast, sprued, pulled off the master cast, invested, and then cast into metal. These two methods are as follows:

2.30.1. **Refractory Cast Method.** A refractory cast can be made in the following two ways: (1) by initially pouring the impression in stone and repouring it a second time in refractory material, or (2) by duplicating master casts and pouring a refractory cast. The first way requires less material and is less time consuming.

2.30.1.1. **Mixing and Pouring the Refractory Material.** Mix and pour the refractory material into the impression in the usual manner. Adhere to the manufacturer's recommended liquid to powder ratios and mix under vacuum for 60 to 90 seconds. Mechanically spatulate the mix under vacuum for 60 to 90 seconds. Pour only the involved portion of the impression and a tooth to either side. Let bench set for 45 minutes before removing the cast. ***NOTE:*** Full-arch refractory casts are required only when the refractory casts are articulated.

2.30.1.2. **Surveying the Cast.** Routinely survey refractory casts to establish the height of contour on abutment teeth. This indicates undercut areas and discourages overwaxing of the pattern and later corrections to seat the framework on the master cast. Do not block out these undercut areas, even when duplicating casts. To do so would eliminate proximal contours needed to properly shape the gingival half of the pattern. Outline the extent of the framework with a wax pencil.

2.30.1.3. **Waxing the Pattern.** Follow the design factors given in paragraph 2.29 when waxing frameworks for resin-bonded FPDs. The dimensions given are for the finished casting. The pattern *thickness* may be increased slightly to allow for finishing.

2.30.1.3.1. Mount the master casts on an articulator in the prescribed manner. Wax the pontic substructure on the *master cast* or modify a preformed plastic substructure pontic form to fit the edentulous space. Ensure adequate space is allowed for porcelain coverage of the pontic. By beginning the wax-up on the master cast, you are able to check the occlusion without having to articulate the refractory cast. The pontic is later transferred to the refractory cast for pattern completion.

2.30.1.3.2. Attach the pontic to the refractory and flow a uniform layer of wax over all areas within the design. Keep in mind the minimum thickness of metal needed for strength and add about a tenth of a millimeter thickness for finishing. Smooth the pattern and prepare to invest.

2.30.1.4. **Trimming the Refractory Cast.** Trim the base of the cast prior to investment in order to fit the appropriate size casting ring. Leave an investment base at least 10 mm thick for strength. After the investment is set, any portion of the base sticking out from the ring can be removed. The pattern is now ready for spruing and investing.

2.30.1.5. **Spruing and Investing the Pattern.** Attach a sprue former to the wax pattern and apply a wetting agent. Line the casting ring with a thick layer of petrolatum; use no other ring liner. Use distilled water instead of the special liquid and vacuum spatulate the mix as before. The reason for these modifications is to restrict expansion and thereby reduce the possibility of mold separation and casting fins. Let the invested ring bench set for at least 60 minutes. Proceed to burnout and casting (paragraphs 2.9 and 2.10).

2.30.2. **Pulled Pattern Method (Figure 2.39):**

2.30.2.1. Articulate the master cast. Use a wax pencil to mark the margin outline on the cast (Figure 2.39-A). Apply a resin to stone separator to the cast.

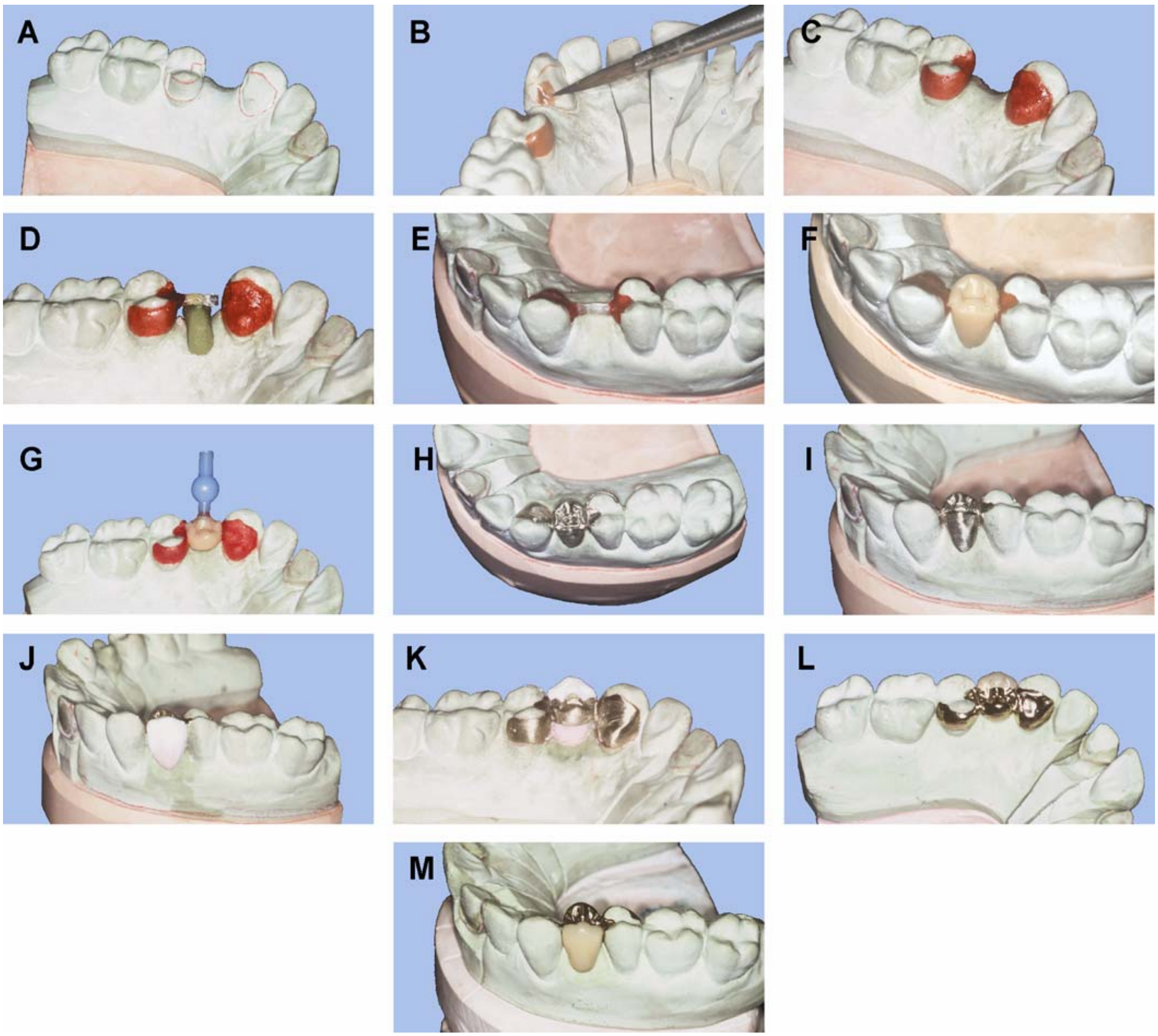
2.30.2.2. Using a pattern resin build up the wing and proximal portions of the retainers (Figure 2.39-B). Pattern resin is used to minimize pattern distortion. Do not extend the resin beyond the margin outline and maintain an even thickness. After the resin has cured carefully remove the resin wings, cutback any margin overextensions, and reduce thick areas (Figure 2.39-C). Replace the completed wings on the cast.

2.30.2.3. Slowly add resin from the proximal of each retainer towards the opposite retainer. Allow the resin to cure before contact is made between the two retainers. This minimizes the amount of distortion between the resin retainers and the abutments. An alternate method is to use a plastic sprue cut to fit between the retainers without applying pressure to the retainers.

Connect one side of the plastic sprue and let the resin cure (Figure 2.39-D). Connect the remaining space between the retainers and the plastic sprue then let the resin cure (Figure 2.39-E). After the resin substructure is fully cured, evaluate it for accuracy and fit.

2.30.2.4. Wax the pontic to full contour. Cutback the pontic following the guidelines for metal-ceramic cutbacks (Figure 2.39-F). Check margins and make any necessary corrections. Another method is to remove .5 to 1 mm of resin from the margins and readapt wax to margin areas.

Figure 2.39. Pulled Pattern Technique for a Resin-Bonded FPD.



2.30.3. **Sprue and Invest.** Sprue and investing is the same as the guidance given in paragraphs 2.7 and 2.8. Take care not to warp the retainers during these procedures (Figure 2.39-G).

2.30.4. **Burnout and Casting.** Place the ring in a cold furnace, raise the temperature slowly (90 minutes or more) to 1500 ^{o}F and heat soak for 1 hour. Follow the guidance in Chapter 3 of this volume for casting of base metal alloys. ***NOTE:*** Base metal alloys, nickel-chrome or chrome-cobalt, are generally used for the resin-bonded technique. As such, meticulous handling of these alloys must be observed each step of the way for successful porcelain bonding. It is important that no more than 25 to 30 percent recast alloy be used with this technique.

2.30.5. **Finishing.** Follow normal procedures for sprue removal, fitting the framework to the master cast, and finishing (Figure 2.39-H and -I). Be prepared for the dentist to request a framework try-in of an extensive restoration to check casting fit. Do not finish or rubber wheel surfaces that are to be bonded to the tooth preparations.

2.30.6. **Porcelain Application.** There are difficulties associated with applying porcelain to this style framework (Figure 2.39-J through -M). The *distinct* path of insertion can make removing the raw porcelain buildup difficult. If a section of the mass breaks away, hopefully it can hopefully be replaced or fresh porcelain added with the framework off the cast. Also, support of the framework during firing procedures must be aided by using metal or ceramic posts with grooves in them. The proximal wrap causes the pontic to be slightly wider than the edentulous space, and shaping the pontic can be an esthetic compromise without showing opaque or metal. A detailed description of this critical area appears in Figure 2.37. Due to these difficulties, expect the dentist to request a try-in after final bisque bake and before staining, glazing, and polishing.

2.31. Bonding Preparation. Have ALL aspects of the restoration completed prior to this step; adjustments and polishing can lead to contamination of the prepared bonding surface.

2.31.1. **Base Metal Alloys.** With the advent of new cements in dentistry today, it is no longer required to acid-etch the bonding surfaces of the retainers. Adhesive cements, such as Panavia® 21, Kuraray Co., and C&B Metabond, require air abrading the retainer's bonding surface with 30 to 50 micron aluminum oxide. Air abrade at 80 to 100 psi for 2 to 3 seconds to produce a matte finish. Then wash the restoration under running water for 1 minute and place it in the ultrasonic cleaner for 2 to 3 minutes in a neutral detergent solution.

2.31.2. **Noble Alloys.** When noble alloys are cast for the substructure, tin-plating is used to prepare the retainers for bonding. This is accomplished by means of an electro-plating process, using one of several commercially available plating machines. First sandblast with aluminum oxide and then deposit a layer of tin approximately 0.5 microns thick, using manufacturer's recommended procedures and plating times. Follow up with washing and ultrasonic cleaning the same as with base metals.

2.31.3. **Storing.** After preparing the retainers for bonding, keep the prostheses in a dry, contamination-free place.

Chapter 3

BASE METAL ALLOYS FOR FIXED PROSTHESES

3.1. Overview. The high increase in the value of gold, beginning in the late 1960s, has been the main force behind the development of gold substitute alloys for dental casting uses. The greatest development has been toward base metal alloys, commonly called nonprecious alloys, which contain no noble metals. The most popular of these have been the nickel-chromium alloy systems. These alloys are not new. Like many other materials used in dentistry, they were initially developed for purposes outside the dental profession. Nickel-chromium (NiChrome™) has been used in industry for many years as heater wire or conductive rod material in the manufacture of heating elements. Nickel-chromium alloys were selected for fixed restoration casting primarily because of their high heat characteristics.

3.2. Prosthodontic Uses. The most popular current use of the nonprecious nickel-chromium alloys in fixed prosthodontics is the casting of substructures or copings for metal-ceramic restorations. An advantage of the base metal alloy in this application is its high sag or distortion resistance at the temperatures needed for the firing of the veneer porcelain. This is attributed to the higher fusion and melting temperatures of the base metal alloy over gold-based alloys designed for comparable use. Because the base metal alloys equal or exceed the mechanical properties of gold in many respects, base metal alloys have been used in all cast metal fixed restorations, with and without porcelain.

3.3. Alloy Composition. Practically all of the current nonprecious alloys for fixed prosthodontic uses are nickel-chromium systems. Composition ranges for the many brands available are approximately 67 to 81 percent nickel and 2 to 20 percent chromium. Other elements such as molybdenum, manganese, aluminum, silicon, and beryllium are added in small quantities ranging from approximately 0.1 to 5.2 percent. The trace amounts of these elements control cast metal grain size, fusion and melting temperatures, hardness, and tensile strength; and they impart other needed characteristics to the alloy depending on its intended use. As a general rule, those additions to the alloy that provide lower melting temperatures usually produce higher hardness and, therefore, restorations that are more difficult to finish. Higher melting alloys are generally less hard and less difficult to finish.

3.4. Possible Hazards:

3.4.1. The element *nickel* may be one of the most common causes of allergic dermatitis. It may be responsible for more allergic reactions than all other metals combined. Laboratory technicians who have been shown to be nickel sensitive by medically valid evidence should be advised of some potential risk with long-term exposure.

3.4.2. Some base metal alloys contain the element *beryllium* to control hardness of the cast alloy and reduce the fusion temperature. Inhalation of beryllium-containing dust particles is known to be a potential health hazard. Industrial safety precautions must be observed and adequate ventilation provided when grinding and finishing beryllium-containing alloys.

3.5. Technique Differences:

3.5.1. The well-established laboratory techniques developed over many years of premium gold alloy use cannot be directly applied to the base metal alloys. This is because base metal alloys, due to their chromium content, have high melting temperatures which usually range between 2000 and 2600 ^{o}F. Such a heat range is beyond the capability of a conventional gas-air torch. Instead, a gas-oxygen torch with multiorifice tip is required to melt base metal alloys. The use of acetylene as a fuel should be avoided because the flame produced from such a source can become too hot. Also, an oxyacetylene flame is rather dirty. When using a gas-oxygen torch, the gas pressure should be between 6 and 8 pounds while the oxygen pressure should be adjusted to 20 pounds.

3.5.2. Base metal alloys are susceptible to oxidation of their component metals and to carbon inclusion in the molten state. For this reason induction casting is preferred for base metal alloy casting and produces the most consistent results.

3.5.3. Due to their high melting temperatures, base metal alloys undergo greater shrinkage or contraction than gold alloys when cooling from the liquid (molten) to the solid state. Consequently, more expansion of the mold is necessary to produce a casting of sufficient size to fit the die without considerable grinding on the internal surfaces of the casting. To compensate for the unusually large amount of shrinkage, burnout temperatures of 1500 to 1600 ^{o}F are recommended. Because gypsum-bonded casting investments cannot be used for such temperature levels, either phosphate or silicate bonded investments must be used. Even these high heat investments show considerable surface breakdown when contacted by over-heated metal, a common occurrence with torch-melted alloy.

3.5.4. In addition to casting shrinkage compensation, the high casting ring temperature is required to maintain the molten or liquid state of the nickel-chromium alloy for as long as possible. Because base metal alloys have only half the density (approximately 9 grams per cubic centimeter [g/cc]) of their gold counterparts, more time is required for the molten metal to fill the casting investment mold cavity by centrifugal force of the casting machine. The speed of the centrifugal arm of the casting machine must be significantly increased to provide the centrifugal force required for base metal casting. The lower density of these alloys also requires special spruing and venting techniques for wax patterns to consistently produce complete castings.

3.5.5. Basic research in laboratory techniques for fixed restorative construction with base metal alloys has shown that manufacturer's instructions for handling of investments are not adequate to produce castings large enough to fit the die. Therefore, modification of the manufacturer's instructions are often necessary to establish routine laboratory procedures for the production of clinically acceptable restorations. Once established, such procedures must be closely followed, otherwise the technique sensitivity of the base metal alloys will result in a product less than satisfactory for clinical use. Remakes of unacceptable restorations quickly offset any potential savings in alloy cost.

3.5.6. Soldering of base metals is also very technique sensitive. The thick oxides that form when soldering can affect or weaken the chemical bond of the porcelain. Therefore, ill fitting FPDs are usually remade rather than soldered.

3.6. Pattern Spruing. Due to the low density of base metal alloys, wax pattern spruing requires the following special attention:

3.6.1. **Direct Spruing of Individual and Multiple Unit Patterns.** Use 8-gauge round wax or plastic for pattern sprue formers. Preformed sprue formers with spherical reservoirs are preferred. Place sprue former attachments at the area of maximum bulk of the pattern. If additional bulk is necessary, add to a noncritical portion of the pattern for sprue attachment. Make sure the point of attachment blends well. It is not unusual for castings to exhibit "cold tear" or "shrink spot" porosity in these attachment areas, but this may be removed when excess metal is cut away. If preformed sprue formers with reservoirs are used to directly sprue multiple unit patterns, attach the sprue formers to the pattern so there is contact between the reservoirs. ***NOTE:*** Connector areas are sometimes chosen as sprue attachment sites.

3.6.2. **Indirect Spruing of Individual and Multiple Unit Patterns.** Use 8-gauge round wax for pattern sprue formers. Use 6- or 8-gauge round wax for the runner and main sprue former leads. The length of the pattern sprues as well as the main sprues should be adjusted to position the runner bar within the thermal zone and the pattern above it. See paragraph 1.52.4.3 for more details on indirect spruing.

3.7. Investment and Burnout Procedures. The higher melting temperature of base metal alloys requires maximum compensation for casting shrinkage. To provide enough expansion of the investment mold cavity, modifications and combinations of traditional investing and burnout techniques may be required. Under ideal laboratory conditions, a procedure including vacuum mixing of investment, hygroscopic set, and high temperature burnout provides consistently high quality castings with acceptable fit on the dies without grinding and force fit.

3.7.1. Line the casting ring with 0.040-inch thick KAOLINER®, which is a trade name for a mat of finely spun fibers of kaolin used as an investment ring liner. It allows maximum expansion of the investment mix while setting and during burnout. Asbestos is generally not resilient enough to allow the expansion needed for base metal alloys. One 0.040-inch thick strip of KAOLINER is equivalent to a double layer of asbestos and does not pose the respiratory health problem of asbestos.

3.7.2. The high heat investment of choice for casting base metal alloys is the phosphate-bonded type. It produces smoother surface castings than the silicate-bonded type. Phosphate-bonded investment is supplied as a powder-liquid system. The liquid portion of the system is a colloidal silicate that can be diluted with water to provide various amounts of investment expansion. Undiluted liquid provides maximum expansion and should be used that way for base metal castings of fixed prosthodontic restorations. Vacuum mix the investment for base metal alloys according to the manufacturer's instructions, followed by 15 seconds of vibration under vacuum to remove escaping gas bubbles.

3.7.3. Immediately place the filled ring in a 100 ^{o}F water bath for a minimum of 45 minutes followed by overnight bench set. Rings may then be placed in a cold oven and brought to 1500 ^{o}F in 1 hour and heat soaked for an additional hour. On completion of burnout, the investment should appear white. Dark areas of investment indicate not all the carbon residue has been eliminated.

3.8. Casting:

3.8.1. **Manual Casting.** Manual casting of base metal alloys, using a gas-oxygen torch and broken arm casting machine, is similar to casting other metal-ceramic alloys. The major difference between these alloys is the appearance of the molten metal when it is ready to cast. Safety precautions are required for eye protection. (Use welder's goggles or glasses approved by Occupational Safety and Health Administration [OSHA] standards.) The following guidelines are for casting with a torch:

3.8.1.1. Adjust the oxygen to 20 psi. Adjust the torch to produce a stable flame with 1/4 inch blue inner cones. A distinct hissing sound should be evident.

3.8.1.2. Place the alloy into a preheated crucible. Lay the round ingots on edge to take advantage of the ability to roll them under pressure of the torch. Place multiple ingots in contact with each other.

3.8.1.3. Heat the alloy using the tips of blue cones 1 1/2 to 2 inches from the ingots. Guide the torch tip in a circular motion to heat all metal evenly.

3.8.1.4. Load the ring when the ingots begin to slump; oxides will not allow the alloy to pool as precious metals do. Molten alloy under the oxide layer will begin to roll and move under the pressure of the flame. Shake the crucible carriage with tongs as you slide it forward. When ingots collapse, cast them immediately.

3.8.2. **Induction Casting.** Induction casting of base metal fixed restorations can be done by using casting machines such as the Ticonium Modular 3. Operating instructions for this machine are as follows:

3.8.2.1. **Preparing the Machine:**

3.8.2.1.1. First, choose and place the crucible for the alloy being used. Carbon crucibles should not be used for base metal alloys because the carbon contaminates alloys containing nickel or palladium. Ceramic crucibles are predominantly used for base alloys, but they can be used for all alloys. Select a cradle and balance the casting arm for the ring size being used. Turn the circuit breaker on and rotate the power switch from 0 to 1 to turn machine on. The white pilot light should now be on.

3.8.2.1.2. Raise the coil around crucible by rotating the casting arm until crucible is over the coil. With your left hand, push the crucible carrier back to the center crucible over the coil. Place the fingers of your right hand under the black handle and lift while pushing the silver lever to the left with your thumb. Ensure the reference pin aligns with the hole beneath it and release the silver lever to lock the coil in the up position.

3.8.2.1.3. Remove any slag from previous castings and adjust the crucible so the spout aligns with the sprue hole in mold.

3.8.2.2. **Premelting the Alloy (for Multiple Ingots).** Load the alloy into the crucible by gently placing ingots into place using tweezers. (Dropping them may break the crucible.) Close the cover and turn the reset switch onto the proper number to begin melt. (A higher number will produce a faster melt.) Turn the reset switch clockwise for a ceramic crucible and counterclockwise for a carbon crucible. To set the electronic eye during premelting:

3.8.2.2.1. Using appropriate eye protection, observe the alloy as it melts. Use visual indicators to determine correct casting setting. Experienced technicians often describe observing “shadows” in the heated alloy to judge this. At the instant a correct melt occurs, observe the numerical readout.

3.8.2.2.2. Raise the lid to stop the melt, push the set point toggle switch down, and rotate the set point knob to obtain numerical reading observed earlier. Record this number for future reference if the machine is used for different alloys.

3.8.3. **Casting.** Close the cover to resume heating. Just prior to reaching casting temperature, open the cover and place the mold into the cradle. When the amber light glows, immediately push the silver lever to the left with your left hand and push the black handle down firmly with your right hand. When the black handle reaches bottom, the arm will begin to spin automatically. Allow the arm to spin for 10 to 15 seconds before pushing the red stop button. The lid will not open until the arm stops completely. ***NOTE:*** Ticonium also makes a flask support that adapts the Ticomatic for casting FPD castings. The only other adjustment that must be made is to set the relay range knob for the metal being cast.

3.9. Finishing Base Metal Castings. Due to their superior physical and mechanical properties, base metal castings are more difficult to grind than their softer, gold-based counterparts. There is a tendency to overwax the patterns for gold castings because it easier to remove the excess bulk in the finished casting.

3.9.1. Make sure the patterns for casting base metal alloys are highly refined and as close to the final form as possible. Keep overwaxing of margins to a minimum. Remove bulk such as sprue cutoff on high-speed equipment (such as a high-speed lathe), using conventional abrasive disks. Abrasives like TiCor® and TiHi®, used to polish RPD frameworks, are good polishing agents for base metal fixed restorations also.

3.9.2. To prevent contamination of the area to be covered with porcelain veneer, use an air-abrasive device such as a microblaster to deliver an aluminum oxide abrasive. This technique offers a clean, conditioned surface with the best opportunity for mechanical and chemical bonding of porcelain.

Chapter 4

ALL-CERAMIC FIXED PROSTHODONTIC RESTORATIONS

Section 4A—Introduction

4.1. Overview:

4.1.1. Changing times and patient needs have brought about viable alternatives to the traditional metal-ceramic system. Today's patients are more health and esthetic conscious. To answer those needs, all-ceramic systems have come on the market that offer excellent alternatives to porcelain fused to metal.

4.1.2. The primary advantage of all-ceramic restorations is improved esthetics. Metal-ceramic restorations do not transmit light through the metal substructure. Light transmission through an all-ceramic restoration more closely resembles nature and, therefore, greatly enhances esthetics. The elimination of the metal collar and darkened subgingival areas are also an advantage to the all-ceramic restoration.

4.1.3. In addition to esthetic benefits, all-ceramic restorations may exhibit improved biocompatibility over traditional metal-ceramic restorations. Abrasion resistance with some systems is more similar to natural teeth, thereby minimizing wear of opposing dentition. Ceramic materials are more compatible with oral tissue than metal, preventing corrosion and tissue reaction.

4.1.4. All-ceramic restoration systems can be used for crowns, inlays, onlays, and veneers. Also, with new materials on the market today, some metal-free FPDs can be made if the technician practices strict adherence to the manufacturer's guidelines. Two of the more popular all-ceramic systems, In-Ceram® by Vident and IPS Empress® by Ivoclar North America, are discussed in Sections 4B and 4C, respectively.

4.2. Preparation Requirements:

4.2.1. All-ceramic restorations require more extensive tooth reduction and strict adherence to dimensional guidelines. Stress distribution is of great concern when designing the all-ceramic restoration. A correctly designed preparation will provide uniform stress distribution without points of stress concentration, which might result in fracture of the resultant restoration. The preparation should be smooth, nonwavy, with no sharp angles or edges. Even reduction of tooth structure is essential for success.

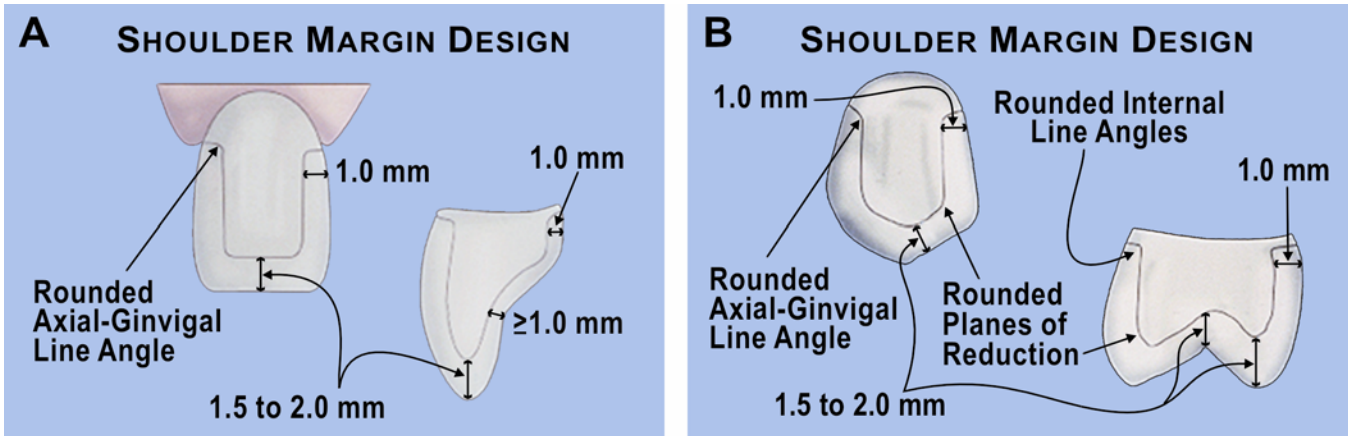
4.2.2. Crowns require a reduction of 1.5 mm on the axial walls and 1.5 to 2 mm on the occlusal or incisal surface. The margin is prepared as a 0.6 to 1.2 mm shoulder with a rounded axial-shoulder line angle (Figure 4.1). Margins with shoulders greater than 100- to 110-degree bevels or knife edge should be avoided. Veneers should have a uniform reduction of 0.6 to 1 mm with a chamfer at the gingival margin. More specific requirements can be found in the manufacturer's directions for the different types of all-ceramic systems.

Section 4B—In-Ceram® System

4.3. Overview. In-Ceram® is a registered trademark of VITA Zahnfabrik, Bad Sackingen, Germany, and distributed in North America by Vident. In-Ceram® Alumina is a glass infiltrated aluminous oxide ceramic substructure on which VitaDur® Alpha porcelain is fired to complete the restoration. In-Ceram® provides a ceramic technique for producing high strength all porcelain crowns and three-unit anterior

FPDs. To begin, complete a master cast with removable dies, using the techniques described in Chapter 1, Section 1F.

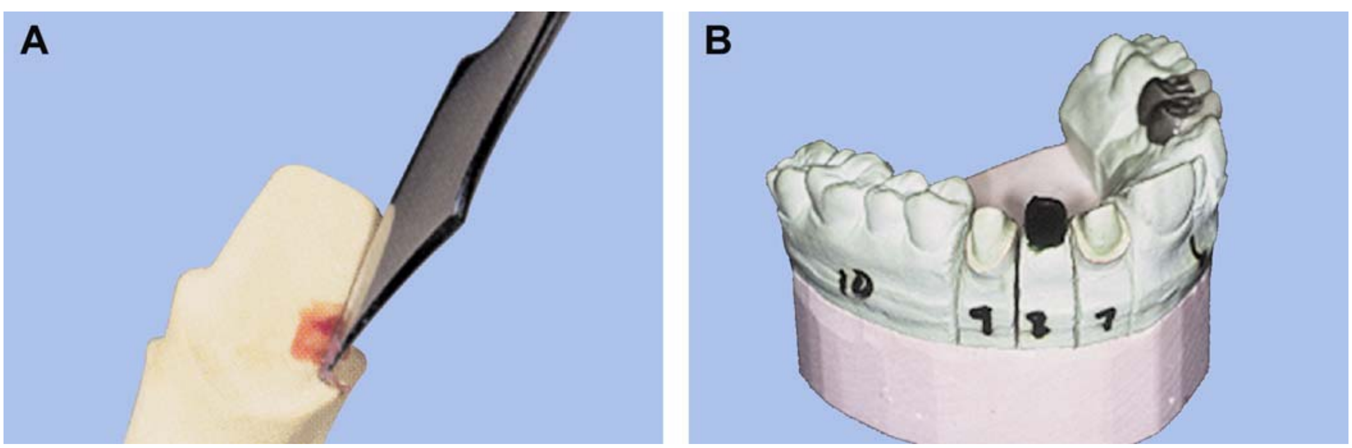
Figure 4.1. Preparation Requirements for All-Ceramic Crowns.



4.4. Procedures. Once the master cast is completed, proceed as follows:

4.4.1. **Die Preparation.** Block out any defects or undercuts on the die with blockout wax and apply interspace varnish (die spacer) (Figure 4.2-A). Application of any other materials to the die is not recommended (including die sealers and hardeners on the margin). These materials are removed in later steps and leave space between the In-Ceram® core and die. If the treatment plan calls for construction of an FPD, wax a prop on the edentulous ridge to provide support for building up the pontic during later steps. The prop must taper to avoid any undercut from an incisal or proximal view (Figure 4.2-B). If built too far facially, the connector's strength will be insufficient. If built too far lingually, the FPD will require extensive pontic substructure buildup that must be reduced later.

Figure 4.2. Die Preparation for In-Ceram® Restoration.



4.4.2. **Duplication.** Duplicate the model with a highly accurate impression material (Figure 4.3-A). Polyvinylsiloxane materials or addition polymerizing silicone are recommended. Because only the prepared site needs impressing, a small, disposable, quadrant impression tray is quite suitable. Use a putty and wash technique of heavy and light body impression materials to create the impression. Inspect the impression for margin integrity.

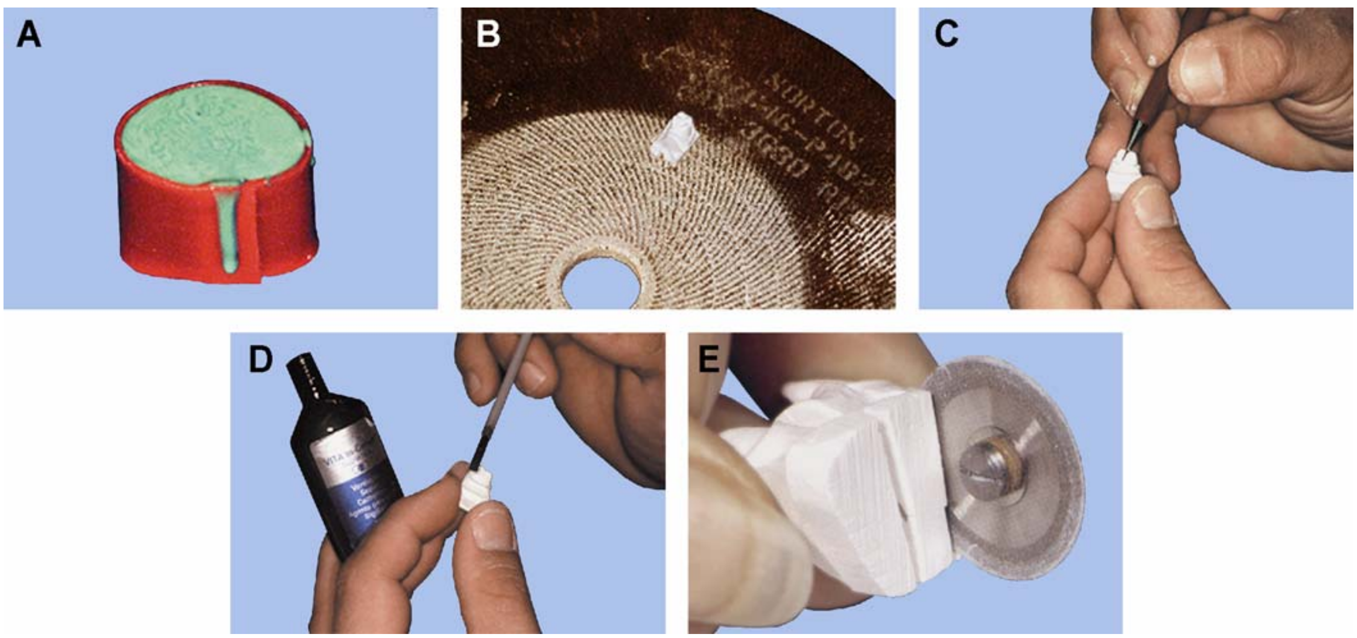
4.4.3. **Special Plaster Model:**

4.4.3.1. Spray the impression with a wetting agent and blow it dry. Strictly follow the manufacturer's instructions for mixing and pouring special plaster. Separate the mold after 2 hours and flatten the base (Figure 4.3-B), taking care not to wet the model when trimming (dry grind).

4.4.3.2. Mark the margins with a graphite pencil and apply a thin coat of sealant to the FPD abutments only (Figure 4.3-C and -D). Do not seal any other areas.

4.4.3.3. Partially section the base of the FPD plaster model with a die saw (Figure 4.3-E). Attach the base to the aluminum oxide slab with cyanoacrylate adhesive and then continue sectioning the model. Plaster models for single unit restorations need only be flattened on the base to prevent the cast from falling over while firing. The special plaster model is are now ready for slip application.

Figure 4.3. Fabrication of Refractory Cast for In-Ceram® Restoration.



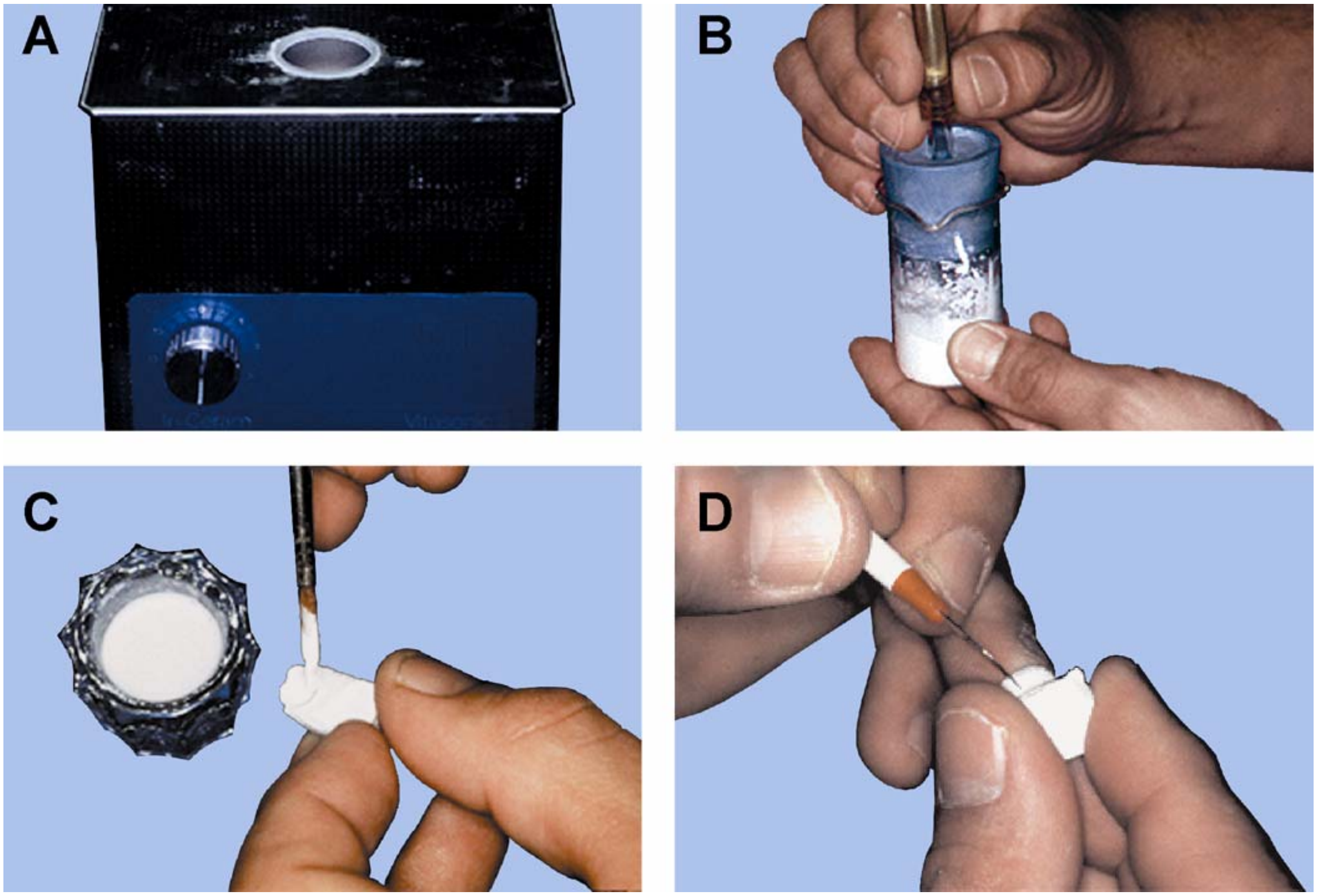
4.4.4. **Mixing Slip Material:**

4.4.4.1. Weigh out exactly 38 grams of VITA In-Ceram®, Alumina Powder. Pour the contents of one ampoule of powder liquid and one drop of In-Ceram additive in the glass-mixing vessel and premix for a few seconds in the Vitasonic II (Figure 4.4-A).

4.4.4.2. Next, place the glass beaker on a vibrator and slowly mix in the alumina powder with a glass mixing rod. (This important step can seem tedious because the particle size of the slip is very fine and does not wet easily with such a small amount of liquid.) Interrupt the mixing process three times to place the mixing vessel in the Vitasonic II for 2 minutes each. Be sure to remove the glass rod before mixing ultrasonically. Once the entire amount of powder has been added, place the mix in the Vitasonic II for 7 additional minutes.

4.4.4.3. The finished mix should be homogenous. Place the prepared slip under vacuum for one minute (Figure 4.4-B) and the pour it from the glass mixing beaker into a plastic cup.

Figure 4.4. Mixing and Applying Slip Material for In-Ceram® Restoration.



4.4.5. **Slip Application:**

4.4.5.1. Slip application is accomplished with a #4 synthetic fiber brush. The material needs to flow off the brush without locking into place (Figure 4.4-C). The moisture content is absorbed into the plaster and previous layers of material, creating a dense rigid coping and substructure resembling wet chalk.

4.4.5.2. Although the finished substructure's dimensions should follow standard criteria, the slip material should be slightly overbuilt and reduced after sintering is complete. Copings and retainers must be at least 0.5 mm thick and connectors should be as large as possible.

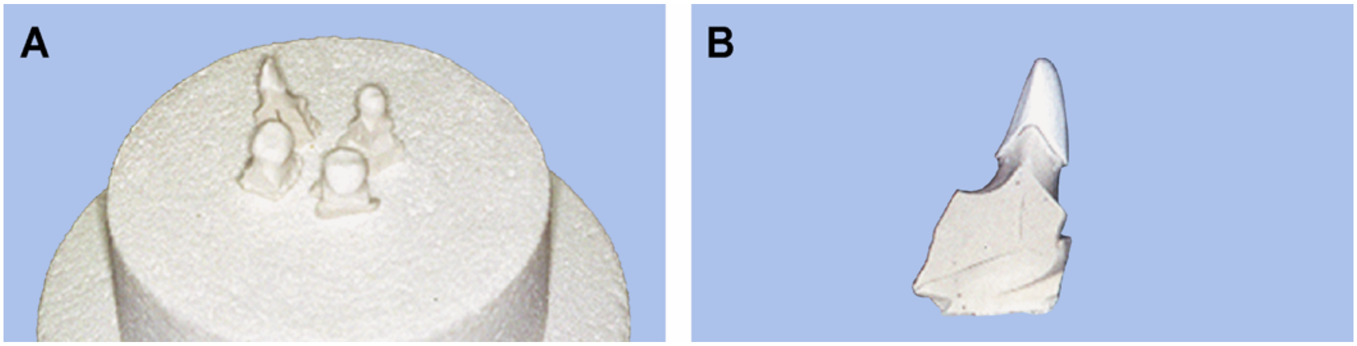
4.4.5.3. Use a sharp flexible #15 scalpel for carving and shaping margins (Figure 4.4-D). Carving the slip material increases chances of cracking the buildup. Therefore, adjustments should be accomplished after sintering when possible. Prior to sintering, apply a layer of In-Ceram Stabilizer to the completed slip buildup after a waiting time of 30 minutes.

4.4.6. **Sintering and Finishing:**

4.4.6.1. The sintering process shrinks the special plaster model, leaving the slip material accurately intact (Figure 4.5-A). The firing program is approximately 10 hours long—6 hours to reach 120 ^{o}C, 2 hours to reach 1120 ^{o}C, and a 2-hour hold. Cool the furnace to 400 ^{o}C before opening the firing chamber. Then cool the substructure to room temperature before handling. Refer to the manufacturer's instructions for more detailed guidance.

4.4.6.2. Remove the die spacer from the master model and gently seat the substructure (Figure 4.5-B). Adjust fit and contours with a fine diamond rotating at low speed. The minimum thickness is 0.5 mm on the facial and lingual surfaces and 0.7 mm occlusally. Proper contours and function must be established before glass infiltration because future adjustment is not possible.

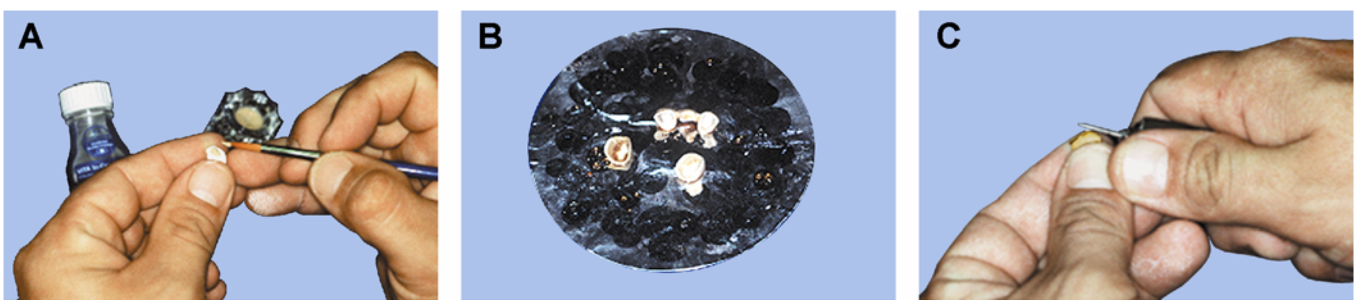
Figure 4.5. Sintering and Finishing In-Ceram® Restoration.



4.4.7. **Glass Infiltration:**

4.4.7.1. Color match the infiltration glass to specific Vita Lumin® shades. Mix the appropriate porcelain with distilled water and apply the mixture to the outside of the restoration (Figure 4.6-A). Leave a portion of the pontic uncovered if fabricating an FPD. The infiltration glass must be absorbed into the slip material like a sponge absorbing water from a countertop. If the entire pontic is covered, an air pocket will be trapped in the center of the pontic, resulting in an area of slip material not infiltrated by the glass. This condition will compromise the strength of the FPD.

Figure 4.6. Glass Infiltration of an In-Ceram® Crown.

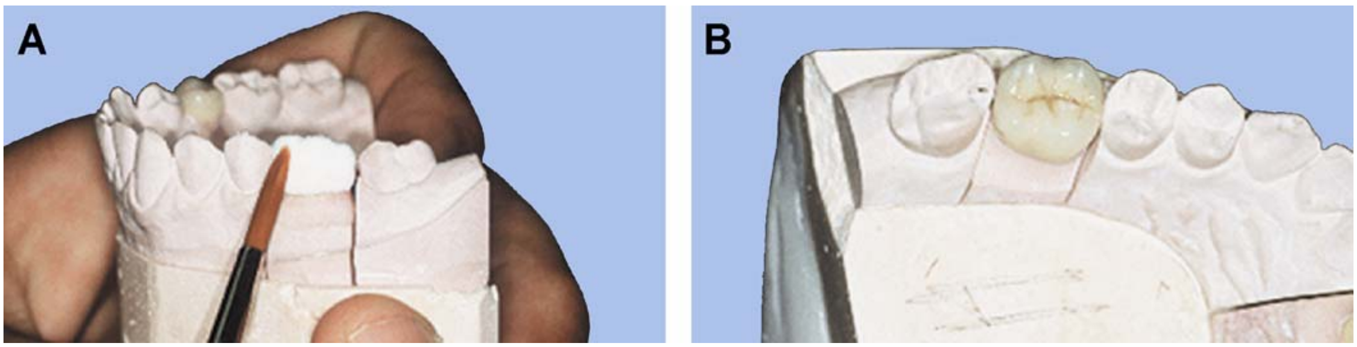


4.4.7.2. Place the unfired restoration on the special, platinum firing tray and fire it according to manufacturer's directions. The firing program includes a 4 to 6 hour hold time at 1100 °C in order to allow the infiltration glass to be absorbed by the sintered slip material (Figure 4.6-B).

4.4.7.3. After firing, remove any excess infiltration glass with a coarse diamond (Figure 4.6-C) and sandblast the remaining glass with aluminum oxide. The substructure must be refired and sandblasted again to ensure no infiltration glass remains on the surface. Refer to the manufacturer's instructions for details.

4.4.8. **Porcelain Application.** Porcelain application is accomplished using VitaDur Alpha aluminous porcelain. Normal porcelain modification and layering techniques are used to complete the buildup (Figure 4.7-A). Follow the manufacturer's directions for firing and glazing the restoration (Figure 4.7-B). Different substructure materials are available for different applications, such as "Spinell" for anterior single unit restorations requiring increased translucency or "Zirconia" for a three-unit posterior FPD.

Figure 4.7. In-Ceram® Restoration Porcelain Application.



Section 4C—IPS Empress® System

4.5. Overview. IPS Empress® is a leucite-reinforced glass ceramic manufactured in ingots of different shades and opacities. The ceramic ingots are pressed into molds formed by using the lost wax technique. There are currently two different systems available—IPS Empress®, used for inlays, onlays, crowns, and veneers, and IPS Empress® 2, used for all of the above plus all-ceramic FPDs. The IPS Empress® system can be used with either of the following methods of fabrication—the staining technique (paragraph 4.6) or the layering technique (paragraph 4.7).

4.6. Staining Technique. The crown or veneer is waxed to full contour, sprued, invested, and then burned out in a conventional burnout oven. After burnout, the mold is transferred to the IPS Empress ® EP500 pressing furnace where a neutral base ceramic ingot is pressed into the mold. The pressed pattern is recovered and fit to the master die. Pigmented characterization ceramic (stain) is applied and fired in a conventional porcelain oven to achieve the desired dentin and enamel effects. Lastly, a fine-grained glazing material is applied and fired to provide a sealed surface with a natural appearing luster and texture.

4.7. Layering Technique. A dentin shade ceramic ingot is pressed just as in the shading technique. The ingots for the layering technique are shaded to correspond to dentin colors of the Vita Lumin® and Chromascop™ shade guides. The pressed dentin core is contoured for enamel porcelain application. Modifiers and incisal porcelains are applied, conventionally fired, and contoured. The restoration is then glazed before insertion. Procedures for this technique are as follows:

4.7.1. **Cast and Die Preparation.** Construct a master cast with removable dies and articulate, using procedures given in Chapter 1, Section 1F, of this volume. Apply a removable die spacer to the dies and ensure the spacer does not cover any portion of the margin.

4.7.2. **Wax-Up.** Wax the crown to the exact desired full contour. At this point evaluate the wax-up for the minimum thickness necessary—1.5 mm axial surfaces, 2 mm incisally, and 1mm shoulder margin. If the wax cutback technique is to be used, cut back the enamel portion, leaving approximately 1.0 mm wax thickness for pressing the dentin core (Figure 4.8). If the cutback will be accomplished in the pressed ceramic, refine the margins now.

Figure 4.8. Wax-Up for an IPS Empress® Crown.

4.7.3. **Spruing:**

4.7.3.1. Attach a single 8-gauge sprue former, 6 to 8 mm long to the incisal area of anterior teeth or the noncritical cusp of posterior teeth. The attachment site should be flared and perfectly smooth to prevent any turbulence when ceramic material flows into the mold (Figure 4.9-A). Do not use multiple sprue formers to the same wax pattern because a suture line may be evident after porcelain pressing. (***NOTE:*** Sprue two to three units of one shade when possible because ingots are expensive and material buttons cannot be pressed again.

4.7.3.2. Seal the opening of the ring base (sprue base) with wax and weigh the base. Attach the patterns on the ring base at least 3 mm apart and 10 mm from the sides of the paper ring (Figure 4.9-B).

4.7.3.3. Unlike conventional castings, sprued patterns must be placed in the thermal zone. The labial surface of anteriors should face center of the mold. This places the thickest portion of the pattern in the thermal zone.

4.7.3.4. Weigh the ring base with attached patterns and subtract the weight of the empty base. This figure is the exact wax weight of the wax patterns. If the pattern weight is less than .24 grams, invest an additional "dummy" pattern. This allows the furnace press plunger to travel at least 1 mm; otherwise, the pressing procedure will not end automatically. Patterns weighing .6 grams or less may be pressed from a single ceramic ingot. Patterns weighing between .6 and 1.4 grams will require 2 ingots of material.

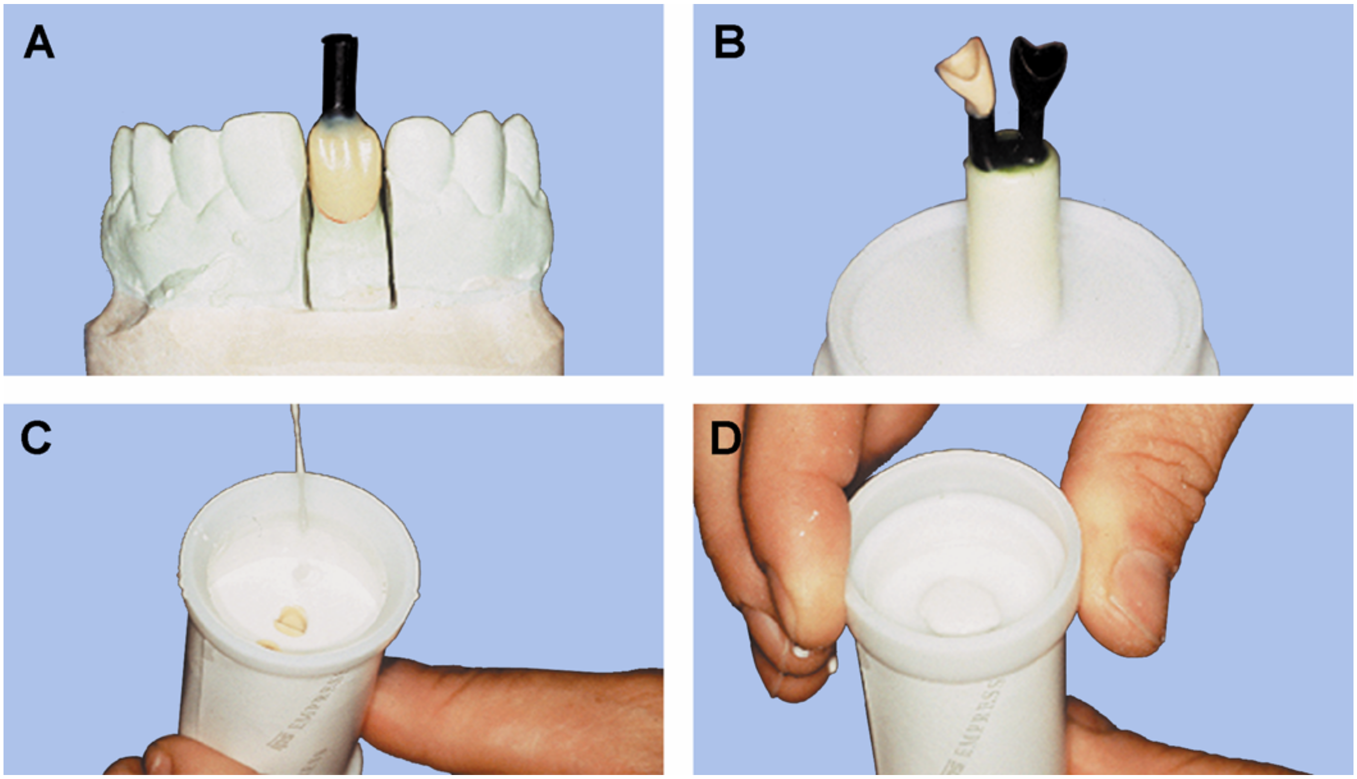
4.7.4. **Investing:**

4.7.4.1. Select a paper investment ring and form a cylinder by pressing the adhesive side along the marked line. Place the ring base on one end of the paper ring and seat the ring stabilizer on the other end.

4.7.4.2. Choose the appropriate investment for the layering or staining technique. Investment for the layering technique is white in color and the staining technique investment is blue. Measure the investment and liquid per the manufacturer's instruction chart and then vacuum mix for 60 seconds.

4.7.4.3. Carefully fill the cylinder just below the ring stabilizer, remove the ring stabilizer, and slowly position investment gauge (Figure 4.9-C and -D). The investment must press through the hole in the gauge. After setting, remove the gauge, ring base, and paper. Scrape only the rough dimple created by the investment gauge. DO NOT alter the 90-degree angle of the mold.

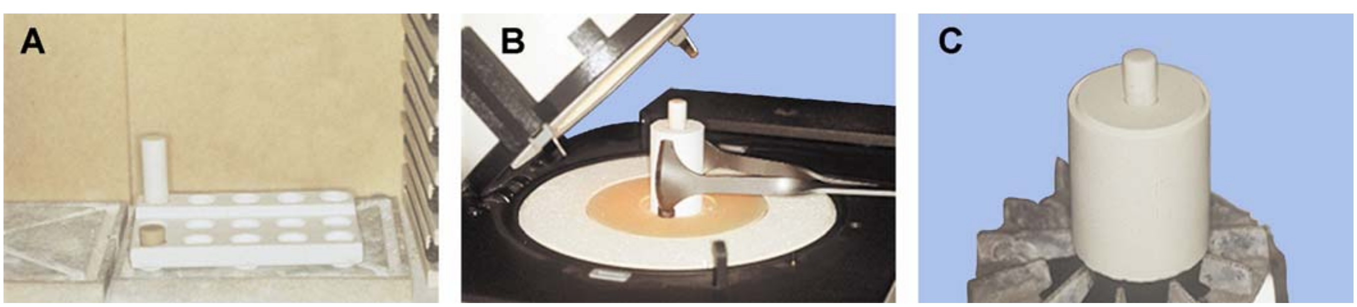
Figure 4.9. Spruing and Investing an IPS Empress® Crown.



4.7.5. **Burnout and Pressing:**

4.7.5.1. Select the appropriate ceramic ingots for the prescribed shade and place them with an alox plunger on the support tray. Place the mold and support tray into a cold burnout furnace (Figure 4.10-A). Heat at a rate of 3 ^{o}C (or 37 ^{o}F) per minute to 850 ^{o}C (or 1560 ^{o}F) and hold for 90 minutes.

Figure 4.10. Burnout and Pressing an IPS Empress® Crown.



4.7.5.2. Remove the mold from the furnace with opening up and immediately place the ingots from the support tray into the hot mold. Place the alox plunger on top of the ingot, ensuring it is fully seated in the mold (Figure 4.10-B). Select the desired program. (Consult the manufacturer's pressing table for exact data.)

4.7.5.3. Position the loaded cylinder in the center of the pressing furnace, manually close the muffle, and press the start button. Check the vacuum and air pressure. The program will run automatically with an audio signal that indicates when the pressing process is complete.

4.7.5.4. The pressing cycle last approximately 45 minutes. To complete the cycle, remove the mold from furnace and place it on a raised wire rack surface to promote quick, even cooling of the pressed mold (Figure 4.10-C).

4.7.6. **Recovery:**

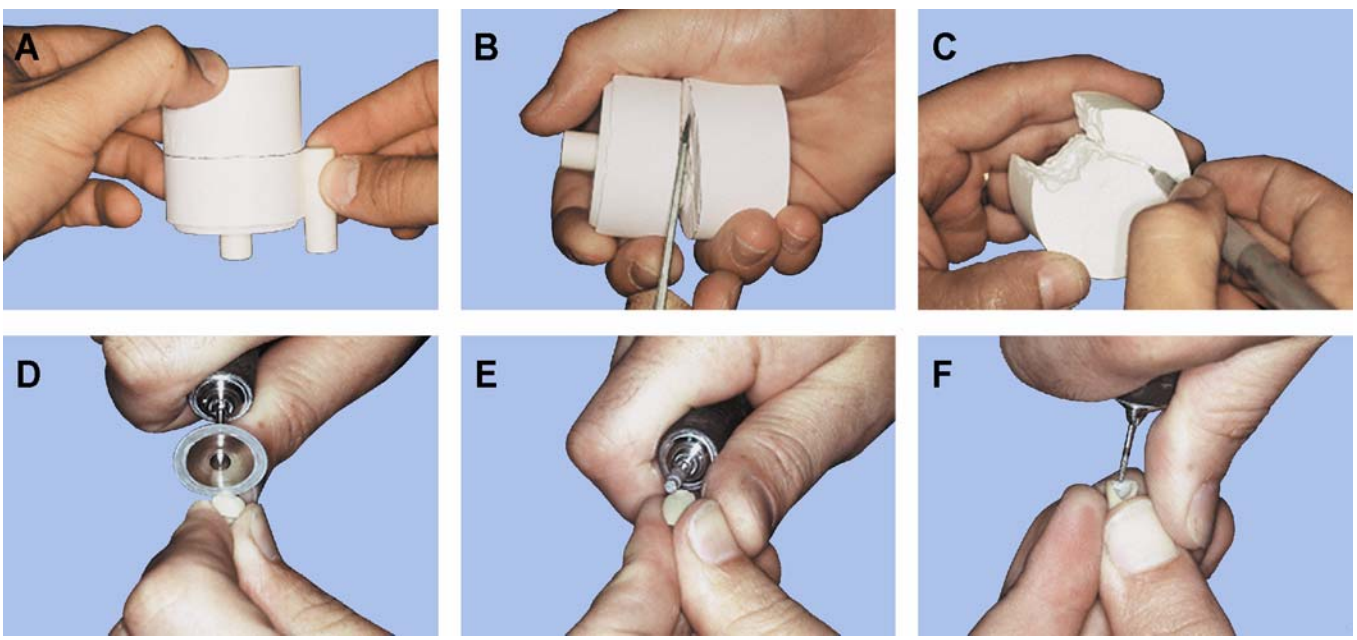
4.7.6.1. Position an unused alox plunger on the outside of the investment mold to measure the depth the first plunger traveled during the pressing. Mark this depth around the outside of the cooled mold (Figure 4.11-A).

4.7.6.2. Cut along the line with a large separating disk and pry at the line with a plaster knife (Figure 4.11-B). Remove the remaining portion of the investment, using glass beads at 58 psi and reducing to 29 psi when the ceramic becomes visible (Figure 4.11-C).

4.7.6.3. Clean residual investment and ingot material from the plunger by blasting with aluminum oxide. Desprue units with a diamond disk and recontour the sprue attachment point (Figure 4.11-D and -E).

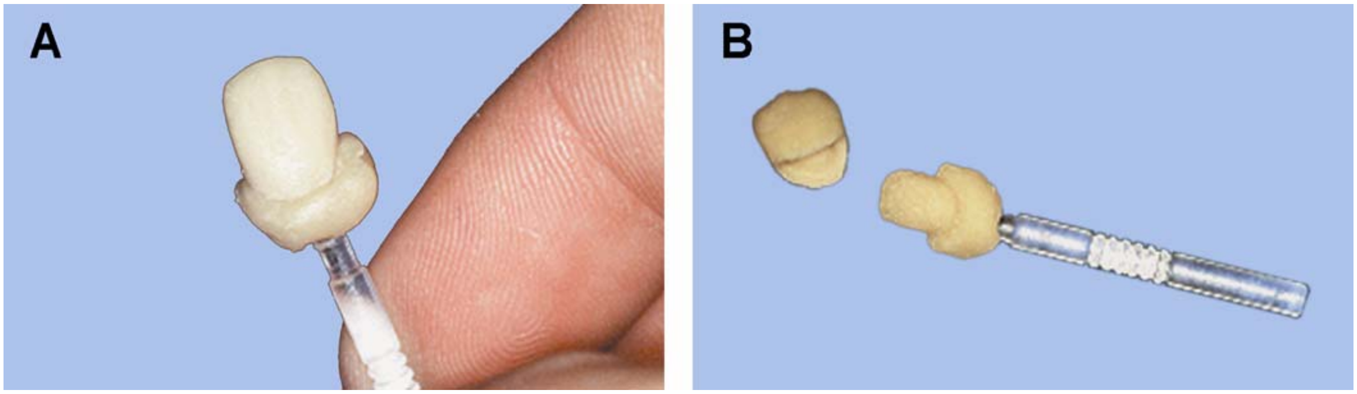
4.7.6.4. Gently position the ceramic unit on the die. If resistance is felt, apply a disclosing medium and carefully remove discrepancies with a diamond point (Figure 4.11-F).

Figure 4.11. Recovery of a Pressed IPS Empress® Crown.



4.7.7. **Fabrication of the Stumpf Die.** A dentin-shaded die is used to evaluate restoration color during the incisal layering and staining procedures. This "stumpf die" is fabricated by using one of nine shades of flexible composite die material selected by the dentist after preparing the natural teeth. Coat the inner surfaces of the pressing with the separating liquid provided in the system. Apply the corresponding die material into the pressing and insert a die holder in the material (Figure 4.12). Light cure the die for 5 minutes in a light curing unit.

Figure 4.12. Stumpf Die Fabrication for an IPS Empress® Crown.

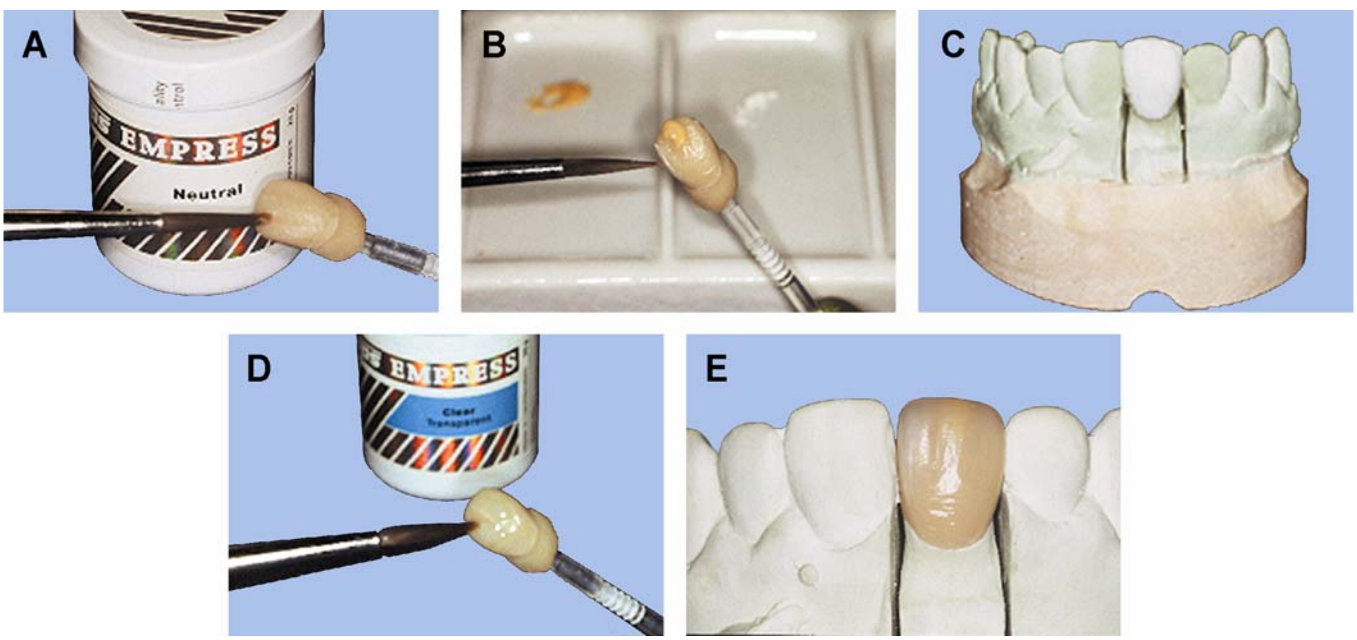


4.7.8. **Crown Completion:**

4.7.8.1. If the crown was pressed to full contour, reduce the enamel portion with diamonds or abrasives, leaving a dentin core of at least .8 mm. Take care not to generate heat while grinding the ceramic material. Excess heat will cause cracking of the pressed ceramic, requiring the restoration to be remade. Slight reduction of all axial surfaces is also necessary to allow for the application of a neutral material layer.

4.7.8.2. When contouring is completed, gently bead blast and steam clean the dentin core. Apply Empress® neutral material over the entire surface and fire in a porcelain oven (Figure 4.13-A).

Figure 4.13. Completion of an IPS Empress® Crown.



4.7.8.3. Next, characterize the dentin, if desired, by applying and firing stains or modifiers (Figure 4.13-B). Apply incisal material to the full contour (Figure 4.13-C). Slightly overbuild the incisal layer and add to the proximal contacts to compensate for shrinkage during firing.

4.7.8.4. After firing the incisal layer, make any necessary final corrections to the shape of the restoration and apply one thin coat of glaze (Figure 4.13-D and -E). Minor corrections to contacts and margins can be accomplished, using Empress® add-on material in a manner similar to standard ceramic correction powders.

Section 4D—Porcelain Laminate Veneers

4.8. Overview. An alternative to the full-coverage, all-ceramic crown is the porcelain laminate veneer. Veneers are a thin shell of porcelain covering the facial surface of the prepared tooth. Veneers offer the same esthetic advantages of the all-ceramic crown with a more conservative preparation. Veneers can be used to cover discoloration and enamel defects, close diastemas, repair chipped teeth, and correct slightly misaligned teeth. Many techniques are available for producing porcelain laminate veneers, including the platinum foil technique, refractory technique, and pressed ceramics. This chapter will discuss only the refractory technique.

4.9. Refractory Technique:

4.9.1. **Master Cast Preparation (Figure 4.14-A).** Pour the impression in die stone and allow to final set. Trim the cast to standard dimensions and remove any soft tissue interference from the margins and interproximal areas. Mark the margins with a red wax pencil and apply die spacer to within 1mm of the margins. If possible, use a removable die spacer to allow for easier seating of the finished veneers on the master cast. Ensure the removable die spacer is compatible with the duplicating material used in the refractory cast fabrication (paragraph 4.9.2).

4.9.2. **Refractory Cast Fabrication:**

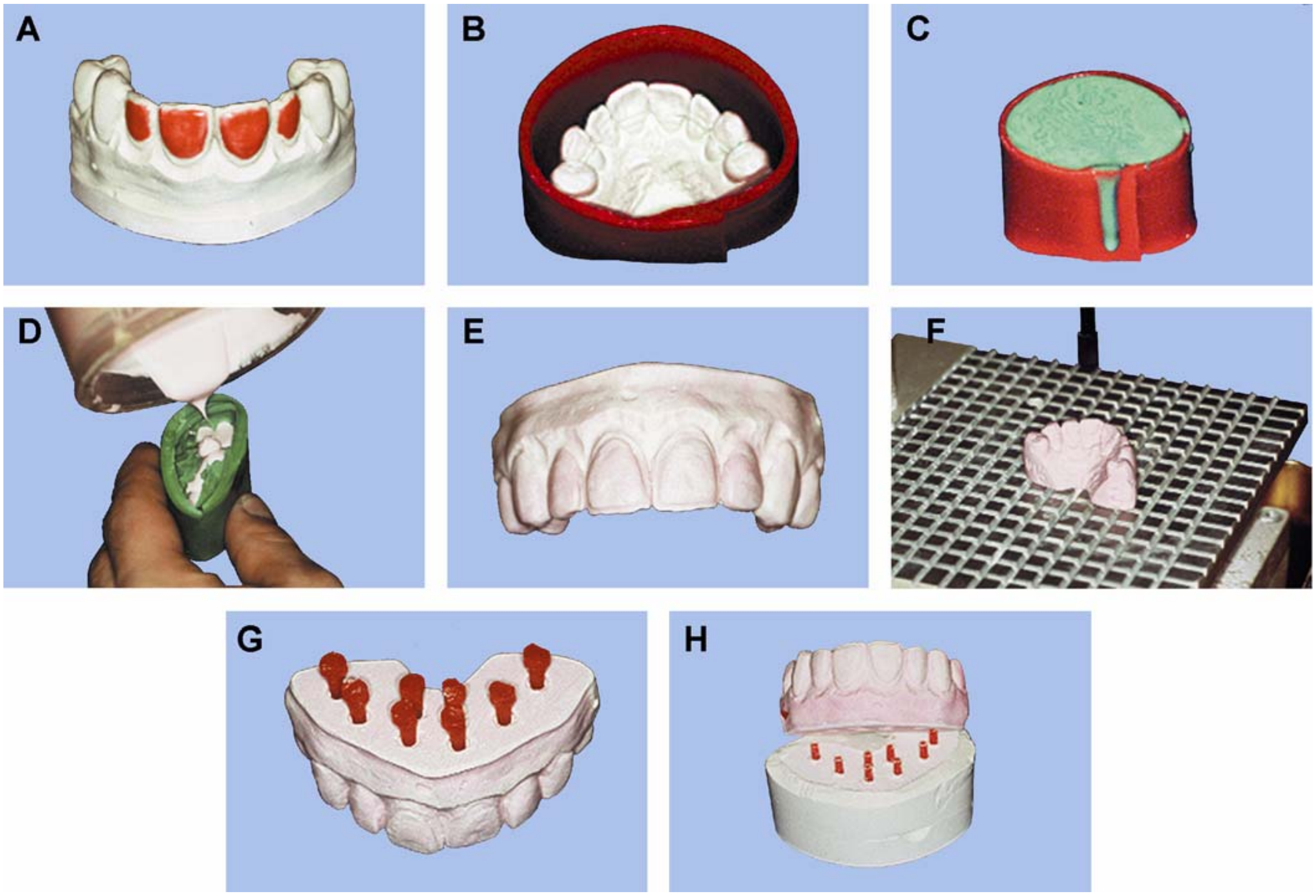
4.9.2.1. Box the master cast to include at least one adjacent tooth on both sides of the prepared teeth (Figure 4.14-B). Using a high quality duplicating material, make a mold of the boxed portion of the master cast (Figure 4.14-C).

4.9.2.2. After the duplicating material has set, remove and inspect the impression for any voids particularly around the margins. Pour the mold with a refractory material designed for use with porcelain veneering systems. Pay close attention to the manufacturer's directions (Figure 4.14-D).

4.9.2.3. Carefully remove the refractory cast from the duplicating material. Inspect the refractory cast for voids in any critical areas. Trim excess material from the base of the cast, ensuring the base is smooth and flat (Figure 4.14-E). Pin and base the cast, using the reverse pin technique (paragraph 4.9.2.4).

4.9.2.4. Seal the bottom of the cast with a die hardener, waterproof sealant. Drill two holes for each die using a pindex or parallel pinning machine (Figure 4.14-F). Insert the dowel pins into each hole. Do not glue the pins in place, but ensure the pins are stable (Figure 4.14-G). Box the cast and pour a stone base. After the stone has set, separate the base from the refractory cast (Figure 4.14-H). When using this technique, it is easier at this time not to separate the cast into individual dies. The cast will be sectioned into individual dies after the first firing and contouring have been accomplished. This method increases the stability of the dies during the porcelain application and contouring steps.

Figure 4.14. Master Cast Technique for Porcelain Laminate Veneers.



4.9.3. **Cast Preparation.** Degass the refractory cast in a burnout oven following manufacturer's directions for the refractory material being used. After degassing, the refractory cast should exhibit a white color. Gray or black areas indicate the need for additional degassing (Figure 4.15-A).

4.9.4. **Porcelain Application:**

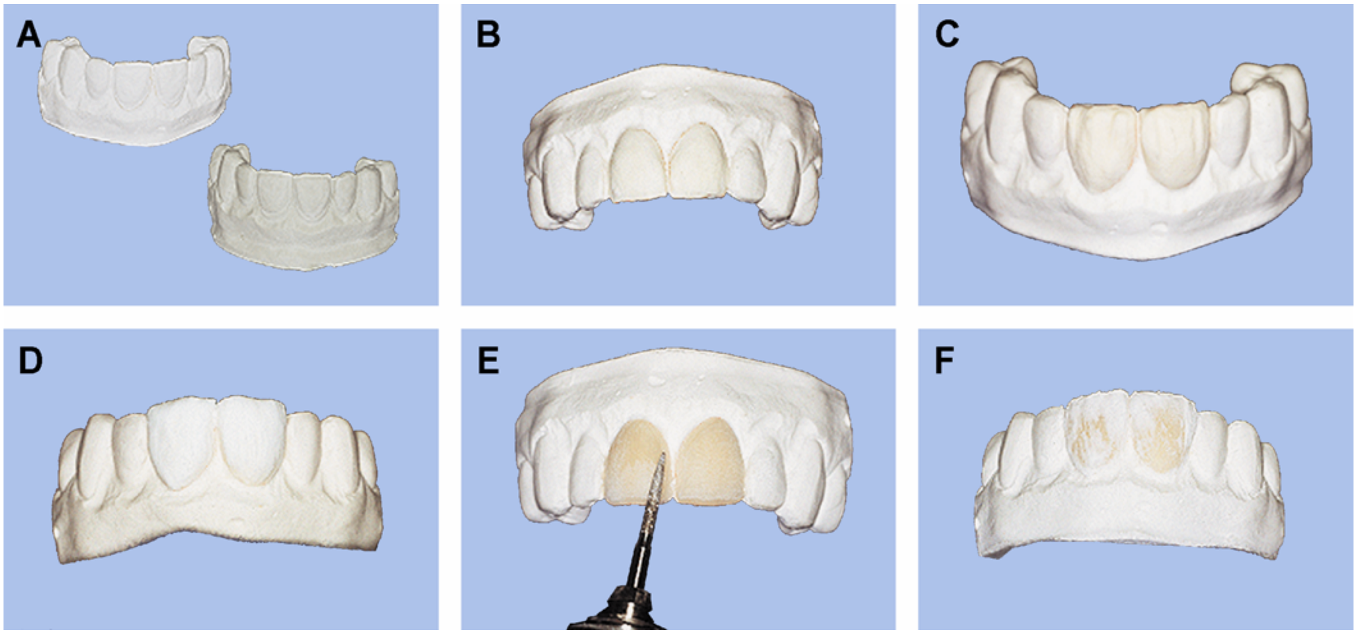
4.9.4.1. First, soak the refractory cast in distilled water to prevent the porcelain from drying out quickly during application. Repeat the soaking process after firing and before each new layer of porcelain is added. (The cast must be cooled completely before soaking.)

4.9.4.2. Mix and apply a masking porcelain layer (Figure 4.15-B). The opacity and depth will vary depending on the esthetic requirements. If you are covering stains or discolored teeth, more masking porcelain is needed than if you are closing diastemas. Dry and fire the porcelain following manufacturer's directions.

4.9.4.3. Mix and apply body porcelain to the cervical margin area and work toward the incisal, tapering to a sheer layer as the incisal edge is approached (Figure 4.15-C). Shape the mamelons with a brush if desired. Apply incisal porcelain from the incisal edge, tapering it onto body porcelain to create natural dentin-enamel blend (Figure 4.15-D). Cut through the embrasures with a sharp instrument to separate the veneers. Fire the veneers in a porcelain oven, using the manufacturer's guidelines for time and temperature.

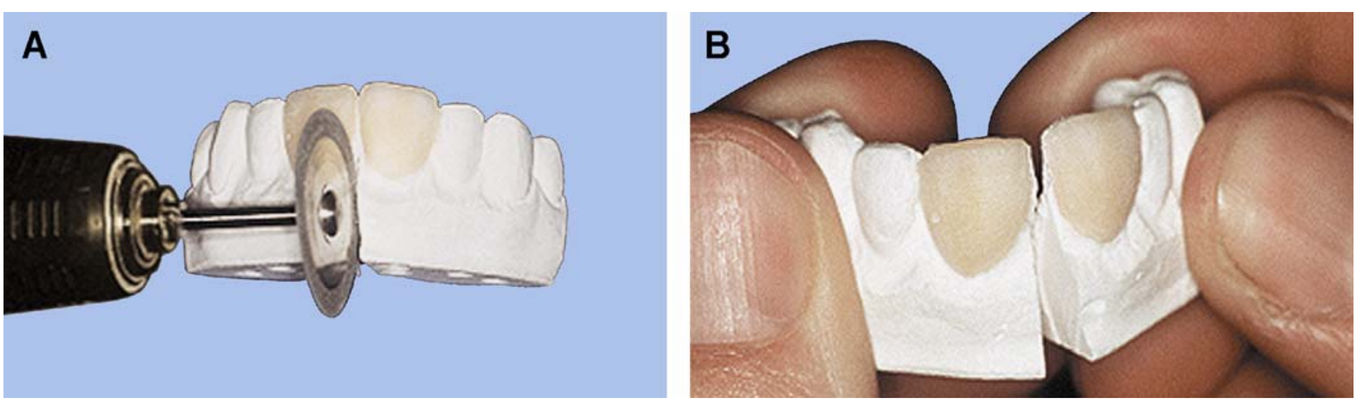
4.9.4.4. Contour the porcelain with a medium to fine grit diamond or stone (Figure 4.15-E). If porcelain additions are necessary, thoroughly clean the veneers and then apply porcelain and fire it in accordance to the manufacturer's guidelines (Figure 4.15-F).

Figure 4.15. Porcelain Application and Contouring.



4.9.5. **Section the Cast Into Individual Dies.** Use a disc to cut section dies that are to be removable. Stop the cuts just shy of the interproximal contact areas (Figure 4.16-A). Use a knife to score a notch from the cut to the contact areas. Place thumbs on both sides of the cut and gently push together until the die breaks apart (Figure 4.16-B).

Figure 4.16. Sectioning the Cast Into Individual Dies.



4.9.6. **Completing the Veneers:**

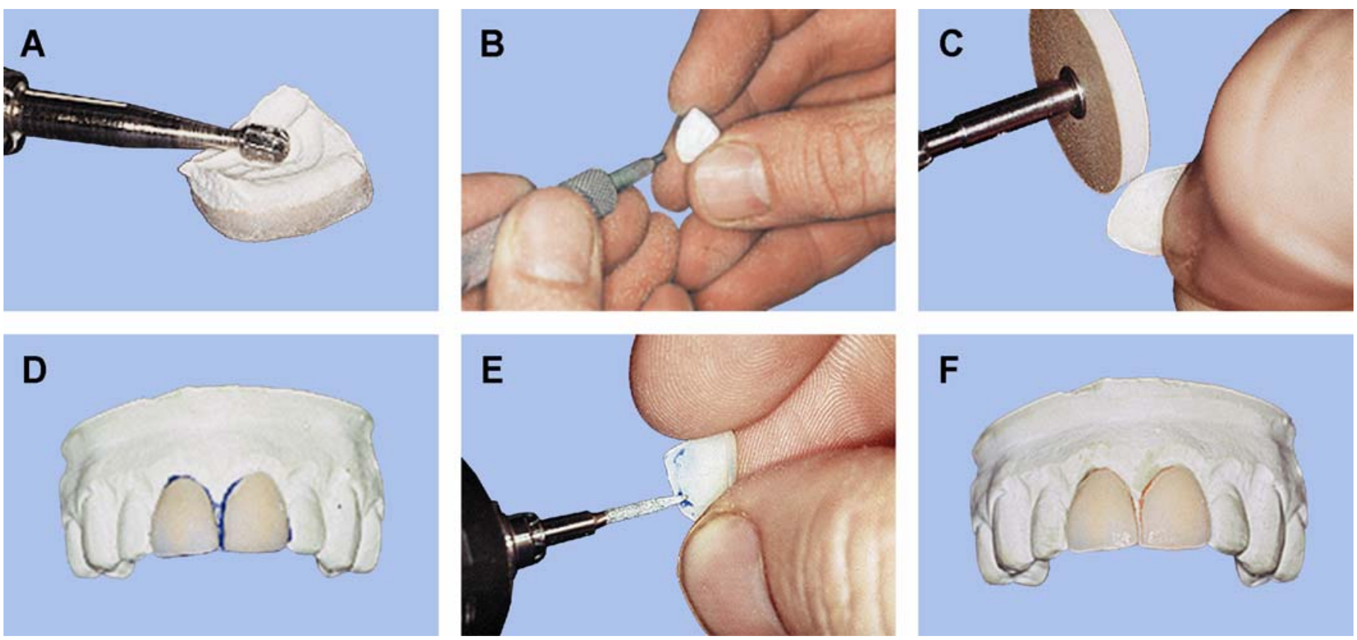
4.9.6.1. Some cases may require porcelain contacts to be added at this point, or marginal areas may need to be added to and refined. To add porcelain, remove the glaze and clean the restoration. Then apply the same porcelain powders originally used during the initial application. Be sure to add enough porcelain to allow for re-contouring. The porcelain addition must be *meticulously applied, shaped,* and *well condensed.* If not, the correction will be evident by a chalky-white border that may be hard to hide with extrinsic stains. Fire the porcelain addition under vacuum and at a slightly lower temperature. After all corrections and contouring are complete, stain as needed and glaze.

4.9.6.2. Divest the completed restoration by removing the bulk of the refractory material from the inside of the veneer with a #8 bur. Be careful not to touch the margins (Figure 4.17-A). Finish cleaning the refractory from the inside of the veneer with 25-micron aluminum oxide or glass beads at 40 psi (Figure 4.17-B). Take care during this step to prevent blasting a hole through the veneer or altering the marginal areas.

4.9.6.3. Seat the veneer on the master cast by first carefully removing any overextensions of the margins with a rubber wheel (Figure 4.17-C). If possible, remove the die spacer from the cast. Use a disclosing medium and gently seat the veneer onto the cast (Figure 4.17-D). Light finger pressure is essential to prevent breaking the thin porcelain veneers. Relieve discrepancies with a fine diamond at slow speeds (Figure 4.17-E). Repeat the procedure until the veneer is completely seated (Figure 4.17-F).

4.9.6.4. Etch the veneers by first covering exterior surfaces with wax and attaching sprue wax to the facial surface to act as a holding device during the etching process. Apply etching gel (7.5 percent hydrofluoric acid) to the inside surface of the veneer. After appropriate etching time has elapsed, neutralize the veneers in a 10 percent solution of baking soda and water or neutralizer provided with the etching gel. Ultrasonically clean the veneer in distilled water.

Figure 4.17. Completing the Veneers.



Chapter 5

FIXED RESIN PROSTHODONTIC RESTORATIONS

Section 5A—Introduction

5.1. Overview. Resin veneered fixed prostheses are becoming increasingly popular in dentistry today. New materials are making it possible to fabricate an esthetic and durable restoration with resin. Resin materials are available to fabricate veneers, inlays, onlays, and full coverage crowns as well as the more traditional metal veneered crowns and FPDs. Resin-veneered restorations are very similar to metal-ceramic restorations in preparation requirements and fabrication technique. All-resin preparations are very similar to the all-ceramic preparations (Chapter 4). This chapter will discuss the fabrication technique for two resin systems currently on the market—Sinfony® by ESPE America Incorporated, and Targis™ by Ivoclar Williams, Ivoclar North America, Incorporated.

Section 5B—Targis™ All Resin Crown

5.2. Overview. Targis™ has many uses in addition to veneering metal crowns. It may be used as a metal-free crown for anterior teeth, inlays, onlays, and veneers. Metal-free posterior crowns and FPDs can be fabricated with Targis™ in conjunction with a Vectris™ substructure. Vectris™ is a fiber-reinforced composite material that replaces the metal framework. However, Vectris™ and Targis™ should not be used to construct a metal-free FPD with multiple pontics between two abutments.

5.3. Cast Preparation. A master cast with removable dies must first be fabricated and articulated. Use the techniques described in Chapter 1, Section 1F, of this volume. When fabricating a Vectris™ FPD substructure, it is helpful to leave the abutments and pontic portions in one piece until after the substructure is completed. Avoid sharp edges on the cast because they can damage the membrane during the formation process. The base of the model must also be flat to prevent it from cracking while under high pressure during later steps. Apply a die hardener and allow it to dry completely. Apply two layers of Targis™ Model Separator, waiting 3 minutes between each layer.

5.4. Metal-Free Bridge Framework Fabrication:

5.4.1. **Silicone Key.** Place a wax wire with a diameter of at least 3 mm between the two abutments and secure in place. Observe the placement of the connectors when positioning the wax wire. This wax represents the pontic and should be modified by adding wax so it is slightly oval in shape (Figure 5.1). Remove segments of the model not associated with the framework. Use silicone to make a key that covers the abutments and the wax wire. Be sure to adapt the silicone to the under side of the wax wire completely with no voids. Leave the occlusal area open. After the silicone has set up, remove the wax wire. Trim any silicone material covering the occlusal surface to allow light to reach the entire occlusal surface during the curing process. Apply two additional coats of separator to the model.

5.4.2. **Spillways.** Use a separating disc to cut two perpendicular spillways off of the pontic channel. The spillways will allow excess matrix to flow off during processing of the Vectris™ substructure known as deep drawing. The fiber reinforced composite will be condensed more homogeneously with this technique.

5.4.3. **Fabrication of Vectris™ Pontics.** Apply Vectris™ glue to the base of the cavity formed by the wire wax. Remove the Vectris™ Pontic from the package and trim a piece of the rope shaped material to fit into the cavity formed by the wire wax (Figure 5.2). Cut a second piece of Vectris™ pontic long enough to cover the entire length of the occlusal surface. Place this rope on top of the first piece. Use the Vectris™ VS 1 curing unit to form and cure the pontic with program P1 for 9 minutes (Figure 5.3). Be sure to follow the manufacturer's operating instructions for the Vectris™ VS1 curing unit.

Figure 5.1. Wax Pontic Placement.

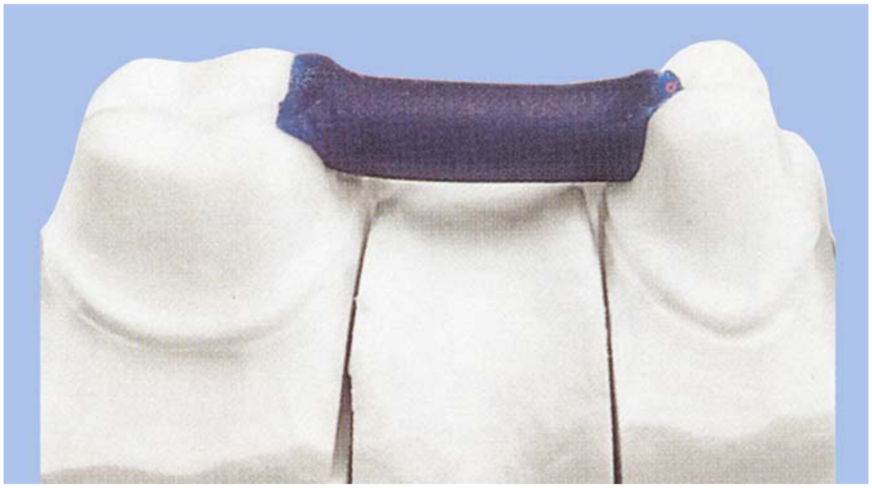
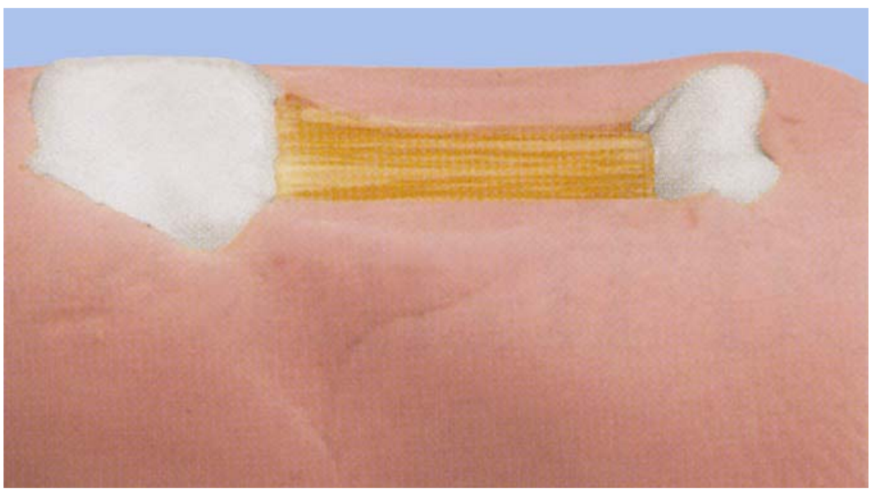


Figure 5.2. Vectris™ Pontic Placement.



5.4.4. **Finishing of the Vectris™ Pontic:**

5.4.4.1. Carefully remove the cured pontic without damaging the silicone key. Trim excess material with a carbide bur to conform to the following dimensions:

5.4.4.1.1. The pontic should be slightly higher than wide (oval in shape).

5.4.4.1.2. The diameter must be at least 2 mm and the pontic must touch the abutments in the proximal area.

5.4.4.1.3. The occlusal stop portion must be a minimum of 0.3 mm thick and cover at least 1/3 of the occlusal area.

5.4.4.2. Blast the contoured pontic with aluminum oxide at 1 bar pressure; then steam clean thoroughly.

Figure 5.3. Vectris™ VS1 Curing Unit.

5.4.4.3. Apply Vectris™ wetting agent on the cleaned pontic and wait for 1 minute. Blow any excess wetting agent off with compressed air.

5.4.4.4. Trim the silicone key used to form the pontic. Expose at least 4/5 of the abutment preparation, leaving the margins covered. Also provide a space below the pontic to adapt the frame around the pontic. Apply 2 additional coats of separator and allow to dry. Return the pontic portion to the dies, using a small amount of Vectris™ glue to hold in place if necessary.

5.4.5. **Trimming of the Vectris™ Frame.** Trim the Vectris™ frame to a size sufficient to cover both abutments and pontic. For maximum adaptation, make small cuts between the abutment and pontic on each side of the material. Apply Vectris™ glue on the pontic and place the trimmed frame on the model (Figure 5.4). Position the model into the Vectris™ VS1 curing unit and deep draw and cure the frame with program P1.

5.4.6. **Finishing of the Vectris™ Frame:**

5.4.6.1. Carefully remove the frame from the model. Trim the frame with a carbide bur to expose the cervical 1/3 portion of the crown. Do not grind on the occlusal surface because this will weaken the frame greatly reducing the strength of the finished prosthesis. The Vectris™ Frame must cover at least 2/3 of the pontic.

5.4.6.2. Blast the finished frame with aluminum oxide at 1 bar pressure and then steam clean. Apply Vectris™ wetting agent on the frame and wait 60 seconds (Figure 5.5).

5.4.6.3. Remove excess with compressed air. Clean the model of any silicone or other impurities and apply 2 layers of Targis™ model separator. The frame is now ready for the application of Targis™ resin material to complete the buildup of the restoration (Figure 5.6-A).

Figure 5.4. Vectris™ Framework Application.

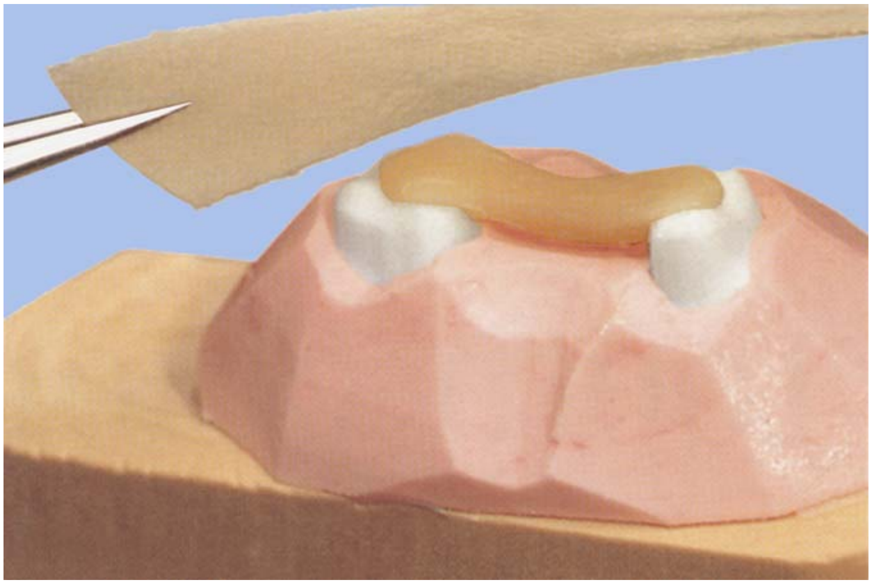
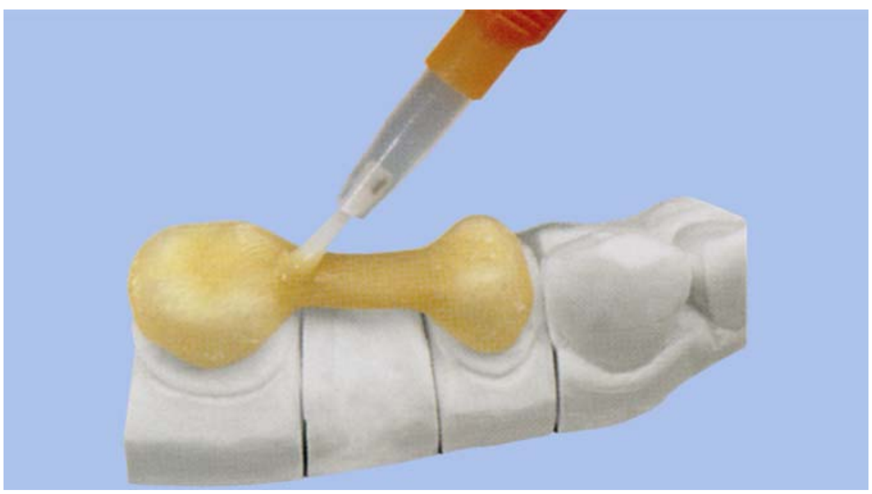


Figure 5.5. Vectris™ Framework Completion.



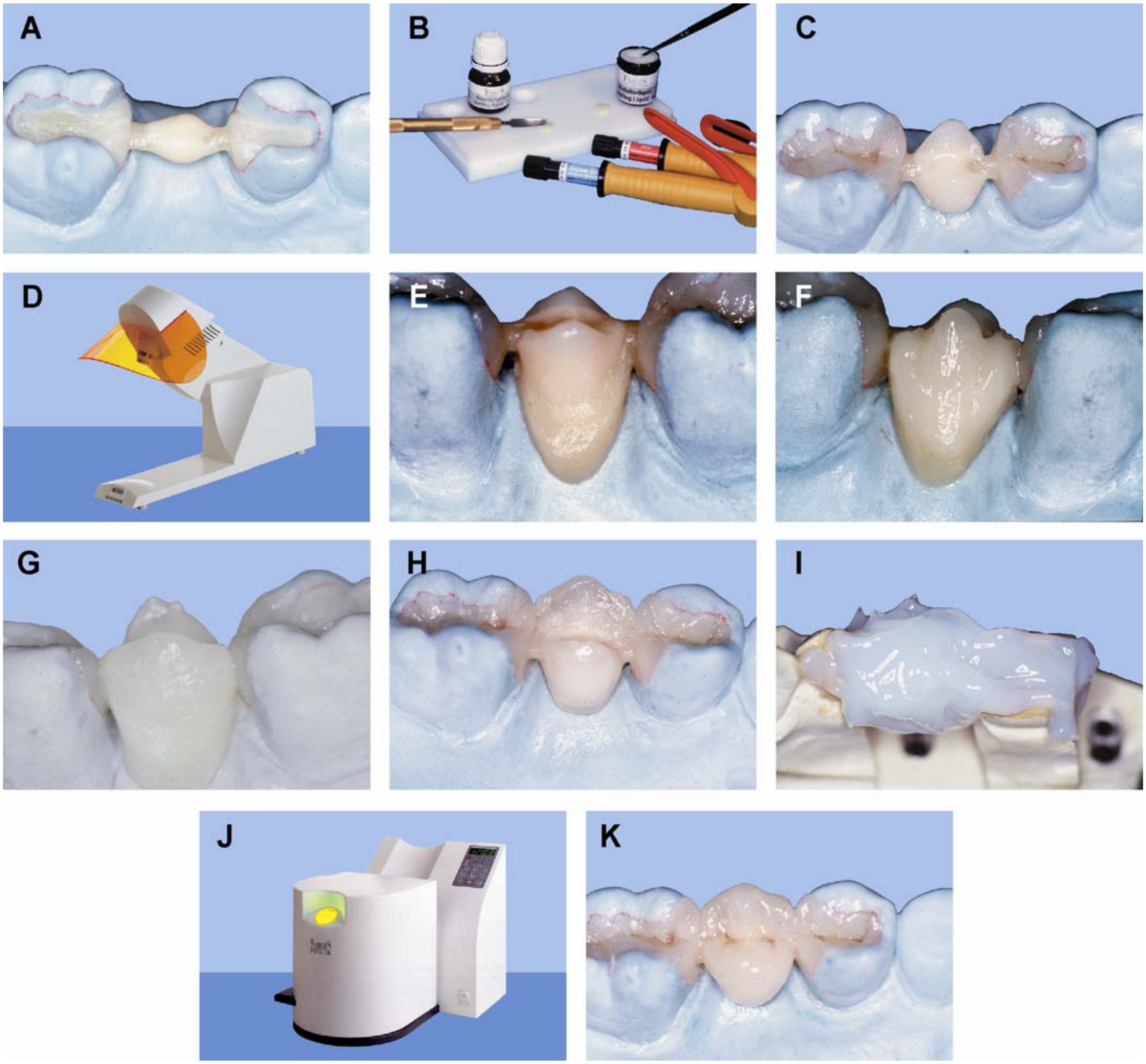
5.5. Targis™ Dentin and Enamel Buildup:

5.5.1. **Application of Basic Shade with Targis™ Base (Figure 5.6-B).** Begin by applying Targis™ base to the entire frame one segment at a time (Figure 5.6-C). Apply the material to the preparation margin. Precure each of these segments for 20 seconds with Targis™ quick-curing light (Figure 5.6-D). After precure is complete, remove the air-inhibited layer with a disposable sponge. Do not to remove the frame from the dies at this time because the Targis™ base is unsupported and easily broken.

5.5.2. **Modeling and Layering:**

5.5.2.1. Apply Targis™ dentin to the restoration, using the normal dentin or incisal buildup technique (Figure 5.6-E and -F). The maximum layer thickness is 2 mm. Precure each segment for 20 seconds in the Targis™ quick before moving on. Do not mix the materials because as this will trap air in the buildup.

Figure 5.6. Targis™ Dentin and Enamel Buildup.



5.5.2.2. Pat the material, using a modeling instrument after it has been dispensed. The modeling instrument can be dipped into a sponge saturated with modeling liquid to reduce the stickiness of the material. After the dentin buildup is complete, the crown may be supplemented, using Targis™ transparent and stains, before the incisal is applied. If using these characterizations, precure each segment with the Targis™ quick for 10 seconds before moving on. Apply Targis™ incisal to complete the contours of the crown (Figure 5.6-G and -H).

5.5.3. **Curing with Targis™ Power.** Apply a generous coat of Targis™ gel to the restoration to prevent formation of an air inhibited layer during curing (Figure 5.6-I). Place the restoration into the Targis™ power curing unit. Heat and light cure it for approximately 25 minutes on program P1 (Figure 5.6-J). Remove it from the unit after curing and wash away the Targis™ gel with running water.

5.5.4. **Finishing and Polishing.** Use carbide burs to accomplish any necessary final contouring. Follow this up by prepolishing the restoration with pumice and a wet brush wheel on slow speed. Do not apply pressure while polishing; slow speeds with little or no pressure give the best results (Figure 5.6-K). Apply Targis™ polishing paste to the restoration and polish without pressure at 8,000 to 10,000 revolutions per minute (rpm). If the desired high gloss is not achieved, the restoration was polished too quickly and with too much pressure.

Section 5C—Sinfony® Resin-Veneered Metal Crown

5.6. Overview. Sinfony® is a light-curing composite system used for veneering fixed and removable restorations with metal frameworks and the individualizing of acrylic and porcelain teeth (Figure 5.7). To prevent fractures with Sinfony®, the material must not be applied less than 0.8 mm for facings and not less than 1mm for occlusal facings.

5.6.1. **Metal Framework.** The framework for a resin-veneered metal crown is very similar to the framework used for a metal-ceramic crown. It is recommended, though, that incisal guidance be in metal to prevent veneer material from shearing off during lateral and protrusive excursions. If the veneer is not under pressure during lateral and protrusive excursions, the resin can be freely extended up to 1.5 mm. For information on the design and fabrication of metal frameworks, see Chapter 2, Section 2C, of this volume. Be sure the metal used is indicated by the manufacturer for use with veneering composites. Finish the framework, polish nonresin bearing surfaces, and steam clean before veneering with Sinfony® (Figure 5.7-A).

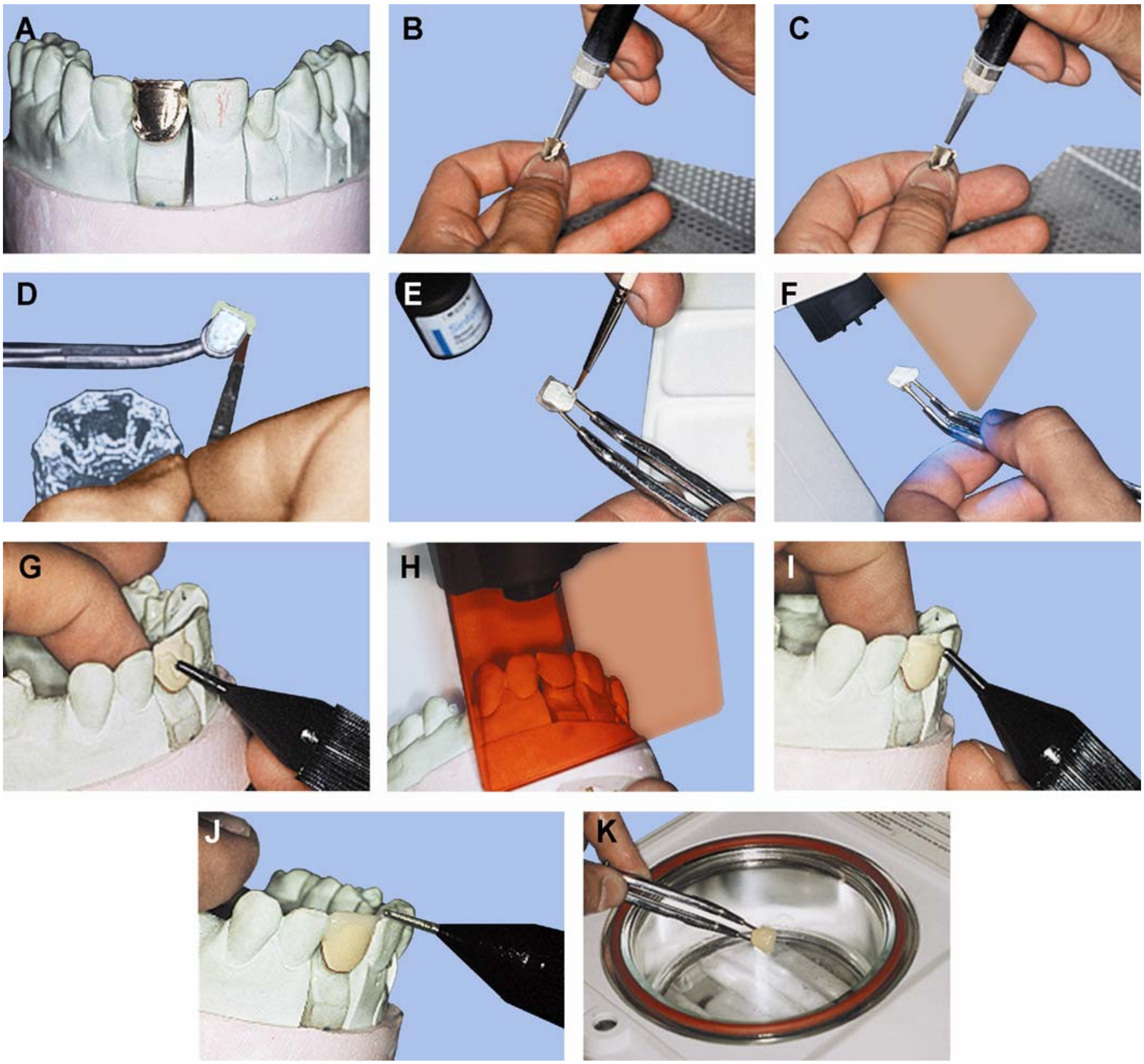
5.6.2. **Retention System.** Mechanical (such as beads) or a chemical bond can achieve retention between the metal substructure and the resin. The ESPE Rocatec® adhesion system is recommended for use with Sinfony®. Rocatec® is a three-step system that chemically bonds the composite to the metal with no marginal gap or any other mechanical retention. The quality of the chemical bond achieved with Rocatec® depends on strict adherence to the manufacturer's directions. If no chemical bonding system is being used, mechanical retention such as beads will need to be incorporated into the veneer's metal surface. Procedures for Rocatec® are as follows:

5.6.2.1. **Step One—Rocatec® Pre (Figure 5.7-B).** Use the Rocatec® Pre side of the Rocatector unit to blast each veneer surface individually. This will clean and create rough indentations on the metal's veneer surface. The blasting time for each restoration is approximately 10 seconds at 2.5 bar pressure. If you are using nonprecious metal, it may be necessary to increase the pressure by raising the regulator on the rocatector unit.

5.6.2.2. **Step Two—Rocatec® Plus (Figure 5.7-C).** Use the Rocatec® Plus side of the Rocatector unit to again blast each veneer surface individually. This creates a partially embedded adhesive coating into the alloy's texture. Blast each restoration for 13 seconds at 2.5 bar pressure. The Rocatector unit is equipped with an acoustic timer as an indicator for completion. It is vital that the blasting direction be perpendicular to the metals surface at a distance of 10 cm. When blasting is complete, there should be a uniform dark coloration on the metal to indicate correct coverage of the material. Do not touch the veneer surface once Rocatec® Plus has been applied because the bond with the Sinfony® veneer can be compromised.

5.6.2.3. **Step Three—Silane Coupling Agent (Figure 5.7-D).** The Rocatec® Plus does not provide an adequate bond with the veneer material on its own. Apply a coupling agent (ESPE Sil) to provide the chemically binding adhesive necessary for the Sinfony® opaquer. Proportion ESPE Sil into a clean dappen dish. Using the special brush provided with the system, apply the solution by soaking the brush tip and brushing over the surface of the veneer. Allow the ESPE Sil to dry at room temperature for 5 minutes; then coat it immediately with opaque.

Figure 5.7. Sinfony® Resin-Veneered Crown.



5.6.3. **Opaque Application (Figure 5.7-E):**

5.6.3.1. Dispense the appropriate opaque (powder and liquid) onto a ceramic mixing tray and mix with a plastic spatula. Mixing time is 45 seconds. Apply a thin masking coat of opaque to the veneer surface. Light cure it for 5 seconds, using the Visio Alpha light curing unit (Figure

5.7-F). Apply subsequent coats and light cure until sufficient masking of the metal has been achieved.

5.6.3.2. As an alternative, coat the entire veneer surface and polymerize it with auxiliary program 1 of the Visio Beta Curing unit. Intensive opaques can be applied at this time to achieve desired effects.

5.6.3.3. Mix intensive opaque to the desired shade and apply to the necessary areas. Cure minimal amounts of the intensive opaque for 10 seconds with the Visio Alpha light; cure larger areas for 30 seconds. Check for complete curing of the opaque, using the wooden tip of a brush and, if necessary, cure for additional time. It is important not to touch the veneer surface because the chemical bonding will be affected.

5.6.3.4. After the opaque layer is completed, immediately begin applying the dentine layer.

5.6.4. **Dentine Application:**

5.6.4.1. Apply a separating agent to any areas of the cast that may be exposed to the Sinfony® materials. Start by building up the dentine directly from the dispenser, or with an instrument, in layers no thicker than 1mm (Figure 5.7-G). Because Sinfony® materials are light sensitive, keep the dispenser closed when not in use.

5.6.4.2. As each 1 mm layer is applied, cure for 5 seconds with the Visio Alpha light (Figure 5.7-H). This intermediate 5-second polymerization leaves a smear layer on the resin that is required for bonding with the next layer. Never grind on or remove this smear layer until the entire buildup has been completed.

5.6.4.3. Sinfony® Opaque Dentin can also be applied at this time to reduce translucency in appropriate areas. Due to the higher opacity of the opaque dentin, ensure these materials are cured fully and not applied thicker than 1 mm. Continue applying Sinfony® dentine layers until the correct dentin contour has been achieved (Figure 5.7-I).

5.6.5. **Incisal Application.** Overlay the buildup with the Sinfony® incisal material in the same manner as the dentine (Figure 5.7-J). Cure each individual layer for 5 seconds with a Visio Alpha curing light. Once the restoration has been built to contour, accomplish final polymerization in the Visio Beta curing unit on the main program for 15 minutes under vacuum (Figure 5.7-K).

5.6.6. **Finishing the Resin Metal Veneer.** Do not grind on the veneer until the final polymerization is completed in the Visio Beta curing unit. Contour the veneer with cross-cut burs. Accomplish additional smoothing with rubber polishers, finishing from coarse to fine polishers. Rubber polishers are especially useful to create a smooth metal-to-resin junction. Use a small white buff wheel without polish to prepolish the veneer. Next, use the opal high luster polishing paste on a polishing wheel to create a high luster. Clean the restoration in an ultrasonic or under running water. Do not use a steam cleaner because heat from the steam cleaner may cause marginal gaps or fractures due to the different thermal expansion values of the resin and the metal.

5.6.7. **Adjustments after Finishing.** If additional resin must be applied after finishing, roughen the surface, moisten with Sinfony® Activator, and wipe off any excess activator with a clean cloth. Proceed to buildup and cure as described in the preceding steps.

Chapter 6

DENTAL IMPLANTS

6.1. Introduction:

6.1.1. The ability to restore a patient's function and esthetics is the ultimate goal in dentistry. Implant technology has brought a whole new dimension to achieving that goal. Since the mid-sixties, implant technology has developed into what is now a viable alternative to conventional prosthodontics. Patients that once had few or no options can now have function and esthetics restored with implant technology.

6.1.2. A dental implant is a prosthetic device implanted within the bone to provide retention and support for fixed or removable appliances (Figure 6.1). Implants can be used to replace single teeth, multiple teeth, or as retainers for dentures. There are many different implant systems currently in use.

6.1.3. This chapter provides an introduction to the principles, basic terminology, and procedures to fabricate dental implants. When fabricating dental implant prostheses, be sure to closely follow the manufacturer's directions for the system being used to maximize the chances of success.

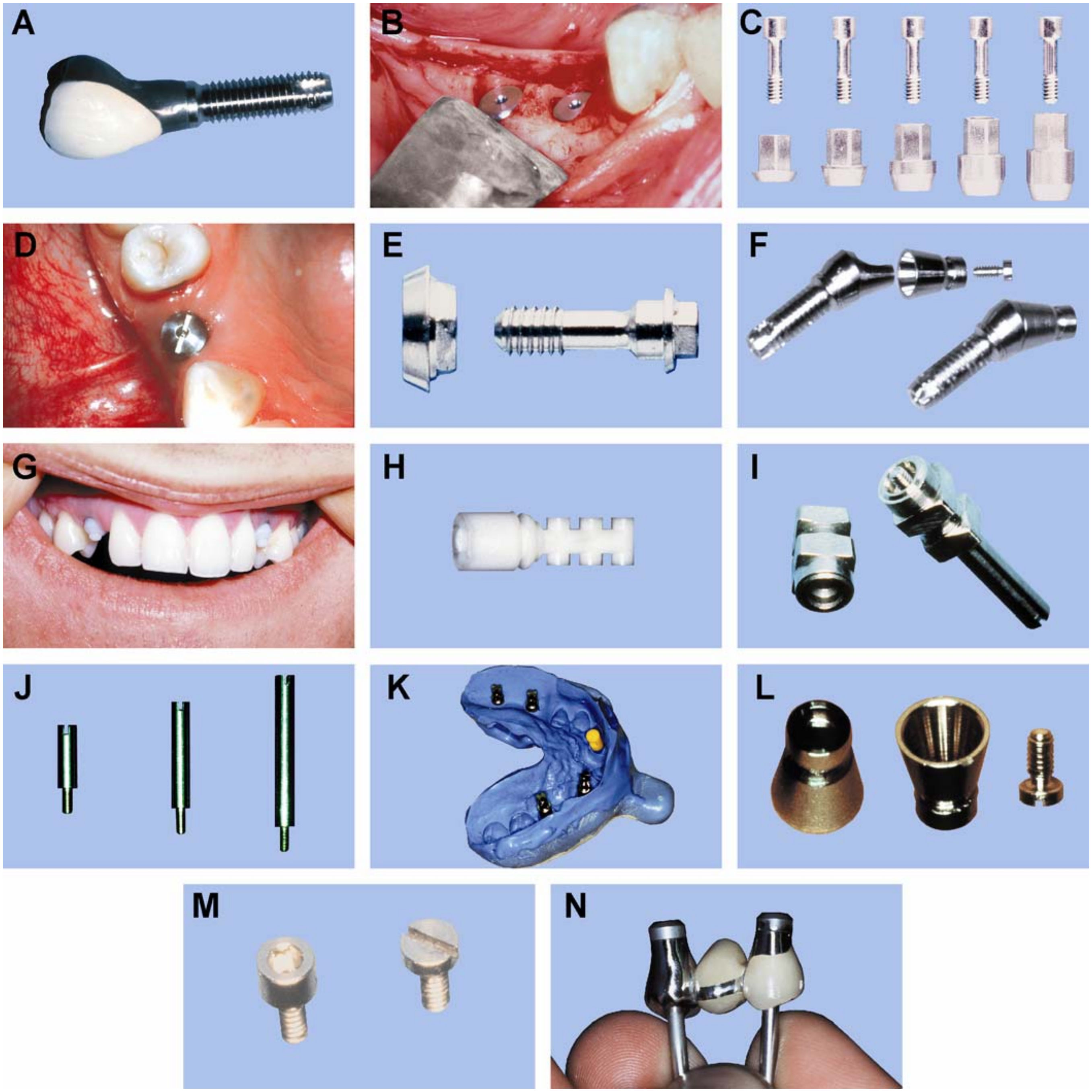
Figure 6.1. Implant Prosthesis.

6.2. Standard Components for Implant Systems. Most implant systems on the market to day are similar in the types of components used (Figure 6.2). The following is a description of the standard components necessary to complete a restoration:

6.2.1. **Fixture (Figure 6.2-A).** The fixture is a permanent device that is implanted into the bone after the dentist has drilled a hole in the proper location and angle. Fixtures can be of screw type, self-tapping screw, hollow cylinder, hollow screw or many other designs. The most common material for fixtures is Titanium. Titanium is an inert material that develops the titanium oxide layer necessary for the bone-to-implant fusion, which firmly holds the fixture in place. The fixture is normally placed entirely inside the bone with an opening that is flush with the surface of the bone.

6.2.2. **Cover Screw (Figure 6.2-B).** The cover screw is placed or screwed into the opening of the fixture at the time the fixture is surgically placed into the bone. Cover screws allow the fixture to osseointegrate with the bone without bone or tissue growing into the opening of the fixture during the healing process.

Figure 6.2. Components of the Implant System.



6.2.3. **Abutment (Figure 6.2-C).** The abutment is the portion of the implant that attaches to the fixture and supports and retains the restorative components. The abutment is situated from the surface of the fixture, at bone level, and through the tissue. It stops normally just at or slightly above the gingival tissue. The abutment is held in place with an abutment screw. There are a variety of sizes and styles of abutments available to adapt to different needs.

6.2.3.1. **Healing Abutment (Figure 6.2-D).** Healing abutments are used in place of standard abutments following second stage surgery (see paragraph 6.5.2). Healing abutments are desired when a specialized abutment is needed for the restoration or when the length of the standard abutment is not known. These abutments are provided as a one-piece abutment and screw. The abutment allows the tissue to heal and reorganize into a unique peri-implant membrane.

6.2.3.2. **Specialized Abutments (Figure 6.2-E).** Each implant system may include specialized abutments, which are used to optimize esthetics, or compensate for the lack of interocclusal space.

6.2.3.3. **Angulated Abutment (Figure 6.2-F):**

6.2.3.3.1. Angulated abutments are used to compensate for fixtures that are not ideally placed. Fixtures need a sufficient amount of bone to be properly implanted.

6.2.3.3.2. There are cases where the fixtures are angled to the facial or lingual due to improper or necessary implant placement. Angulated abutments can correct this angulation problem up to 30 degrees. However, a correction of this magnitude would create a destructive lever system on the final restoration. This is most commonly seen when a severe labial undercut in the anterior alveolar ridge dictates labial angulation of the fixture. Restoring the dentition with a standard abutment in this position would result in an access channel for the gold screw to emerge through the facial surface of the restoration. Angulated abutments compensate for this by angling the implant a position where the restoration will be placed esthetically.

6.2.3.4. **Healing Caps (Figure 6.2-G).** Healing caps are placed on top of the standard abutment during the healing process after second stage surgery. The healing cap protects the abutment screw and the precision milled surfaces of the standard abutment until the restoration or provisional restoration is ready to be inserted.

6.2.4. **Temporary Components (Figure 6.2-H).** Temporary components are usually a cylinder, tube, or cap on which a provisional restoration is fabricated. The temporary component attaches to the abutment with a screw, temporary cement, or friction gripping of precisely manufactured components available with some implant systems. The temporary is commonly used in place of the healing cap.

6.2.5. **Impression Coping (Figure 6.2-I).** The impression coping is placed or screwed on top of the abutment before the final impression is made. The impression coping is then picked up inside the impression material to transfer the exact location of the fixture or abutment to the master cast. Before the impression is poured with dental stone, an abutment replica (analog) is attached to the impression coping. The cast is then poured, resulting in the analog being positioned in the same location on the cast as the fixture or abutment is in the patient's mouth.

6.2.6. **Guide Pins (Figure 6.2-J).** Guide pins screw directly in to the standard, specialized, or angulated abutments; gold cylinders; abutment replicas; or temporary components. They are used during laboratory procedures to ensure the restorative components remain in precise contact with the abutment replica. Guide pins should be used during surgery, final impression, framework wax-up, and porcelain application to ensure proper esthetic and functional fabrication of restorations.

6.2.7. **Abutment Replicas (Figure 6.2-K).** The abutment replica (laboratory analog) is an exact reproduction of the abutment that attaches to the fixture. It is used as the master die for the technician. The abutment replica attaches to the impression coping prior to pouring the final impression. After the final impression is separated from the master cast, the abutment replica is three dimensionally positioned on the master cast exactly as the abutment is positioned in the patient's mouth.

6.2.8. **Gold Cylinder (Figure 6.2-L).** The gold cylinder is the restorative component that attaches to the abutment and around which the restoration is built. It is normally 3 to 4 mm in height. The technician attaches the gold cylinder to the abutment replica with a guide pin and then waxes the restoration around cylinder, leaving a hole in the top for access to the screw that holds the cylinder in place. The wax-up is then cast to the gold cylinder, using the lost wax technique.

6.2.9. **Gold Screws (Figure 6.2-M).** Gold screws are used clinically to attach the temporary or permanent restoration to the abutment. Two types are used. One is a flat head screw with a slot, and the other is a flat head screw with a internal hexagon or square. The internal hexagon screw has a taller screw head and requires greater interocclusal space.

6.2.10. **Protection Caps (Figure 6.2-N).** The protection cap is a stainless steel cap that attaches to the gold cylinder. It should be in place any time sandblasting, grinding, or polishing is accomplished. Its purpose is to protect the surface and shape of the prosthetic component that attaches to the abutment.

6.3. Procedural Overview. The steps for fabricating an osseointegrated implant are shown below (and in Figure 6.3):

6.3.1. The diagnostic cast is articulated and a preliminary wax-up is accomplished to determine functional and esthetic requirements (Figure 6.3-A).

6.3.2. The dentist accomplishes treatment planning to decide on number and location of implant fixtures. A radiographic stent may be used to help determine if enough bone is available for the implant fixtures (Figure 6.3-B).

6.3.3. A surgical template is fabricated to assist the surgeon in placing the implants in the proper location (Figure 6.3-C).

6.3.4. The first surgical procedure performed is placing the implant fixtures into the bone with the cover screw (Figure 6.3-D).

6.3.5. The second surgical procedure performed is placing the abutment and healing cap (Figure 6.3-E).

6.3.6. Provisional restoration is made if necessary (Figure 6.3-F).

6.3.7. The custom tray is made for the final impression (Figure 6.3-G).

6.3.8. A master cast is made from the final impression and articulated (Figure 6.3-H).

6.3.9. The prosthesis framework is constructed (Figure 6.3-I and -J).

6.3.10. The porcelain, resin, or denture is processed to the framework (Figure 6.3-K).

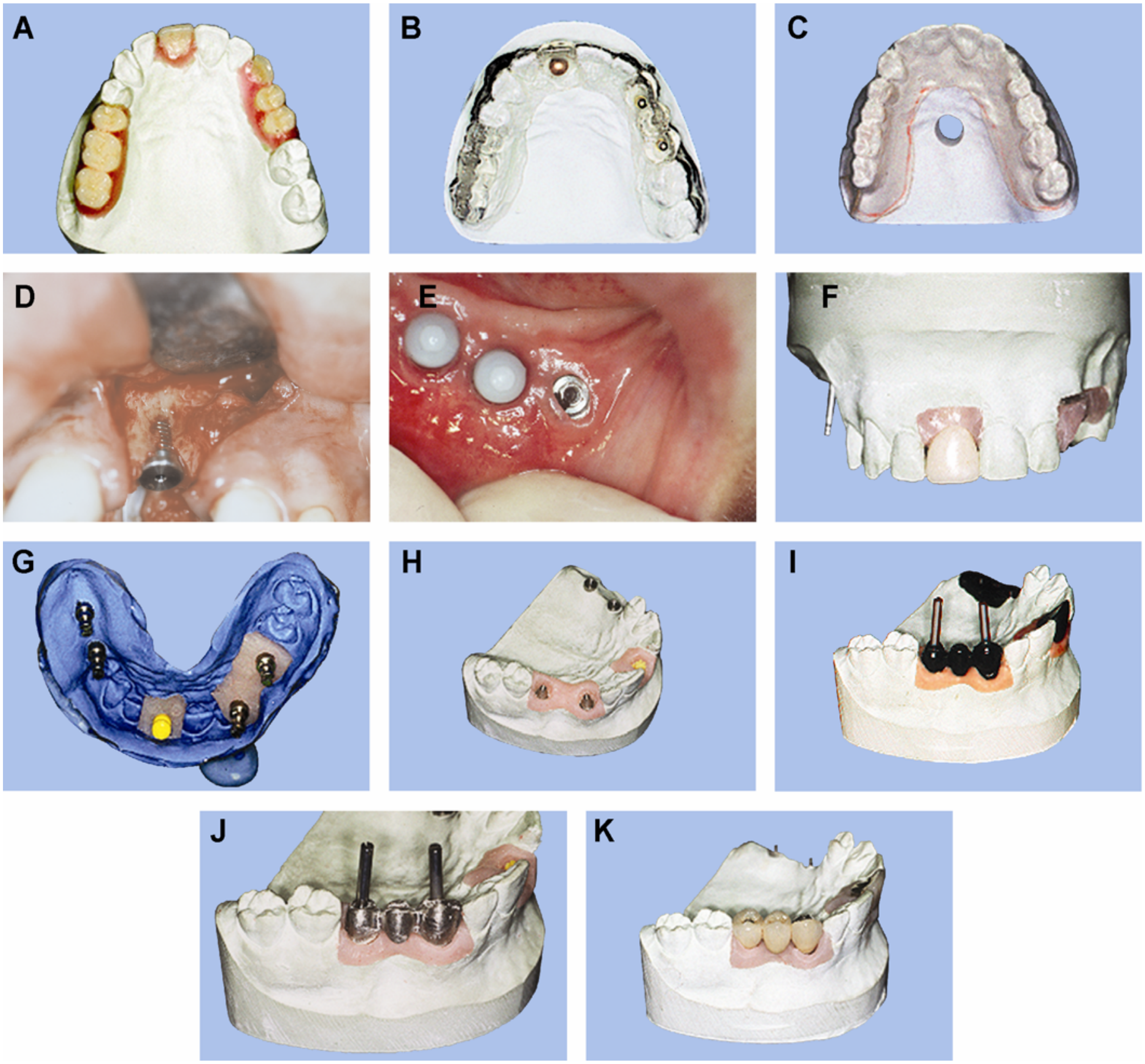
6.3.11. The prosthesis is inserted.

6.4. Osseointegration Process:

6.4.1. Implants are placed into the mandible or maxillae and held in place through osseointegration. Osseointegration is defined as the direct bone anchorage of an inert material (usually Titanium) that provides a foundation to support the prosthesis. After the implant fixture has been placed into the bone, osseointegration requires new bone formation to firmly hold it in place.

6.4.2. When the implant is first inserted, a layer of oxide forms on the Titanium implant. A layer of glycoprotein approximately 100 microns thick then forms and provides hard direct contact between the bone and the implant fixture's oxide. Over time, spongy (cancellous) bone develops around the fixture, which will eventually form into compact bone as occlusal forces are applied.

Figure 6.3. Fabricating a Fixed Implant.



6.4.3. Bone-to-implant interface occurs at approximately 3 to 6 months after surgical placement of the implant fixture. The mandible is composed mostly of harder compact cortical bone and, consequently, heals faster than the softer cancellous bone found in the maxillae.

6.4.4. To complete the process, bone-to-implant infusion must occur. An advantage of osseointegration is the ability to transmit occlusal forces directly to the bone. However, careful planning must be done to ensure these forces are distributed more vertically than laterally to reduce traumatic failure of the implant.

6.5. Implant Surgery. Surgery to place the implants is usually accomplished in the following two stages:

6.5.1. **First Stage Surgery.** First stage surgery is the process of placing the implant fixtures into the bone, as follows:

6.5.1.1. First, a tissue flap reflection is done to expose the bone. Next, a series of drilling and countersinking procedures are done to produce the proper size hole to receive the fixture. Drilling is accomplished at slow speeds with irrigation to dissipate any frictional heat that may be generated, which would damage the bone thereby compromising osseointegration. Depending on the type of fixture, the hole may need to be tapped to produce threads on the wall of the bone.

6.5.1.2. The fixture is then screwed or tapped into place with the top of the fixture located at the surface of the bone. A cover screw is screwed into the top of the fixture to prevent tissue or bone growth from contaminating the top surface of the fixture. The tissue is then readapted and sutured in place. The fixture remains covered while healing and bone-to-implant fusion takes place. This process will take from 4 to 6 months depending on the type of bone.

6.5.1.3. A temporary prosthesis is used after several weeks have past, but care must be taken not to apply pressure on the fixture during healing. This could cause implant failure, due to exposure and bacterial infiltration.

6.5.2. **Second Stage Surgery.** Stage two surgeries are more of a minor soft tissue surgery to expose the fixture and attach the abutments:

6.5.2.1. The fixture is first located though the tissue with the help of the surgical stent and an explorer. After the cover screw is located, a small incision is made to expose the cover screw. A punch is then used to remove tissue and expose the entire cover screw. After removing the cover screw, all soft and hard tissue is cleaned away from the fixture opening.

6.5.2.2. Next, the appropriate type of abutment is attached to the fixture, using the abutment screw. If a specialized, esthetic, or angled abutment is used for the restoration, a healing abutment is placed at this stage. When the correct length of standard abutment is used, the abutment should be at or 1 mm higher than the gingival margin in the maxilla and 1 to 2 mm in the mandible. Make sure the abutment is not to long for both esthetics and speech function.

6.5.2.3. After the standard abutments are secured in place, healing caps are placed over the abutment to protect the precision surfaces during the healing process. If a temporary prosthesis is to be used, a healing cap will not be necessary.

6.6. Radiographic Templates:

6.6.1. Radiographic templates are used during the radiographic examination to assist in the diagnosis of implant placement in the patient (Figure 6.4). Radiographic template are clear acrylic with ball bearings, or metal rods, positioned in the template as radiographic reference points above the implant fixtures proposed positioned.

6.6.2. The template can help show the amount of bone available for the implant fixture by comparing the known size of the metal component in the templates to the amount of bone shown on the radiograph regardless of distortion.

6.6.3. Metal rods are also positioned through the center of the proposed restoration, paralleling the axial inclination of the restoration, so it can be used as a guide to the ideal buccal or lingual angle of the implant fixture. In addition, the mesial-distal distance between teeth for single implant fixtures can be evaluated. Any anatomic anomalies may also be discovered, utilizing the guide template.

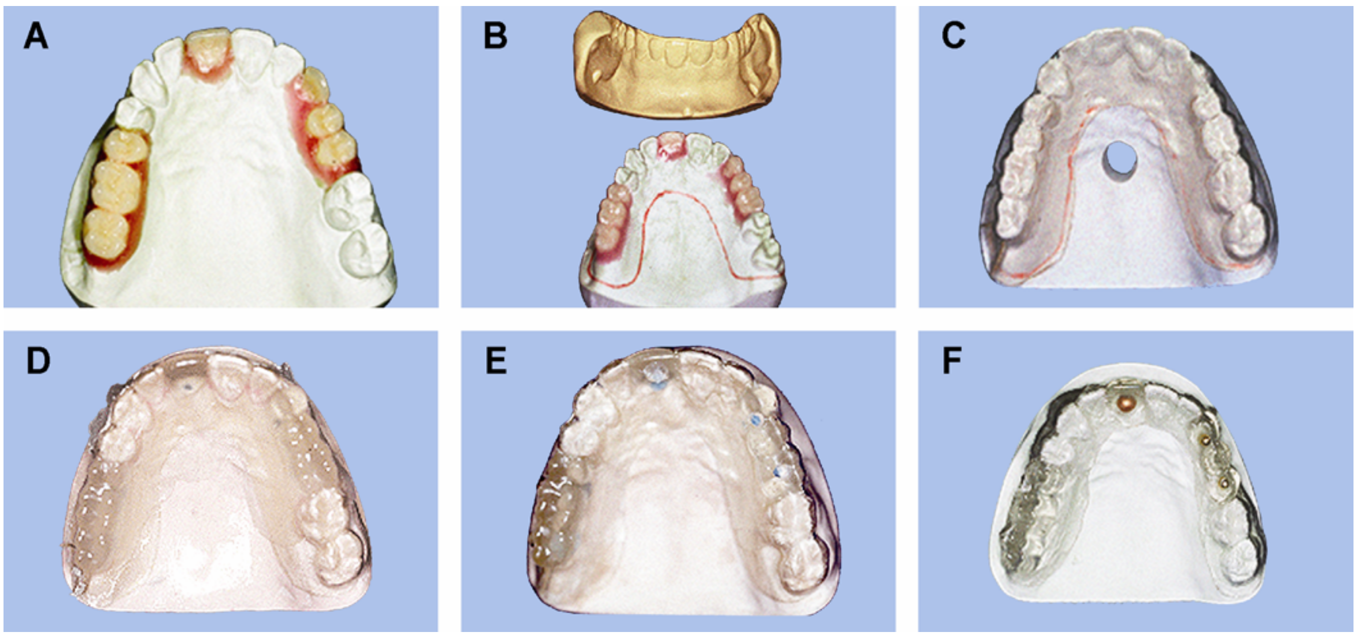
6.6.4. To fabricate a partial edentulous radiographic template:

6.6.4.1. Articulate the diagnostic cast in MI or use the occlusal registration provided by the dentist.

6.6.4.2. Perform a diagnostic wax-up. Denture teeth may be used or a full contour wax-up performed (Figure 6.4-A). After the wax-up is completed and evaluated, it is a good idea to fabricate a tooth position index with silicone putty for later use.

6.6.4.3. Duplicate the diagnostic cast and wax-up using any standard duplicating process (Figure 6.4-B).

Figure 6.4. Fabricating a Partially Edentulous Radiographic Template.



6.6.4.4. Fabricate a vacuum-formed template of the duplicate cast using clear template material (Figure 6.4-C). Trim the template to just below the gingival margins of the existing teeth and include all of the diagnostic waxed-up areas. After the template is trimmed, lightly air-abrade the areas that are edentulous on the diagnostic cast.

6.6.4.5. Remove the diagnostic wax-up from the diagnostic cast. Survey and block out any undercuts in the edentulous areas of the cast.

6.6.4.6. Apply a separator to the diagnostic cast. Mix self-curing clear acrylic and fill the edentulous areas of the template (Figure 6.4-D). Place the template onto the diagnostic cast and ensure it is seated properly. After the acrylic has cured, trim any excess acrylic, smooth, and polish.

6.6.4.7. The dentist will clearly mark the position of the implants on the diagnostic cast.

6.6.4.8. Place the template on the diagnostic cast. The marks for the position of the implants should be visible through the clear acrylic. Carefully drill a hole at the site of each proposed implant (Figure 6.4-E). The hole must be at the exact location and correct axial inclination of the proposed implants.

6.6.4.9. Place a metal radiographic indicator into each hole and seal in place with acrylic or cyanoacrylate (Figure 6.4-F).

6.6.5. To fabricate a fully edentulous radiographic template:

6.6.5.1. Duplicate the existing denture with clear acr ylic, using the technique from Volum e 1, Chapter 7, Section 7AK.

6.6.5.2. The dentist will precisely mark the position of the implants on the cast.

6.6.5.3. Place the duplicated denture on the cast and drill holes through the clear denture at the position of each proposed im plant. The holes must be at the exact loca tion and correct axial inclination of the proposed implants

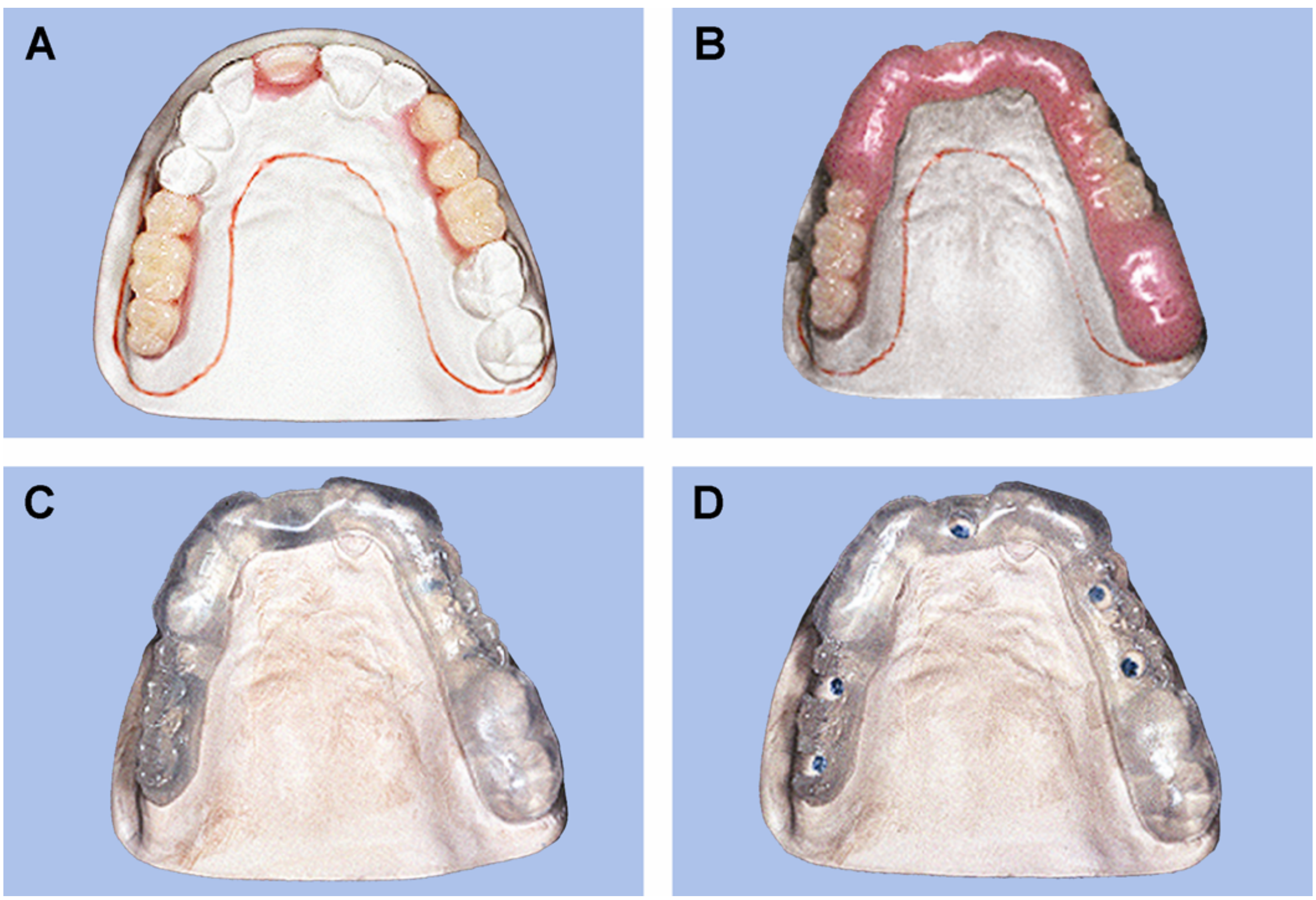
6.6.5.4. Place a m etal radiograph ic indicato r into each hole and seal in place with acrylic o r cyanoacrylate.

6.6.5.5. Trim and the polish the template as needed.

6.7. Surgical Guide Templates:

6.7.1. Surgical guide templates are used during the fi rst stage surgery as a gui de to implant fixture placement (Figure 6.5). The surgical guide tem plate provides the surgeo n with a prosthetic guid e to placement and angulation of fixtures.

Figure 6.5. Fabricating a Partially Edentulous Surgical Guide Template.



6.7.2. Surgical guide templates are essentially th e sam e as radiographic templates. The m ain difference b etween the two is that n o m etal ind icators are p laced in th e surgical guide tem plate. However, the proposed implant area is hollowed out to provide room for the surgeon to drill in to the bone with the surgical guide template in place.

6.7.3. The diagnostic wax-up of the proposed restorations is reproduced in acrylic to act as the guide for the buccal-lingual placement of the implants.

6.7.4. To fabricate a partially edentulous surgical guide templates:

6.7.4.1. Articulate the diagnostic cast in MI or use the occlusal registration provided by the dentist.

6.7.4.2. Perform a diagnostic wax-up (Figure 6.5-A). Denture teeth may be used or a full contour wax-up performed. The silicone putty matrix that was made when fabricating the radiographic template may be used to accomplish the wax-up.

6.7.4.3. Finish the wax-up for the surgical guide template by extending wax over the occlusals of the teeth adjacent to the diagnostic wax-up (Figure 6.5-B). This will be used as a positive seat for the guide template.

6.7.4.4. Process the wax-up in clear acrylic, using the same procedures as processing denture bases (Figure 6.5-C). Trim and polish the completed surgical guide template.

6.7.4.5. Clean the diagnostic cast of all wax and have the dentist mark the ideal locations for the implant fixtures on the cast.

6.7.4.6. Seat the surgical guide template on the cast and cut out guides in the areas of the proposed implants. The guide slot should not interfere with the facial contour of the restorations. The guide slot must also be wide enough to accommodate the various drills for the size of the implant being used (Figure 6.5-D).

6.7.5. To fabricate for an edentulous surgical guide template:

6.7.5.1. Evaluate the existing denture to see if it meets the functional and esthetic demands of the patient. Make any necessary adjustments:

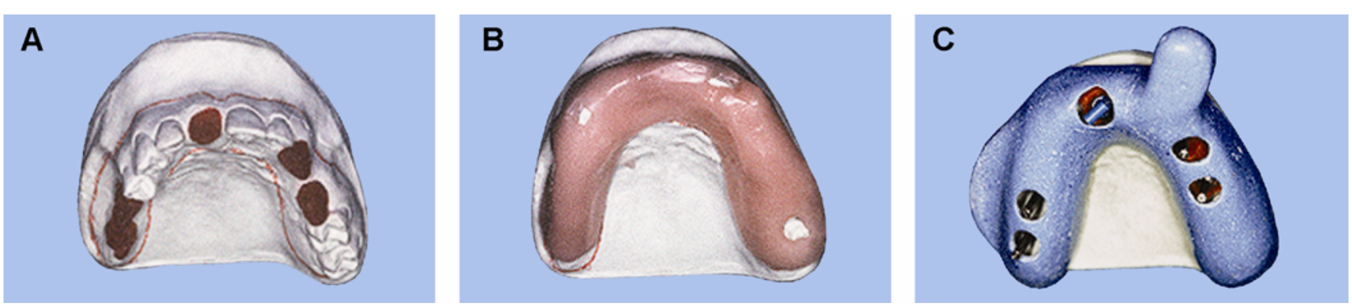
6.7.5.2. Duplicate the denture in clear acrylic, using conventional methods.

6.7.5.3. The dentist will now mark the implant sites on the cast. (The sites should not interfere with the placement of teeth nor should the angulation affect the facial-lingual inclination of the teeth.)

6.7.5.4. Cut guide holes or a slot at the sites of the proposed implant fixtures. This will give the surgeon a starting point to drill the holes for the fixtures without affecting the positioning of the teeth for the restoration.

6.8. Custom Tray. Requirements for fabricating an implant custom tray (Figure 6.6) are essentially the same as those for a standard denture or fixed custom tray:

Figure 6.6. Fabricating an Implant Custom Tray.



6.8.1. The tray must provide for patient comfort while maintaining a uniform thickness of impression material. It must also provide a stable access area for impression copings that utilize guide pins. This is accomplished by an opening in the area above the implants.

6.8.2. Depending on the impression copings used, not all require an opening in the tray. Some impression copings stay on the abutment when removing the impression from the mouth and then are removed and placed into the impression.

6.8.3. The following procedures describe an open impression tray with square impression copings and guide pins: (***NOTE:*** Impression copings that are removed in the impression are recommended for increased accuracy.)

6.8.3.1. To open the custom tray for implant restorations, the dentist first makes an alginate impression for the diagnostic cast. This is done with the healing caps in place on the abutments. The impression is poured and trimmed, using the standard guidelines for diagnostic cast.

6.8.3.2. Follow the dentist's guidelines for designing the tray and block out any significant tissue undercuts.

6.8.3.3. Block out the area around the healing abutments with wax or clay (Figure 6.6-A). Using the dentist's guidelines, apply the necessary amount of relief to the tissue areas to be impressed (Figure 6.6-B).

6.8.3.4. Mix and apply custom tray material to the cast in the usual manner. The only difference is to leave the area open over the blockout that was applied to the healing abutments. After the material has cured, trim the tray to the design line and remove all blockout material (Figure 6.6-C).

6.9. Master Cast. Accuracy of the master cast (Figure 6.7) is of the utmost importance. Precisely accomplish the following steps to ensure the fit of the finished restoration:

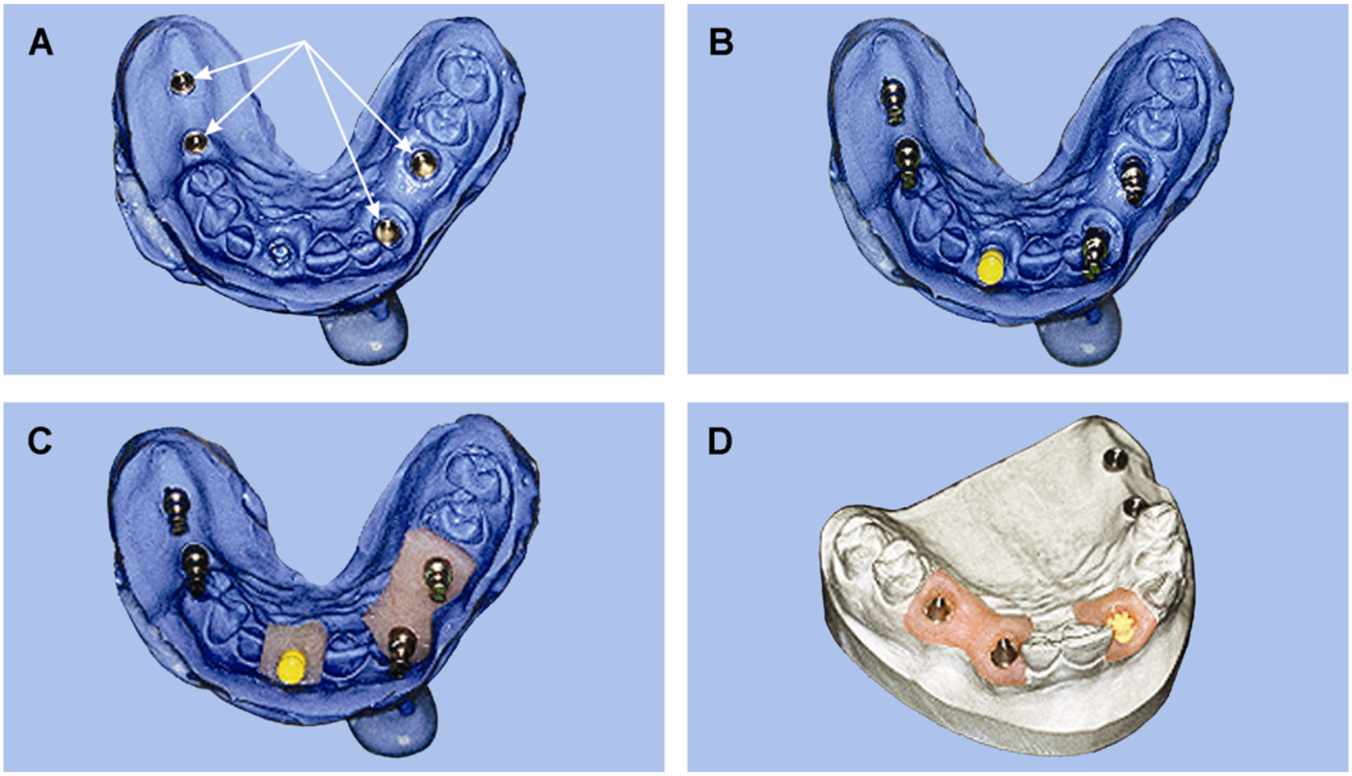
6.9.1. Disinfect the impression and then examine the impression copings for stability in the impression material. Also, look for overflow impression material on the seating surfaces of the copings (Figure 6.7-A). Any excess material indicates the copings were not properly seated on the abutments during the impression procedure and, therefore, the impression will need to be reaccomplished.

6.9.2. To attach abutment replica for square impression copings with guide pins, remove the guide pins and gently blow air through the holes to remove debris. Seat an abutment replica on each of the impression copings and attach with a guide pin (Figure 6.7-B).

6.9.3. To attach abutment replica for tapered impression copings, examine the tapered copings' surface imprint in the impression for any debris or impression defects. Attach an abutment replica to each of the impression copings and then carefully seat the copings into the impression. Firmly seat each coping back into the impression before moving onto pouring the impression.

6.9.4. Use a soft tissue model in the area of the abutments. After the abutment replicas are in place, pour soft tissue material directly into the impression. Because the soft tissue material and impression material are normally both vinyl polysiloxanes, a good separating medium must be first applied to the impression. Apply soft tissue material around each of the abutments, leaving the end of each abutment replica exposed for stone to be poured around it (Figure 6.7-C). When pouring, do not allow the material to run into the adjacent teeth areas.

Figure 6.7. Master Cast Procedures.



6.9.5. Bead and box the impression if necessary. Vacuum mix the die stone and pour the impression. Be careful not to use excess vibration, which may dislodge some types of impression copings.

6.9.6. After the stone has completely set, remove the guide pins and lift the impression from the cast. If tapered impression copings are used, remove the impression with a snap. Examine the cast for any discrepancies. (Ensure the precision surfaces of the abutment replicas are clean and free of any stone.) Trim the cast in the usual manner (Figure 6.7-D).

6.10. Provisional Restorations:

6.10.1. **After First Stage Surgery.** Temporary, complete or partial dentures can be inserted when the sutures are removed (7 to 10 days after surgery). Existing complete or partial dentures can easily be made to fit over the implant sites. Simply relieve the fixture area of the denture acrylic and reline it with soft-tissue conditioner. Do not apply any pressure to the fixture sites at this time. If acrylic is protruding through the soft liner, perform additional reduction and apply more soft tissue conditioner. Reline the denture in the conventional manner after 1 month.

6.10.2. **After Second Stage Surgery.** At this point, the abutment and healing caps are protruding through the tissue. For complete dentures, relieve enough acrylic to seat the denture without any interference with the healing cap and then reline it again with a soft-tissue conditioner.

6.10.3. **Provisional Restoration for a Single-Tooth, Cement-Retained Implant:**

6.10.3.1. **Laboratory-Fabricated Provisional (Figure 6.8).** First, take an impression and make a cast with a soft tissue section around the abutment replica. Next, place a temporary cap on the abutment replica and adjust the length so there is no interference with the opposing occlusion (Figure 6.8-A and -B). If a light-cured resin is going to be used it can now be applied, cured, and shaped to the desired contours (Figure 6.8-C). You may also wax up a tooth directly to the temporary cap and process it with heat cured acrylic in the necessary shade. After processing, finish, polish, and ready the provisional for cementation with temporary cement.

Figure 6.8. Laboratory-Fabricated Provisional.

6.10.3.2. **Clinically Fabricated Provisional.** The dentist will seat a temporary cap onto the abutment in the patient's mouth. The cap is then adjusted to the proper length. A prefabricated crown shell is then selected to fit over the temporary cap. Additional modifications to the cap may be necessary at this time to provide for sufficient thickness of resin around the cap. The prefabricated shell is filled with proper tooth-colored resin. After the resin has cured, the provisional is removed from the mouth, trimmed, and polished. The finished provisional is held in place with temporary cement.

6.10.4. **Provisional Restoration for a Screw-Retained Implant:**

6.10.4.1. For a screw-retained, all-acrylic provisional, fabricate a cast with abutment replicas properly positioned and then articulate the cast. Position and attach temporary cylinders onto the abutment replicas, using gold screws or guide pins. Adjust the occlusion and eliminate all lateral and protrusive interferences. At this point, roughen the modified temporary cylinder to enhance the bond with the resin. Apply heat-cured or self-cured acrylic resin or composite resin to the temporary cylinders. Check the resin for occlusal, lateral interferences, and esthetics. Be sure to clean the access holes, thus enabling the guide pin or gold screws to be removed and replaced easily. Finish and polish the provisional restoration.

6.10.4.2. For a screw-retained, cast framework provisional:

6.10.4.2.1. Fabricate maxillary and mandibular casts and articulated them with abutment replicas in place. Position temporary cylinders and reduce them in length to allow seating of temporary tubes over the temporary cylinders. Adjust the temporary tubes to eliminate any occlusal or excursive interference.

6.10.4.2.2. Wax up a framework over the tubes. Place copings over the tubes with a connecting bar between the abutments. Wax up a framework with retentive beads.

6.10.4.2.3. Sprue, invest, and cast the completed framework, utilizing the lost wax technique. After casting, make necessary adjustments to the framework and fit it to the temporary cylinders. Place the temporary cylinders on the abutment replicas with long guide pins.

6.10.4.2.4. Next, cement the framework in place over the temporary cylinders. The framework is now ready for light-cured, self-cured, or heat-cured acrylic resin to be applied, finished, and polished.

6.11. Procedures for Single-Tooth, Cemented Restoration:

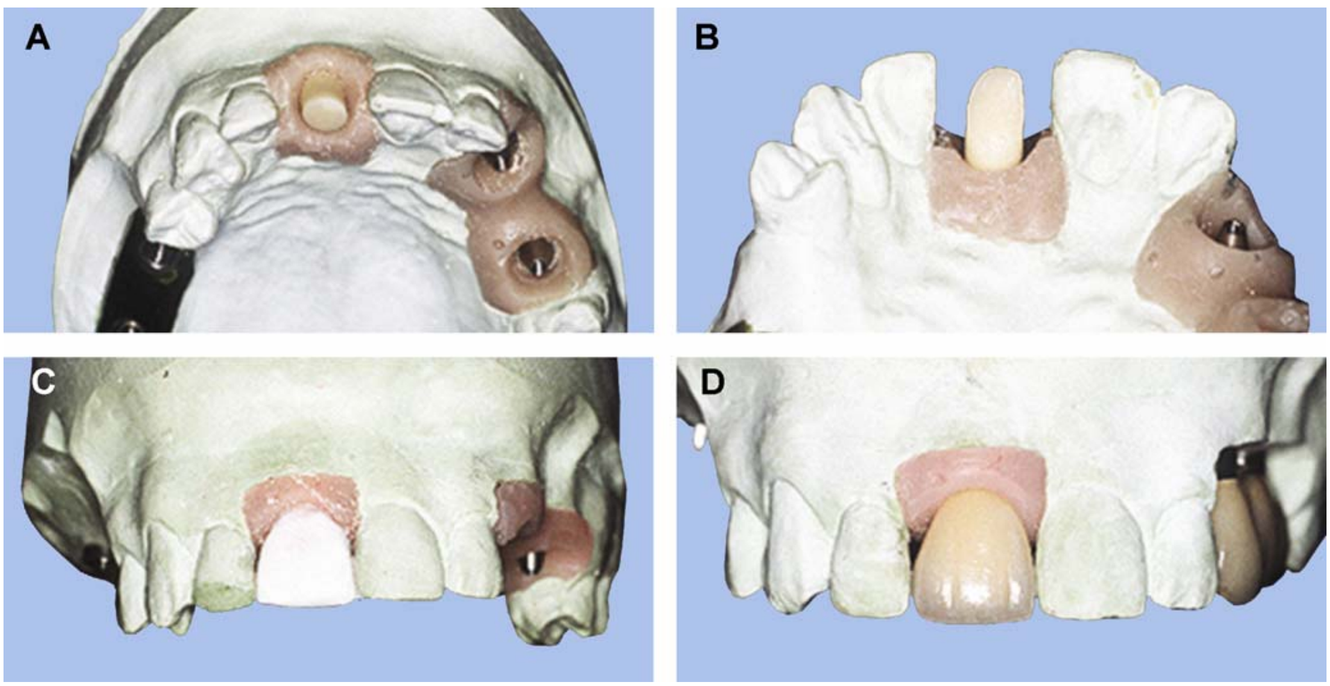
6.11.1. For a single-tooth implant, a hex-shaped abutment is used to prevent rotation of the restoration. The dentist will use an abutment positioned 2 to 3 mm below the tissue to prevent a metal band from showing when the restoration is inserted.

6.11.2. There are three methods to fabricate a cement-retained, single-tooth implant—a ceramic cap restoration (paragraph 6.12), a gold cylinder restoration (paragraph 6.13), and a burnout cap restoration (paragraph 6.14).

6.11.3. All of these methods involve first fabricating a master cast with an abutment replica in place. When making the master cast, soft tissue silicone material is applied around the abutment replica. Care must be taken to not run silicone material into the adjacent teeth areas. The soft tissue material will allow for accurate gingival shaping of the restoration. After the casts are fabricated, articulate the master and opposing casts on a semiadjustable articulator.

6.12. Ceramic Cap Restoration. Ceramic caps (Figure 6.9) are made of densely sintered aluminous porcelain and offer the esthetic advantages of the all ceramic crown. Ceramic caps are available in different lengths, and they are selected based on the interarch space available for the restoration.

Figure 6.9. Cement-Retained, Ceramic-Cap Implant.



6.12.1. **Ceramic-Cap Preparations:**

6.12.1.1. Seat the appropriate ceramic cap (for example, CeraOne®) onto the abutment replica, check for necessary occlusal space, and evaluate the axial inclination (Figure 6.9-A and -B). It may be necessary to reduce areas on the ceramic cap to provide room for a layer of porcelain to be applied to achieve the contours of the completed restoration. If reduction of the cap is required, use diamond burs on a high-speed, water-cooled handpiece to avoid fracturing the porcelain.

6.12.1.2. The minimum thickness of the ceramic cap must be at least 0.5 mm after adjustments are made. Rinse the contoured ceramic cap under running water and then clean it with hot steam or place it in a ultrasonic water bath for 10 minutes. Before applying porcelain to the ceramic cap, remove any embedded water by placing it in a warm furnace for 5 minutes.

6.12.2. **Porcelain Application:**

6.12.2.1. Porcelain that is compatible with an aluminous core must be used to layer the ceramic cap. Conventional metal-ceramic porcelains cannot be used with ceramic caps due to the incompatibility with the aluminous porcelain core. Standard procedures for porcelain application described in Chapter 2 are used to complete the porcelain buildup (Figure 6.9-C). For firing times and temperatures, be sure to follow the manufacturer's directions of the porcelain system used.

6.12.2.2. After the porcelain application, contour and glaze the restoration. It is now ready to be disinfected and sent to the dentist for insertion (Figure 6.9-D).

6.13. Gold Cylinder Restoration. Gold cylinders are a cast-to pattern used mainly in the posterior area. Wax is applied directly to the gold cylinder to form a substructure, which will be cast using a noble metal-ceramic alloy.

6.13.1. **Substructure Wax-Up:**

6.13.1.1. Place the gold cylinder onto the abutment replica and secure it with a guide pin. Wax a metal-ceramic substructure to the gold cylinder, using the techniques in Chapter 2. The wax should extend down to the chamfer on the gold cylinder with a minimum thickness of 0.5 mm.

6.13.1.2. The completed wax-up is then invested, cast, and finished, using the lost wax technique. If debubblizer is used, *paint it* only onto the wax pattern because debubblizer on the gold cylinder may cause metal casting flash. Take care to avoid trapping bubbles inside the gold cylinder when investing. Any bubbles inside the gold cylinder after casting are difficult to identify. Bubbles on the seating surface of the gold cylinder can give false readings or abrade the plastic, when seating against the abutment replica. Also take extreme care to avoid abrading or damaging the abutment-cylinder surface when removing bubbles.

6.13.2. **Porcelain Application.** Conventional metal-ceramic porcelain systems and techniques are used to build up and complete the restoration. After porcelain is applied, contoured, glazed, and polished, the restoration is ready for insertion.

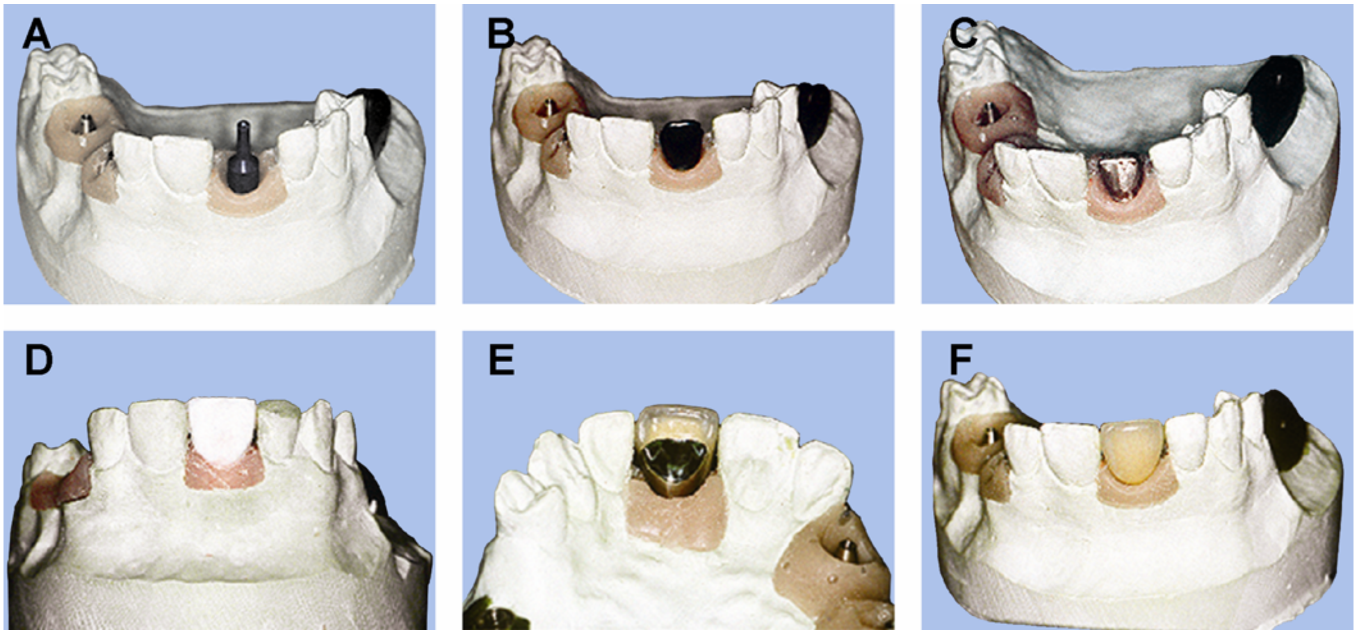
6.14. Burnout Cap Restoration. An acrylic resin cap can also be used to fit over the abutment. The procedures for the burnout cap are very similar to the gold cylinder method. The burnout cap is first seated onto the abutment replica (Figure 6.10-A). Next, complete a metal ceramic substructure wax-up over the burnout cap (Figure 6.10-B). This wax-up is cast, using conventional lost wax techniques, and porcelain is applied as described in the gold cylinder method above (Figure 6.10-C through -F). The disadvantage of the burnout cap is the absence of the machined fit with the abutment, which is present in the gold cylinder method. One advantage of the burnout cap is that it is less expensive than other methods.

6.15. Procedures for Screw-Retained Restorations:

6.15.1. **Overview (Figure 6.11):**

6.15.1.1. Single tooth restorations must use the hex-shaped abutment to prevent rotation of the prosthesis. Multiple tooth restorations will use two round or conical abutments to prevent rotation. Screw-retained restorations are normally fabricated using one of two methods, a completely cast (castable) substructure or a cast-to substructure.

Figure 6.10. Cement-Retained, Burnout-Cap Implant.



6.15.1.2. The procedures for screw-retained restorations are very similar to the procedures for making cement-retained restorations, except for a channel to allow access to the screw that retains the restoration. With screw-retained restorations, it is essential the implant fixtures be properly angled so the access hole for the screw is in an acceptable position. The screw opening must be on the lingual for anterior teeth or on the occlusal for posterior teeth. If the angle of the implant is not ideal, an angulated or custom abutment is used to correct the angle or to better position the screw access hole. As with the cement-retained restoration, a master cast must first be fabricated with the abutment replicas in place. It is also a good idea to incorporate the soft tissue cast when fabricating the master cast (paragraph 6.9).

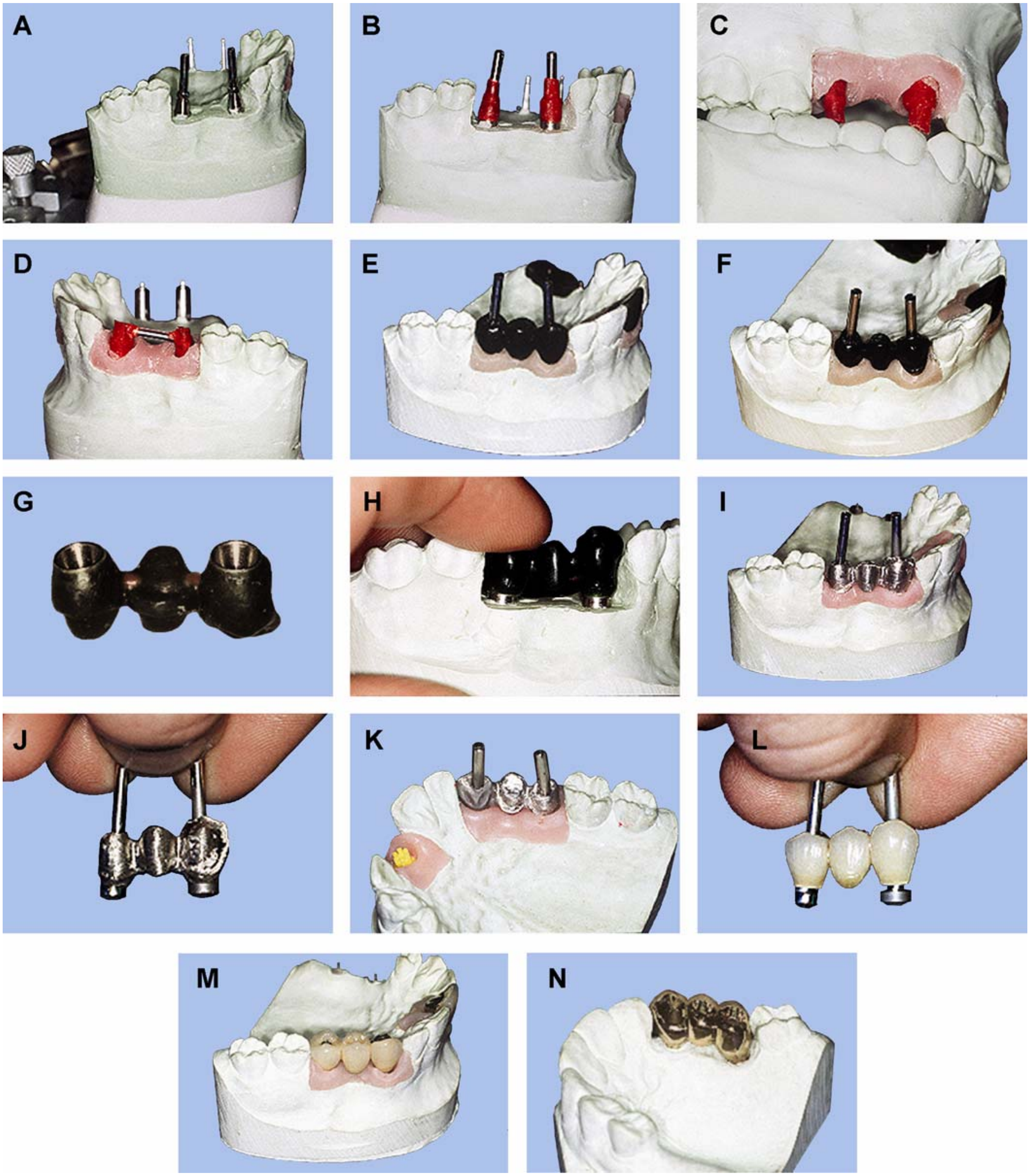
6.15.2. **Screw-Retained, Cast-To Substructure.** Articulate the master and opposing casts on a semiadjustable articulator, using an occlusal bite registration. Evaluate the vertical space to determine which size gold cylinder will best fit. Before placing the gold cylinder, ensure the surface of the abutment replica is clean for accurate seating. Attach a gold cylinder to each abutment replica, using a guide pin (Figure 6.11-A). (Usually, the 10 mm guide pin is sufficient in length.)

6.15.2.1. **Substructure Wax-Up:**

6.15.2.1.1. When waxing the framework, keep in mind that it is necessary to support all porcelain applied to the framework during firing cycles by cast metal. Therefore, the screw access opening will need to be lined with a layer of metal. Accomplish this by creating a resin chimney around the guide pin. Build the resin around the guide pin up to a point that will be slightly above the occlusal surface (Figure 6.11-B).

6.15.2.1.2. After the resin cures, remove the guide pin and grind in the occlusion until the resin chimney is no longer above the occlusal surface (Figure 6.11-C). Then wax up the substructure, following all guidelines previously given in Chapter 2 for metal-ceramic restorations (Figure 6.11-D and -E).

Figure 6.11. Screw-Retained, Cast-To Restoration.



6.15.2.1.3. When cutting back the wax-up, use the soft tissue portion of the cast to ensure the metal collar will be subgingival (Figure 6.11-F). In addition, all portions of the gold cylinder, except the chamfer, need to be covered in wax. The porcelain will only bond to cast metal, not the gold cylinder. The metal of the gold cylinder does not form an oxide layer, which prevents a porcelain-to-metal bond. Use magnification to ensure all wax is removed from the chamfer portion of the gold cylinder (Figure 6.11-G).

6.15.2.1.4. When fabricating a FPD pattern before investing the substructure, check the fit of the wax-up on the abutment replicas. Use one gold screw to attach one abutment and then look to ensure the opposite end is fully seated (Figure 6.11-H). Repeat this step for the other abutment. If rocking occurs, cut the wax-up, attach both abutments, and then reseal the cut area.

6.15.2.2. **Investing and Casting:**

6.15.2.2.1. Use conventional spruing techniques to produce implant substructures. If debubblizer is used, *paint it* only onto the wax pattern. Debubblizer on the gold cylinder may cause metal casting flash. Be sure to follow manufacturer's directions for mixing investment and burnout procedures.

6.15.2.2.2. Cast by using the normal metal ceramic casting technique. Keep in mind that the melting range of the alloy used must be lower than the melting range of the gold cylinder. For this reason, a noble alloy is used. Nonprecious alloys should not be used to cast over gold cylinders.

6.15.2.3. **Finishing the Substructure:**

6.15.2.3.1. Remove all investment from the casting carefully to avoid damage to the gold cylinder. Usually, the investment will fall out of the internal portion of the gold cylinder by tapping on the sprue. If sandblasting is necessary, protect the gold cylinder with wax or protection caps.

6.15.2.3.2. Use magnification to inspect the casting for bubbles, fins, or any defects. Pay particular attention to the gold cylinder seating surface and screw access hole.

6.15.2.3.3. After the gold cylinder and screw access hole is clean, seat the framework onto the cast and check the fit (Figure 6.11-I). If necessary, an FPD can be cut with a disc through the pontic, reattached to the abutment replicas with guide pins, sealed together with resin, and soldered.

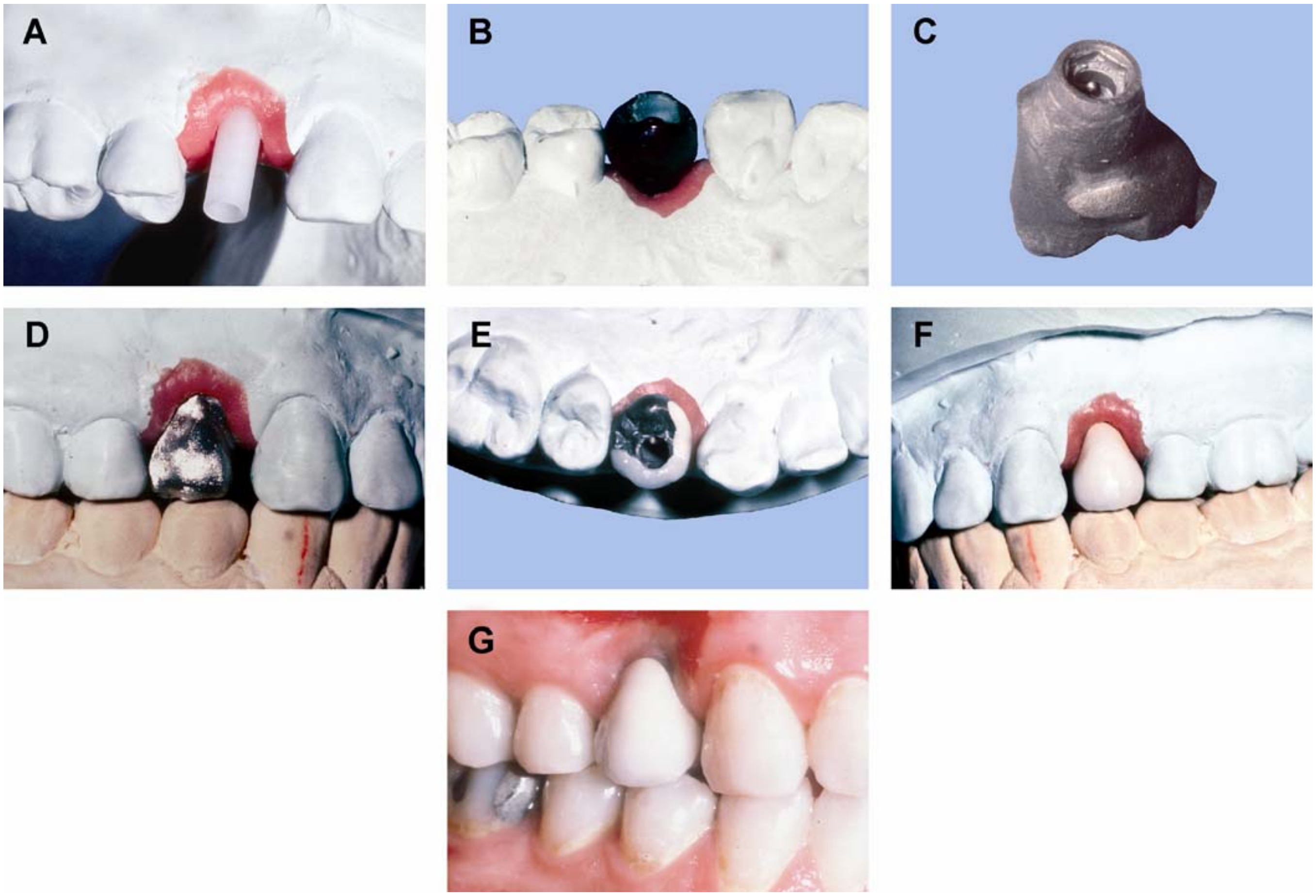
6.15.2.3.4. After a precise fit to the abutment replicas is established, attach a protection cap with a guide pin before proceeding to metal finishing (Figure 6.11-J). Always use protection caps to protect the internal and seating surfaces of the gold cylinder. Now, finish the porcelain bearing surfaces in the same manner as any porcelain fused to metal crown Figure 6.11-K). At this point, FPD frameworks should be tried in the mouth to check for proper fit.

6.15.2.4. **Applying Porcelain (Figure 6.11-L through -N).** First, prepare the framework in the manner prescribed by the porcelain manufacturer. Porcelain application is essentially the same for implants as conventional metal ceramic crowns. ***EXCEPTION:*** Clean all porcelain from inside the screw access holes and gold cylinder seats before firing and use protection caps while grinding porcelain during contouring procedures.

6.15.3. **Screw-Retained, Castable Substructure (Figure 6.12):**

6.15.3.1. A common type of screw-retained, castable substructure is known as the U.C.L.A. abutment. The U.C.L.A. abutment is a plastic pattern that serves as both the abutment and the gold cylinder and is screwed directly to the implant fixture (Figure 6.12-A). The U.C.L.A. abutment has a 0.5 mm collar on the plastic pattern that serves as the metal porcelain junction. Fabrication procedures are essentially the same as the cast-to screw-retained implant.

Figure 6.12. Screw-Retained, Castable Substructure.



6.15.3.2. Start by fabricating the master cast, using a fixture replica versus the abutment replica. Articulate the completed master and opposing casts on a suitable articulator.

6.15.3.3. Next, wax the substructure following guidelines for metal ceramic substructures (Figure 6.12-B). Be sure to extend the screw access hole to the height of the occlusal surface to give support to the porcelain when firing.

6.15.3.4. Cast the wax-up, using a porcelain compatible metal (Figure 6.12-C). Prepare the casting for porcelain, then apply, fire, and contour porcelain to the necessary contours (Figure 6.12-D through -G). Ensure the screw access hole is free from porcelain or any other material.

6.15.3.5. The last step is to finish or mill the surface of the restoration that seats against the implant fixture. When a castable substructure is used, the surface that seats against the implant fixture is not as smooth as a machined abutment supplied by an implant manufacturer.

6.15.3.6. These two surfaces must have intimate contact for successful retention of the restoration. The best way to accomplish this is to use an electric discharge machine (EDM). The EDM uses electric current to spark erode the surface of the casting until it has a smooth intimate contact with a implant fixture replica. Another method is called lapping. It uses grinding compound and small hand drill to lap or grind the surface of the casting against an implant fixture replica until it is smooth and has intimate contact with the fixture replica.

6.16. Procedures for Implant-Retained Removable Prosthesis. Several different types of implant devices can retain removable prostheses. Common devices are the bar and clip attachment (paragraph 6.17 and Figure 6.13), magnets, and ball attachment. The common number of implants used to retain a denture is two. The fabrication procedures for prostheses that use these attachments are very similar.

6.17. Bar and Clip Retained Overdenture. One popular type of plastic bar and clip attachment for a removable prosthesis is called the Hader bar. A Hader Bar is cast in to metal and uses a plastic retaining clip that can be easily replaced when necessary. The bar and clip normally uses two implants—usually one in each canine area, using a standard abutment and gold cylinder with a bar connecting the gold cylinders. Located inside the resin on the tissue side of the denture is a plastic clip that retains the denture when seated.

6.17.1. **Custom Tray and Master Cast.** First, make a custom tray (Figure 6.13-A) by following the steps outlined in paragraph 6.8. Using the custom tray, the dentist will take a final impression with impression copings on the abutments (Figure 6.13-B). Attach abutment replicas to the impression copings and then pour and trim the final impression (Figure 6.13-C). (Additional guidance on the master cast is available in paragraph 6.9.)

6.17.2. **Baseplate and Occlusion Rims.** Attach gold cylinders to the abutment replicas, using long guide pins. Block out around each abutment to prevent the baseplate resin from attaching to the gold cylinders. Make a standard baseplate with the areas around the gold cylinders open (Figure 6.13-D). When making the occlusion rims, leave the area around the guide pins open to prevent the wax from interfering with access to the guide pins (Figure 6.13-E). Use standard dimensions for the occlusion rims (Volume 1, Chapter 7, Section 7H).

6.17.3. **Articulation.** Articulate the master cast and opposing, using the face bow and interocclusal registration. It may be necessary to use shorter guide pins to eliminate interferences with the opposing cast.

6.17.4. **Trial Denture:**

6.17.4.1. Follow standard tooth arrangement procedures for the desired type of setup. If interference is encountered with the guide pins, the tooth must be altered or omitted for the try-in (Figure 6.13-F). If a tooth is altered for the try-in, a replacement tooth will be set during the final wax-up when guide pins are no longer used. The completed setup will then be tried in the patient's mouth and evaluated for function and esthetic requirements.

6.17.4.2. Make any necessary changes to the setup using the dentist guidance from the try-in (Figure 6.13-G). In order to maintain the relationship of the setup to the abutments, make a silicone facial matrix of the final setup. Be sure to make grooves in the land areas of the cast before making the matrix to help reorient it to the cast later.

6.17.5. **Bar Fabrication:**

6.17.5.1. First, attach the gold cylinders to the master cast, using guide pins (Figure 6.13-H). Cut a piece of plastic bar to fit between the gold cylinders passively. Keep the plastic bar straight to allow for easy seating of the clip.

6.17.5.2. Position the plastic bar a minimum of 2 mm above the tissue to allow for easy cleaning. Attach to the gold cylinder with inlay wax (Figure 6.13-I).

6.17.5.3. Flow the wax over and around the gold cylinder to blend in the bar attachment. Sprue, invest, and cast the completed wax-up (Figure 6.13-J).

6.17.5.4. Finish the casting to the polished stage without altering the shape of the bar. When finishing, use protection caps on the gold cylinders to prevent damage to the seating surfaces (Figure 6.13-K). Attach the finished bar to the abutments with gold screws and check for an accurate fit (Figure 6.13-L).

Figure 6.13. Bar and Clip Overdenture Procedures.

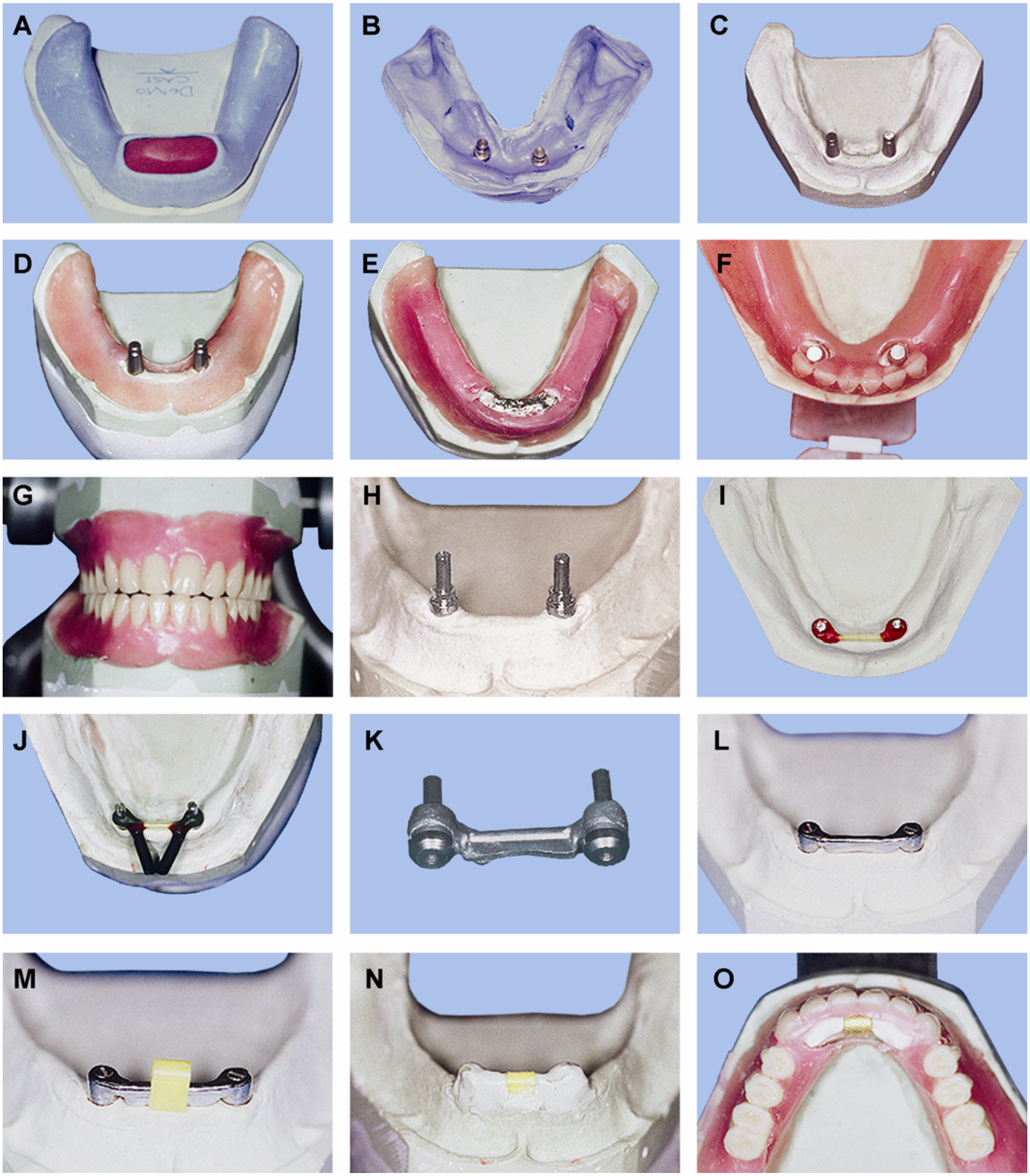
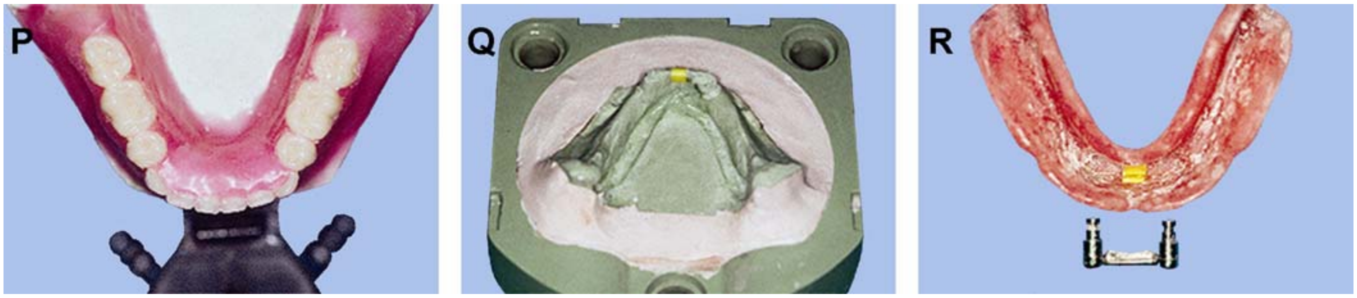


Figure 6.13. Continued.



6.17.6. **Denture Completion:**

6.17.6.1. Position the fabrication plastic clip on the bar and adjust the clip to follow the contours of the tissue when the clip is fully seated onto the bar (Figure 6.13-M).

6.17.6.2. Seat the clip and apply stone to stone separator to the anterior portion of the cast. Mix and flow stone around the bar to blockout the entire bar, leaving the clip exposed and flush with the top of the block out (Figure 6.13-N). This allows the clip to be picked up in the resin when processing the denture base without engaging any resin around the bar.

6.17.6.3. Remove the teeth from the trial denture wax-up and seat them into the silicone matrix made earlier (paragraph 6.17.4.2). Seat the matrix onto the indexes in the master cast land area and flow the wax, attaching the teeth to the cast (Figure 6.13-O). Fill in all space with wax and contour the denture base to complete the final wax-up (Figure 6.13-P).

6.17.6.4. Verify the occlusion and then proceed to process the denture base, using standard processing techniques (Figure 6.13-Q). When deflasking, be careful to avoid damaging the bar.

6.17.6.5. Remount the denture to the articulation and equilibrate any processing errors. Finish and polish the denture using conventional techniques. Remove the fabrication clip and install the final retentive clip. This final step is usually completed during insertion of the completed denture (Figure 6.13-R).

Chapter 7

SPECIAL PROSTHESES

Section 7A—Treatment Appliances

7.1. Types of Basic Orthopedic Appliances:

7.1.1. **Introduction.** The basic orthopedic appliance has many different names, including night guard, maxillary orthopedic appliance, occlusal orthopedic appliance, and occlusal splint. A basic orthopedic appliance can be made of hard or soft material for either the maxillary or mandibular arch. The hard appliance may be fabricated, using self-curing orthodontic acrylic, heat-cured acrylic, light-cured acrylic, microwave-cured acrylic, or vacuum-formed plastic. The soft appliance is usually fabricated, using mouthguard material (0.15-inch thick). This section will describe the self-curing, sprinkle-on technique.

7.1.2. **Patient Treatment:**

7.1.2.1. These appliances can be used to (1) stabilize the teeth, (2) treat temporomandibular disorders and provide pain relief, (3) increase occlusal vertical dimension, and (4) reduce an excessive rate of tooth wear.

7.1.2.2. The basic orthopedic appliance may be fabricated with the mandible in different positions. These positions can range from centric relation to any position forward of centric relation that can be tolerated by the patient. The centric relation position of the mandible (or terminal hinge position) provides for the most repeatable position of the mandible.

7.1.2.3. A basic orthopedic appliance can be a passive appliance that uses a flat surface parallel to the occlusal plane or an active appliance that usually has occlusal indentations approximately 1 mm deep guiding the mandible to a predetermined position on the appliance.

7.1.2.4. Most basic orthopedic appliances are made with simultaneous, even contact of all posterior stamps cusps and incisal edges of the opposing arch in the centric position provided by the dentist. These appliances are usually fabricated with a mutually protected occlusion, which provides for a anterior guide plane that acts as a guiding ramp to disclude all potential posterior eccentric contacts.

7.1.3. **Procedures for Construction of a Basic Orthopedic Appliance (Self-Cured Acrylic):**

7.1.3.1. **Mount Casts:**

7.1.3.1.1. Before the appliance can be made, the casts must be mounted on an articulator with the desired mandibular position and a space separating the opposing teeth. For specific procedures on articulating, refer to Volume 1, Chapter 6.

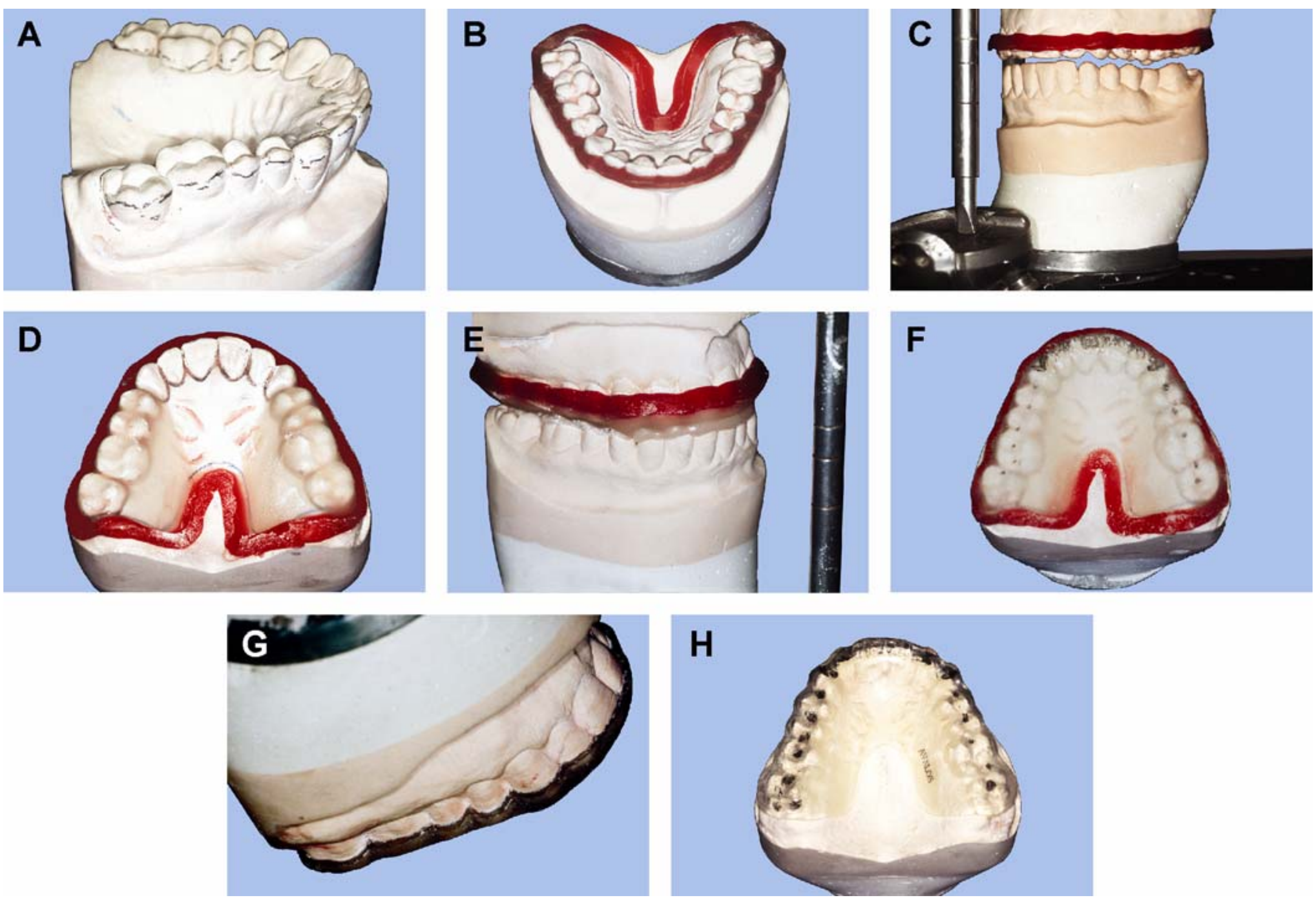
7.1.3.1.2. Although it is not absolutely essential for the maxillary cast to be mounted using a facebow transfer, it will provide a more accurate relationship of eccentric contacts and centric contacts if the vertical opening is to be changed.

7.1.3.1.3. Lateral records may also be used to adjust the horizontal condylar guidance. If the dentist provides these records, you will be able to program the articulator to simulate the mandibular movements of the patient. If these records are not provided, the dentist must be willing to accept some degree of error in these positions and make the necessary adjustments in the mouth. If the dentist does not provide a facebow transfer, he or she must provide an interocclusal record of the same thickness and relationship desired for the finished appliance. (Be sure to tighten the set screw on the incisal pin to prevent the occlusal vertical dimension from moving accidentally.)

7.1.3.2. **Survey and Design.** Once the casts have been properly mounted on the articulator with the desired amount of occlusal vertical dimension opening, the next step is to survey the maxillary cast (Figure 7.1-A). Survey the buccal and lingual surfaces of the posterior teeth with a carbon marker. The design of the appliance should extend 0.5 mm beyond the height of contour on the buccal of the posterior teeth and 1 to 1.5 mm below the incisal edge along the labial surfaces of the anterior teeth. The lingual design should be a horseshoe shape that covers the rugae.

7.1.3.3. **Block Out Undercuts.** Using baseplate wax, block out undercuts along the lingual gingival crevice, embrasures, margins of restorations, deep occlusal grooves, and prominent rugae. Apply utility wax, following the design along the facial surfaces of the teeth and inside the palate to establish the border of the appliance (Figure 7.1-B). Seal the utility wax to the cast and flatten the top edge of the wax, just exposing the design line. The utility wax will help control the flow of acrylic and establish a definite border to the appliance.

Figure 7.1. Basic Orthopedic Appliance.



7.1.3.4. **Set the Guide Table for Anterior Guidance.** Set the incisal guide table to ensure there is adequate space for acrylic in lateral and protrusive excursions.

7.1.3.4.1. Loosen the centric locks and place the upper member of the articulator in protrusive. Rotate the incisal guide table until the incisal guide pin separates the anterior teeth 1 to 2 mm at the closest point (Figure 7.1-C). Tighten the set screw on the guide table at this position.

7.1.3.4.2. Place the upper member into a lateral excursion. Adjust the appropriate incisal guide table wing until the guide pin separates the posterior teeth 1 to 2 mm at the closest point. Lock the guide table set screw at this position. Repeat this step for the other lateral excursion.

7.1.3.5. **Apply Resin.** Orthodontic resin provides the best appliance and is easiest to control. Apply a tinfoil substitute to the maxillary arch and opposing occlusal surfaces. To minimize the shrinkage and distortion that always accompanies the polymerization of acrylic resin, apply the resin in sections (Figure 7.1-D), using the sprinkle-on technique. The first three applications of acrylic provide a minimum thickness of resin and must not be allowed to contact the mandibular teeth.

7.1.3.5.1. Sprinkle the polymer on one of the posterior sections to include only the occlusal and lingual surfaces of the teeth and tissue. Moisten the powder with monomer and keep it moist to prevent porosity. Close the articulator and check to see that the mandibular cusps do not contact resin. Allow each section to cure before proceeding to another. To help reduce porosity in the cured appliance, place the cast in a closed container with a monomer-soaked cotton roll while the curing process takes place.

7.1.3.5.2. After the three sections have been joined together, sprinkle the resin for the occlusal portion of the appliance. Moisten the previously formed base with monomer and sprinkle resin onto the entire occlusal surface.

7.1.3.5.3. Build up the resin thick enough so opposing cusp and incisal edges will contact when the articulator is closed. Let the resin become doughy and then close the articulator into centric position. Repeatedly close the articulator and move the upper member through lateral and protrusive excursions while the resin is still in the doughy state (Figure 7.1-E).

7.1.3.5.4. In the anterior region, the goal is to create an inclined plane that discludes all potential posterior eccentric contacts. With the incisal guide table properly set (paragraph 7.1.3.4), this should be easily achieved.

7.1.3.5.5. When all the imprints have been established, close the articulator and place it in a closed container; for example, a small plastic bucket with lid. Allow the resin to polymerize according to the manufacturer's guidelines.

7.1.3.6. **Refining Contacts:**

7.1.3.6.1. The occlusal contacts must be refined through identification of the various imprints and adjustment. Good methods for distinguishing between centric and eccentric contacts use red and black articulating film.

7.1.3.6.2. Place a piece of red articulating film on the occlusal surface and gently tap the articulator closed until red marks are readily visible on the acrylic. Next, use the black articulating film on the occlusal surface, following the imprints made, to identify the eccentric contacts. The objective of adjusting the centric contact areas is to reduce the broad base contact to a smaller point contact.

7.1.3.6.3. Only the mandibular buccal cusp tip indentations at the greatest depth are permitted to remain. Care must be taken when reducing the broad base contacts to avoid grinding through the acrylic and damaging the cast. If holes are ground through into the cast, they cannot be accurately repaired because a portion of the cast is now missing.

7.1.3.6.4. In lateral and protrusive movements, the anterior bite plane bears the functional load for the appliance. Therefore, all posterior eccentric contacts must be eliminated and anterior guidance "ground in" to produce a smooth, gliding motion. When fully adjusted, the appliance should hold the shim stock between the appliance and all mandibular buccal cusps in centric occlusion only. When the shim stock is pulled through the anterior region, it should be able to drag across the mandibular anteriors in centric occlusion.

7.1.3.6.5. In the eccentric positions, the posterior cusps should not touch the acrylic resin and the anterior should only cause a posterior separation of 1 to 2 mm. The contacts should appear like those in Figure 7.1-F.

7.1.3.7. **Bulk Finishing.** Most of the finishing should be done while the appliance is on the cast to minimize distortion or warpage. Remove the utility wax from the borders of the appliance. If necessary, boiling water may be used to eliminate the wax, but care must be taken to avoid warping the appliance. Reduce the overall bulk of the appliance until you obtain a uniform thickness of approximately 1 to 2 mm. Contour the resin along the facial contours in a scalloped fashion approximately 1 mm thick (Figure 7.1-G). Be careful not to eliminate any of the centric stops or disturb the anterior guidance.

7.1.3.8. **Completion.** Carefully remove the appliance from the cast by gently lifting from the posterior area first to allow the appliance to disengage the undercuts on the facial of the anterior teeth. The acrylic resin along the facial should extend 0.5 mm beyond the height of contour of the posterior teeth and 1 to 1.5 mm below the incisal edge of the anterior teeth. Lightly pumice and polish the occlusal areas and avoid eliminating any of the contacts incorporated into the appliance. Exercise extreme caution not to overheat the resin and warp the appliance during pumicing and polishing. Clean and disinfect the appliance before delivery (Figure 7.1-H).

7.2. Soft Acrylic Mandibular Orthopedic Appliance. A basic orthopedic appliance using soft resilient mouthguard material is essentially fabricated in the same manner as the thermoplastic vinyl mouth protector discussed in paragraph 7.4. The only significant differences are that a mandibular cast is often used and dentists often desire the material to extend as far as possible into the posterior lingual flange area.

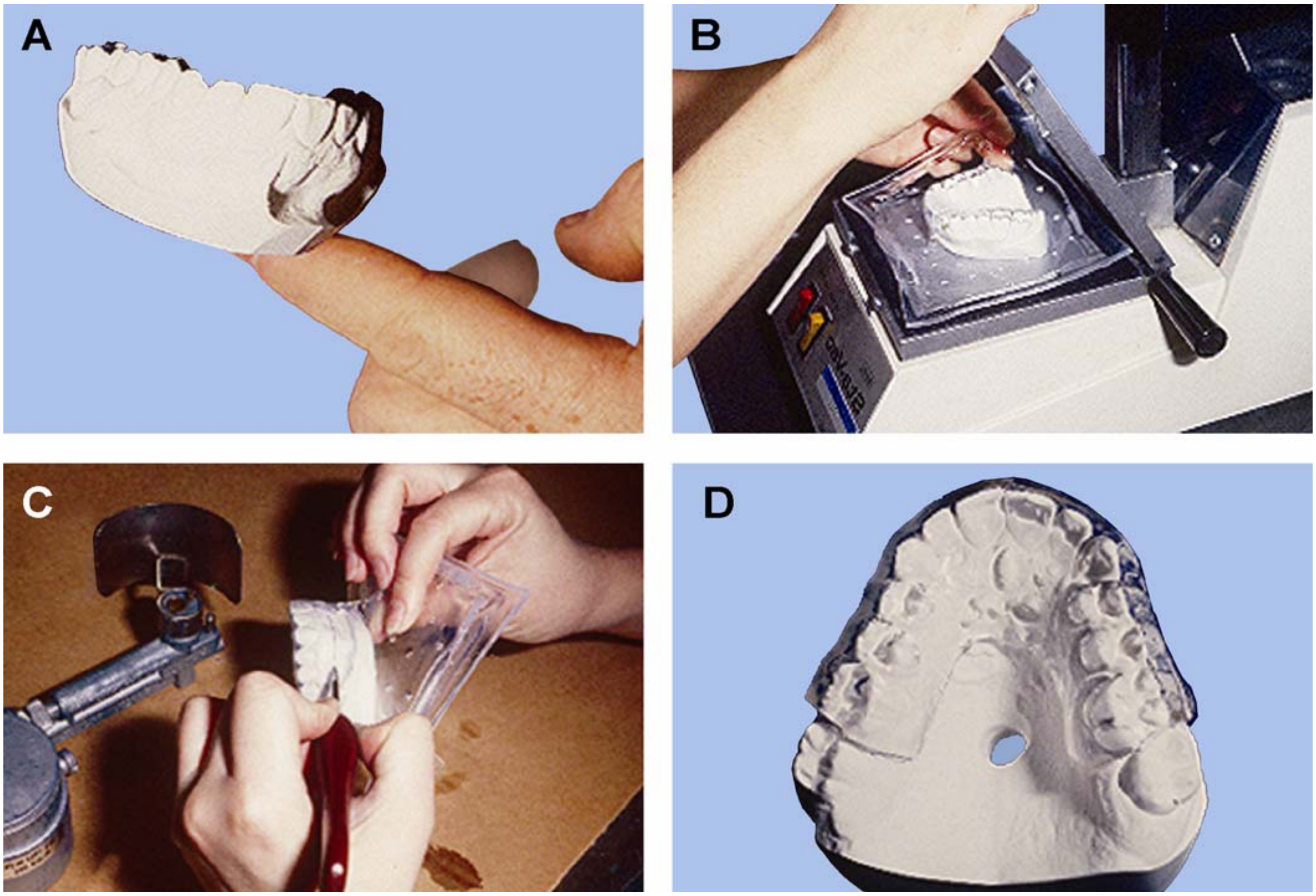
7.3. Other Basic Orthopedic Appliance Designs. Depending on treatment needs, dentists will occasionally request different designs for oral orthopedic devices. Such devices may include anterior bite planes, mandibular bilateral posterior splints, and anterior repositioning devices. Consult the prescribing dentist for specific fabrication details.

7.4. Fabricating a Thermoplastic Vinyl Mouth Protector. In the fabrication of a vinyl thermoplastic mouth protector, the dentist will furnish an alginate impression of the patient's maxillary arch. The dental technician will perform the following steps (Figure 7.2):

7.4.1. Pour a master cast in artificial stone.

7.4.2. After separating the cast from the impression, draw the outline of the mouthguard on the cast with a soft lead pencil. Trim the cast as close to the outline as practical. (The thickness of the base should not exceed 6 mm). Do not create undercuts on the cast that would interfere with removal of the mouth protector. The reason for trimming the cast as specified is to facilitate the vacuum formation and minimize stretching and thinning of the vinyl plastic during the molding (Figure 7.2-A). A large, oversized cast would result in a thin mouth protector with poor serviceability. At this time, allow the cast to dry because air will not pass through a cast saturated with water. Print the patient's name on the cast.

Figure 7.2. Mouth Protector Fabrication.



7.4.3. Determine the exact molding procedure used. To some extent, this depends on the type of equipment used. The directions furnished by the manufacturer should produce satisfactory results. Most commercial machines consist of a perforated plate connected to a source of vacuum, an electrical heating element, and a metal frame the vinyl plastic blank is clamped into. The molding procedure in general is as follows:

7.4.3.1. Clamp a vinyl plastic sheet in the frame and place it under the heater. Estimate the molding temperature by the amount the sheet of vinyl plastic material "sags" as it softens. Excessive softening of the material will result in undesirable stretching and thinning of the mouth protector. Sharp reproductions of the surface detail are not necessary.

7.4.3.2. Dip the dry cast in water for 2 or 3 seconds and place in position on the perforated plate. This wetting provides enough surface moisture to prevent the vinyl plastic from sticking, but it does not affect the passage of air through the cast.

7.4.3.3. Turn the vacuum on and move the frame to the molding position. Hold in this position until the vinyl plastic is completely adapted to the cast (Figure 7.2-B).

7.4.3.4. Turn off the vacuum and release the clamp on the frame. Set the cast with the mouth protector aside until it cools thoroughly.

7.4.3.5. After cooling, trim excess vinyl plastic material away with scissors or a warm knife blade (Figure 7.2-C). Remove the mouth protector from the cast and polish the periphery with pumice. Clear any cloudy areas caused by polishing by lightly flaming the mouth protector over a Bunsen burner or with an alcohol torch. Clean and disinfect the mouth protector and replace it on the cast until it is delivered to the patient (Figure 7.2-D).

7.5. Sleep Apnea Appliance. Sleep apnea is a condition in which airflow is restricted, causing breathing interruptions during sleep. In some cases, an appliance can be made to reduce the chances of interruptions and allow air to freely pass into the lungs. The sleep apnea appliance repositions the lower jaw and tongue during sleep to prevent the airway from closing. To fabricate the appliance, the dentist first takes diagnostic impressions and a bite registration with the mandible in approximately 75 percent protrusive and with a 10-mm incisal opening.

7.5.1. **Constructing a Sleep Apnea Appliance (Figure 7.3):**

7.5.1.1. **Duplicate the Master Casts.** First, block out any interproximal undercuts on the master casts and then provide a set of working casts, using standard duplicating procedures.

7.5.1.2. **Design and Articulate the Casts.** Extend the design to the attached gingiva area on the facial surface of the maxillary and mandibular casts. The mandibular cast's lingual design should extend below the gingival margin, but not into major undercut areas. The lingual of the maxillary may be a full palate or horseshoe design. Trim the bases of the working cast as close to the design cast as possible. This will facilitate the flasking process later. Articulate the working casts using the bite registration provided (Figure 7.3-A).

7.5.1.3. **Wax Up the Appliance.** Apply a uniform 2 to 3 mm thickness of baseplate wax to the design of the maxillary and mandibular cast. Fill the interocclusal space between the maxillary and mandibular arches from the first premolar to the second molar. This will leave an opening in the anterior area from canine to canine (Figure 7.3-B).

7.5.1.4. **Flasking:**

7.5.1.4.1. Because of the vertical height of the wax-up, flasking must be accomplished in a jumbo flask or two maxillary flasks combined. When using two maxillary flasks, combine two lower sections with one center section between them. Half-fill the center and lower section of the flask with flasking stone. Adapt the flasking stone into the tongue space of the wax-up and then submerge the wax-up into the flask covering the entire wax up with stone (Figure 7.3-C).

7.5.1.4.2. Smooth the surface of the lower half flasking before the stone sets completely and then apply separator to the stone (Figure 7.3-D).

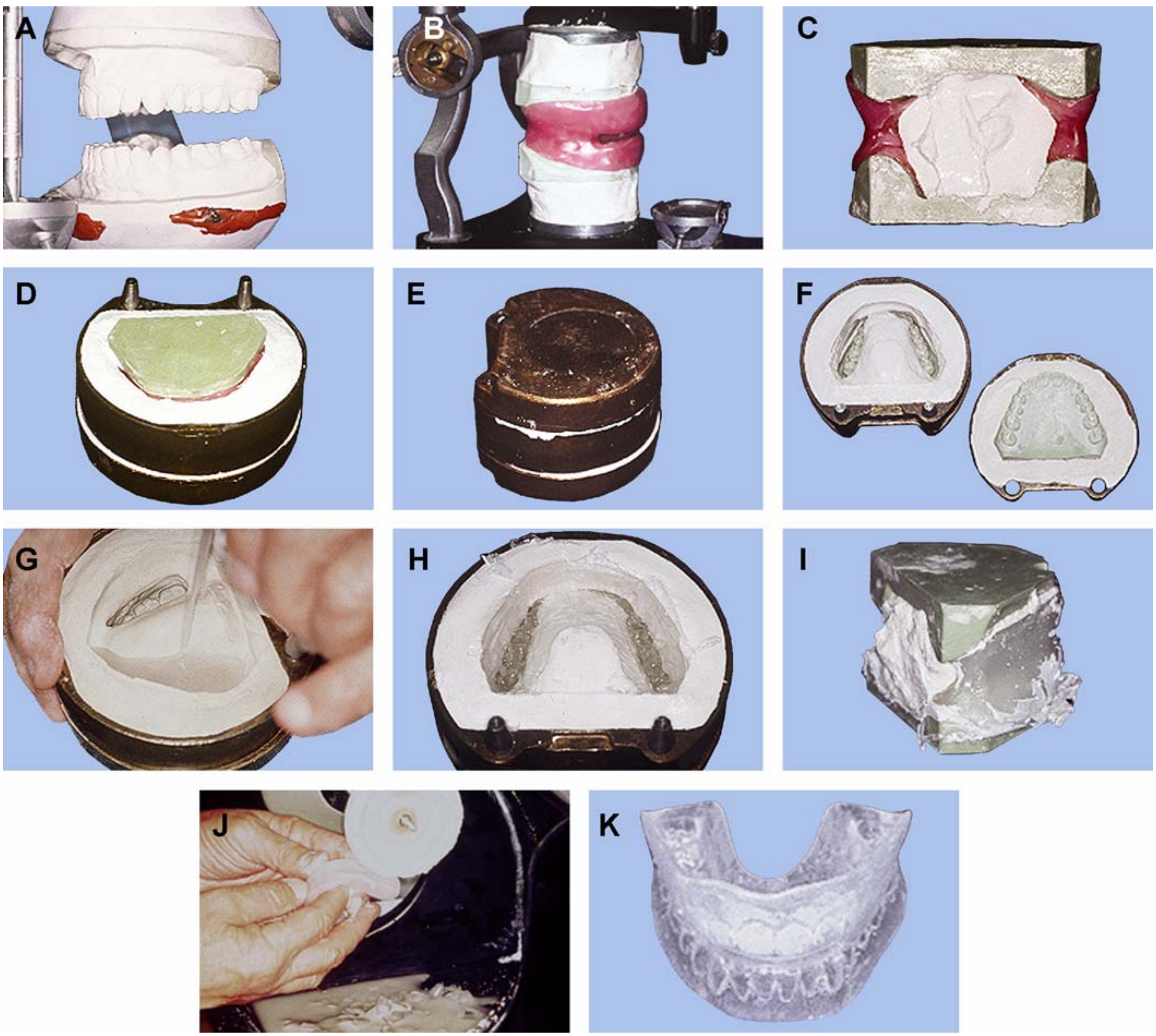
7.5.1.4.3. Mix the flasking stone for the upper half flasking. First, fill the areas around the cast. Then fill the remaining lower flask section with stone and invert it onto the lower half flasking. Excess stone should be visible between the lower and upper portions of the flask to ensure the flask is full (Figure 7.3-E). Allow the stone to set before proceeding to boilout.

7.5.1.5. **Boilout.** Place the flask in boiling water for 5 minutes to soften the wax, but not melt it into the stone. Separate the flask and remove as much wax as possible. Place the mold back into boiling water to remove the remaining wax. Scrub and rinse the mold thoroughly to remove all residues (Figure 7.3-F). Apply a runny mix of separator to the mold while it is still warm. Then tip the mold on end to allow excess separator to drain.

7.5.1.6. **Packing and Curing.** Use a soft heat cured acrylic for the appliance. The acrylic is soft when warm and hardens as it cools. This allows the appliance to flex over the contours of the oral cavity without any other retention devices. Mix the material according to the manufacturer's directions and pour it into the lower half mold (Figure 7.3-G). Trial pack the mold several times to be sure it is densely packed (Figure 7.3-H). Place the mold into a flask carrier and cure it according to the manufacturer's directions.

7.5.1.7. **Deflasking and Finishing.** Remove all stone from around the cast, leaving the appliance in place (Figure 7.3-I). Place the cast in warm water to soften the acrylic and then gently remove the appliance from the cast. Be careful because the material is more susceptible to tearing when it is in a softened state. Before finishing, soak the appliance in cold water to keep the acrylic hard while grinding on it. Smooth any rough areas and trim the appliance to the design line. Pumice and polish as usual (Figure 7.3-J).

Figure 7.3. Sleep Apnea Appliance.



7.6. Surgical Splints:

7.6.1. **Types of Splints.** A splint is an appliance, either rigid or flexible, used to immobilize displaced or movable dentition. In the treatment of certain types of jaw fractures, the oral surgeon first reduces the fracture by bringing the displaced bone segments into normal alignment and then fixes them in position by the method best suited to the patient's needs. Later, when healing of the fragments has progressed sufficiently, the fixation apparatus is removed and a splint may be inserted in the patient's mouth until healing is completed. (In some instances, the splint may serve as the fixation apparatus from the beginning of treatment.)

7.6.2. **Variations in Splint Design:**

7.6.2.1. Splints are made in different forms to deal with the variety of problems encountered in treatment. The dentist will prescribe the requirements the splint must satisfy. The dental technician must have a broad knowledge of the principles involved in splint fabrication so the basic technique can be modified to meet any of these requirements.

7.6.2.2. Splints can be made of acrylic resin or cast metal. Those made of metal are less bulky than those made of acrylic resin. One advantage of an acrylic resin splint is that it is radiolucent. Periodic radiographs can be made through it to check the progress of healing without removing the splint from the patient's mouth. This paragraph covers the fabrication of one simple case of each type, including examples of modifications.

7.6.3. **Fabricating an Acrylic Resin Fixation Splint (Figure 7.4):**

7.6.3.1. **Impressions and Casts.** The dentist will furnish alginate impressions of both dental arches. Carefully and completely rinse the impressions of all saliva and debris and then disinfect. Remove the excess moisture with a blast of air and pour the master casts in artificial stone. Original master casts are never used as working casts. If the splint is to be used for fixation of a fracture case and the fracture has not been reduced (because the patient's bone fragments have not been realigned), section the master cast at the line or lines of fracture and reassemble the fragments in proper position and occlusion. Then make a duplicate cast for this purpose.

7.6.3.2. **Design:**

7.6.3.2.1. Mark a line along the junction of the middle and incisal (or occlusal) thirds of all teeth on their facial and lingual surfaces (Figure 7.4-A). This line represents the superior border of the prosthesis. If the vertical overlap of the maxillary anterior teeth is excessive, the line may have to be placed more gingivally on the facial surfaces.

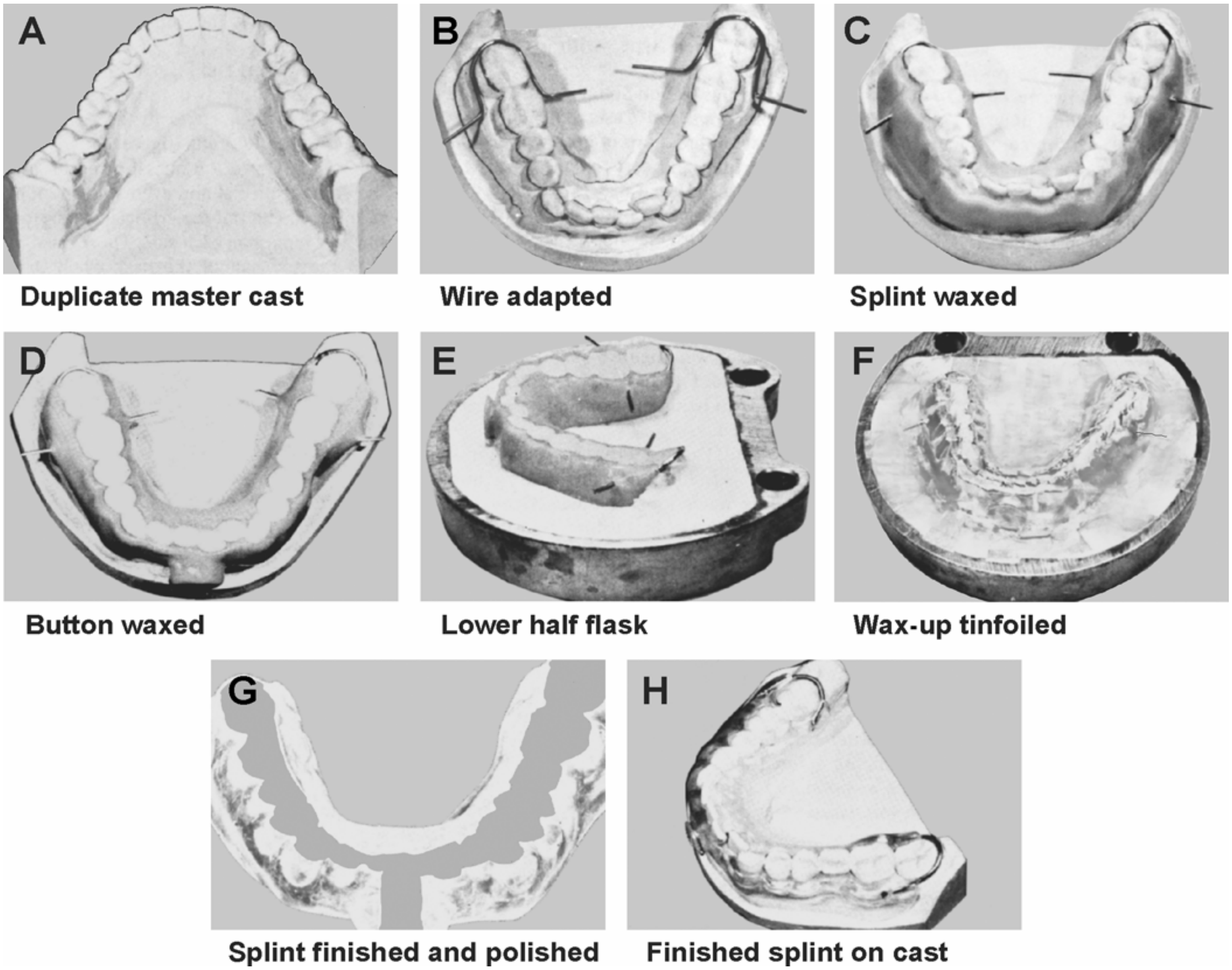
7.6.3.2.2. Make a line on the facial surface of the cast, halfway between the gingival border of the teeth and the buccal sulcus. Mark another line on the lingual surface of the cast halfway between the gingival border of the teeth and the floor of the mouth. These lines represent the inferior border of the prosthesis.

7.6.3.2.3. Complete the outline of the design by marking vertical lines on the facial surface of the last molar on each side of the arch.

7.6.3.3. **Hinges.** The splint consists of a lingual and two facial sections joined by wire hinges running distal to the last molar on each side.

7.6.3.3.1. On each side, closely adapt 14-gauge, half-round wire to the distal surfaces of the last molar to be included in the splint (Figure 7.4-B). Keep the wire as close as possible to the gingiva without impinging on soft tissue.

Figure 7.4. Acrylic Resin Fixation Splint.



7.6.3.3.2. Carry each wire around onto the facial and lingual surfaces of the teeth as far forward as the center of the next tooth. Bend the ends of the wire laterally at right angles and cut off the excess, leaving about 12 mm jutting out facially and lingually. Do not adapt the wires too close to the facial and lingual surfaces of the teeth. There should be a slight space (about 1 mm) that will allow the splint material to flow around the wires, embedding them.

7.6.3.3.3. Tack the hinges into position with sticky wax.

7.6.3.4. **Wax-Up and Flasking:**

7.6.3.4.1. Apply two thicknesses of baseplate wax, sealing their edges to the design on the cast. Make the outer surface flat and smooth (Figure 7.4-C).

7.6.3.4.2. Grind the incisal or occlusal thirds of the stone teeth flat and even with the top surface of the wax. Cut out the artificial stone from under the wire hinges on each side to allow the wires to be pulled with the top half of the flask when the flask is opened (to eliminate wax).

7.6.3.4.3. Attach a 6 mm wax button to the facial surface at the midline (Figure 7.4-D). The completed splint will be sectioned through the button vertically. The dentist will use the halves of the button as anchors for wiring the two facial sections together in the mouth. Additional undercut buttons or metal lugs can be placed in convenient areas to provide anchor points for intermaxillary traction.

7.6.3.4.4. Trim any excess wax at the borders to the previously drawn design. The edges should be sharp, definite, and at right angles to the cast. Fill any edentulous areas with wax. Half-flask the case in the usual manner for processing acrylic resin (Figure 7.4-E).

7.6.3.4.5. If using translucent acrylic resin, tinfoil the wax-up well (Figure 7.4-F). (Some types of translucent acrylics suggest the use of tinfoil rather than tinfoil substitute to achieve a clear product.) Consult the manufacturer's directions for the type of acrylic used.

7.6.3.4.6. Full flask the case, using the stone cap method to help deflasking after the case has been processed.

7.6.3.5. **Packing, Processing, and Finishing:**

7.6.3.5.1. Eliminate the wax by immersing the flask in boiling water for 5 minutes. Open the flask and remove all the wax by flushing as usual. Apply tinfoil to the cast.

7.6.3.5.2. Pack acrylic resin and process as usual. After bench cooling for 30 minutes, immerse the flask in cold water for 15 minutes.

7.6.3.5.3. Deflask and recover the splint.

7.6.3.5.4. Finish and polish the prosthesis as usual. Use an acrylic resin finishing bur to create a slight groove around the base of the button at its point of attachment.

7.6.3.6. **Sectioning the Splint:**

7.6.3.6.1. Section the splint faciolingually at the midline of the facial segment and mesiodistally through the center of each edentulous space (Figure 7.4-G). Use either a thin disc or a jeweler's saw.

7.6.3.6.2. Carefully trim the gingival border to adapt the splint to the duplicate working cast (Figure 7.4-H).

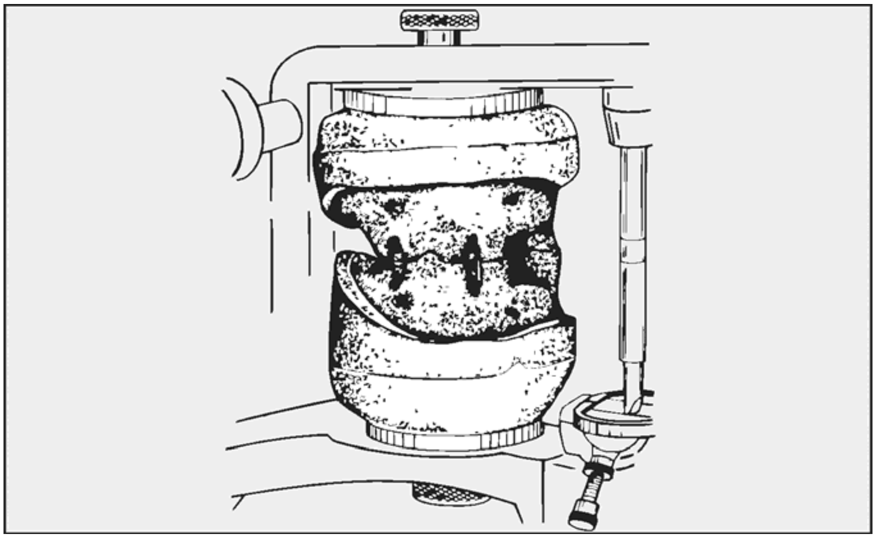
7.6.4. **Fabricating an Edentulous Fixation Splint (Gunning Splint):**

7.6.4.1. Edentulous fixation splints are used to immobilize fractured edentulous maxillae and mandibles. They are also used when the patient does not have complete dentures that can be modified for use as a fixation splint.

7.6.4.2. A splint consists of record bases and occlusion rims processed in acrylic resin (Figure 7.5). First, the dentist modifies the rims to match the patient's occlusal vertical dimension by orienting the wax rims in centric relation. Next, a V-shaped notch is carved into the occlusal surface of one of the occlusion rims. A V-shaped projection is then added to the opposing occlusion rim to provide a means of positively orienting the two edentulous arches. This notch arrangement helps maintain the fractured maxillae and mandible in proper centric relation and occlusal vertical dimension until healed. The anterior segments are left open so the patient can eat more easily and expel food in the event of choking.

7.6.4.3. The splints are processed by using the same procedures as acrylic resin complete dentures. At the direction of the dentist, bend several wire hooks and attach them to the splint by using autopolymerizing acrylic resin. The wires are used with rubber elastics for intermaxillary fixation.

Figure 7.5. Gunning Splint.



7.7. Specifications and Laboratory Procedures for Cast Arch Bars:

7.7.1. An arch bar is a splint-like device used to hold jaw fragments together in proper alignment in a patient's mouth. The need for such a device most often arises because of injury.

7.7.2. A cast arch bar is a band of metal cast to fit around a dental arch, against the facial surfaces of remaining teeth. The bar has a number of lugs that protrude from its gingival border.

7.7.3. Arch bars are frequently used in pairs, one maxillary and one mandibular. Each bar is wired in place on an arch, using remaining natural teeth for anchorage. The two bars are then held together by rubber bands or heavy duty, silk thread. The idea is not only to hold a jaw's fragments together with the bar, but to stabilize a broken jaw against one that is not broken. This inter-arch stabilization is essential if the broken jaw is to heal in good occlusion with its opponent. The purpose of these specifications is to standardize construction procedures so the resulting arch bars will fulfill the requirements of oral surgeons and best serve the needs of the patient.

7.7.4. Because many patients are hospitalized while awaiting the construction of the bars, construction procedures should be given top priority and the fabrication expedited by all reasonable means.

7.8. Impressions and Jaw Relationship Record for Cast Arch Bars. As always, the dentist is obligated to make the best impression possible. Making an impression of a patient's fractured jaw is difficult. Such patients are in pain and have extreme difficulty opening their mouths wide enough to accommodate impression trays. When appropriate, an interocclusal record should accompany the case.

7.9. Construction Specifications for Cast Arch Bars:

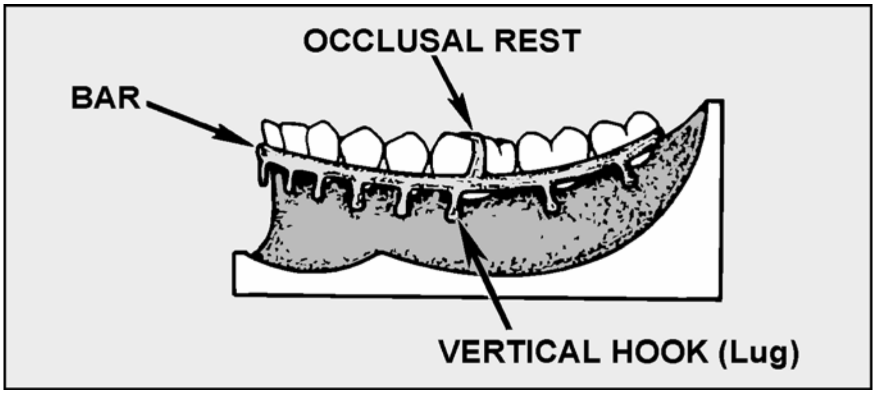
7.9.1. **Bar:**

7.9.1.1. The bar must have adequate, uniform thickness and width to resist distortion or breakage.

7.9.1.2. The gingival-occlusal width should equal 2 to 2 1/2 mm with a faciolingual thickness 1 to 1 1/2 mm. Use the larger dimensions when the arch bar will be fabricated using gold alloys. Base metal alloy is stronger and can be a little less bulky. Build the bar so it has a flat surface in contact with each tooth. The bar will traverse the area on the facial surfaces of the crowns between the contact points and the gingival tissue.

7.9.1.3. The gingival edge of the bar should come to within 0.5 to 1 mm of the midfacial surface junctions of gingivae and teeth (Figure 7.6). Hopefully, the occlusal border of the bar will be at least 1 mm gingival to the contact points of the teeth to allow easier wiring and better jaw fragment stabilization.

Figure 7.6. Cast Arch Bar Seated on the Working Cast.



7.9.1.4. Extend the bar around the arch in a relatively straight line with no interproximal contouring or festooning. Relieve the interproximal areas enough to prevent pressure on interproximal papillae. Arch bars that extend into interproximal areas are very difficult to ligate to teeth because there is not enough working room.

7.9.2. **Occlusal Rests.** Place at least one occlusal rest on each side of the arch. The rests are essential to help position and support the bar in the patient's mouth. The rest may be placed on a buccal groove or on a marginal ridge area, depending on where space is available. Make absolutely sure the rests do not prevent opposing natural teeth from making contact in MI.

7.9.3. **Vertically Oriented Traction Lugs (Hooks):**

7.9.3.1. There should be 1 to l 1/2 mm clearance between the inner surface of the lug and the gingival tissue under it. In this raised condition and paralleling the gingival surface, the dentist should have no trouble wrapping ligature material around opposing lugs. Also, the lug will not stab into the patient's cheek.

7.9.3.2. About one lug per tooth is needed. Position the lugs in the centers of anterior teeth and premolars, favoring the mesial 1/3 of molar teeth. Place a lug at the distobuccal corner of the most posterior tooth to help maintain the ligature wire in proper position during placement of the bar.

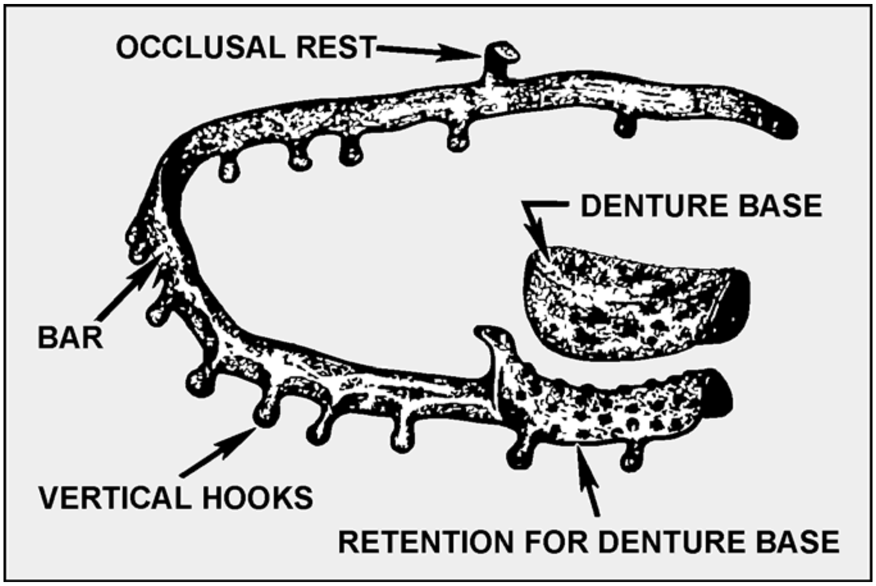
7.9.3.3. The average length of a lug from the arch bar to the tip should be 3 to 4 mm. The lug should be cylindrical with a bead or ball on the tip. No sharp edges or corners should be present to cut ligature material. The lug should be between 1 and 1 1/2 mm in diameter and the junction between the bar and the lug should be of sufficient bulk to eliminate the possibility of breakage when ligature traction is applied.

7.9.4. **Denture Base (Figure 7.7):**

7.9.4.1. Sometimes, a patient does not have enough natural teeth remaining in an arch to stabilize broken jaw segments with a conventional cast arch bar. Therefore, a denture base that occludes with opposing teeth can be added to one or more sections of an arch bar to provide additional stabilization. Plan for a space between the proximal face of the denture base and the adjacent tooth. The space permits passage of a ligature wire that fastens the arch bar to the tooth.

7.9.4.2. All facially located flanges should be 3 to 4 mm short of the sulcus. The lingual flange of a mandibular denture base should be 2 to 3 mm short of the lingual sulcus when the floor of the mouth is active. For those denture base additions that might cover the palate, the posterior border of the palate should be short of the vibrating line. Do not bead or scrape the cast for a posterior palatal seal.

Figure 7.7. Cast Arch Bar With Denture Base Modification.



7.10. Laboratory Procedures for Cast Arch Bars:

7.10.1. **Pouring and Designing Casts.** Pour casts in vacuum spatulated dental stone. Either the dentist draws the design on the cast or the technician transfers the design from the prescription to the cast.

7.10.2. **Blocking Out and Relieving the Master Cast (Figure 7.8):**

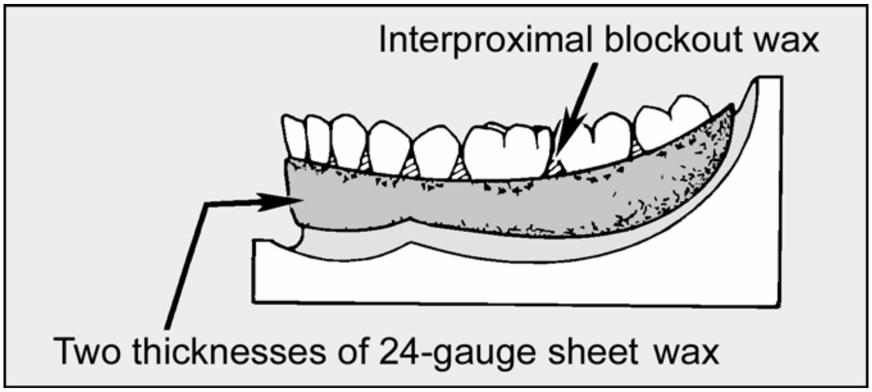
7.10.2.1. Place 2 thicknesses of 24-gauge wax, 6 to 8 mm wide strips, over the cast's facial attached gingivae, from the distal of the most posterior tooth on one side of the arch to the distal of the most posterior tooth on the opposite side. Orient the occlusal border of the wax about 0.5 mm occlusal to the junction of tooth and gingivae on each tooth's midfacial surface. Seal the edges of the wax in place securely.

7.10.2.2. Block out the interproximal area by overfilling it slightly with blockout wax. Be sure the blockout wax extends from the occlusal edge of the relief wax to the occlusal or incisal aspects of the teeth to prevent the bar from impinging on the soft tissue in the interproximal areas.

7.10.2.3. If the arch bar is going to have an attached denture base, relieve the cast as prescribed by the dentist (under the proposed denture base retention grid).

7.10.3. **Duplicating the Master Cast.** Duplicate the master cast in refractory material and wax dip the cast following standard procedures.

Figure 7.8. Blockout and Relief of the Master Cast.



7.10.4. **Waxing:**

7.10.4.1. Make a gold arch bar a little bulkier than one made from chrome alloy. Make the bar from 8-gauge half-round wax. Before waxing, scrape the edges to eliminate the sharpness. As previously mentioned, the occlusogingival width should equal 2 1/2 mm and the wax shape about 1 1/4 mm thick.

7.10.4.2. With the flat side toward the teeth, adapt the wax shape to the facial surfaces. Make the gingival edge of the wax coincide with the occlusal edge of the sheet wax relief, as represented on the refractory cast. Make the vertical lugs of 18 gauge round wax shapes.

7.10.4.3. Dip the tips of the lug patterns in molten wax to form small balls on the ends. Position the shapes relative to tooth surfaces as previously described. Do not smash the wax preforms while they are being placed. Lugs should extend about 3.5 mm from the gingival edge of the bar toward the sulcus. Ensure the waxing of occlusal rests and denture base areas follows common RPD guidelines.

7.10.5. **Spruing, Investing, and Casting.** Sprue, invest, and cast the pattern in base metal alloy or gold, using the same procedures as those for RPDs.

7.10.6. **Polishing the Casting.** Do not cut the sprues off until polishing procedures are almost done. If the casting is not supported in some way, it will bend.

Section 7B—Face Form Cast (Moulage)

7.11. Custom-Fitted Mask. Because their faces have unusual shapes, some aircrew members who use oxygen masks during flying duties cannot wear the standard sizes. These people require a custom-fitted mask. The flight surgeon will determine when this is necessary and will request the dental facility to fabricate a face form cast. From a prosthodontic viewpoint, face form casts can be essential in making maxillofacial prostheses. The face form cast must be (1) made of artificial stone, (2) free of voids and nodules, and (3) an accurate reproduction of the face. It must cover the entire facial area from at least 2 inches above the eyebrows to at least 2 inches below the chin and slightly anterior to the tragus of the ear.

7.12. Procedures for Making a Face Form Cast:

7.12.1. Before beginning these procedures, explain the complete operation to the patient in detail. Specify that he or she will have to breathe through straws placed in the nostrils. Emphasize the feeling of enclosure and the slight difficulty in breathing that might be encountered. Constant reassurance during the entire procedure will help the patient avoid the feeling of panic.

7.12.2. This procedure must be completed in a minimum of time and can be accomplished best by thorough preplanning. All equipment and materials must be laid out for immediate availability (Figure 7.9). Items required are a 16- by 20-inch cardboard sheet, cloth towel, petrolatum, rope caulking, alginate spray adhesive, knife, large round burnisher, bulk, cotton, large diameter flexible straws, paper clips, and soft wire solder.

Figure 7.9. Required Equipment and Materials.

7.12.3. Working together during the impression phase, the dentist and assistant will:

7.12.3.1. Place the patient in a horizontal position and cover with plastic apron to protect his or her clothing (Figure 7.10).

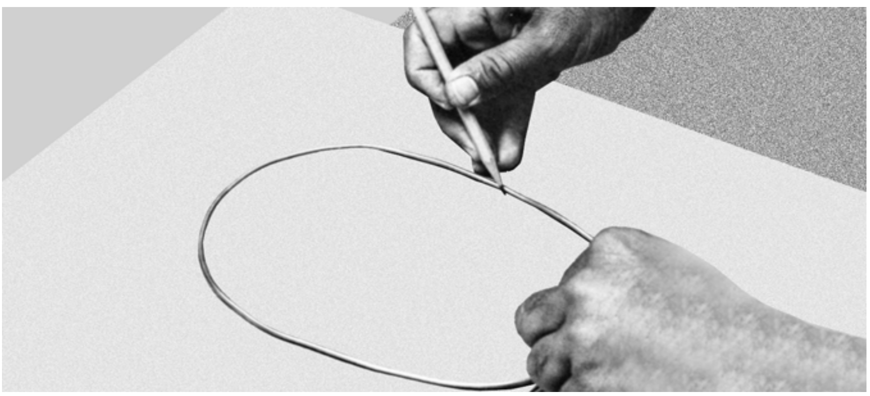
Figure 7.10. Patient Reclined in a Horizontal Position.

7.12.3.2. Bend a length of pliable wire solder around the patient's face to form an outline (Figure 7.11).

7.12.3.3. Center the molded wire on the 16- by 20-inch cardboard sheet and trace the inner circumference with a pencil (Figure 7.12).

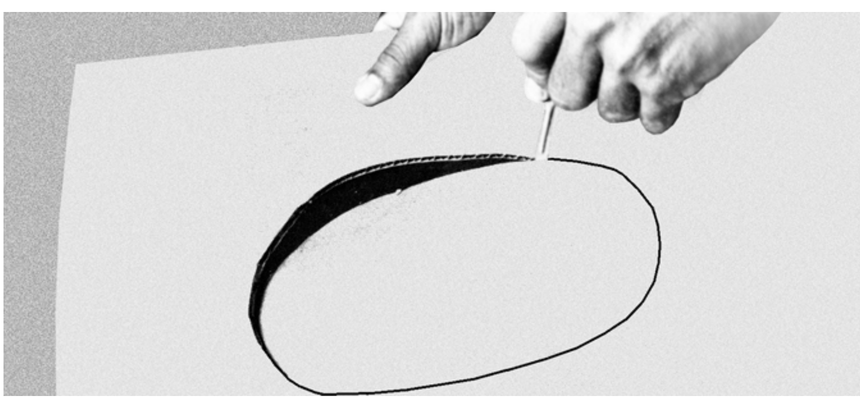
Figure 7.11. Measuring Facial Diameter With a Length of Wire Solder.

Figure 7.12. Tracing Facial Diameters on a Cardboard Sheet.



7.12.3.4. Cut and remove the area within the outline from the cardboard sheet (Figure 7.13).

Figure 7.13. Cutting the Facial Outline From the Cardboard.

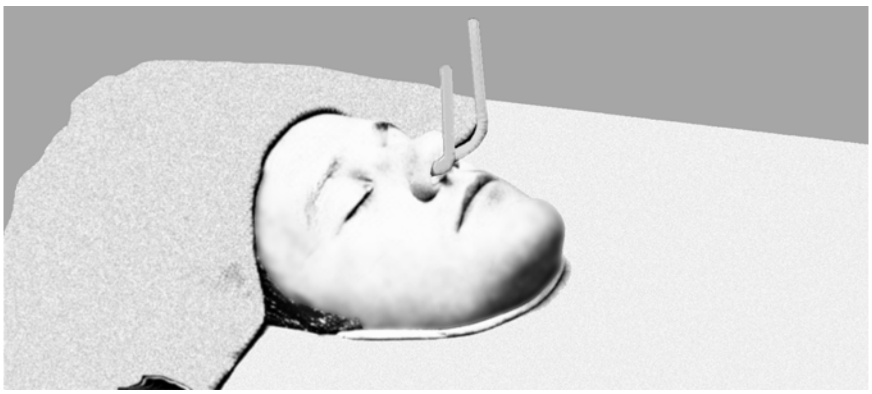


7.12.3.5. Place the cardboard sheet over the patient's face. The cardboard should fit loosely. If necessary, trim it to prevent distortion of the facial tissues. Support the cardboard from underneath, using folded cloth towels. Fill the space between the cardboard and tissue by gently adapting rope caulking cord (Figure7.14).

7.12.3.6. Fold a dampened towel and drape across the patient's forehead to keep the impression material out of the patient's hair (Figure 7.14). Generously coat all exposed hair (eyebrows, eyelashes, and sideburns) with petrolatum (vaseline).

7.12.3.7. Cut one end of each of two straws approximately 1 inch from the flexible portion. Insert these ends gently into the nostrils. Carefully pack a well lubricated (vaseline) piece of bulk cotton into each nostril around the straws for support (Figure 7.14). A large ball-shaped burnisher is an excellent packing instrument. Be sure to have the patient close his or her mouth and breathe through the straws to determine breathing tolerance.

Figure 7.14. Patient Prepared for the Impression.



7.12.3.8. Prepare three batches of regular set alginate. Measure the powder and liquid for each batch and place it in separate containers. Use three separate mixing bowls. Measure cold tap water for each batch and place in a separate bowl. All three batches require approximately 8 scoops of alginate powder.

7.12.3.9. The first mix should be thinner than the subsequent mixes and its water-to-powder ratio should be 2 to 1. The two succeeding mixes should have a ratio of 1 1/2 to 1.

7.12.3.10. Pour the first mix (thin) over the facial tissues while the dentist distributes it with the fingers to prevent bubble formation (Figure 7.15). Prepare second and third mixes while the first mix is being applied. Apply this thicker alginate with spatulas to build up a layer approximately 3/8 inch thick.

7.12.3.11. While the alginate is still tacky, insert bent paper clips or unfolded 4 by 4 gauze pads into it (Figure 7.16).

7.12.3.12. Trim the set alginate away leaving a minimal margin of approximately 1/2 inch (Figure 7.16). To increase the adhesion between the alginate and supporting stone, spray the surface of the alginate with an adhesive material. Shield the ends of the straws to prevent inhalation of the spray (Figure 7.17).

7.12.3.13. During the next procedure, the assistant prepares a flowable mix of fast setting stone. Use slurry water concentrate to shorten the setting time of stone. Apply the stone with spatulas to cover all of the exposed impression material to a depth of 1/2 inch (Figures 7.18 and 7.19). Several mixes of stone will be required.

Figure 7.15. Applying Alginate Mix to the Face.

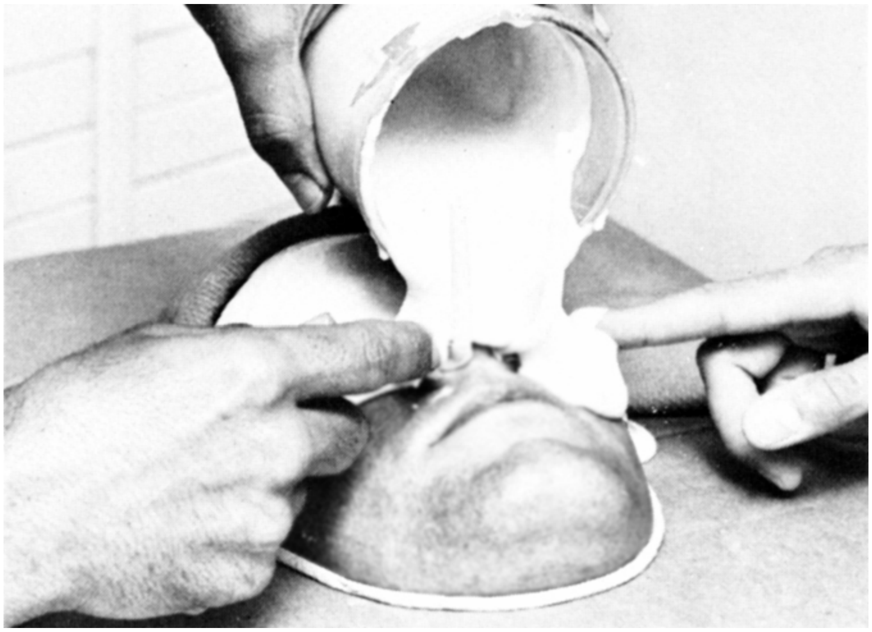
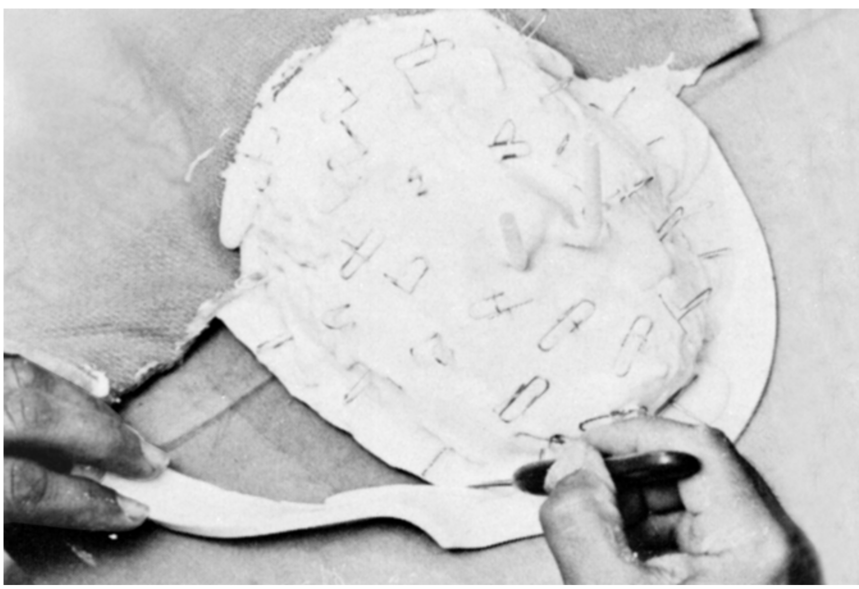


Figure 7.16. Trimming Excess Alginate After Completion of the Impression.



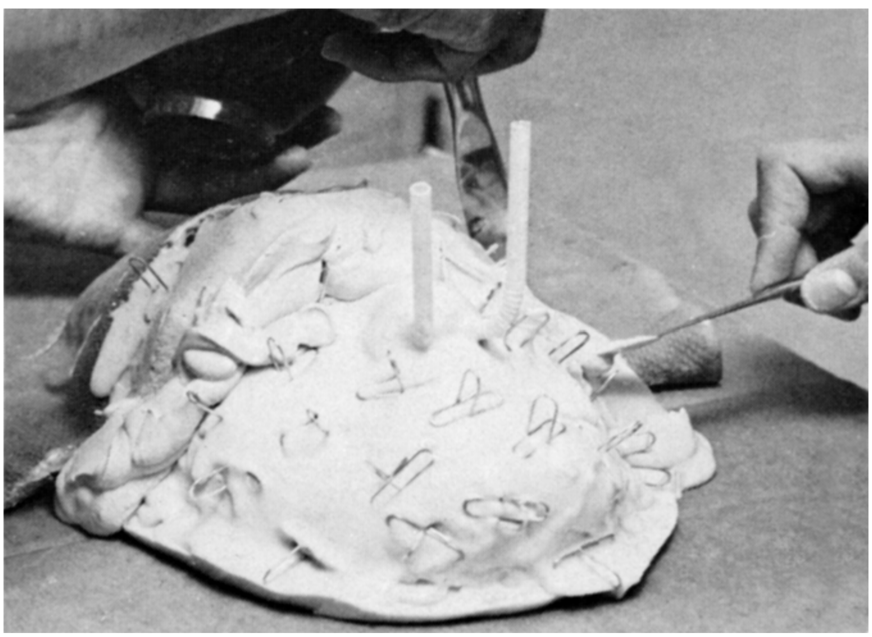
7.12.3.14. When the heat of crystallization can be felt in the stone, remove the towel from the forehead and release the impression by pulling it away from the forehead first.

7.12.3.15. The impression is ready for pouring (Figure 7.20). Remember that the stone support is fragile, especially around the nose. Support the impression during pouring by using folded towels on the side of the stone.

7.12.3.16. Make a soupy mix of stone and cover the entire surface of the alginate with a thin layer. Apply subsequent mixes of regular consistency to build approximately a 3/4 inch thickness of stone over the impression.

Figure 7.17. Shielding Straws While Spraying Adhesive for Alginate.

Figure 7.18. Applying Supporting Stone to the Alginate Impression.



7.12.3.17. Allow the stone to set approxim ately 1 hour. Separate the cast and trim the edges to prepare it for shipment (Figures 7.21, 7.22, and 7.23).

Figure 7.19. Supporting Stone Layer Completed to a Depth of 1/2 Inch.

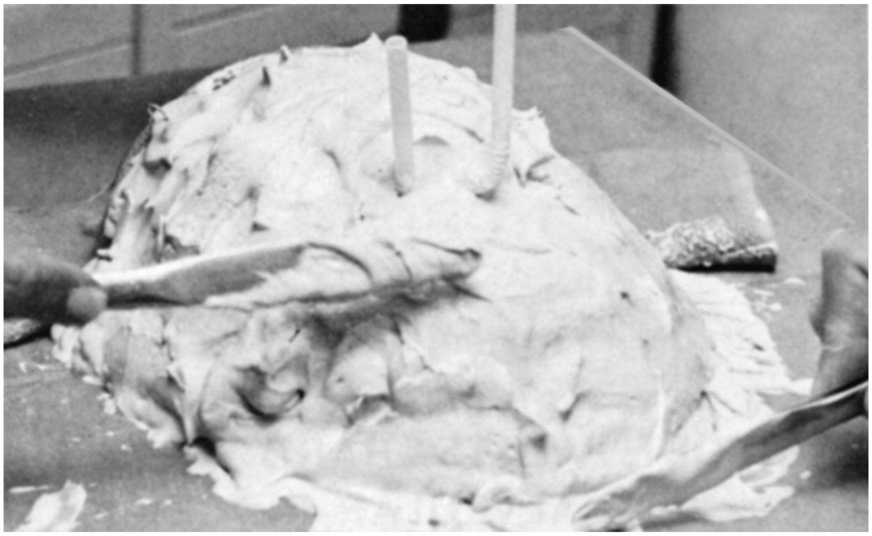


Figure 7.20. Looking Into the Completed Impression.

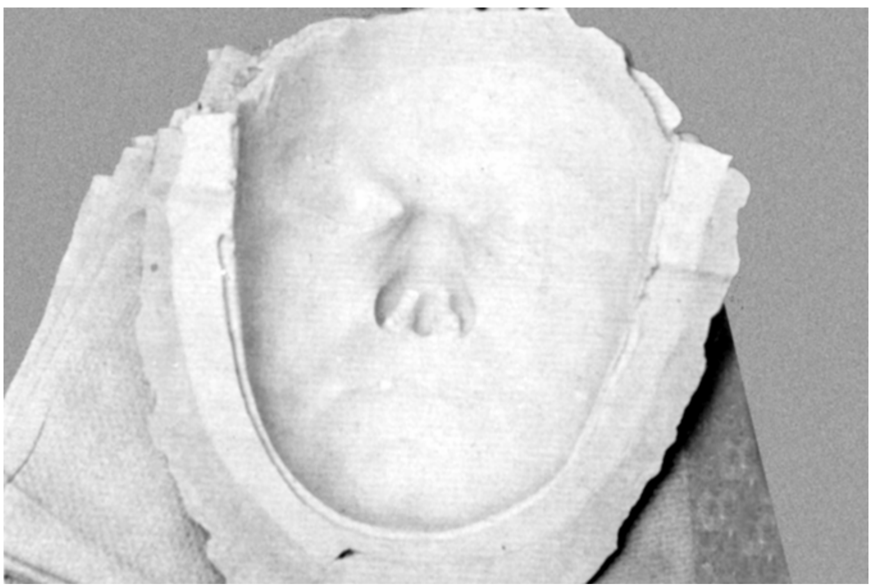


Figure 7.21. Oblique View Showing Cast Thickness.

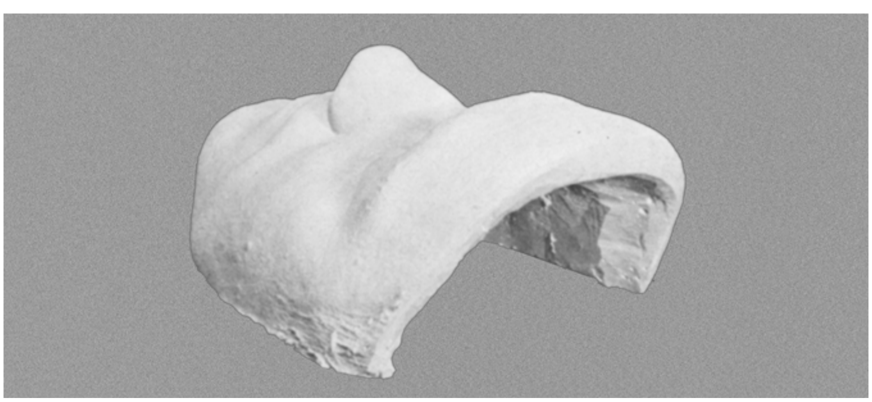


Figure 7.22. Lateral View of the Face Form Cast.

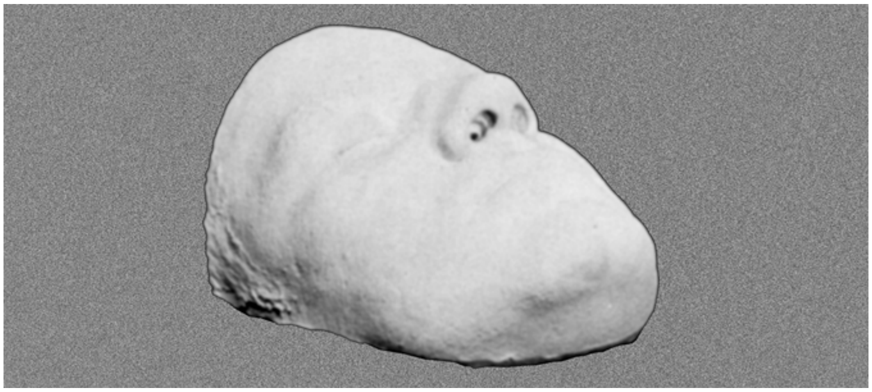
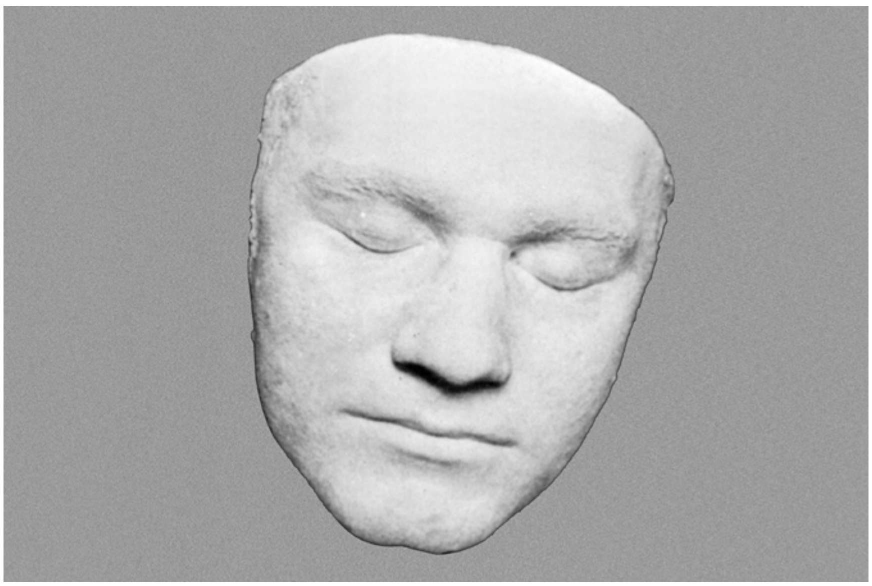


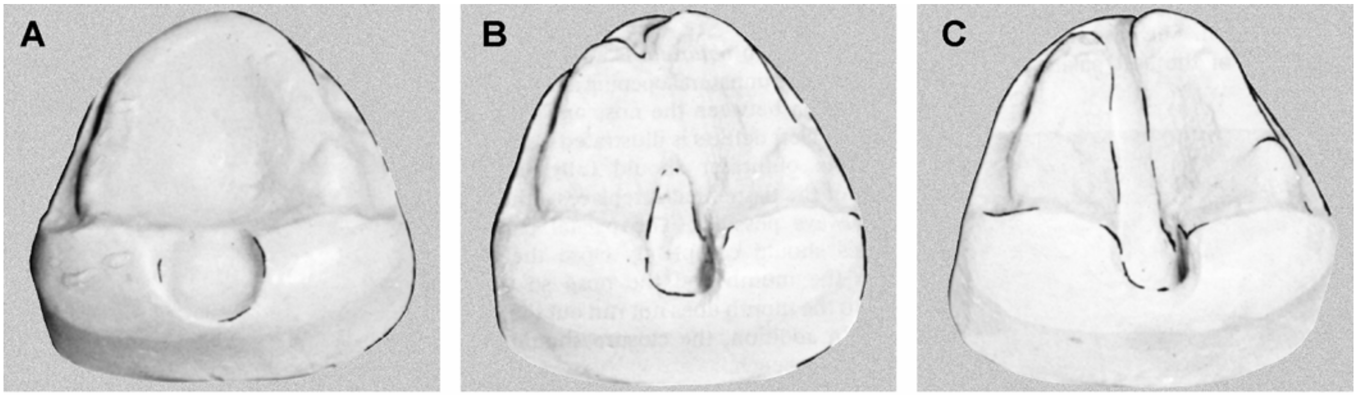
Figure 7.23. Frontal View of the Face Form Cast.



Section 7C—Cleft Palates and Obturators

7.13. Cleft Palate. A cleft palate is a defect in the roof of the mouth and the nasal cavity. Clefts may be confined to the soft palate (Figure 7.24-A), or they may include all or part of the hard palate (7.24-B). Palatal clefts may extend anteriorly to include clefts of the anterior alveolar ridge (Figure 7.24-C). If a cleft is present at birth, it is called "congenital." If it is a result of injury, disease, or surgery, it is called an "acquired cleft."

Figure 7.24. Cleft Palates.



Cleft of the soft palate | Cleft of the soft palate and part of the hard palate | Extensive cleft involving the soft palate, hard palate, and alveolar ridge

7.14. Obturator. An obturator is a prosthetic device that closes the unnatural opening and reestablishes the separation between the nose and mouth. The anatomy of cleft defects is illustrated in Figure 7.25. Ideally, the obturator should fully restore the function of the tissue it replaces, although this is not always possible. The palatal part of the prosthesis should completely close the opening between the mouth and the nose so food taken into the mouth does not enter the nasal cavity. In addition, the closure should help restore distinct speech. An obturator usually has three functional sections (Figure 7.26), depending on the size and extent of the cleft:

7.14.1. **Palatal Section.** This is the base that covers the hard palate and part of the soft palate. When natural teeth remain, it carries clasps for retentive purposes.

7.14.2. **Pharyngeal Section or Bulb.** This is the roughly spherical section that extends into the pharynx. It is formed and contoured so the pharyngeal muscles, by contracting, close off the mouth and pharynx from the nasal cavity during swallowing. When the obturator base is well retained and the bulb is small and light, the bulb is made from a solid piece of plastic. If the opposite conditions prevail, a hollow bulb is made instead.

7.14.3. **Velar Section.** This is the intermediate part that supports the bulb and attaches to the base.

7.15. Retention Factors:

7.15.1. Developing adequate retention for the prosthesis can be easy or difficult, depending on the number, shape, and distribution of remaining natural teeth; strength and direction of muscle pull; amount of peripheral seal that can be obtained; extent of tissue coverage; presence of scar tissue; and size and weight of the pharyngeal section.

7.15.2. A principle that is always used in obturator design is to obtain all of the tissue coverage the patient can tolerate. Undercuts are used where possible, even if it is necessary to extend the base into the nasal cavity. Scribing a bead line in the cast around the periphery of the design usually improves peripheral seal. The dentist knows which tissues are soft and which are hard and will prescribe the exact borders of the prosthesis as well as the depth and position of any beading that is to be done.

Figure 7.25. Normal and Cleft Palate Anatomy Contrasted.

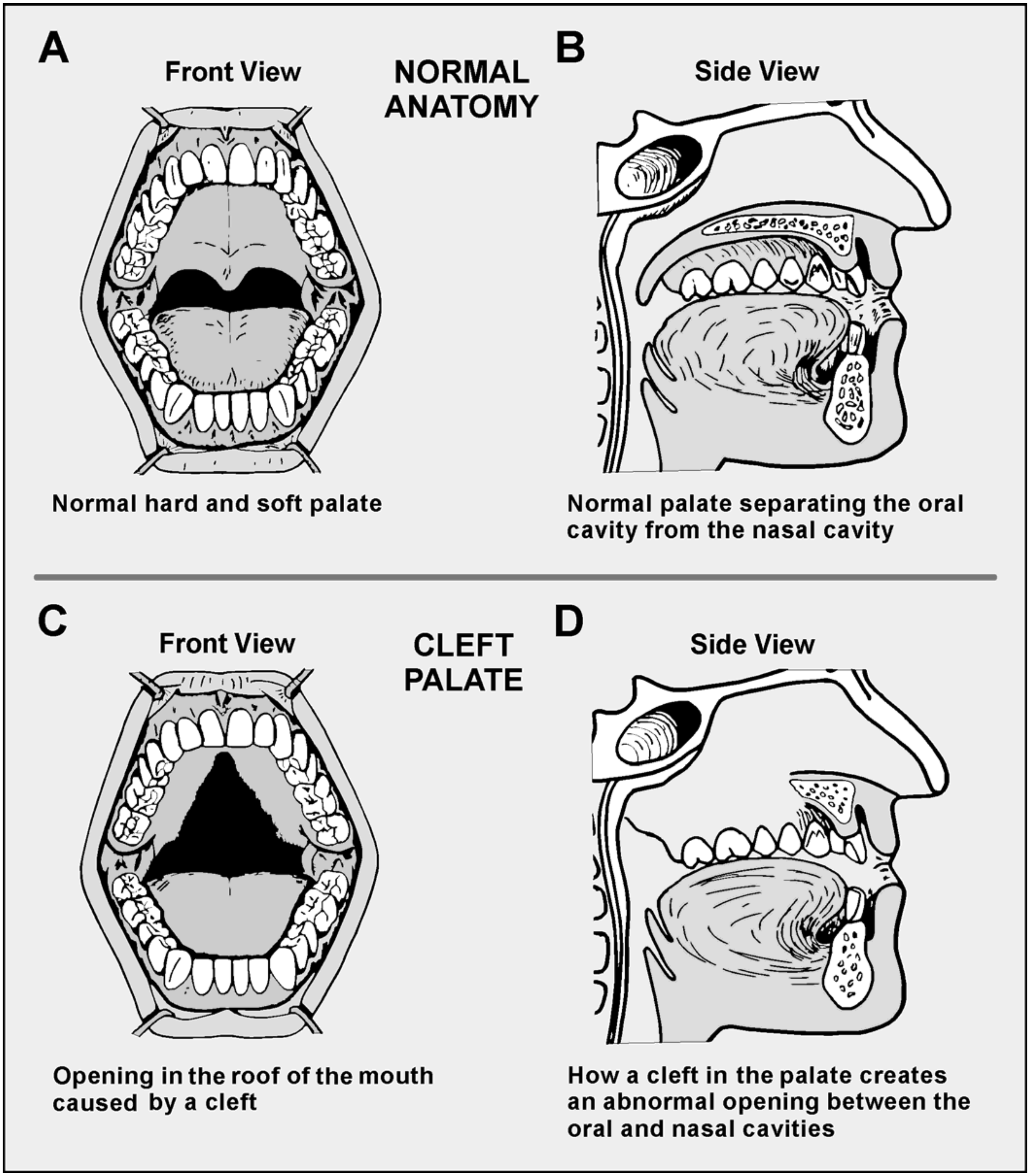
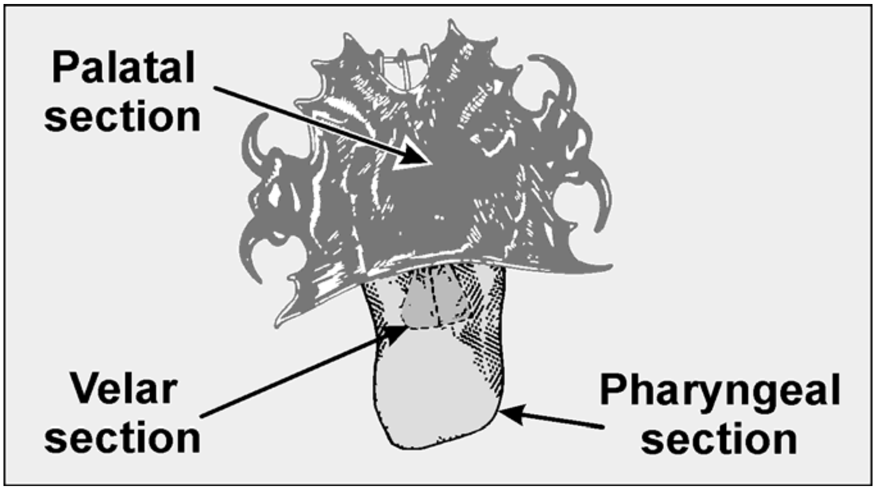
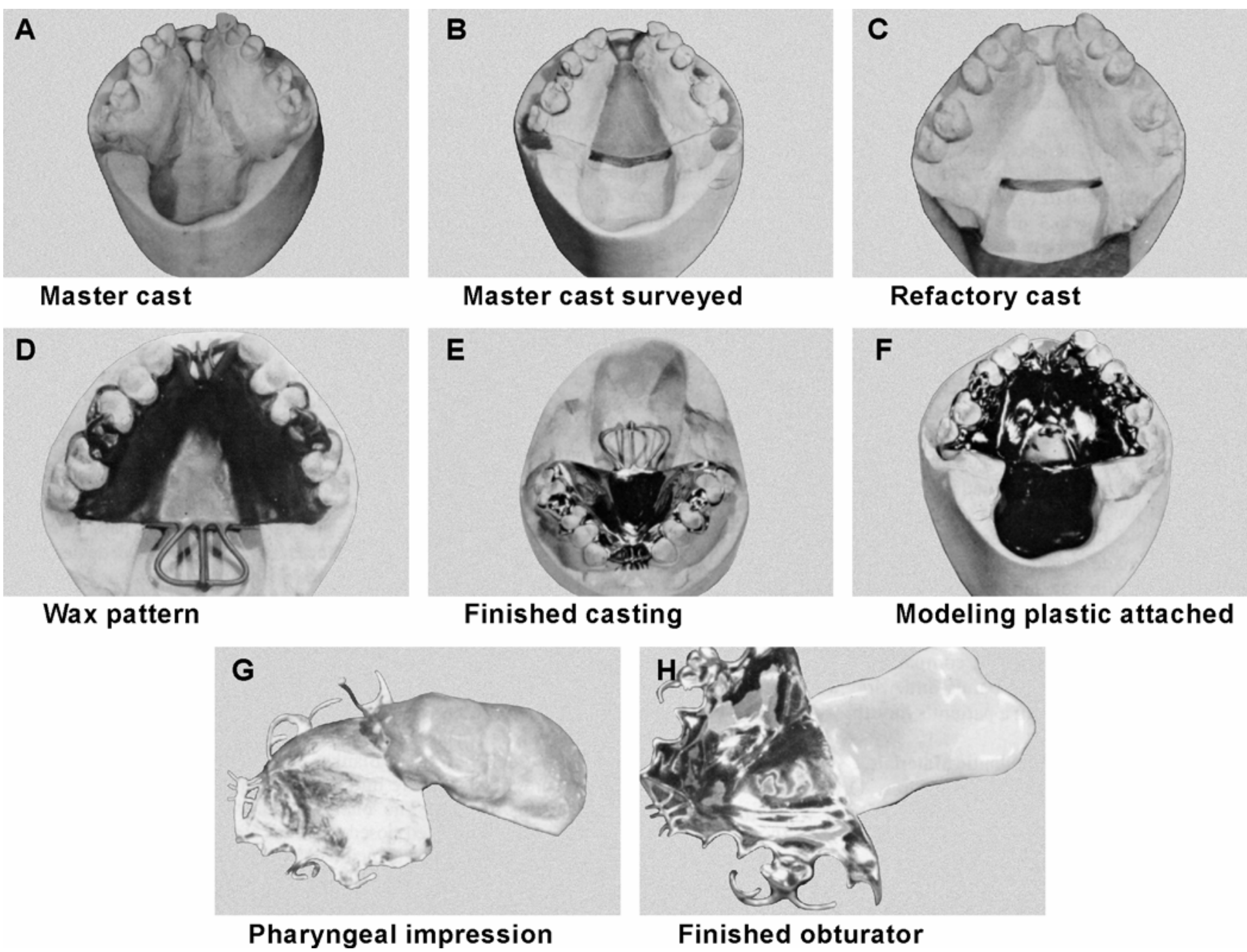


Figure 7.26. Parts of the Obturator.



7.16. Fabrication Procedures. The palatal section of the prosthesis is usually made first with an attachment on its posterior border to which the pharyngeal portion is later added. The fabrication process is shown below (and in Figure 7.27):

Figure 7.27. Obturator Fabrication.



7.16.1. The dentist furnishes a preliminary impression and prescribes the outline for an individual impression tray and the material from which it is to be made.

7.16.2. Final impressions must be handled with a great deal of care. They represent painstaking work by the dentist as well as discomfort and fatigue for the patient. When boxing and pouring one of these impressions, the plaster and pumice method gives you the most control with the least potential for distortion. See Volume 1, Chapter 7, for guidance on the plaster pumice method.

7.16.3. Pour an artificial stone master cast as soon after the dentist makes the impression as possible. Duplicate the master cast before surveying. The duplicate can be used as a backup in case of accident (Figure 7.27-A).

7.16.4. Survey the master cast. Place the design for the prosthesis on the master cast in the same way as for a conventional RPD (Figure 7.27-B).

7.16.5. Block out tooth and soft tissue ridge undercuts in the usual manner. Place relief wax over edentulous ridge areas where indicated. Block out the cleft defect with modeling clay.

7.16.6. Duplicate the (blocked out) master cast in refractory investment (Figure 7.27-C). (Make another duplicate of a blocked out master cast in dental stone for framework fitting purposes.)

7.16.7. Wax the retainers and connectors, using the same methods as for a conventional RPD framework. Wax in a strong retention loop to retain and support the pharyngeal section of the obturator (Figure 7.27-D).

7.16.8. Invest and cast the pattern. Finish and fit to a duplicate master cast. Final polish the casting (Figure 7.27-E).

7.16.9. The dentist will make sure the framework fits the patient's mouth, take modeling plastic and attach it to the retention loop, soften the modeling plastic, and place the entire apparatus in the patient's mouth. He or she will direct the patient to go through a series of movements to mold the modeling plastic into a bulb shape. Sometimes the dentist will coat the modeling plastic bulb with a secondary impression material (low fusing wax) to pick up fine details (Figure 7.27-F and -G).

7.16.10. Process the pharyngeal section in acrylic resin (Figure 7.27-H). When the bulb portion is going to be solid, flask, pack, and process it in the usual manner. If the dentist has ordered a hollow bulb, special processing techniques are required. For descriptions of techniques used to make hollow obturator bulbs, consult the following articles:

7.16.10.1. Matalon, V. and LaFuente, H.: *A Simplified Method for Making a Hollow Obturator*. Journal of Prosthetic Dentistry, Vol 36: p. 580, Nov 76.

7.16.10.2. Chalian, V.A. and Barnett, M.O.: *A New Technique for Constructing a One Piece, Hollow Obturator After Partial Maxillectomy*. Journal of Prosthetic Dentistry, Vol 28: p. 448, Oct 72.

Section 7D—Custom Earpiece

7.17. Introduction:

7.17.1. A custom earpiece is an acrylic device fabricated to custom fit the patient's ear and used to deliver sound to the ear by way of a hollow tube. The increase in comfort of a custom earpiece versus a standard earpiece is considerable and easily justifiable when one considers the amount of time personnel, such as aircrews or air traffic controllers in critical situations, spend depending on precise reception.

7.17.2. Traditionally, many different types and models of standard earpieces, which are relatively expensive and usually fit poorly, are used in the work environment. One standard model consists of several rubber bulbs from which the user selects the best fit. A solution for military members is to have a custom earpiece fabricated.

7.17.3. The custom earpiece is composed of acrylic that fills the inner "C" portion of the patient's ear and supports an earmold ring and spring located in the center of the acrylic (Figure 7.28-A). A hollow channel is located from the earmold ring to the end of the ear canal portion of the acrylic to deliver the sound. A hollow tube is then connected to the earmold ring from the radio or device that will be monitored by the operator. Paragraph 7.18 discusses the fabrication of a custom earpiece.

7.18. Fabricating a Custom Earpiece:

7.18.1. **Making the Impression.** The dentist will make an impression of the patient's inner "C" portion of the ear using a polyvinylsiloxanne or comparable impression material (Figure 7.28-B). The impression is then disinfected and taken to the laboratory for the fabrication process.

7.18.2. **Fabricating an Alginate Mold:**

7.18.2.1. Make an alginate mold of the impression. Cut any excess impression material that extends beyond the inner "C" portion of the ear (Figure 7.28-C). Cut the exterior surface of the impression material flat to create the surface where you will later place the earmold ring.

7.18.2.2. Use a standard paper cup to make an alginate mold of the impression. First, place the impression inside the cup to ensure there is at least 6 mm of clearance around the entire impression. Mix two scoops of alginate to 100 ml of water and vacuum mix for approximately 15 seconds.

7.18.2.3. Apply alginate onto the impression first to reduce the possibility of trapping air. Then pour the remaining alginate into the cup and set or sink the impression until the outer portion is flush with the top of the alginate (Figure 7.28-D).

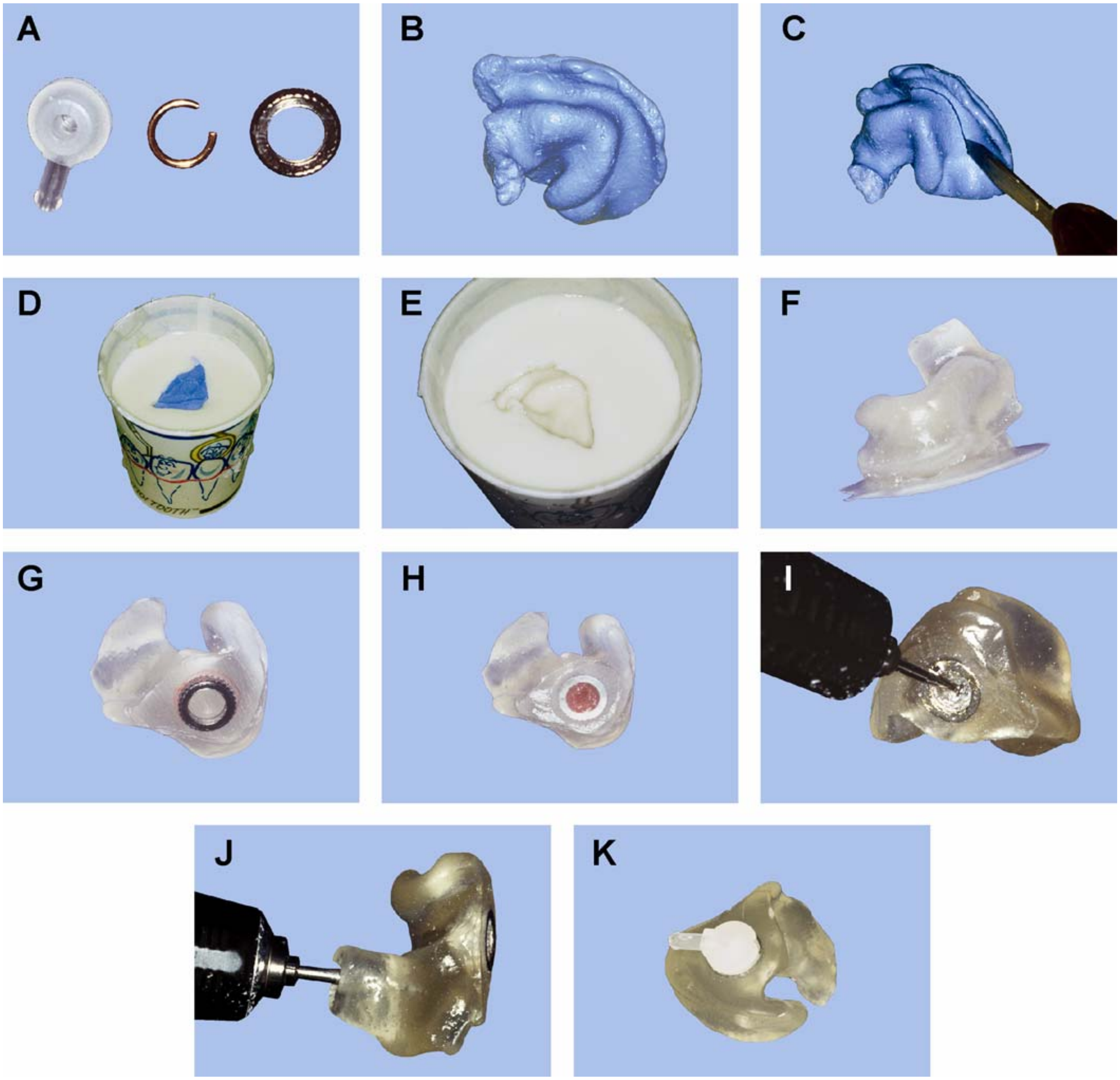
7.18.2.4. After the alginate has set, use small burst of air to remove the impression. Be careful—the alginate is soft and can be easily torn. Check inside to see if there are any voids or loose material that can be easily filled or removed.

7.18.3. **Pouring the Acrylic Earpiece.** Use clear orthodontic acrylic to fill the alginate mold and form a dense acrylic resin earpiece. Mix a 2 to 1 polymer/monomer ratio to achieve a runny mix that can be poured into the mold. The mix should be thin enough to fill all of the little intricate areas of the alginate mold. As you pour the acrylic into the cup, slightly tilt the cup in different directions so you do not trap air in some of those hard-to-reach areas. Because orthodontic acrylic shrinks about 7 percent of its bulk, you need to fill slightly above the top of the mold (Figure 7.28-E). Cure the acrylic according to the manufacturer's directions.

7.18.4. **Earmold Ring and Spring Placement:**

7.18.4.1. After the acrylic has cured, remove the earpiece from the alginate mold (Figure 7.28-F). Flatten the outer portion of the acrylic earpiece that was exposed from the alginate mold to create a surface that will accept the earmold ring. Place the ring on the flat surface in a position that allows an adequate amount of resin around the border of the ring, and then trace around the ring (Figure 7.28-G).

Figure 7.28. Fabricating a Custom Earpiece.



7.18.4.2. Using the outline of the earmold ring as a guide, make a hole in the acrylic so the ring will sit flush with the top of the acrylic and have approximately 1.5 to 2 mm of space around the ring.

7.18.4.3. Next, place the earmold spring into the ear mold ring. Apply a small amount of clear utility wax into the opening of the earmold ring to ensure acrylic does not fill the ring. Place the ring into the recessed area and sprinkle acrylic around the ring to seal it in place (Figure 7.28-H).

7.18.4.4. After the acrylic has cured, smooth the area around the ring with a carbide bur (Figure 7.28-I).

7.18.5. **Finishing the Custom Earpiece.** Use a #8 round bur to create an echo chamber under the ring (Figure 7.28-J). The chamber should be no less than 5 mm in depth and the same or slightly larger than the ring. This allows for the sound to be slightly amplified to increase the hearing ability of the person wearing the custom earpiece. With a small round bur, create a channel from the echo chamber to the end of the ear canal. Finish this sound canal by using a #6 or #8 round bur to widen the canal. Complete the custom earpiece by rounding any sharp edges. Then pumice and polish the appliance (Figure 7.28-K).

Chapter 8

WEIGHTS AND MEASURES

8.1. Carat and Fineness of Gold Alloy:

8.1.1. **Overview.** Information giving the amount of pure gold in an alloy is usually supplied by the manufacturer on the alloy wrapper. It may be stated in terms of either "carat" or "fineness."

8.1.2. **Carat.** *Carat* is the number of parts of gold in 24 parts of alloy. Think of the unit of gold as being divided into 24 smaller units. The number of these small units that are pure gold is the carat number. For example, if the alloy is 12 carat, 12 of the 24 parts (or 50 percent) are gold. If the alloy is 24 carat, it is *all* gold.

8.1.3. **Fineness.** *Fineness* is the number of parts of gold in 1, 000 parts of alloy. For example, the alloy is 750 fine, then 750 of these parts (or 75 percent) are gold; Therefore, 500 fineness is exactly one-half (or 50 percent) gold.

8.1.4. **Conversion:**

8.1.4.1. *Percent is* the number of parts of gold in 100 parts of alloy. A simple method for converting the carat to fineness (or the fineness to carat) is to use the following formula:

$$\frac{\text{carat}}{24} = \frac{\text{fineness}}{1{,}000}$$

8.1.4.2. Table 8.1 contains a carat and fineness conversion chart. In addition, paragraph 8.1.4.3 shows conversion examples.

Table 8.1. Carat and Fineness Conversion Chart.

I T E M	A Carat	B Fineness	C Percent
1	24 1,000		100
2	22	916	91.6
3	20	833	83.3
4	18	750	75
5	16	666	66.6
6	14	583	58.3
7	12	500	50
8	10	416	41.6

8.1.4.3. Conversion examples are as follows:

8.1.4.3.1. **Carat to Fineness Conversion.** For example, convert 12 carat to fineness as follows:

12:24 = X: 1,000 or $\frac{12}{24} = \frac{X}{1000}$

Cross multiply: 12 x 100 = 12,000

Divide 12,000 by 24 = 500

Fineness is 500.

8.1.4.3.2. **Fineness to Carat Conversion.** For example, convert 500 fineness to carat as follows:

$$X:24 = 500: 1{,}000 \text{ or } \frac{X}{24} = \frac{500}{1000}$$

Cross multiply: 24 x 500 = 12,000

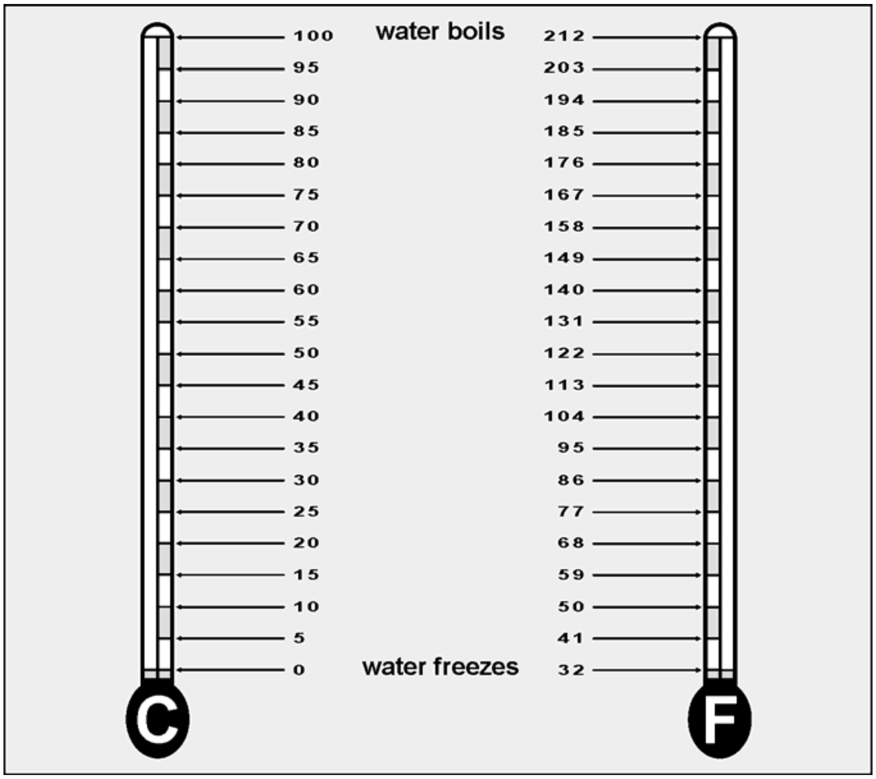
Divide 12,000 by 1,000 = 12

Carat is 12.

8.2. Measuring Temperature:

8.2.1. **Scales (Figure 8.1).** Temperatures are commonly measured on a Fahrenheit (F) scale, where 32 ^{o}F is the freezing point of water and 212 ^{o}F is the boiling point, or on a Centigrade (C) scale, where 0 ^{o}C is the freezing point of water and 100 ^{o}C is the boiling point.

Figure 8.1. Centigrade-Fahrenheit Conversion Scale.



8.2.2. **Conversion.** Centigrade can be converted to Fahrenheit or vice versa by means of the following formula: 9C = 5F - 160.

8.2.2.1. **Centigrade to Fahrenheit Conversion.** To convert Centigrade to Fahrenheit, multiply the Centigrade temperature by 9, add 160, and then divide the total by 5. For example:

Centigrade = 100 ^{o}

9(100) = 5F – 160

900 + 160 = 5F

$$\frac{1060}{5} = F$$

212 ^{o} = Fahrenheit

8.2.2.2. **Fahrenheit to Centigrade Conversion.** To convert Fahrenheit to Centigrade, multiply the Fahrenheit temperature by 5, subtract 160, and divide the total by 9. For example:

Fahrenheit $= 212^{o}$

$$9C = 5(212) - 160$$
$$9C = 1060 - 160$$
$$C = \frac{900}{9}$$

Centigrade $= 100^{o}$

8.3. Systems of Measuring Weight. The following four systems of weight measurements are used in the dental laboratory: avoirdupois (commercial), apothecaries (medicine and drugs), troy (precious metals and alloys), and metric (some pharmaceuticals, such as alcohol). The grain is the basic unit in the avoirdupois, apothecaries, and troy systems, but *not* in the metric system. See Figure 8.2 for a comparison of the various systems.

Figure 8.2. Comparison of Weight Measurements.

Avoirdupois Weight		**Metric Equivalent**
27.34 grains (gr)	1 dram	—
16 drams	1 ounce (oz)	28 grams
16 oz	1 lb	453 grams
Apothecaries Weight		**Metric Equivalent**
20 gr......................................	1 scruple	—
3 scruples	1 dram	—
8 drams	1 oz	31 grams
12 oz	1 lb	373 grams
Troy Weight		**Metric Equivalent**
24 gr......................................	1 penny weight (dwt)	—
20 dwt	1 oz	31 grams
12 oz	1 lb	373 grams

8.4. Measurements of Length. The metric system of measuring is the most universally used in dental measurements. Figure 8.3 compares metric length to linear length.

Figure 8.3. Comparison of Metric and Equivalent Linear Lengths.

Metric System of Lengths

1,000 microns	1 millimeter
10 millimeters	1 centimeter
100 centimeters	1 meter

Equivalent Linear Lengths

1 millimeter	0.039 inches
25.4 millimeter	1 inch
2.54 centimeters	1 inch
30.5 centimeters	1 foot
91 centimeters	1 yard
1 meter	39.37 inches

8.5. Measure of Liquid or Volume:

8.5.1. The basic unit of the metric system of liquid measurement is the cubic centimeter (cm^3) or milliliter (ml) (Figure 8.4). One cm^3 of water at 39.5 ^{o}F weighs 1 gram.

8.5.2. Either the apothecaries wine measure or the metric system is used to measure the volume of liquids. Figure 8.5 compares apothecaries and metric equivalents.

8.6. Standards. *Gauge* is a measure of thickness that can be applied to metal wire, sheet metal, wire wax, and sheet wax. The Brown and Sharpe wire gauge or the American wire gauge—the two are the same—represent a standard for wire and sheets that do not contain iron. The Brown and Sharpe (or American Wire) conversion measurements appear in Table 8.2. ***NOTE:*** The use of this particular standard is common, but not necessarily universal.

8.7. Melting Points of Pure Metals. The melting point of aluminum is 1218 ^{o}F, gold is 1945 ^{o}F, lead is 621 ^{o}F, and silver is 1761 ^{o}F.

Figure 8.4. One Cubic Centimeter.

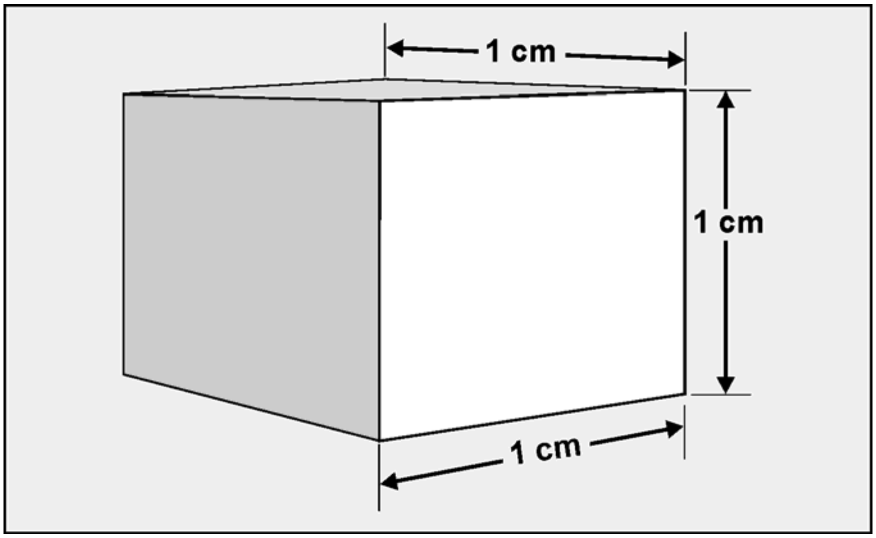


Figure 8.5. Comparison of Apothecaries and Metric Equivalents.

Apothecaries		Approximate Metric Equivalent
8 fluid drams	1 fluid ounce (oz)	29 milliliters (cm^3)
16 fluid oz	1 pint	473 milliliters
2 pints	1 quart	946 milliliters
4 quarts	1 gallon	3785 milliliters

Metric		Approximate Apothecaries Equivalent
1 milliliter	1 milliliter	16.23 minims
100 milliliters	1 deciliter	3.5 fluid ounces
1,000 milliliters	1 liter	2.11 pints

Table 8.2. Brown and Sharpe Gauge (or American Wire Gauge).

ITEM	A	B	C
	Gauge	Inches	Millimeters
1	6	0.1620	4.12
2	7	0.1443	3.67
3	8	0.1285	3.26
4	9	0.1144	2.91
5	10	0.1019	2.59
6	11	0.0907	2.30
7	12	0.0808	2.05
8	13	0.0720	1.83
9	14	0.0641	1.63
10	15	0.0571	1.45
11	16	0.0508	1.29
12	17	0.0453	1.15
13	18	0.0403	1.02
14	19	0.0359	0.91
15	20	0.0320	0.81
16	21	0.0285	0.72
17	22	0.0253	0.64
18	23	0.0226	0.57
19	24	0.0201	0.51
20	25	0.0179	0.45
21	26	0.0159	0.40
22	27	0.0142	0.36
23	28	0.0126	0.32
24	29	0.0113	0.29
25	30	0.0100	0.15
26	31	0.0089	0.23
27	32	0.0080	0.20
28	33	0.0071	0.18
29	34	0.0063	0.16

Chapter 9

DENTAL LABORATORY EQUIPMENT IDENTIFICATION, PREVENTIVE MAINTENANCE, AND SAFETY

9.1. Introduction:

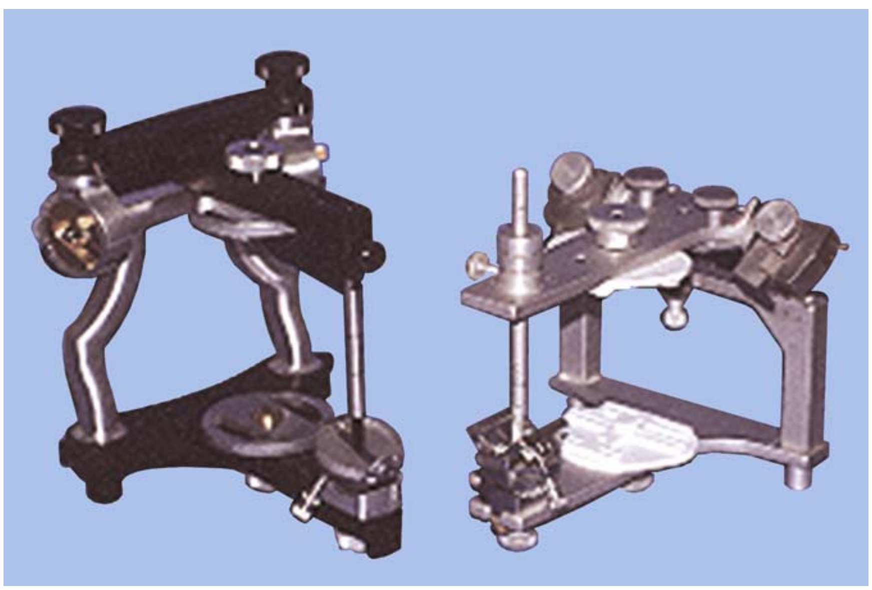
9.1.1. If you are a novice technician, this chapter provides guidance for identifying various kinds of common equipment. It gives instruction in routine maintenance and issues warnings about hazards of the equipment. Manufacturers routinely furnish complete maintenance and operating procedures with each new piece of equipment. If these documents are not received with the machine, contact the manufacturer and request instructions.

9.1.2. The laboratory supervisor is obligated to extract detailed, in-house operating maintenance and safety instructions from the manufacturer's directions. Compiled into clear, concise form, these instructions are required reading for all operators of the equipment. Although there are important measures you can take to prolong the life of the equipment and to ensure the safe, proper function of the equipment, you must recognize your limitations. Never attempt to make a major adjustment or repair. Almost all medical facilities have a medical equipment repair section of technicians trained to repair these machines. Contact them for any major adjustment or repair.

9.2. Articulator:

9.2.1. **Purpose.** An articulator is a mechanical device, which represents the temporomandibular joints and the jaw members, to which maxillary and mandibular casts are attached. It is used to set artificial teeth in prosthetic appliance fabrication. Two types of articulators, Whip-Mix and Hanau H2 158, are shown in Figure 9.1.

Figure 9.1. Whip-Mix and Hanau H2 158 Articulators.



9.2.2. **Maintenance:**

9.2.2.1. At the first sign of improper operation, clean the articulator with wax solvent, dry it with a blast of air, apply a light film of machine grade oil or graphite, and wipe off the excess oil or graphite to prevent an accumulation of dust and debris.

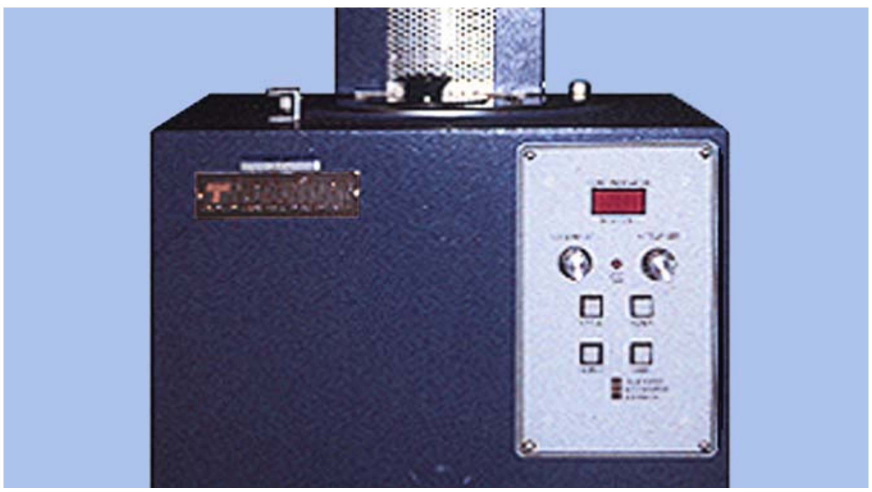
9.2.2.2. When the articulator is not in use, store it in a clean, dry atmosphere away from dust and acid fumes. Never use a hammer or pliers to make adjustments.

9.2.2.3. Gasoline and naptha are flammable and leave an oxide film which attacks the metal. Alkalies present in scouring powders form a residue which restricts movement of the members. Never use the sand blaster, shell blaster, or sandpaper to remove plaster or stone from the instrument. Mounting rings and the articulator under them are particularly susceptible to corrosion. Coat the rings and the areas of the articulator they contact with a very thin film of vaseline.

9.3. Autoduplicator:

9.3.1. **Purpose.** The autoduplicator (Figure 9.2) conditions laboratory hydrocolloid by chopping it into small pieces and liquefying it by a high heat breakdown. After breakdown, the unit automatically cools the prepared colloid to a holding (storage) temperature of 125 to 127 ^{o}F.

Figure 9.2. Ticonium® Autoduplicator.



9.3.2. **Maintenance:**

9.3.2.1. Check the temperature daily. Do not leave the thermometer in the unit because the blades may strike the thermometer and cause damage to the duplicator.

9.3.2.2. Drain and clean the unit monthly. Unplug the duplicator and lift off the top; the motor and blades come off with the lid. Place this top section so the blades are not damaged. Wipe the blade assembly and inside of the tank with a sponge or cloth. Remove any debris and thoroughly clean the bottom of the tank and then reassemble the unit.

9.3.2.3. Remove the valve assembly weekly for cleaning and lubricating. Use the rubber tipped rod provided with the unit as a plug. Remove the stop screw on the back of the valve and pull out the handle. Clean it thoroughly, lubricate it lightly with silicone grease, reinsert it into the valve body, and replace the stop screw.

9.3.3. **Safety Considerations.** Handle the duplicator properly. Keep your hands out of the tank when the machine is operating because the blades are sharp and will damage your hands.

9.4. Hygroscopic Water Bath:

9.4.1. **Purpose.** The water bath (Figure 9.3) is used in conjunction with the hygroscopic investing technique for crown and fabrication. If properly calibrated, the bath raises room temperature water to 100 °F and maintains the water at that temperature. Immersion of an invested mold in this bath allows uniform expansion of the invested wax pattern and ensures a 100-percent humid atmosphere necessary for the hygroscopic component of investment expansion.

Figure 9.3. Hygroscopic Water Bath.

9.4.2. **Maintenance.** Periodically, check the temperature setting with a thermometer to ensure the unit maintains a temperature of 100 °F. Clean the holding tank and exterior of the unit weekly to prevent an accumulation of investment material residue.

9.4.3. **Safety Considerations.** Check the power line and plug daily for defects.

9.5. Shell or Sand Blaster:

9.5.1. **Purpose.** The shell blaster and sand blaster have identical construction characteristics (Figure 9.4). They differ only in abrasive content and use as follows:

9.5.1.1. The shell blaster uses crushed walnut shells as an abrasive. It is used to remove gypsum products from an acrylic resin prosthesis during the deflasking operation. Walnut shells do not affect the teeth or denture base.

9.5.1.2. The sand blaster uses zircon grit as an abrasive. It is used in cast RPD work to remove casting investment and surface oxides from the metal framework. Never use the sand blaster on acrylic or porcelain.

9.5.2. **Maintenance.** Preventive maintenance is the same for both units. Shake the dust bag daily if applicable. Clean the bottom of the unit weekly, removing chunks of gypsum and other debris. Replace shells or sand as required. Replace a worn nozzle as needed, using operating manual instructions for guidance. Replace gloves if they are torn or holes appear. Change the viewing glass when it becomes pitted. Drain the air line periodically to eliminate condensed moisture.

9.5.3. **Safety Considerations.** Wear safety glasses or goggles. Do not operate the unit with the door or drawer open because this unit operates on 90 to 100 pounds per square inch of air pressure. Be sure protective gloves are in good repair. Check air and electrical connections for cuts, wear, or other damage.

Figure 9.4. Shell or Sand Blaster.

9.6. Bunsen Burner:

9.6.1. **Purpose.** This burner (Figure 9.5) is used in the laboratory for heating wax-carrying instruments and a variety of other procedures where an open flame heat source is required.

Figure 9.5. Hanau Touch-O-Matic® Burner.

9.6.2. **Maintenance.** The burner has few moving parts and requires little maintenance. When wax or similar materials drop into the burner, remove the burner assembly from the unit and clean it in boiling water. After boiling and before reattaching the burner assembly, blow out any excess water from pilot tube, gas inlet tube, and flame orifice. Be sure the small round O-ring attached to the projecting brass tubing of the burner is replaced before reassembly.

9.6.3. **Safety Considerations.** Use an approved, noncollapsible hose for connecting the burner to a gas outlet. Inspect the unit and hose for loose connections and defects. Never place your head or arms over the flame when you reach for other objects. Turn the burner off when not in use.

9.7. Casting Machine (General):

9.7.1. **Purpose.** Casting machines are devices that fling molten metal into a mold. The Unitek ®

Autocast is an electronic induction type casting machine used to cast all kinds of dental alloys (Figure 9.6). In the Air Force, the casting machine is used primarily to cast metal-ceramic substructures, but it can also be used to cast full gold units or RPD frameworks. Induction casting machines use an electromagnetic field which is set up around the metal. It melts the metal by electrical resistance.

Figure 9.6. Casting Machine (Unitek® Autocast).

9.7.2. **Maintenance.** Clean the casting well of any debris after each use. No other lubrication or maintenance is required.

9.7.3. **Safety Considerations.** Keep your hands clear of the casting arm and always balance the casting arm before burnout of the mold. Wear safety glasses or goggles. Do not operate this machine when water leaks are evident or water is present near the machine—this is a *high voltage* and *amperage* unit. Keep debris out of the well, especially under the coil assembly.

9.8. Broken-Arm Casting Machine With Safety Lid:

9.8.1. **Purpose.** This type of casting machine (Figures 9.7 and 9.8) is used to melt conventional and porcelain fused-to-metal gold alloys and cast them by centrifugal force into a heated mold. The machine requires an external heat source to melt the metal, usually a gas and air blowpipe. The casting machine is spring loaded and wound to operate.

9.8.2. **Maintenance.** Make sure the arm is balanced to prevent vibration damage and certain miscast. Lubricate the machine with three drops of oil at the base of the rotating shaft after 200 castings. When winding the machine, do not exceed four turns because too many turns will weaken or break the spring. Keep the casting well cleaned and dusted.

9.8.3. **Safety Considerations.** Always wear safety glasses and make sure the blowpipe is pointed in a safe direction. Keep your hands clear when you release the casting arm. Ensure the well of the casting machine is clean and uncluttered. Use proper tongs to handle the casting rings.

Figure 9.7. Broken-Arm Casting Machine With Safety Lid.

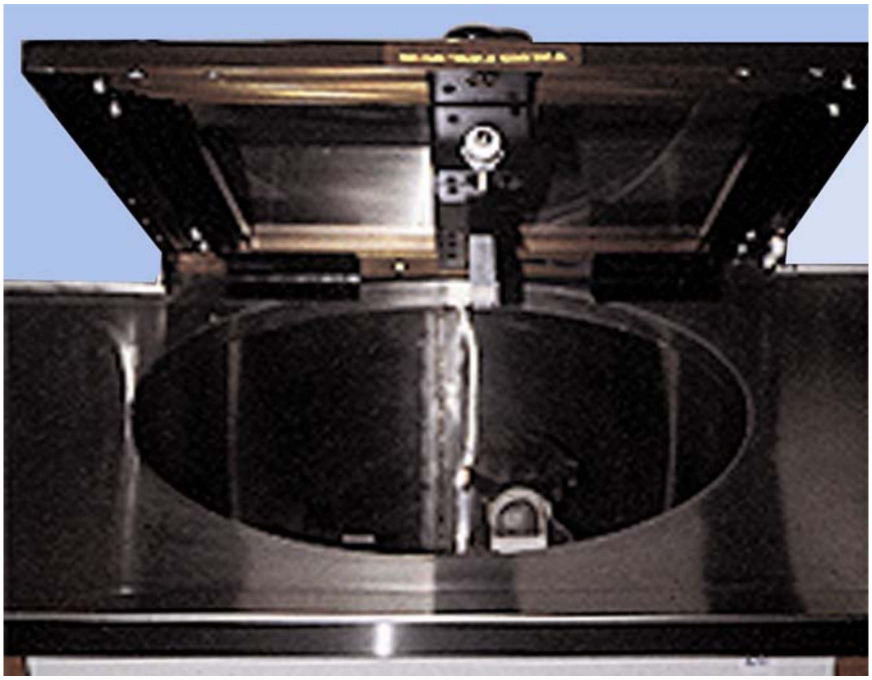
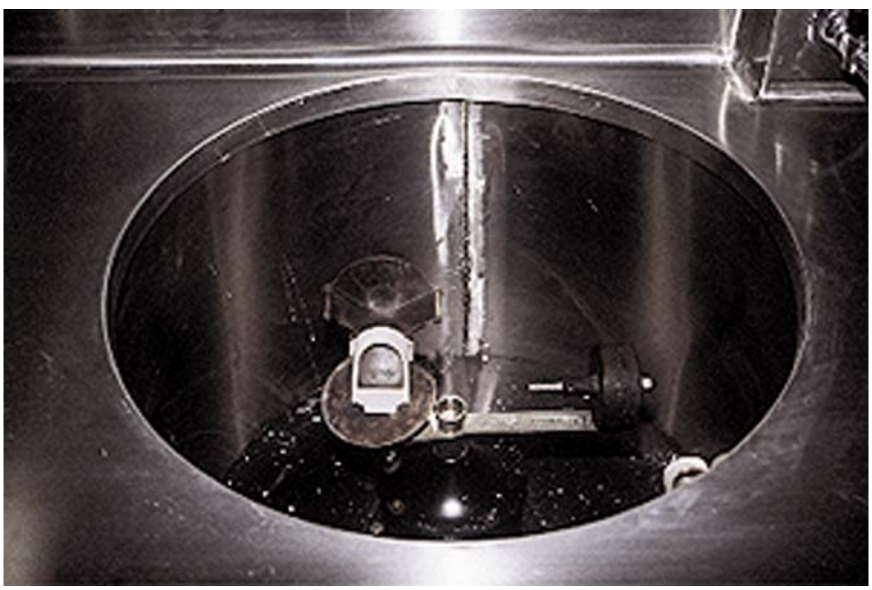


Figure 9.8. Broken-Arm Casting Machine.



9.9. Ticomatic® Electric Casting Machine:

9.9.1. **Purpose.** The Ticomatic casting machine (Figure 9.9) is similar to, but larger than the Unitek® Autocast. The Ticomatic is primarily designed to cast RPD frameworks, but it can be modified for other applications.

Figure 9.9. Ticomatic® Casting Machine.

9.9.2. **Maintenance.** Keep the well of the casting machine clean. Remove all debris that might interfere with the coil drop and prevent the safety switch from working. Do not oil the coil assembly rods. Use a powdered lubricant (molybdenum disulfide is recommended) and wipe off any excess. Remove the crucible slide holder once a month and clean the tracks. Clean all sliding surfaces and lubricate them with the powdered lubricant. Do not neglect to lubricate the two contact fingers on the coil assembly. (These must be vertical and tight.) Be sure the crucible is in good condition.

9.9.3. **Safety Considerations.** Keep your hands clear of the casting arm (Figure 9.10). Wear safety glasses or goggles. DO NOT operate this machine when water leaks are evident or water is present near the machine. This is a high voltage and amperage unit. Keep debris out of the casting well, especially under the coil assembly. Be sure the arm is balanced. DO NOT, under any circumstances, raise the coil assembly while the arm is rotating.

9.10. Pneumatic Chisel:

9.10.1. **Purpose.** The pneumatic (air) chisel (Figure 9.11) is primarily used to break or fracture artificial stone; for example, divesting processed dentures, removing stone from the tongue space of mandibular casts, or removing stone from the mounting rings.

9.10.2. **Maintenance.** Place six drops of lightweight oil in the air inlet daily. Check air pressure (90 pounds per square inch is necessary for efficient operation). Check the air periodically for moisture content and drain the air line as required.

9.10.3. **Safety Considerations.** Wear safety glasses when you deflask dentures. Keep the area clean and free of debris. Be sure attachments are securely attached into the nozzle.

9.11. Wells® Quick-Release Chuck:

9.11.1. **Purpose.** When it is correctly installed on a bench lathe, the Wells® Quick-Release Chuck allows the operator to change chucks and burs while the lathe is in motion, which greatly decreases the time spent in the finishing and polishing procedures (Figure 9.12).

Figure 9.10. Ticomatic® Casting Arm.

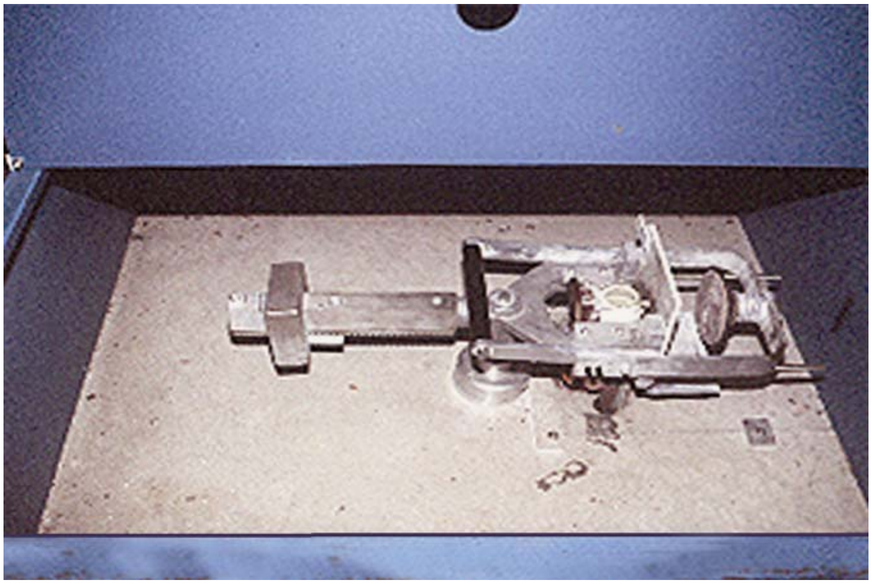
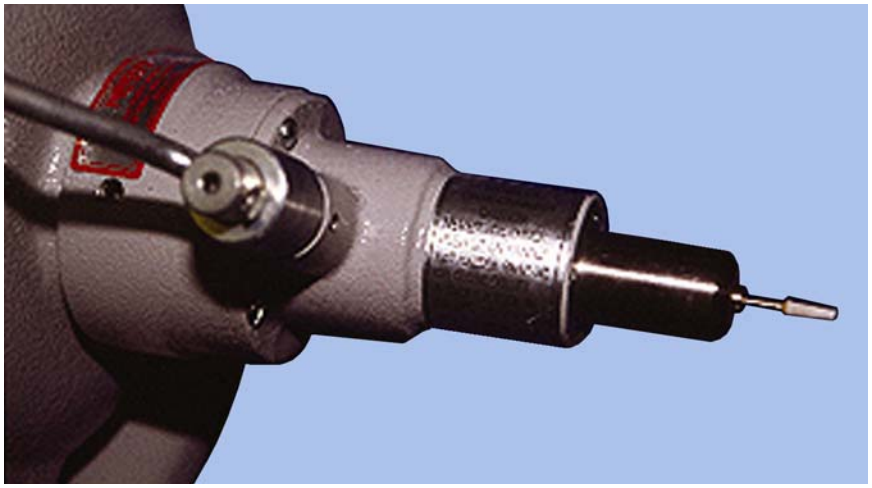


Figure 9.11. Pneumatic Chisel.

9.11.2. **Maintenance.** Do not attempt to operate the chuck unless it is properly installed on the lathe. Never use oil or solvents of any kind on it. Never close the collet without a tool (chuck or bur) in the collet. Allow the clutch spring to slowly engage the clutch. (Never push up on the handle or let the handle snap up.) Do not remove or attempt to defeat the purpose of the safety strap. Clean the collets once a week.

9.11.3. **Safety Considerations.** See paragraph 9.25.3 for safety precautions on the standard bench-mounted lathe.

Figure 9.12. Wells® Quick-Release Chuck.



9.12. Ultrasonic Cleaning Unit:

9.12.1. **Purpose.** The ultrasonic cleaning unit is filled with locally or commercially prepared cleaning compounds (Figure 9.13). It uses ultrasonic vibrations to clean dental restorations, appliances, and small equipment items.

Figure 9.13. Ultrasonic Cleaning Unit.

9.12.2. **Maintenance.** Never run the machine dry. Always ensure there is at least 1 inch of solution in the tank. There should be enough cleaning solution to completely cover the items being cleaned in the tank or beaker. Clean the holding tank and exterior surfaces of the unit periodically. Replace the drain cap before refilling the tank. Use aluminum foil to test the effective operation of an ultrasonic cleaning unit. Place a piece of foil, large enough to cover at least half the tank area, in the tank and set the timer for 5 minutes. (A properly functioning unit will have created multiple holes in the foil.)

9.12.3. **Safety Considerations.** Never put highly flammable liquids in the tank. Do not place your fingers in the cleaning solution while the unit is activated. Do not imerse unit into water to clean the tank. Check the power line and plug daily for defects. Keep the area around the unit clean and dry.

9.13. Hanau Model II® Curing Unit:

9.13.1. **Purpose.** Curing or polymerization of acrylic resins is a chemical reaction between the polymer and monomer. Heat generated by this reaction may cause an internal temperature as high as 300 °F. When monomer boils, it results in a porous denture base. The objective in curing is to control the temperature generated by the polymerization so the monomer does not boil. A curing unit (Figure 9.14) must contain:

9.13.1.1. A positive means of controlling the rate of heating.

9.13.1.2. A rack to prevent flask and heating coil contact.

9.13.1.3. A volume of water that is sufficient to prevent too rapid a rise in temperature.

Figure 9.14. Hanau Model II® Curing Unit.

9.13.2. **Maintenance.** Check the electrical cord for wear or damage. Ensure the unit has a grounding plug. Check the unit for water leaks in the tank or valve. Drain and clean the tank periodically, removing debris with a stiff brush (not a steel one) and cleaning solvent. Remove lime deposits by soaking with acetic acid (vinegar). Perform the following operational check at least monthly:

9.13.2.1. Fill the tank half full of water. Set the Station 1 thermostat at 165 °F and the timer for 1 1/2 hours. Set the Station 2 thermostat at 212 °F and the timer for 2 1/2 hours. Cover the tank and turn the switch to "ON." (The water should reach 165 °F in approximately 50 minutes.) Check the temperature with an accurate thermometer.

9.13.2.2. Make sure both clocks run simultaneously so the control of the heating coil is transferred to Station 2 as Station 1 expires. (The water temperature should reach 212 °F in about 25 minutes.) Again, check the temperature with an accurate thermometer.

9.13.2.3. If the machine malfunctions, do not attempt to repair or adjust it. Call your medical equipment repair technician to perform necessary adjustments.

9.13.3. **Safety Considerations.** Be careful when you remove cases from this curing unit. The water in the tank, as well as flask and carriers, remains hot for long periods of time. Before each use, check the power line and plug for defects.

9.14. Ivocap® Curing Unit:

9.14.1. **Purpose.** The unit (Figure 9.15) provides a controlled environment during curing of dentures, using the Ivocap injection mold technique. It raises water temperature to 100 °C and maintains it during the curing process.

Figure 9.15. Ivocap® Curing Unit.

9.14.2. **Maintenance.** Periodically check the power cord for damage. At least monthly, perform an operational check to ensure water temperature is maintained at 100 °C. Always ensure there is an adequate number of insulation floaters to cover the water's surface. As sediment builds up, clean the tank with a brush and mild solvent.

9.14.3. **Safety.** Be careful when removing the flask from the boiling water following the curing process. Ensure the area around the curing unit is kept clean and dry.

9.15. Pindex® Dowel Pin Drill:

9.15.1. **Purpose.** The dowel pin drill (Figure 9.16) is used to drill parallel dowel pin holes in the underside of an initial pour of a working cast. Specially designed dowel pins are then cemented in the holes and the cast base is completed. The dowel pin drill has a light beam or mechanical pointer used to position the drill bit directly under the tooth preparations.

9.15.2. **Maintenance.** Frequently vacuum or brush away accumulated dust and debris. Do not use air pressure to clean the machine because the pressure may force dust into the moving parts. Replace the drill bit when it is no longer sharp. Excessive pressure must be used during drilling if the drill bit is allowed to become dull.

9.15.3. **Safety Considerations.** Do not lower the work table suddenly or too quickly. Instead, use a slow gradual motion and always allow the drill to do the cutting. Wear safety glasses when operating the machine or cleaning the dowel pin holes of debris with compressed air.

Figure 9.16. Pindex® Dowel Pin Drill.

9.16. Ticonium® Electro Polisher:

9.16.1. **Purpose.** The Ti-Lectro® polisher (Figure 9.17) polishes cast RPD metal frameworks, using an electrolytic depleting process.

9.16.2. **Maintenance.** The corrosive characteristics of acid require special maintenance precautions. After polishing, rinse the electrode clip in neutralizing solution to prevent the corrosive effects of the Ti-Lectro® solution on the electrode clip. Wash off any acid on the controller unit. Drain the solution and clean the sediment out of the bowl twice a week. Replace worn clips as required. Clean the rinse bowl daily. Clean corroded electrical contacts as necessary.

9.16.3. **Safety Considerations.** To avoid injury while using the Ti-Lectro® polisher, careful steps must be taken. Always use rubber gloves, an apron, and a protective face shield when operating the machine. Keep the acid solution covered when the polisher is not in use. Use the polisher in a well ventilated area. If any of the solution gets on hands or clothing, wash it off immediately.

9.17. Denture Flask:

9.17.1. **Purpose.** A denture flask (Figures 9.18 and 9.19) is used to form the mold that processes the acrylic resin portion of the prosthesis. The flask is comprised of four sections or parts, the knockout plate, bottom half (drag), top half (cope), and cap (lid). Each flask has the same number on all of its parts, except the knockout plate. It is imperative to keep the parts with the same numbers together because they are machined to fit each other.

Figure 9.17. Ticonium® Electro Polisher.

Figure 9.18. Denture Flask (Closed).

Figure 9.19. Denture Flask (Exposed View).

9.17.2. **Maintenance.** Clean and apply a light coat of petrolatum to the flask after each use. Always use the ejector press, not a metal hammer, to remove the molds. When the brass on the flask tarnishes, restore its appearance with fine steel wool or a fine emery cloth.

9.18. Electric Handpiece:

9.18.1. **Purpose.** The electric handpiece (Figure 9.20) is a handheld electric motor with a revolving spindle and a chuck in the front to hold burs, stones, and mounted points. It provides ease of changing burs and a great degree of maneuverability while contouring prostheses.

Figure 9.20. Electric Handpiece.

9.18.2. **Maintenance.** To care for the handpiece, always check the manufacturer's instructions. Handpieces contain permanently sealed and lubricated bearings that do not require lubrication. Brush the motor housing daily to remove dust , using accessory brush provided. Clean the handpiece chuck and motor at least weekly to remove dust and debris. Never start the handpiece while the chuck is in the release position because this could damage the unit.

9.18.3. **Safety Considerations.** Do not wear loose fitting clothing or jewelry because they could become caught in moving burs. Watch for spinning stones and burs and keep them away from your fingers. Do not use attachments that vibrate or do not run true. Always wear safety glasses.

9.19. Beeswax Heater:

9.19.1. **Purpose.** The beeswax (Figure 9.21) heater is designed to melt refined beeswax and maintain the wax at a holding temperature between 270 and 300 ^{o}F. It is used primarily for wax-dipping refractory casts in RPD fabrication.

9.19.2. **Maintenance.** Prevent the beeswax from burning by periodically checking the holding temperature with a thermometer. Clean the debris from the holding tank and exterior of the unit each time the wax is changed.

9.19.3. **Safety Considerations.** Before each use, inspect the power line and plug for defects. Use a potato masher or similar carrier to immerse the casts into the molten wax. Do not drop the casts into the molten wax because the splashing of hot wax can result in serious burns. Avoid touching the exterior of the unit during and immediately after its operation. Wear safety glasses or goggles to prevent eye injury. Always keep the wax pot away from the edge of the bench to reduce chances of tipping it over.

Figure 9.21. Beeswax Heater.

9.20. Dura Dip® Electronic Wax Heater:

9.20.1. **Purpose.** The Dura Dip® electronic wax heater (Figure 9.22) is used to melt specially prepared inlay wax for the wax-dipping technique used to form coping patterns. The unit's electronic circuitry and sensor allow precision adjustment of the molten wax's temperature.

Figure 9.22. Dura Dip® Electronic Wax Heater.

9.20.2. **Maintenance.** Never pry unmelted wax from the well because severe damage to the silicone diode temperature sensor may result. Keep the wax well covered when not in use. Periodically remove the cover and clean any excess wax that may have collected.

9.20.3. **Safety Considerations.** Check the power line and plug before each use. Avoid contact with the hot molten wax.

9.21. Electric Wax Heater (General):

9.21.1. **Purpose.** The electric wax heater (Figure 9.23) is used to melt a variety of dental waxes. It maintains the waxes at a workable temperature without overheating them.

Figure 9.23. Electric Wax Heater.

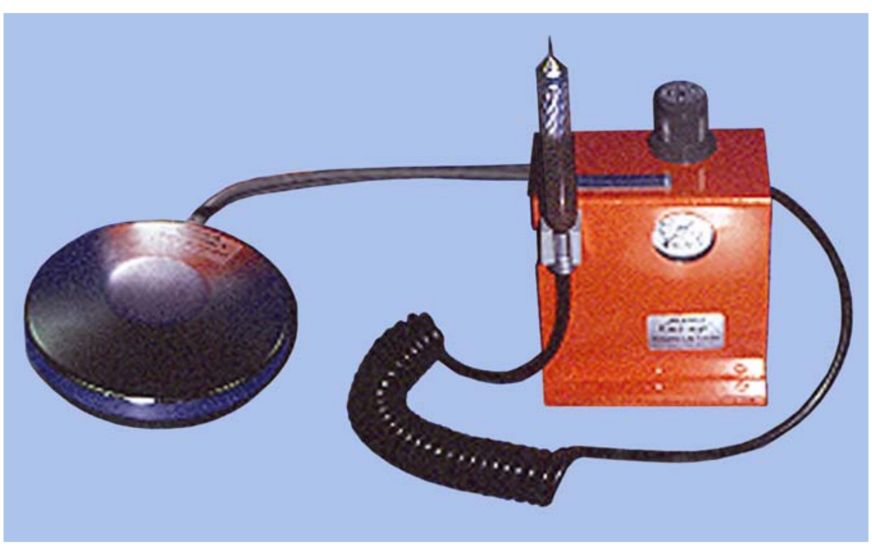
9.21.2. **Maintenance.** Clean the unit periodically to prevent accumulation of debris in the bottom of the wax compartments.

9.21.3. **Safety Considerations.** Check the power line and plug for defects. Handle the unit carefully when it is activated. Unplug it when not in use.

9.22. High Speed Turbine Handpiece:

9.22.1. **Purpose.** This air driven handpiece (Figure 9.24) with bur rotation from 0 to 300,000 rpm uses friction grip burs and enables you to accomplish fine detailed contouring of porcelain occlusals.

Figure 9.24. High Speed Turbine Handpiece.



9.22.2. **Maintenance.** Never run handpiece without a bur in the chuck. Lubricate the headpiece after 3 to 5 hours of operation or at the end of each workday. (See the manufacturer's manual for guidance.) Always ensure burs are true before using them. Ensure the air pressure is set at the manufacturer's recommendation; higher air pressure could damage the handpiece.

9.22.3. **Safety Considerations.** Always fully seat burs before operation. Safety glasses must be worn while operating handpiece.

9.23. Whip-Mix® Vacuum Investor:

9.23.1. **Purpose.** The vacuum investor (Figure 9.25) is used to spatulate and evacuate air from a mix of gypsum material. It is used primarily for mixing hydrocal to pour impressions and vacuum spatulating investments used in the fabrication of crowns and FPDs. It is also used to mix alginate impression material.

Figure 9.25. Whip-Mix® Vacuum Investor.

9.23.2. **Maintenance.** Insert the blades into the mixing bowl before positioning the shaft in the chuck. Maintain the correct level in the oil jar. Continue to run the unit for 1 minute after use to oil the vacuum chamber and remove the moisture from the pump. Clean the bowl and attachments as soon as possible after use. Occasionally check all O-rings and fittings to ensure proper vacuum is maintained. LUBRIPLATE, which is supplied with the machine, should be applied several times a year to the shaft and O-rings. Replace the gauze in the debris trap as required.

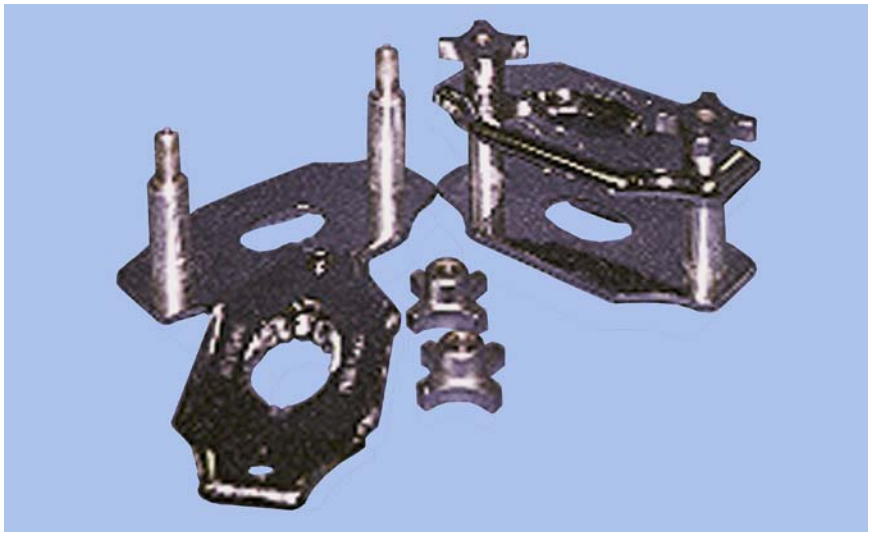
9.23.3. **Safety Considerations.** Use precautions against electrical shock. Keep your fingers away from the rotating parts.

9.24. Reline Jig:

9.24.1. **Purpose.** When used correctly, the sectional jig (Figure 9.26) is a fast, accurate way to reline dentures. This technique eliminates the need for flasking and mounting in an articulator, yet produces excellent results.

9.24.2. **Maintenance.** General cleaning is all this equipment requires.

Figure 9.26. Jectron® Reline Jig.



9.25. Bench-Mounted Lathe:

9.25.1. **Purpose.** This lathe (Figure 9.27) with the Wells Quick-Release Chuck combination is used for a variety of grinding, finishing, and polishing procedures in the dental laboratory.

Figure 9.27. Bench-Mounted Lathe.

9.25.2. **Maintenance.** The bearings are factory sealed and require no lubrication. Do not flip the switch from "HIGH" to "LOW" to slow the machine down. The chuck must be periodically cleaned and lubricated to prevent rusting and ensure its smooth function.

9.25.3. **Safety Considerations.** Check the cord and plug for wear or damage. Wear protective safety glasses during finishing and polishing procedures. Do not leave a running lathe unattended. Turn it off when not in use. Check all chucks and attachments to ensure they are securely mounted before you start the lathe. Do not use attachments that vibrate or do not run true. Do not make adjustments or replace chucks, wheels, or similar attachments while the lathe is running, unless the machine is equipped with an automatic chuck. Do not attempt to stop a running lathe by grasping the attachment with your hands.

9.26. Lathe Polishing Unit:

9.26.1. **Purpose.** This unit is equipped with a suction device to draw smoothing and polishing agents away from the operator (Figure 9.28 and 9.29). It is used to low-speed polish cast RPD frameworks and gold FPDs. It is also used for all types of acrylic resin restorations.

Figure 9.28. Kavo® Polishing Unit.

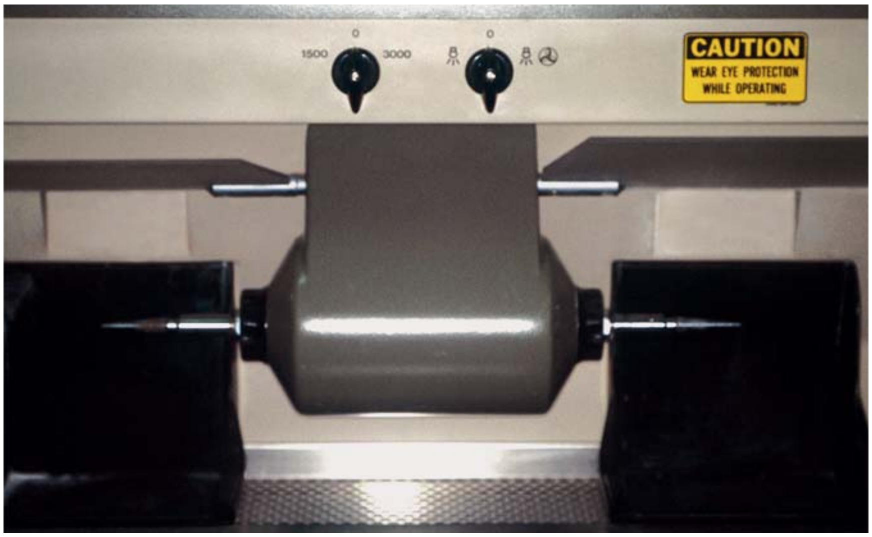


Figure 9.29. Floor-Mounted Lathe.

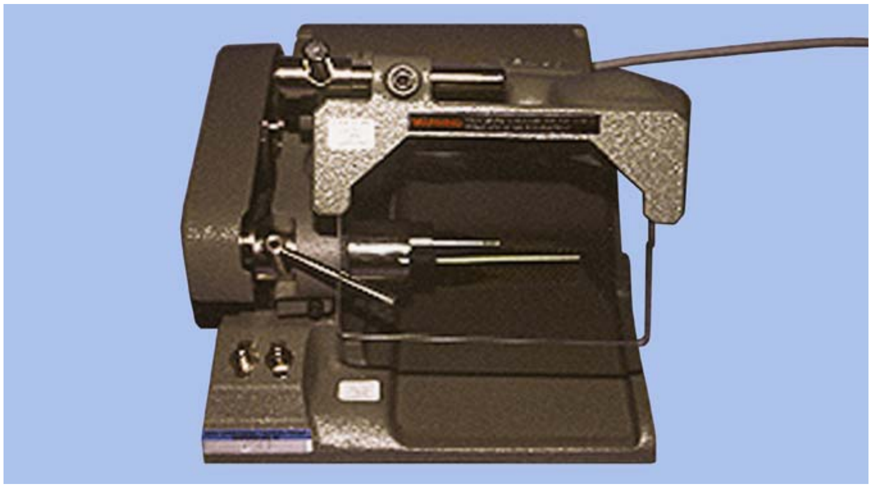
9.26.2. **Maintenance.** Dust and clean the motor housing and unit daily. Replace the filters as required.

9.26.3. **Safety Considerations.** Wear safety glasses. Check electrical connections for wear or damage. Use light pressure. Do not talk to anyone while using this machine. Release the prosthesis if it hangs in the polishing wheel. Do not try to hurry any polishing procedure.

9.27. High-Speed, Metal-Finishing Lathe:

9.27.1. **Purpose.** The extremely hard chrome alloy used in removable partial denture construction requires a high-speed lathe for finishing and polishing (Figure 9.30). ***NOTE:*** This lathe is not recommended for finishing gold.

Figure 9.30. High-Speed, Metal-Finishing Lathe.



9.27.2. **Maintenance.** Oil the motor every 6 months with three drops of light machine oil in each oil cup. Maintain correct belt tension. (If the belt is too loose, the spindle will not turn.) Adjust the tension by loosening the screws under the spindle housing and turning the spindle clockwise. Use proper light bulbs in the unit's light receptacle. Clean and oil the collet after each day's use. Never close the collet without a mandrel in place because the clutch is plastic and will freeze up if the collet is allowed to lock. Follow the manufacturer's directions for inserting, removing, or releasing the attachments. Always hold a truing stone to mounted wheels and mounted rubber points while they are turning on the lathe and before using them on practical work.

9.27.3. **Safety Considerations.** Always wear safety glasses. Pay strict attention to your work. Keep the belt guard in place while the lathe is running. Be sure the collet releases the bur shank. Keep fingers out of the belt guard and away from the stones and burs. Keep the glass shield in place and make sure it is not cracked or broken. Use the vacuum apparatus to draw off grinding dust. Check the power line and plug for defects before each use.

9.28. Comco® Microblaster and Work Station:

9.28.1. **Purpose.** The microblaster (Figure 9.31) has many air abrasive uses. It can be used to remove investment and oxide residue from castings, prepare metal substructure surfaces before and after the oxidation step, prepare porcelain surfaces prior to subsequent firings, cut detailed anatomy into porcelain occlusals, and polish metal surfaces. The unit can use 25- to 50-micron sized aluminum oxide abrasive or 50-micron glass beads (for polishing). Regulate the air pressure to change the cutting power of the abrasive. Comco also makes an optional dust collection system the microblaster and work station can use as a base.

9.28.2. **Maintenance:**

9.28.2.1. Do not depressurize the microblaster after each use. It is designed to be pressurized in the morning and not depressurized until the end of the day.

Figure 9.31. Comco® Microblaster and Work Station.

9.28.2.2. When the tank cover is removed to change the powder, brush the excess powder off the top of the tank and out of the threads. A small stiff brush is ideal for this purpose. At weekly intervals, spray or wipe a dry lubricant such as graphite, molycote, or teflon powder on the tank threads. If an aerosol dispenser is used, the lubricant is suspended in a solvent. Allow a few minutes for the solvent to evaporate before closing. When using an aerosol, always shield the inside of tank from the spraying operation. Routinely inspect the threads on the tank and cover for excessive wear.

9.28.2.3. Each day, slide the hose back through the pinch valve tube about 1/2 inch. When 6 to 9 inches have been pushed back, reverse the procedure. This will greatly increase the life of the hose.

9.28.2.4. Each week, with the machine turned off and depressurized, examine the handpiece abrasive hose for soft spots. Examine the hose in the area of the pinch valve and along the first 2 or 3 inches next to the fitting at the rear panel. The hose should be evenly firm along its length without any soft spots. Whenever a soft spot is detected, cut back the hose to that point and reattach it to the fitting.

9.28.2.5. Each month, pull the power cord plug and remove the cabinet cover. Inspect the unit for obvious leaks. Clean thoroughly with small brush and vacuum hose. (Never use air or try to blow abrasives unless you are working in a large efficient hood.) Replace the power cord, energize the machine, and blow out the lines for a few seconds. Cover the microblaster and return the unit to service.

9.28.2.6. If the machine malfunctions or is in need of a replacement part, do not attempt to repair or adjust it. Instead, call the medical equipment repair person to have a qualified technician service the unit.

9.28.3. **Safety Considerations.** Keep the work station lid closed when the microblaster is in use. Do not direct the air blast in a direction that would cause the abrasive to enter underneath fingernails or into an exposed cut. Check the power cord and plug before use.

9.29. ESPE Rocatector® Microblaster:

9.29.1. **Purpose.** The Rocatector microblaster (Figure 9.32) is a part of the ESPE Visogem® system that creates a gap free bond between the metal substructure and the veneer material. First, sand blast (Rocatec-Pre) each metal substructure blast to clean the surface. Next, blast the metal substructure with a material (Rocatec-Plus) that creates an adhesive coating onto the metal in preparation for the veneer application.

Figure 9.32. ESPE Rocatector® Microblaster.

9.29.2. **Maintenance.** It is very important to fill the blasting material into the correct storage chamber. Filling the blasting material into the wrong storage chamber will cause the bond between metal and veneer material to be lost. Store blasting materials in a clean dry area. Periodically check to ensure the level in storage containers is above minimum level. If the material drops below minimal level, a sufficient layer of adhesive coating may not be applied to the metal substructure during the application process. Air pressure should be at least 2.5 bars for proper operation.

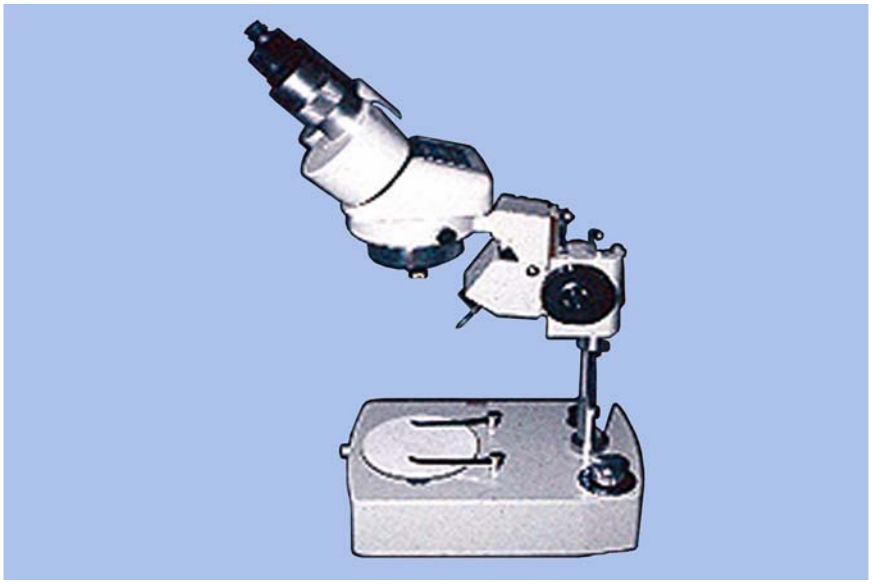
9.29.3. **Safety Considerations.** Keep the lid on the Rocatector closed when in use. Do not direct the air blast in a direction that would cause the abrasive to enter underneath fingernails or into an exposed cut. Check the power cord and plug before use.

9.30. Microscope:

9.30.1. **Purpose.** A microscope is mainly used in the laboratory to trim dies, facilitate waxing margins on crowns, and seat castings (Figure 9.33). A microscope can also be used anytime magnification is needed.

9.30.2. **Maintenance.** The eyepiece and lenses should never be wiped while dry. Dust can be removed with a camel's hair brush or air. Lens paper, folded and moistened with an approved lens cleaner such as xylol or xylene, should be used to clean glass surface. Periodic service may be needed and should only be done by a qualified authorized technician.

Figure 9.33. Stereo Microscope.



9.31. Dehydrating Oven:

9.31.1. **Purpose.** A dehydrating oven (Figure 9.34) is used to dry refractory casts prior to sealing them with beeswax.

Figure 9.34. Dehydrating Oven.

9.31.2. **Maintenance.** The inside of the furnace should be cleaned and vacuumed at least weekly.

9.31.3. **Safety Considerations.** Take precautions for handling hot materials. Never place a sealed container in the oven. Periodically check the power line and plug for defects.

9.32. Fixed Prosthetic Burnout Oven:

9.32.1. **Purpose.** The burnout oven (Figure 9.35) is used for wax elimination, preheating, and heat treatment. The paramount requirements of a burnout oven are:

9.32.1.1. An accurate pyrometer.

9.32.1.2. A method of controlling the rate of temperature rise.

9.32.1.3. A positive means of maintaining a constant temperature.

Figure 9.35. Fixed Prosthetic Burnout Oven (Jelenko Accu-Therm II 750®).

9.32.2. **Maintenance.** Clean the muffle of the burnout oven to remove all debris. Vacuum inside the muffle as required. Check the pyrometer of the oven every 3 months. Use temperature pills or a pure metal to check for proper calibration. Never operate the burnout oven at higher temperatures than those recommended by the manufacturer. Keep the muffle door closed when the furnace is cooling because an open door leads to too rapid cooling which may crack the muffle.

9.32.3. **Safety Considerations.** Check the electrical connections for fraying. Locate the oven within easy reach of the casting well. Keep the area clean and uncluttered. Use tongs to handle hot rings.

9.33. Porcelain Oven:

9.33.1. **Purpose.** A porcelain oven (Figures 9.36, 9.37, and 9.38) is a specialized unit designed for firing porcelain in the fabrication of crowns and FPDs.

9.33.2. **Maintenance:**

9.33.2.1. Clean and dust the outside of the unit daily. Do not wipe the pyrometer with a rag because wiping may magnetize the needle. Dust the glass with a soft brush. Keep the muffle clean and free of debris and flakes of porcelain. Cool the furnace with the door closed because rapid cooling may crack the muffle. Use pure metals with known melting points or temperature pills to calibrate the muffle.

Figure 9.36. Dentsply® Multimat 99 Porcelain Oven With Movable Muffle.

Figure 9.37. Jelenko® Commodore 100 With Stationary Muffle.

9.33.2.2. Place the metal strip on the sagger tray and insert the tray into the furnace.

9.33.2.3. Set the temperature control at the melting point of the metal used. Adjust the current to achieve a rise of 100 ^{o}F per minute.

9.33.2.4. Observe the metal until it melts. Check the pyrometer. If the temperature is lower than the control was set for or if the metal has not melted, calibrate the furnace. Refer to the operating instructions to locate the adjustment screw. Using a small screwdriver, turn the screw until the pyrometer agrees with the temperature control.

9.33.2.5. Cool the furnace and then repeat the procedure to check the calibration.

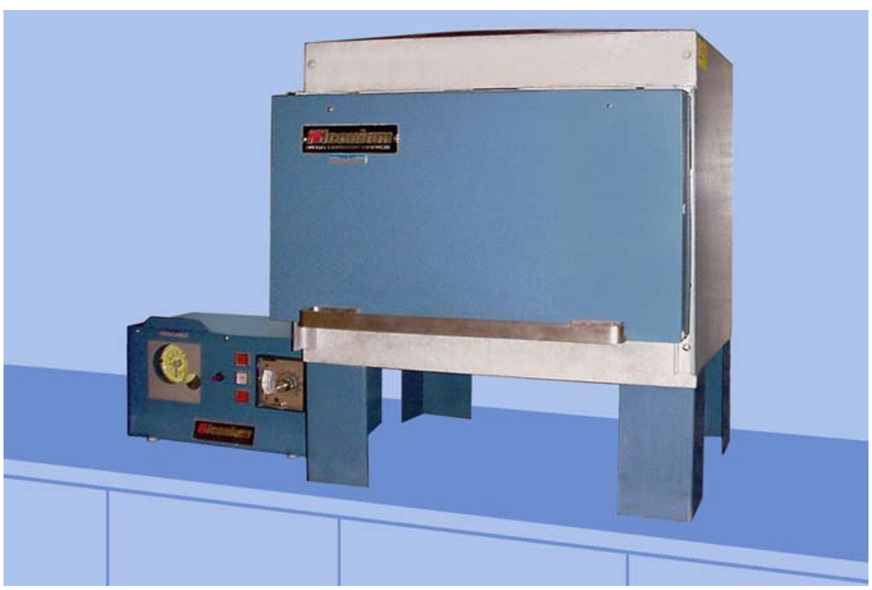
Figure 9.38. Ivoclar® Programat P-80 With Hinge Muffle.

9.33.3. **Safety Considerations.** The porcelain furnace operates at high temperatures. Use safety equipment and be careful handling hot items.

9.34. Ticonium® Super Oven:

9.34.1. **Purpose.** The Ticonium® super oven (Figure 9.39) burns out up to 20 cases (molds) at one time. It has a spring-loaded door that opens upward. It is used primarily for burning out RPD framework molds.

Figure 9.39. Ticonium® Super Oven.



9.34.2. **Maintenance.** Maintenance is the same as for standard ovens, except for the springs on the door, which must be replaced as they weaken. There are also vent holes placed in the upper left and right back of the oven that need to cleaned periodically to ensure a clean burnout. The super oven must be calibrated every 90 days. The procedures below should be followed closely for correct operation:

9.34.2.1. With the oven at room temperature, turn the unit on. Immediately check the temperature reading to make sure it corresponds to the room temperature. If a discrepancy exists, adjust the indicator. (Any difference in temperature found here will also be present at higher temperatures.)

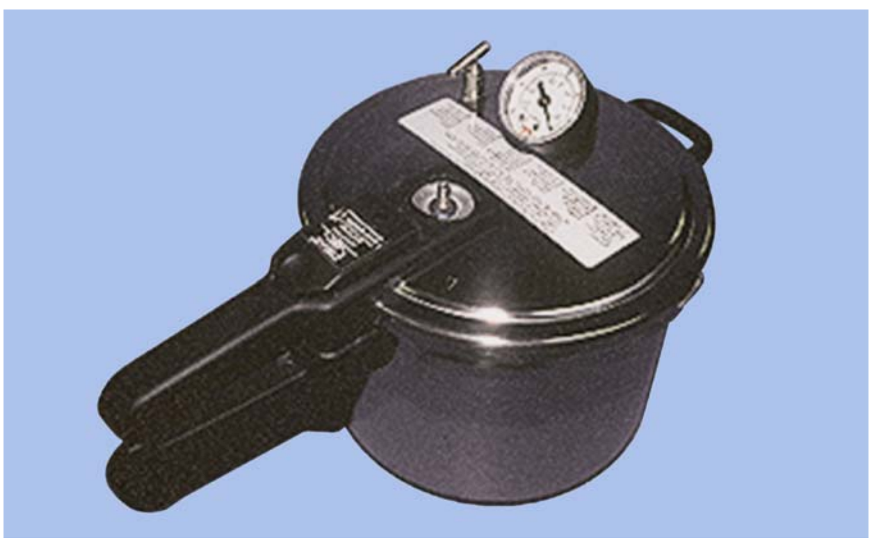
9.34.2.2. After observing the pyrometer, run the temperature up to 1300 ^{o}F. Check for accuracy with temperature pills. Do not attempt further adjustment or repair of this unit.

9.34.3. **Safety Considerations.** Wear safety glasses and use heat reflecting gloves. Use proper tongs when handling hot molds. Mark hot molds with warning signs. Use an asbestos slab to hold hot molds after casting. Keep the inside of the oven and adjacent areas clean and uncluttered. Be sure the oven is in easy reach of the casting machine.

9.35. Pressure Pot:

9.35.1. **Purpose.** The pressure pot (Figure 9.40) is a device used for curing relines and repairing complete dentures and denture base areas of RPDs when the procedure is accomplished with autopolymerizing acrylic resin. Curing the resin under pressure significantly reduces the possibility of porosity.

Figure 9.40. Pressure Pot.



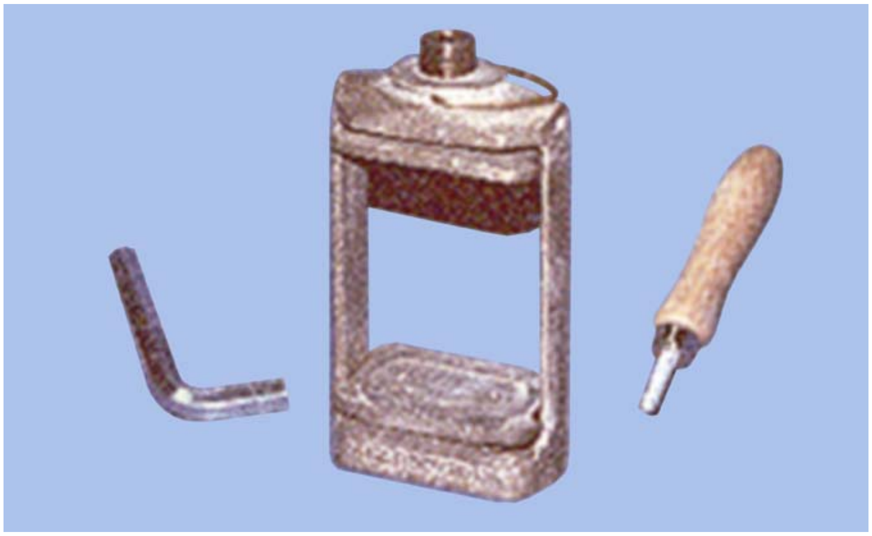
9.35.2. **Maintenance.** Periodically check seals, air inlets, and outlets for malfunctions. Activate the pressure relief valve to ensure it is operational. Periodically lubricate the gasket to prevent from drying out.

9.35.3. **Safety Considerations.** Never exceed the maximum air pressure indicated in the manufacturer's instructions because excessive pressure may cause the pot to explode. Never apply heat to the pot when pressurized. Always exhaust all air before opening the pot.

9.36. Carrier Flask Press:

9.36.1. **Purpose.** After dentures are packed with a press, the flasks are transfer to a carrier press (Figure 9.41) to be placed in the curing unit. The carrier press has two strong stainless steel springs that hold flasks under about 400 pounds of evenly distributed pressure.

Figure 9.41. Carrier Flask Press.



9.36.2. **Maintenance.** In addition to general cleanliness, inspect the stainless steel springs periodically for possible replacement.

9.36.3. **Safety Considerations.** The bulk of the metal (compress and flasks) retains heat after curing. Because it can cause serious burns, handle this heavy unit carefully before and after the processing procedure.

9.37. Hydraulic Flask Press:

9.37.1. **Purpose.** The hydraulic flask press (Figure 9.42) is used for packing acrylic resin under pressure into denture molds. It uses hydraulics to apply pressure.

9.37.2. **Maintenance.** Periodically lubricate the large piston under the lower pressure plate, the small piston, the threads of the pressure screw, and the bearing surface of the pressure screw at the upper pressure plate. Maintain the hydraulic oil level in the reservoir at approximately 1/8 inch below the reservoir plug. Only check this level when the control valve is open and the pressure handle is down.

9.37.3. **Safety Considerations.** Do not exceed the manufacturer's recommendations on the pressure gauge. Excess pressure will in all likelihood fracture or displace the teeth and cause possible damage to the pressure gauge. Keep your hands free of the pressure plate during its operation.

9.38. Pneumatic Flask Press:

9.38.1. **Purpose.** The pneumatic press (Figures 9.43 and 9.44) is used for packing acrylic resin under pressure into denture molds. This press uses compressed air to apply pressure.

Figure 9.42. Ivocap® Hydraulic Flask Press.

Figure 9.43. Pneumatic Flask Press.

9.38.2. **Maintenance.** Only general cleaning is required.

9.38.3. **Safety Considerations.** Never operate the press without a flask. Always center the flask under the press. Use only air pressure regulated to manufacturer's recommendations.

9.39. Biostar® Pressure-Moulding Machine:

9.39.1. **Purpose.** This machine (Figure 9.45) is used to adapt round or square acrylic resin blanks onto casts by downward pressure from a pressure chamber located above the cast. Interim partial dentures, mouthguards, and orthodontic appliances can be processed with this machine.

9.39.2. **Maintenance.** Clean or replace block out pellets as needed. Do not exceed the optimal working pressure of 5 bars. Ensure the seal area between the pressure chamber and the ring on the working platform remains clean for proper seal during pressurizing. Clean the exterior of the machine regularly.

Figure 9.44. Ivocap® Pneumatic Press.

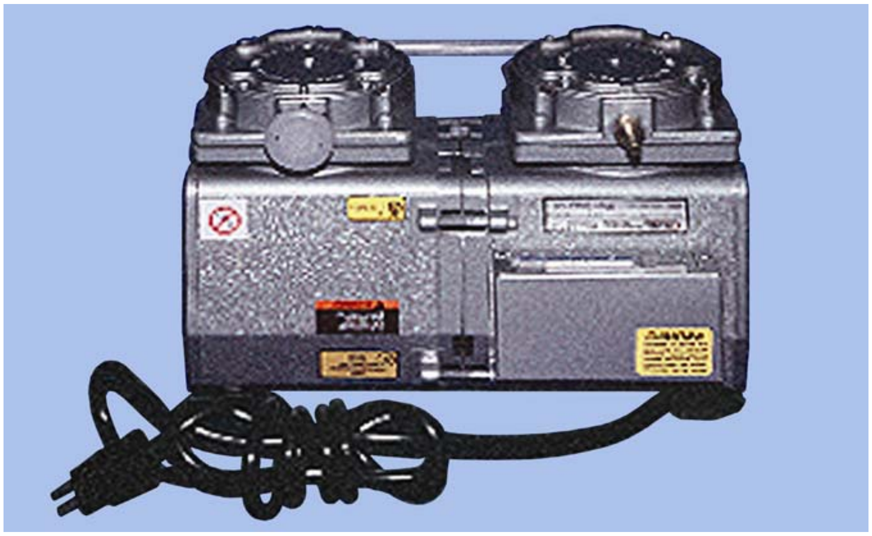
Figure 9.45. Biostar® Pressure-Moulding Machine.

9.39.3. **Safety Considerations.** Wear safety glasses while operating the machine. Always use the handle when moving the heating element. Check the power cord periodically for fraying or other damage.

9.40. Vacuum Pump:

9.40.1. **Purpose.** The vacuum pump (Figure 9.46) and similar other pumps are used to evacuate air from the firing chamber of porcelain firing furnaces. Vacuum pressure achieved is normally measured in inches of mercury.

Figure 9.46. Vacuum Pump.



9.40.2. **Maintenance.** Read the manufacturer's recommendations for maintenance on each type of pump. Most pumps require the intake and exhaust filters to be periodically checked and cleaned. If applicable, the oil in the vacuum pump should be replaced every 90 days or any time a change in color is noted in the inspection eye.

9.40.3. **Safety Considerations.** When performing maintenance on the pump, disconnect the power cord and vent all air lines to avoid personnel injury.

9.41. Laboratory Electronic Scale:

9.41.1. **Purpose.** This scale (Figure 9.47) is used to weigh wax patterns to estimate the amount of metal required for casting. It can also be used to weigh dental stone and investments in the laboratory.

Figure 9.47. Laboratory Electronic Scale.

9.41.2. **Maintenance.** Keep the housing and pan free of dust and debris to ensure accurate weighing. Avoid rough treatment to the scale because it can damage the internal sensor. Because lengthy exposure to extreme heat or cold can affect its accuracy, the scale should be operated at room temperature. Calibration is preset at the factory. If recalibration is necessary, return it to an authorized service center.

9.42. Precious Metal Balance Scale:

9.42.1. **Purpose.** This scale (Figure 9.48) is used for weighing precious metals in the laboratory. The scale readout is in grams.

Figure 9.48. Precious Metal Balance Scale.

9.42.2. **Maintenance.** The instrument must be cleaned after each weighing and covered with a dust protector when not in use. The precision measurement evaluation laboratory (PMEL) may periodically evaluate the accuracy of the scale.

9.43. Electric Soldering Unit:

9.43.1. **Purpose.** The electric soldering unit (Figure 9.49) is used to solder RPD frameworks.

9.43.2. **Maintenance.** Keep the unit clean. Replace the carbon holders and carbon and ground prongs when they are no longer fit for use. Ensure electrical connections are kept clean.

9.43.3. **Safety Considerations.** Check the power line and plug before use. Wear safety glasses when soldering.

9.44. Hydroflame® Soldering Unit:

9.44.1. **Purpose.** The Hydroflame® soldering unit (Figure 9.50) converts water into hydrogen and oxygen to the correct proportion for ideal combustion. An alcohol booster unit is also used in the unit's operation to lower the flame temperature to a more practical point. The hydroflame soldering unit is particularly suited for delicate soldering operations.

Figure 9.49. Electric Soldering Unit.

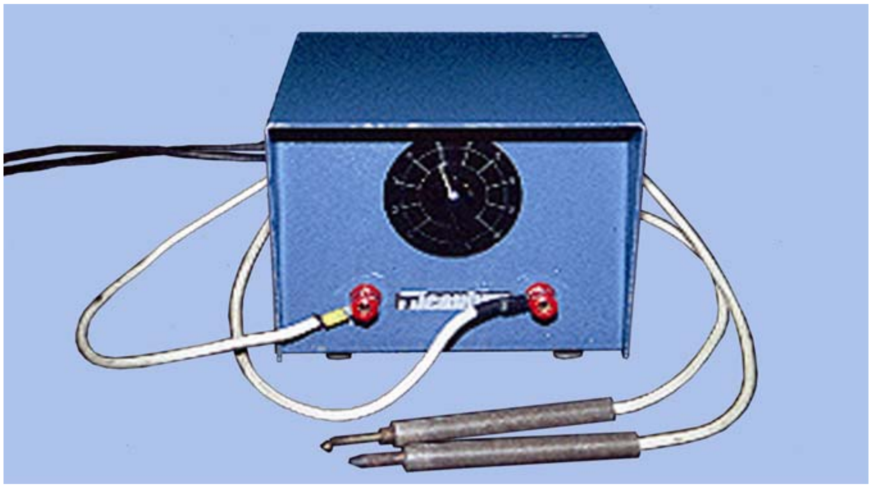


Figure 9.50. Hydroflame® Soldering Unit.

9.44.2. **Maintenance:**

9.44.2.1. Before each day's use, run the cleaning wire through the torch tip. Check the generator electrolyte and booster fluid levels daily. Replenish fluid levels as necessary. When replacing the friction-fit torch tops, insert the tip with a pushing and twisting motion until it is tightly held on the torch handle.

9.44.2.2. Thoroughly clean and dry (or change) the stainless steel filter assembly every 3 months or 250 operating hours. Disconnect the booster hose from the gas generator outlet after extinguishing the flame and turn off the unit. (If it is not disconnected within 5 minutes, a vacuum will created. The vacuum will then draw the booster fluid back into the generator and contaminate the electrolyte.)

9.4.4.2.3. Replace the electrolyte when it becomes contaminated or before 1,500 operating hours have elapsed. When you switch from "low" to "high," pause momentarily at the center "off" position to avoid overloading the fuse.

9.44.3. **Safety Considerations.** Unplug the power cord from the wall outlet when you are not using the unit, and before you check the electrolyte and booster fluid levels. Avoid skin contact with the electrolyte fluid because it is extremely caustic. Do not place your face, particularly your eyes, close to or over an open filler tube or booster. Never allow an open flame, lit cigarette, or other hot, glowing material near the open mouth of the filler tube or booster because hydrogen and oxygen gases remain inside the generator for an hour after the electricity has been turned off. Wear safety glasses when you solder.

9.45. Steam Cleaner:

9.45.1. **Purpose.** The steam cleaner (Figure 9.51) is used to clean using pressurized steam. It can be used on metal-ceramic frameworks and full gold crowns and to remove wax and debris from casts.

Figure 9.51. Steam Cleaner.

9.45.2. **Maintenance.** Drain the steam under pressure at the end of each workday. Once a month, turn the steamer off, disconnect the power cord from the electrical outlet, and check all internal electrical connections for tightness.

9.45.3. **Safety Considerations.** Always keep the steam nozzle pointed in a safe direction. Do not allow the water level to fall below the lower red line on the gauge glass because a reduced water level ultimately causes premature element failure.

9.46. Boilout Tanks:

9.46.1. **Purpose.** Boilout tanks (Figure 9.52) are used primarily to soften and remove wax from invested denture flasks. Tanks can also be used to clean instruments and other metal objects.

9.46.2. **Maintenance.** Be sure the standpipe is in place before the pump is operated to eliminate stone and debris from being drawn through the pump. Allow the tank to cool and excess wax to be remove before draining and cleaning. Lubrication of the three oil cups on the pump is necessary every 4 months. Use 2 to 3 teaspoons in the front cup (for pump bearings) and 10 to12 drops in each of the rear cups on motor. Always have at least 5 inches of water in the tank before igniting the burners. If the tank is equipped with a wax or plaster trap, clean it at least monthly.

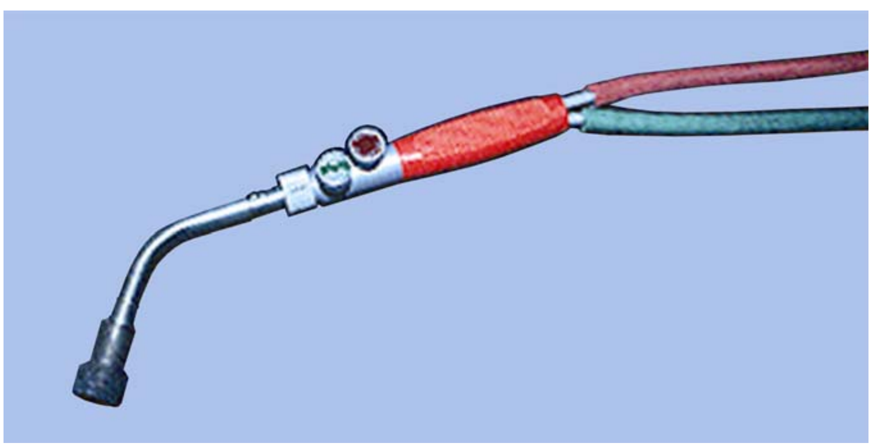
Figure 9.52. Boilout Tanks.

9.46.3. **Safety Considerations.** Always wear safety glasses and heat resistant gloves when operating the tank. If, during the lighting procedure, the pilot will not stay lit after several tries, turn the gas completely off and call a service technician. Stand clear of the facets when the pump is turned on to avoid being burned by splashing hot water.

9.47. Gas and Air Casting Torch (Multiorifice Blowpipe):

9.47.1. **Purpose.** This torch (Figure 9.53) is used primarily to melt and solder metals and alloys. The gas to air ratio is easily adjusted to provide the required heat intensity. Figure 9.53 shows the blowpipe with a casting tip attached. A smaller tip is used during soldering procedures to provide a smaller, more concentrated flame.

Figure 9.53. Gas and Air Casting Torch.



9.47.2. **Maintenance.** Periodically inspect the adjustment knobs of the torch for gas and air leaks. Check the casting or soldering tip before using it to ensure it is not clogged with dirt and debris.

9.47.3. **Safety Considerations.** Use noncollapsible-type hoses for the gas and air connections. Inspect the hoses for defects before each use. Never leave the torch unattended while lit.

9.48. Alcohol Torch:

9.48.1. **Purpose.** This hand-operated torch (Figure 9.54) is ideal for setting up teeth, waxing, light soldering, and a variety of uses demanding accurate control of a pointed flame.

Figure 9.54. Alcohol Torch.

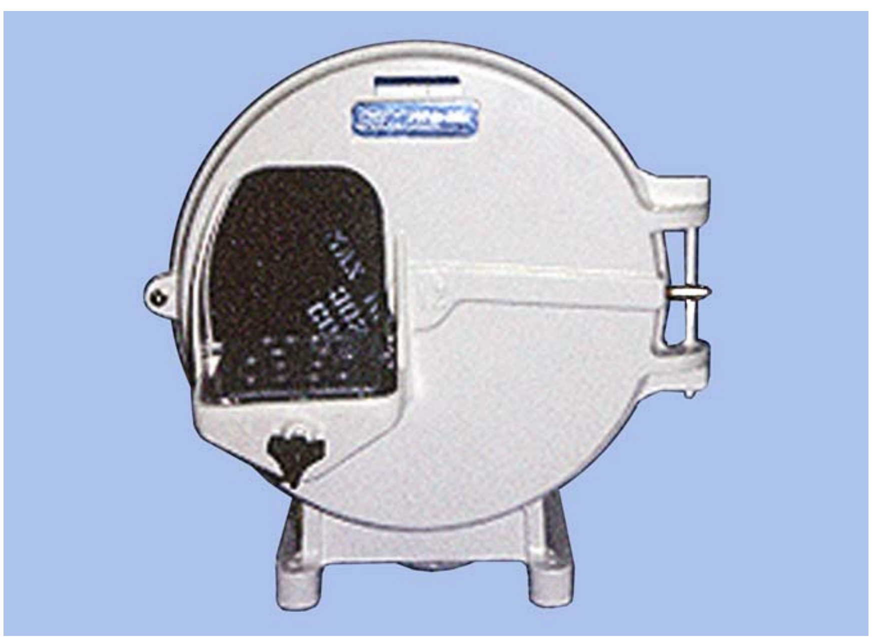
9.48.2. **Maintenance.** Check the nozzle tip to ensure it is free of obstructions. Replace the bellows diaphragm as needed. Clean the exterior of the pump daily to prevent accumulation of waxes and compounds.

9.48.3. **Safety Considerations.** Extinguish the torch when it is not in use by covering the wick with the attached wick shield. Do not leave the torch unattended while lit.

9.49. Cast Trimmer:

9.49.1. **Purpose.** The cast trimmer (Figure 9.55) is used to trim and contour the casts to a workable size.

Figure 9.55. Cast Trimmer.



9.49.2. **Maintenance.** If applicable, lubricate the wheel shaft by placing two drops of medium grade oil in each of the two exposed oil cups every 2 weeks. Use sufficient water to prevent clogging the trimmer wheel with gypsum grindings. Let the water run at least 1 minute after the grinding is complete to flush all particles out of the drain. Clean the trimmer at least monthly or more frequently, depending on the amount of usage. Do not allow the trap or drain to become clogged before cleaning it. Check connecting hoses for water leaks. Apply only light pressure while trimming the cast. If the wheel does not cut, follow the manufacturer's directions to replace it. If the unit does not run smoothly, call the medical equipment repair personnel.

9.49.3. **Safety Considerations.** Wear safety glasses when operating the cast trimmer. Check the cord for wear or damage. Keep your fingers away from the wheel.

9.50. Ticonium® Twin Controller:

9.50.1. **Purpose.** The twin controller (Figure 9.56) is an electronic device that automatically operates the Ticonium Super Oven or a vertical loading oven. When properly adjusted, it activates an oven, maintains a predetermined maximum burnout temperature for specific time periods, and deactivates the oven after the programmed burnout time elapses.

Figure 9.56. Ticonium® Twin Controller.

9.50.2. **Maintenance.** Do not subject the instrument to excessive shock, vibration, dust, moisture, or oil seepage. Make sure the ambient temperature where the controller is located does not exceed 130 ^{o}F.

9.50.3. **Safety Considerations.** Inspect the power line and plug daily for defects.

9.51. Vacuum Former:

9.51.1. **Purpose.** This unit is a vacuum adapter of sheet plastic (Figure 9.57). It is used for rapid fabrication of record bases, custom impression trays, surgical bases, mouth guards, night guards, and temporary FPDs.

9.51.2. **Maintenance.** Inspect the rubber sealing gasket for cracks and deterioration and replace as necessary. Inspect the vacuum holes in the platform to ensure they are free of obstruction. Clean the exterior of the unit.

9.51.3. **Safety Consideration.** Inspect the electrical cord and plug daily for defects. Use the handle of the machine to raise and lower the heating coil.

Figure 9.57. Vacuum Former.

9.52. Vibrator:

9.52.1. **Purpose.** The vibrator (Figure 9.58) is used to get a mix of a gypsum product to move when you pour impressions and perform various investing procedures. It is also used to increase the density of the mix by eliminating air through vibration. A rheostat control is used to adjust the intensity of the vibration from a gentle agitation to a vigorous shaking. The intensity of the vibration is directly proportional to the viscosity of the mix.

Figure 9.58. Vibrator.

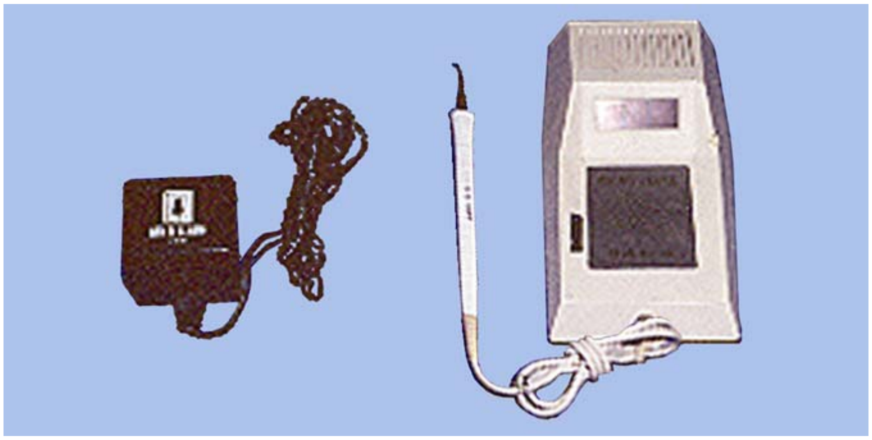
9.52.2. **Maintenance.** General cleaning of the pouring platform and body of the vibrator should be done every day.

9.52.3. **Safety Considerations.** Check the power line and plug for defects before each use. Always turn the unit to the lowest setting on the rheostat after each use.

9.53. Electric Waxing Unit:

9.53.1. **Purpose.** This unit (Figure 9.59) is a precision electronic waxing instrument. It has several different waxing tips that correspond to the conventional hand instruments used for waxing and carving. The temperature of the tip can be controlled to suit the operator's needs.

Figure 9.59. Electric Waxing Unit.



9.53.2. **Maintenance.** Never cover the top vent holes. Do not allow wax or debris to enter the unit through the vent holes. Only a qualified technician should open the unit for any repairs. Do not set the temperature higher than necessary. Do not use the standard waxing tip holder above 450 °F. Keep the spatula tips clean and free of carbonized wax.

9.53.3. **Safety Considerations.** Turn the unit off when it is not in use. Do not mount the spatula stand on the waxing unit.

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Surgeon General

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

AFPD 47-1, *Dental Services*
AFMAN 37-123, *Management of Records*
AFPAM 47-103, Volume 1, *Dental Laboratory—Basic Sciences, Removable Prosthodontics, and Orthodontics*
Air Force Records Disposition Schedule (RDS)

Abbreviations and Acronyms

BBC—buffing bar compound
cm^3—cubic centimeter
cm—centimeters
DI—disto-incisal
dwt—penny weight
EDM—electric discharge machine
FPD—fixed partial denture
g/cc—grams per cubic centimeter
gr—grain
lb—pound
MID—mesio-incisal-distal
MI—maximum intercuspation
ml—milliliter
mm—millimeter
MOD—mesio-occlusal-distal
MO—mesio-occlusal
OSHA—Occupational Safety and Health Administration
oz—ounce
PMEL—precision measurement evaluation laboratory
psi—pounds per square inch
RPD—removable partial denture
rpm—revolutions per minute
SDS—saturated calcium sulphate dihydrate solution

Terms

abrasive—A range of coarse to fine granules with sharp edges used for smoothing, grinding, or polishing.
abrasive paste—An abrasive suspended in a paste commonly used to smooth off small irregularities on denture teeth after gross grinding.
absorption—Taking up a substance into the mass of another.

abutment—
1. On RPDs, it is the tooth on which a clasp is placed to support and retain the removable partial denture.
2. On fixed partial dentures, it is the tooth to which the retainer is cemented.
3. On implants, it is the part that supports and/or retains the prosthesis.

accelerator—A substance that speeds up a chemical reaction.
acid—Any one of a group of corrosive chemicals used to clean oxide layers or surface contaminants from gold castings.
acid etching—
1. In clinical dentistry, treating the enamel, generally with phosphoric acid, by removing approximately 40 microns of rod cross-section for resin retention.
2. As a laboratory procedure, using electrolysis or chemicals to remove a microscopic layer of metal to produce mechanical retention for resin bonding. (Do not confuse with electropolishing, which occurs to a much greater degree.)

acrylic resin—A plastic widely used in dentistry for making denture bases, provisional crowns, custom trays, etc.
acrylic resin impression tray—See custom tray.
acrylic resin veneer—A tooth-colored layer of plastic placed over the facial surface of a metal crown to improve the crown's appearance.
ADA Specification—A detailed description of the qualities and properties required of a dental material as set forward by the American Dental Association (ADA).
adhesion—The sticking together of unlike substances.
adjustment—A modification to a dental prosthesis to enhance fit, function, or appearance.
agar—A gelatin-like substance obtained from certain seaweeds (algae) and used in compounding reversible hydrocolloid impression materials.
Aker's clasp—See circumferential clasp.
alginate—An irreversible type of hydrocolloid made from a salt of alginic acid.
align—To properly position in relation to another object or objects.
alloy—A metal consisting of a mixture of two or more pure metals.
alveolar process—Part of the mandible and maxilla that surrounds and supports the roots of natural teeth.
alveolus—The bony socket holding the root of a tooth by the periodontal ligament.
amalgam—An alloy of mercury, silver, and other metals used as a restorative material.
amorphous—Not having a definite crystalline structure.
anatomic crown—The part of a tooth covered with enamel.
anatomic teeth—Denture teeth with cusp angles of 30 degrees or more.
anneal—To heat a metal, followed by a controlled cooling to remove internal stresses and create a desired degree of toughness, temper, or softness to the metal.
anode—The positive pole of an electric source.
anterior guidance—See mutually protected articulation.
anterior guide pin—The pin fitting into the upper member of the articulator, resting on the anterior guide table, that maintains a selected amount of vertical separation. Also called incisal guide pin.
anterior guide table—Component of the articulator on which the anterior guide pin rests to maintain occlusal vertical dimension and influence articulator movements. Also called incisal guide table.
anterior teeth—The central and lateral incisors and the cuspids of either arch.
anterior tilt—A term used in surveying the master cast; when the cast is tipped on the surveyor table so the anterior part of the cast is lower than the posterior.

anteroposterior—Extending from the front, backward.
anteroposterior curve—The anatomic curve established by the occlusal alignment of the teeth, from the cuspid through the buccal cusps of the posterior teeth, when viewed from the side. Also called the curve of Spee.
antiseptic—Chemical agent applied to tissue to inhibit growth of microorganisms.
apical—Pertaining to the apex or root tip.
apical foramen—The opening at the end of a root of a tooth through which the tooth receives its nerve and blood supply.
approach arm—The part of a bar clasp connecting the retentive portion to a removable partial denture framework.
aqua regia—A mixture of three parts hydrochloric acid and one part nitric acid. Used for removing a layer of gold.
arch—See dental arch.
arch form—The general contour or shape of the arch. Patients' arches are sometimes classified as square, tapering, or ovoid, according to their general shape.
arcon articulator—An articulator having the condyle elements attached to the lower member in the same way condyles are an anatomic feature of the mandible in a human skull.
arrangement—See tooth arrangement.
arrow point (gothic arch angle)—On an articulator, the pointed pattern made by the intersecting working and balancing paths of a stamp cusp as it travels out of maximum intercuspation. The maximum intercuspation (MI) position is the apex of the arrow.
articular disc—The circular-shaped, flat piece of fibrocartilage lying between the condyle of the mandible and the glenoid fossa of the temporal bone.
articulating paper—Colored paper or film, usually supplied in strips, used intraorally and in the laboratory to detect contact between the maxillary and mandibular teeth.
articulation—

1. The place of union or junction of two or more bones of the skeleton.
2. In dentistry, the contact relationship between the occlusal surfaces of the teeth during function.

articulator—A mechanical device representing the temporomandibular joints and jaws to which maxillary and mandibualr casts can be attached for performing prosthodontic procedures.
artificial stone—See dental stone.
asbestos substitute—A strip used to line a casting ring used to invest fixed prosthodontic units; replaced asbestos strips.
asepsis—A pathogen-free condition.
attrition—The wearing away of the biting surfaces of the teeth.
autogenous glaze—A natural glaze.
autopolymerizing resin—Resin whose polymerization is initiated by a chemical activator.
auxiliary lingual bar—An extension from the lingual bar of a mandibular RPD framework used to stabilize loose, periodontally involved anterior teeth. Also called a supplemental Kennedy bar.
axial—Lines, walls, or surfaces parallel with the long axis of a tooth.
axis—An imaginary line passing through a body, around which the body may rotate; for example, transverse horizontal axis.
axis orbital plane—The horizontal plane established by the transverse horizontal axis of the mandible with a point on the inferior border of the right or left bony orbit (orbitale). Can be used as a horizontal reference point; corresponds to the Frankfort plane.
backing—The metal plate constructed to fit the slot or pins of the porcelain facing. May be cast in the laboratory or manufactured.

balanced articulation—The bilateral, simultaneous, anterior, and posterior occlusal contact of teeth in centric and eccentric positions. Also called balanced occlusion.
balanced occlusion—See balanced articulation.
balancing side—See nonworking side.
balancing side occlusal contacts—See nonworking side occlusal contacts.
bar—A major connector used in RPD construction to connect the right and left sides of the framework.
bar clasp—A type of clasp in which the retentive tip approaches the undercut from below the survey line. Also called infrabulge clasp.
basal seat area—See denture foundation area.
base—The part of a removable prosthesis that retains artificial teeth and replaces the alveolar process and gingival tissues. The base of a removable prosthesis is made of metal or denture resin.
base metal—Any metal element that doesn't resist tarnish and corrosion. Any metal that is not noble.
baseplate—See record base.
baseplate wax—A hard, pink wax used for making occlusion rims, waxing dentures, and many other dental procedures.
beading—

1. As in "beading a cast," to score a cast in any desired area to provide a seal between the finished prosthesis and the soft tissue.
2. As in "beading an impression," to rim an impression with a wax strip before pouring so all critical impression landmarks show up in the cast.

bead line—The indentation resulting from beading the cast.
beeswax—The wax derived from the bee's honeycomb; used in many dental waxes.
Bennett Movement—See laterotrusion.
bicuspid or premolar—A tooth having two cusps.
bifurcated—(forked) Having two roots.
bilateral—Having two sides. Any RPD having a major connector is called a bilateral appliance.
biocidal—Destructive to living organisms.
biteplane—See occlusal plane.
blind vent—See chill set.
block out—The process of eliminating undesirable undercut areas of a cast or denture. Most frequently used in preparing a cast for RPD construction. The undercut areas below the survey line on the teeth are blocked out with wax.
blockout tool—A rod used in the surveyor spindle to remove excess wax between the height of contour and the gingival border of abutment teeth on master casts.
blow torch—A device designed to mix gas and air so it can be ignited. The flame is directed on an object to heat or melt the object.
body of a clasp—Connects rest and clasp arms to the minor connector.
boiling point—The temperature at which the vapor pressure of a liquid is equal to the external pressure.
Boley gauge—A caliper-like instrument calibrated in millimeters and used for fine measurements in the laboratory.
bolus—The chewed up mass of food and saliva.
borax or sodium tetraborate—A white crystalline substance used as a flux in soldering and casting procedures.
boxing an impression—Wax wrapped around the impression for confining the dental stone as the cast is poured.
boxing wax—A pliable wax in strip form, used to box an impression.
bracing—The resistance to displacement in a lateral direction from masticatory forces.

bracing arm—See reciprocal arm.
brass—An alloy of about 60 to 70 percent copper; the remainder is zinc.
bridge—See fixed partial denture.
Brinell hardness—An index number denoting the relative surface hardness of a material, usually abbreviated "Bhn." Used in testing softer metals and nonbrittle materials such as gold, copper, and silver.
broken stress fixed partial denture—See interlock fixed partial denture.
bruxism—A clenching of the teeth accompanied by lateral motion in other than chewing movements of the mandible. Grinding or gritting of the teeth usually during sleep or nervous tension. Causes excessive wear of occlusal surfaces.
buccal—Pertaining to the cheek. The surface of the tooth toward the cheek.
buccal frenum—A connecting fold of membrane attaching the cheeks to the alveolar ridge in the bicuspid region of each arch. (plural: buccal frena)
buccal groove—Landmark on the buccal surfaces of mandibular molars, extending vertically from the occlusal surface down toward the cemento-enamel junction.
buccal notch—The V-shaped notch in the impression or denture formed by or for the buccal frenum.
buccinator muscle—The cheek muscle.
buff—To polish by rubbing or by holding the object against a revolving felt wheel impregnated with a polishing agent.
bur—A small rotating instrument used in the dental hand piece for cutting acrylic resin or metal. Also used by the dentist to cut enamel or dentin.
burlew discs—The rubber wheels impregnated with pumice, used for polishing dental restorations.
burn out—See wax elimination.
burn out temperature—The temperature that must be reached to properly eliminate a wax pattern from the mold and expand the mold.
burnish—The drawing or flattening out of a malleable metal through pressure. If a rounded instrument is repeatedly rubbed across the margin of a soft gold casting and the tooth, the gold will be thinned and spread over onto the enamel of the tooth.
butt joint—A type of joint in which the two pieces to be joined touch each other, but do not overlap.
calculus—The hard calcium-like deposit that forms on teeth and on artificial dentures.
cameo surface—The viewable portion of the denture. The part of the denture base normally polished. Includes the facial and lingual surfaces of the teeth.
Camper's line—An imaginary line on a patient's face running from the anterior border of the ala of the nose to the superior border of the tragus of the ear. The dentist uses this line to check the orientation of the occlusal plane of a complete denture.
canine—A tooth having one cusp or point; the third tooth from the midline. So named because it corresponds to the long teeth of a dog. Also called a cuspid.
canine or cuspid eminence—The prominence of labial bone that overlies the root of the upper canine
canine guided articulation—A form of mutually protected articulation in which the canines disengage the posterior teeth during an excursive mandibular movement. Also called cuspid guidance.
cantilever fixed partial denture—A fixed partial denture supported on only one end with one or more abutments.
cap—A term used for the top of a denture flask.
capillary attraction—The characteristic by which, because of surface tension, a liquid in contact with a solid is elevated or depressed as in a capillary tube.
carbon marker—A graphite stick that fits into the surveyor spindle. Used to make a line or mark on the master cast when surveying.

carborundum—A trade name for silicon carbide. Extremely hard blue crystals used as an abrasive in many dental stones and points.
caries—Tooth decay.
carnauba wax—A type of wax obtained from the South American palm tree used in some dental materials.
cast—

1. The positive reproduction of the mouth in stone or similar material on which a prosthetic appliance can be constructed.
2. To produce a shape by thrusting a molten liquid into a mold possessing the desired shape.

cast base—The portion of the removable prosthesis covering the edentulous ridges and supporting artificial teeth; made of metal. Also called metal base denture.
casting—

1. An object formed in a mold
2. The process of forming a casting in a mold.

casting machine—A device designed to hold the investment mold and melted metal that has the capability of forcing the melted metal into the mold by either centrifugal force, air pressure, or vacuum.
catalyst—A substance that accelerates a chemical reaction without affecting the physical properties of the material involved.
cathode—The negative pole of a source of electric current.
cement—Dental luting agents with the dual purpose of holding the casting on a tooth and protecting the pulp against thermal shock.
cementum—A soft, bone-like structure covering the root surface of the tooth.
centigrade—A heat measuring scale calibrated so the freezing temperature of water is 0 degrees and the boiling temperature of water is 100 degrees.
centimeter—A hundredth of a meter; 2.54 centimeters equals 1 inch.
central fossa—The rounded, relatively shallow depression found in molars in the approximate middle of the occlusal surface.
centric occlusion—The occlusion of teeth when the mandible is in centric relation; may or may not coincide with MI.
centric relation—A maxillomandibular relationship in which the condyles articulate with their respective discs in the anterior-superior position of the glenoid fossa against the articular eminences.
centrifugal—A force in a direction from the center, outward.
centripetal—A force in a direction from the periphery toward the center; the opposite of centrifugal.
ceramic—Having to do with the use of porcelain.
ceramic crown—A ceramic restoration restoring a clinical crown without a supporting metal substructure.
ceramo-metal—See metal ceramic restoration.
ceresin—A mineral wax often used as a substitute for beeswax.
cervical—Pertaining to the neck of a tooth.
cervical line—The line where the cementum and enamel join. Also known as the cementoenamel junction.
cervix—The neck of a tooth.
chalk—Calcium carbonate. A powder used for final polishing.

characterization—

1. (Dentures) Anything done to a denture to make it look natural, including staining the denture base, making special tooth arrangements, and staining the denture teeth.
2. (Metal ceramic restorations) Staining and/or modifying the surface texture and shape to make the restoration look natural.

checked tooth—A tooth with a hairline crack.
chewing cycle—See masticatory cycle
chill set—A riser or vent that does not extend outside the mold.
Christensen's phonemenon—The space occurring between opposing occlusal surfaces during mandibular protrusion. Occuring because of disclusion of posterior teeth in protrusion due to condylar guidance.
chroma—Saturation of a hue.
chuck—The lathe attachment that grips the various burs, abrasive wheels, or buffing wheels.
circumferential clasp—A clasp that approaches the undercut portion of a tooth from above the survey line.
clasp—The part of RPD that partly encircles the abutment tooth and helps to retain, support, and stabilize the appliance.
clasp arms—The shoulders and tips of a clasp; the part of the clasp that extends from the body out to the tip.
clasp shoulder—The part of the clasp arm that connects the body to the retentive terminal; the portion of the clasp arm closest to the body.
cleft palate—An opening in the palate in the hard or soft palate or in both. An acquired cleft palate is caused by surgery, disease, or accident. A congenital cleft palate is present at birth.
clinical crown—That part of a crown visible in the mouth above the gum line.
closed bite—Slang for decreased occlusal vertical dimension.
coalescence—The result of firing porcelain at an extremely high temperature.
cohesion—The molecular attraction by which the particles of a body are united throughout their mass.
cold cure—The polymerization of acrylic resins at room temperature. See autopolymerizing resin.
cold flow—A change in shape or dimension at a temperature lower than the normal softening point of the material.
collar—The neck of an artificial tooth below the cervical line used to embed and retain the tooth in a denture base.
combination clasp—A circumferential clasp assembly having one cast arm and one wrought wire arm.
compensating curve—The combination of the two curves made when the denture teeth are set on anteroposterior and lateral curves for purposes of achieving a balanced articulation.
complete denture—A dental prosthesis replacing all natural dentition and the associated structures of the maxilla or mandible.
compression molding—The method of denture molding employing a two-piece split mold. Acrylic resin dough is placed between the two halves of the mold, compressed, and cured under pressure.
concave—Curving inward; dished in.
condensation—The process of making a substance more compact.
conductivity—The property of conducting heat or electricity. Silver and copper are two of the best conductors.
condylar guidance—A device on an articulator intended to produce guidance in the articulator's movements similar to that produced by the paths of the condyles in the temporomandibular joints.
condylar guide inclination—The angle formed by the inclination of a condylar guidecontrol surface of an articulator to a specified reference plane; for example, horizontal condylar guide inclination.

condylar indication—The scale on the articulator measuring the amount of condylar inclination.
condylar path—The path of the mandibular condyle in the temporomandibular joint during mandibular movement.
condyle—The rounded articular surface at the articular end of a bone. In the temporomandibular joint, it is football shaped and found on the end of the condyloid process of the mandible.
condyle head—See condyle.
congenital—A condition occurring in the offspring before birth.
connective tissues—The tissues that bind together and support the various structures of the body.
connector—

1. In RPDs, a part of the framework that serves to connect two parts with another. Connectors are divided into major and minor.
2. In fixed prosthodontics, the portion of a fixed partial that connecting the retainers and the pontics.

contact surface—The area on a tooth touching an adjacent tooth. Normally found on both mesial and distal surfaces of all teeth except the third molars. Also called contact area.
continuous bar connector—A type of lower RPD that employs a second or auxilliary bar with a lingual bar. Also called a continuous bar retainer and double lingual bar.
contour—

1. (noun) The shape of a surface.
2. (verb) To shape into a desired form.

convex—A surface curved outward toward the viewer.
cope—The upper half of a denture flask.
coping—A thin covering or crown.
copper band—The hollow cylinders of thin copper in various diameters used to make impressions for crowns and inlays.
coronal—Pertaining to the crown portion of a tooth.
creep—To change shape permanently due to prolonged stress or exposure to high temperatures.
crest of the ridge—The high point of the alveolar ridge.
crossbite—See reverse articulation.
cross-section—A cut section of an object made so the cut is perpendicular to the object's long axis.
crown—

1. In anatomy, the part of the tooth covered by enamel.
2. In the laboratory, an artificial replacement that restores missing tooth structure with a metal or ceramic restoration.

crucible—The heat resistant container used to hold the metal while it is melted in preparation for casting.
crucible former—The device used to hold the sprued wax pattern upright in the casting ring when it is invested. Shaped to form a funnel for the gold as it enters the mold. Sometimes erroneously called a sprue former.
crushing strength—The amount of pressure required to crumble or crush a material.
crystallization—The solidification of a gaseous or liquid substance.
cure of denture—See polymerization.
Curve of Spee—See anteroposterior curve.
cusp—A cone-shaped elevation on the occlusal surface of a molar or bicuspid and on the incisal edge of the cuspid.
cuspid—See canine.

cuspid line—The vertical line the dentist scribes on the record rims to indicate the position the cuspid is to occupy in the setup.
custom tray—An impression tray made on a preliminary cast used to make the final impression.
cyanoacrylate—A quick setting adhesive. Also called super glue.
dappen dish—A glass medicine dish.
debubblizer—A wetting agent used to lower surface tension of the water in an investment so it flows more easily over the wax pattern.
decalcification—The loss or removal of calcium salts from calcified tissues. Characterized by areas of white, splotchy opacity on the surfaces of teeth.
deciduous tooth—A tooth that will be replaced by a permanent tooth.
decreased occlusal vertical dimension—A reduction in the distance between two points when the teeth are in occlusal contact. Also called closed bite.
deflask—The removal of the denture from the mold in the flask.
dehydrate—To remove the moisture from a substance.
density—The mass of a substance per unit volume.
dental arch—A term given to the horseshoe-like arrangement of either the upper or lower teeth or the residual ridge.
dental implant—A prosthetic device implanted within the bone to provide retention and support for a fixed or removable appliance.
dental plaster—A gypsum refined by grinding and heating.
dental stone—A specially calcined gypsum physically different from dental plaster in that the grains are nonporous and the product is stronger.
dental wax—Any of the various waxes used in dentistry.
dental wrought wire—An alloy in wire form manufactured by drawing it through die plates of varying diameters.
dentin—The tissue of the tooth underlying the enamel of the crown that makes up the bulk of the substance of the tooth.
dentition—The natural teeth as a unit.
dentulous—With teeth; as opposed to edentulous (without teeth). Also called dentate.
denture—See complete denture.
denture base material—The material of which the denture is made; exclusive of the teeth.
denture border—

1. The margin of the denture base at the junction of the polished surface and the impression surface.
2. The peripheral border of a denture base at the facial, lingual, and posterior limits. Also called peripheral roll.

denture foundation area—The surfaces of the oral structures available to support a denture.
denture staining—The process of adding pigments to the facial flange of the denture to more closely simulate natural mouth tissue.
deoxidizing—To remove oxides from the surface of a gold alloy by heating the alloy in an acid or other proprietary agent. Also called pickling.
deoxidizing investment—See reducing investment.
desiccate—To make dry; to remove all moisture.
desirable undercut—The part of an abutment tooth below the survey line that can be engaged by the clasp tip to retain the RPD.
developmental groove—A groove formed by the union of two lobes during the development of the crown of a tooth.
devitrification—To eliminate vitreous (glass) characteristics partly or wholly; to recrystallize.

diagnosis—The determination of the nature of the disease condition present in a patient.
diagnostic cast—A reproduction of the mouth for the purpose of study and treatment planning.
diamond point—Small mounted points impregnated with diamond particles, used in the dental hand piece.
diastema—A space between the teeth.
diatoric—A channel placed in the denture tooth as a mechanical means of retaining it in the denture base.
die—The positive reproduction of a prepared tooth in any suitable substance.
dimensional stability—The ability of a material to retain its size and form.
direct current—The current in which the electricity flows along a conductor in one direction.
direct inlay technique—The method of inlay construction in which the wax pattern is made on the tooth in the mouth by the dentist.
direct retainer—The part of an RPD appliance designed to directly resist dislodgement; for example, the clasp.
disc—A flat circular plate, usually impregnated with an abrasive agent, used in the laboratory to smooth and polish. The abrasive agent may be silica, garnet, emery, or some other agent.
disclude—Separation of the maxillary and mandibular teeth.
disinfectant—An agent that kills infecting agents; for example, phenol.
distal—A surface facing away from the midline of the mouth; the distal surface of a tooth.
double lingual bar—See continuous bar connector.
dough—The moldable mixture formed by combining acrylic resin powder and liquid.
dovetail—A widened portion of a prepared cavity used to increase retention.
dowel—A post, usually made of metal, fitted into the prepared root canal of a natural tooth. Also called post and core.
drag—A term for the lower half of a denture flask.
dry heat—The heat of a flame (as opposed to moist heat from a water bath).
ductility—The property of a metal that permits it to be drawn into a wire without breaking.
duplicate cast—A cast produced from an impression of another cast.
duplicating a cast—The process of producing a duplicate cast.
duplicating material—A substance such as hydrocolloid used to make an impression so an accurate copy of the cast can be produced.
eccentric—Any position of the mandible other than its normal position.
edentulous—Without teeth; may be an area, arch, or entire mouth.
elastic—Susceptible to being stretched, compressed, or distorted and then tends to resume the original shape.
elastic limit—The extent to which a material may be deformed and still returned to its original form after removal of the force.
electric current—The flow of electrons from one point to another.
electrode—Either pole of an electric mechanism.
electrolyte—The liquid used in electroplating.
electroplating—The process of covering the surface of an object with a thin coating of metal by means of electrolysis.
electropolishing—The removal of a minute layer of metal by electrolysis to produce a bright surface.
elongation—The amount a metal will stretch before breaking.
embrasure—The space defined by surfaces of two adjacent teeth. The space is divided into occlusal/incisal, facial, lingual, and gingival areas.

emergence profile—The contour of a tooth or restoration, such as a crown on a natural tooth or dental implant abutment, as it relates to the adjacent tissues.
emery—An abrasive substance used as a coating on paper discs used to smooth and polish.
eminence—A prominence or projection, especially on the surface of a bone.
enamel—The white, compact, and very hard substance that covers and protects the dentin of the crown of teeth.
enamel rod—The microscopic prisms, held together by an intercementing substance and forming the bulk of the enamel.
endodontia—The branch of dentistry dealing with diagnosing and treating nonvital teeth.
envelope of motion—The three-dimensional space made by the mandibular border movements in which all unstrained mandibular movement occurs.
equilibration of occlusion—See occlusal equilibration.
erosion—The superficial wearing away of tooth substance due to chemical agents. Most often seen on labial and buccal surfaces.
esthetics—Harmony of form, color, and arrangement. The quality of a pleasing appearance.
etiology—The causative factors which produce a disease.
eugenol—

1. An aromatic oil derived from clove oil to relieve pulpal pain.
2. May also be combined with zinc oxide to make a temporary sedative cement.
3. A principal ingredient in zinc oxide eugenol impression pastes.

excursion—The movement occurring when the mandible moves away from MI.
external or lateral—Surfaces farther from the medial plane.
extracoronal—Outside of the crown portion of a natural tooth.
extraoral—Outside of the mouth.
extrinsic—Outside, as opposed to intrinsic or inside.
extrinsic coloring—Coloring from without; applying color to the external surface of a prosthesis.
extrusion—The movement of teeth beyond the natural occlusal plane; may be accompanied by a similar movement of their supporting tissues and/or bone.
face form—The outline of the face from an anterior view.
face profile—The outline of the face from the side or lateral view.
facebow—A device used to record the relationship between the maxillae and the temporomandibular joints and to transfer this relationship to the articulator.
facebow fork—A device used to attach the facebow to an occlusion rim, or to index the maxillary teeth, for a facebow transfer.
facial—

1. Pertaining to the face.
2. The surface of the tooth or appliance nearest the lips or cheeks. Used synonymously for the words buccal and labial.

facing—The thin veneer of porcelain or resin that closely fits a metal backing; used in fixed dentures and RPDs.
facial moulage—A negative reproduction of the face made out of artificial stone, plaster of paris, or other similar materials.
female attachment—See matrix.
festooning—Shaping and contouring a denture wax-up or the cured denture base to simulate natural tissue.
fin—A flash of excess metal that results from a fracture in the investment mold.
fineness—The proportion of pure gold in a gold alloy; the parts per 1,000 of gold.

finish line—

1. On an artificial tooth, the raised line in the cervical region used as a guide to trim the wax on the denture base material.
2. In RPDs, the special preparation placed in the metal to form a definite sharp junction between the metal and acrylic resin.

finishing—

1. The process of smoothing and trimming a prosthesis before its final polish.
2. The entire procedure of smoothing and polishing.

first molar—The 6-year molar. The sixth tooth from the midline.

fissure, dental—A fault in the surface of a tooth caused by the imperfect joining of the enamel of the different lobes.

fistula—An abnormal passage resulting from incomplete healing.

fixed bridge—See fixed partial denture.

fixed partial denture—A fixed dental prosthesis, cemented to the prepared teeth or attached to implants, restoring one or more, but fewer than all of the missing natural teeth.

fixture—

1. Something fixed or attached.
2. The intraosseous portion of a dental implant.

flange—The part of the denture base that extends on the facial or lingual surface from the finish lines of the teeth to the periphery.

flash—

1. The overflow of denture base material that results from over-packing a denture mold.
2. The thin metal fins that sometimes occur on castings.

flash point—The temperature at which a vapor ignites.

flask—

1. A metal case or tube used in investing procedures. Holds the casts and the investment during the packing and curing phases of denture construction. The metal ring used to invest a wax pattern.
2. To flask or surround; to invest.

flasking—The process of investing a waxed pattern to create a mold.

flat plane tooth—See nonanatomic teeth.

flexible—Capable of being bent without breaking.

flexure line—See vibrating line.

flow—Deformation of a material under loading.

flow on wax—To melt and apply the wax in liquid form.

flux—

1. A substance used to increase fluidity and prevent or reduce oxidization of a molten metal.
2. Any substance applied to the surfaces to be joined by soldering to clean and free them from oxides and promote union.

foil—An extremely thin, pliable sheet of metal, usually of variable thickness.

foramen—An opening in a bone or tooth allowing for the entrance or exit of blood vessels and nerves; for example, the apical foramen in the tooth.

fossa—An anatomical pit, groove, or depression.

fovea palatina—Two small pits or depressions in the posterior aspect of the palate, one on each side of the midline at or near the attachment of the soft palate to the hard palate.

fox plate—A device occasionally used by dentists to establish the occlusal plane on occlusion rims. Used to compare with arbitrary lines or planes on the head; for example, Camper's line.

framework—The metal skeleton of an RPD or metal-ceramic fixed partial denture.

Frankfort horizontal plane—A horizontal plane represented in profile by a line between the lowest point on the margin of the orbit to the highest point on the margin of the auditory meatus. It nearly parallels the upper member of an articulator, making it a useful plane of orientation for setting denture teeth.
freehand waxing—A method of waxing in which wax is flowed from an instrument directly onto the refractory cast to form the removable partial denture framework.
freeway space—See interocclusal rest space.
frenum—See frenulum. (Plural: frenums or frena.)
frenulum—The small band or fold of connective tissue covered with mucous membrane that attaches the tongue, lips, and cheeks to adjacent structures.
friable—Capable of being easily crumbled into small pieces; brittle.
frontal bone—The bone that forms the front part of thecranium.
fulcrum—The support on which a lever rests when a force is applied. In RPDs, an abutment tooth may act as a fulcrum for the appliance.
fulcrum line—An imaginary line through the abutment teeth around which an RPD would rock if not prevented from doing so.
functional mandibular movements—All natural, proper, and characteristic movements of the mandible made during speaking, chewing, yawning, swallowing, etc.
furnace—
1. burnout—The gas or electric oven used to eliminate the wax from a mold.
2. porcelain—A specially constructed oven used to fuse dental porcelain.

fusible—Able to be melted.
fusion temperature—The highest temperature to which an alloy can safely be exposed in the soldering process. Usually close to the lower limit of the melting range.
gauge—A measure of the thickness or diameter of an object.
galvanic current—A current of electricity produced by chemical action between two metals suspended in liquid.
garnet—An abrasive, glass-like coating on paper discs used for smoothing and polishing.
gelatin—The solidification of a liquid substance in which a gel forms and acts as a matrix between the undissolved particles. Alginate gels as it sets.
gingiva—The gum tissue.
gingival crevice—The shallow fissure formed by the attachment of the gingiva to the crown of the tooth.
gingivectomy—The removal of the gingival tissue from around the necks of the teeth.
gingivitis—An inflammation of the gingiva.
glaze—The final firing of porcelain in which the surface is vitrified and a high gloss is imparted to the material.
gold—A noble metal used extensively in dentistry, most commonly in the form of an alloy.
gold alloy—An alloy consisting of gold mixed with other metals, such as silver, platinum, copper, and palladium.
grain—The basic unit for the apothecaries' avoirdupois and troy systems of weight. A troy grain is 1/24 of a pennyweight.
grain growth—The merging of smaller grains into larger grains of metal during prolonged heating of the appliance at excessively high heat. This process produces a brittle metal.
gram—A unit of weight in the metric system, equal to approximately 15 grains in the apothecaries' system of weight.
groove—A long narrow depression on the surface of a tooth, such as the indentation between two cusps.

group function—Multiple contact relations between the maxillary and mandibular teeth in lateral movements on the working side; simultaneous contact of several teeth act as a group to distribute occlusal forces. Also called unilateral balance.
gypsum—The natural hydrated form of calcium sulfonate.
half flasking—The process of investing the denture in the lower or first half of the denture flask.
hamular notch—See pterygomaxillary notch.
handpiece or straight handpiece—The instrument used to hold and spin burs and mounted points in dental operations.
hard palate—The anterior two-thirds of the roof of the mouth composed of relatively hard, unyielding tissue.
hardening heat treatment—See tempering.
heat soaking—The process of allowing the invested inlay or RPD to remain in the oven at the burnout temperature for a prescribed length of time to remove all carbon and properly expand the mold.
heat treatment—In its broadest sense, the annealing or tempering of an alloy. (Sometimes the term heat treatment is confined solely to the tempering.)
heel of a denture—The posterior extremities of a denture. The heel corresponds with the retromolar pad area of the lower denture and the tuberosity area of the upper denture.
height of contour—The greatest circumference of the crown of a tooth.
high lip line—The horizontal line the dentist marks on the occlusion rim to indicate the approximate level of the upper lip when the patient smiles. Used to help select the length of the anterior teeth.
highly adjustable articulator—An articulator that allows replication of three dimensional movement of recorded mandibular motion.
hinge axis—See transverse horizontal axis.
hinge joint—A joint that moves in only two directions, such as the knee joint.
horizontal overlap—The projection of teeth beyond their antagonists in a horizontal direction. Also called overjet.
hue—The basic color. White, black and grays possess no hue.
humidor—A container used to maintain a humid atmosphere.
hydration—The addition of water to a substance. Plaster that has absorbed water from the air is said to be hydrated.
hydrocal—A form of gypsum that is harder and more durable than ordinary dental plaster.
hydrocolloid—An impression material used extensively in dentistry. It may be reversible agar type or irreversible alginate type.
hydrocolloid, irreversible, alginate type—An impression material supplied as a powder to be mixed with water. It can only be used once; hence, the name “irreversible.”
hygienic pontic—A pontic that is easier to clean because it has a domed or rounded cervical form and does not have contact with the ridge. Generally used in the posterior where esthetics are of no concern.
hyperplasia—The abnormal overgrowth of a part. Increase in size and number of cells.
hyperplastic tissue—Excessive tissue proliferation, usually as a response to chronic irritation.
immediate denture—A complete denture or RPD fabricated for placement immediately following the removal of natural teeth.
implant—See dental implant.
impression—A negative reproduction of a given area.
impression paste—A material usually supplied as a base and a hardener to be mixed together and used as a corrective impression material.
impression plaster—Plaster of paris made expressly for impressions of the mouth. It contains accelerators and, usually, coloring and flavoring agents. It may also contain starch.

impression tray or stock tray—See stock impression tray.
impression tray, individual—See custom tray.
impression, final—An impression used to form the master cast.
impression, functional—An impression that captures supporting structures in the form they will assume during mastication.
impression, pickup—An impression in which an object is lifted off the teeth by the impression material. When the cast is poured, the object will be seated in its proper place on the cast.
impression, two-piece—An impression taken in two separate steps with (usually) two separate types of impression materials.
incisal—The cutting edge of the anterior teeth.
incisal edge—The biting edge of an anterior tooth.
incisal pin—See anterior guide pin.
incisal rest—A rigid extension of an RPD that contacts a tooth at the incisal edge.
incisal table—See anterior guide table.
incisive foramen—An exit hole for blood vessels and nerves found behind the maxillary central incisors in the midline. The foramen is covered by the incisive papilla.
incisive papilla—A small pad of tissue located at the midline just behind the crest of the maxillary ridge which protects the vessels and nerves as they exit from the incisive foramen.
incisor—Teeth with cutting edges; the centrals and laterals.
inclination—Deviation of the long axis of a tooth with respect to a vertical line of reference. The four basic directions of inclination are described as facial, lingual, distal, and mesial.
inclined plane—A surface that slopes at an angle from the horizontal plane.
index—A guide, usually of a rigid material, used to reposition teeth or other parts in some original position.
indirect inlay technique—A method of waxing the pattern on a die outside of the mouth.
indirect retainers—A part of an RPD framework located on the opposite side of the fulcrum line from tipping forces and designed to counteract those forces.
induction casting machine—A specially constructed casting machine that melts metal by using an electric current of extremely high frequency.
induction current—The process of generating an electric current in a conductor using a magnetic field.
inferior—Below**.**
infrabulge—The area on a tooth below the survey line.
infrabulge clasp—See bar clasp.
ingot—Gold supplied in the form of one or two pennyweight (1.55 or 3.1 grams) pieces. Some of the base metal alloys are supplied in small cylinders and are also called ingots.
initial set—The first hardening of a gypsum product.
injection flask—A denture flask designed to permit compression molding of an acrylic resin denture with a sprue leading into the mold.
injection molding—The method of denture molding by adapting a plastic material into a closed mold by forcing or pressing the material through sprue channels.
inlay—A restoration made to fit inside a prepared tooth cavity and cemented into place.
insertion—

1. The attachment point for a muscle in the bone or other structure to be moved.
2. See placement.

intaglio surface—The portion of the denture or other restoration having its contour determined by the impression; the internal or reversal surface of an object. Also called internal surface or tissue surface.

interarch distance—The interridge distance; the vertical distance between the maxillary and mandibular edentulous arches under specified conditions. Also called intermaxillary space.
intercondylar distance—The distance between the rotational centers of two condyles.
interdigitation—See maximum intercuspation (MI).
interim prosthesis—A fixed or removable prosthesis, designed to enhance esthetics, stabilization, and/or function for a limited period of time, after which it is replaced by a permanent prosthesis.
interlock—A device connecting a fixed unit or a removable prosthesis to another fixed unit.
interlock fixed partial denture—A fixed partial denture constructed in two pieces containing a matrix and patrix. Also called broken stress fixed partial denture.
intermaxillary space—See interarch distance.
intermediate abutment—A natural tooth located between terminal abutments serving to support a fixed or removable prosthesis.
internal or medial—Surfaces closer to the medial plane.
interocclusal rest space—The difference between the vertical dimension at rest and the vertical dimension in occlusion. Also called freeway space.
interproximal—Between adjoining tooth surfaces.
interproximal space—The space between two adjacent teeth.
intraoral—Within the mouth.
intraoral tracing—A tracing made within the mouth.
intrinsic coloring—Coloring from within; the incorporation of a colorant within the material of a prosthesis or restoration.
inverted spruing—A method of spruing a cast RPD in which a hole is made in the investment model so the sprue approaches the wax pattern from underneath.
invest—To envelop or embed an object in an investment material.
investment—

1. The gypsum material used to enclose a denture wax pattern in the flask, forming a mold.
2. In fixed or removable prosthetics, a heat resistant material used to enclose a wax pattern before wax elimination.

investment cast—See refractory cast.
jacket crown—See ceramic crown or resin crown.
jaw—A common name for the maxillae or mandible.
jaw relation—See maxillomandibular relationship.
Kennedy classification—A system of classifying partially edentulous arches based on the pattern of tooth loss.
key—

1. The preparation, such as a groove made in an object, against which a stone matrix is poured. The hardened stone matrix can then be removed and returned to its original position as often as desired.
2. To prepare a surface with a cut or groove.

Knoop hardness—A surface hardness test using a diamond stylus.
labial—Pertaining to the lips. The surface of an anterior tooth opposite the lips.
labial bar—The metal piece or major connector connecting the right and left sides of a lower RPD. Contoured to the labial tissue anterior to the lower teeth.
labial frenum—The connective tissue attaching the upper or lower lip to the alveolar ridge at or near the midline.
labial notch—The V-shaped indentation in an impression or denture, formed by or for the labial frenum.
lamina dura—The layer of compact bone forming the wall of a tooth socket.

land area—The portion of a dental cast extending beyond the impression's replica surface, laterally defining the area between the end of the replica's surface and the cast.
lateral condylar path—The path of the condyle in the temporomandibular fossa when the mandible moves laterally.
lateral incisor—An anterior tooth located just distal to the central incisor. The second tooth from the midline.
lateral interocclusal record—A jaw relationship record of the teeth with the mandible in a functional position.
laterotrusion—Condylar movement on the working side in the horizontal plane. This term may be used in combination with terms describing condylar movements in other planes; for example, laterodetrusion, lateroprotrusion, lateroretrusion, and laterosurtrusion.
ledging—The process or method of forming a ledge in the blockout wax on an abutment tooth. The ledge is created in the exact area where the retentive tip of the clasp is to be placed.
lesion—Any hurt, wound, or local degeneration.
leverage—A mechanical principle in which force is multiplied by extending the lifting force farther from and on the opposite side of the fulcrum from the object to be moved.
line angle—The angle formed by the union of two surfaces of a tooth. The junction of the mesial surface with the labial surface of an incisor is called the mesiolabial line angle.
lingual—Pertaining to the tongue. The surface of a tooth or prosthesis next to the tongue is the lingual surface.
lingual bar—The metal piece of a major connector used to connect the right and left sides of a lower RPD. It is contoured to the lingual tissue behind and below the anterior teeth.
lingual flange—The part of a denture or impression extending from about the crest of the ridge to the periphery on the lingual surface.
lingual frenum—The band of tissue attaching the tongue to the floor of the mouth.
lingual notch—

1. The indentation on the lingual periphery of a lower impression made by the lingual frenum.
2. An indentation provided in the same area of the denture to allow free movement of the lingual frenum.

lingual plate—The solid plate of metal that is continuous with the lingual bar and rests against the lingual surfaces of the anterior teeth. It functions as a connector and sometimes as a periodontal splint for loose teeth.
lingual rest—A rest on an RPD placed on the lingual surface of an anterior tooth. Sometimes used on the free end of a cantilever fixed partial denture.
lingualized articulation—A denture occlusion using anatomic maxillary teeth against nonanatomic mandibular teeth. Also called lingualized occlusion.
long axis—An imaginary line passing lengthwise through the center of a tooth.
low fusing alloy—Any one of the alloys that melt at very low temperatures.
major connector—A part of an RPD framework connecting one side of the appliance with the other. A lingual bar is an example.
male attachment—See patrix.
malleability—The property of a metal that permits it to be extended in all directions without breaking.
malocclusion—Defective occlusion or deviation from normal occlusion.
malposition—Incorrect positioning of teeth.
mamelons—Small elevations of enamel present on incisors as they erupt; quickly worn down during mastication.
mandible—The lower jaw.

mandibular—To refer to the mandible or lower jaw.
mandibular translation—The translatory (medio-lateral) movement of the mandible when viewed in the frontal plane.
mandrel—The spindle or shank that fits into the lathe chuck or handpiece and holds a stone or disc.
margin—
1. A border or boundary, as between a tooth and a restoration.
2. The outer edge of a crown, inlay, or onlay.

marginal ridge—The elevations of enamel forming the mesial and distal boundaries of the occlusal surfaces of the posterior teeth and the mesial and distal boundaries of the lingual surfaces of the anterior teeth.
masking—The process of applying an opaque covering to camouflage the metal component of a prosthesis. Also called opaqueing.
masseter muscle—A muscle of mastication that extends from the external surface of the angle of the mandible to the zygomatic process.
master cast—The positive reproduction in stone made from the final impression.
master impression—The negative impression from which the master cast is made.
mastication—The chewing of food.
masticatory cycle—A three-dimensional representation of mandibular movement produced during the chewing of food. Also called chewing cycle.
matrix—
1. The mold in which something is formed to use as a relationship record. See index.
2. The portion of a dental attachment system that receives the patrix. Also called female attachment.

maxilla—The upper jaw.
maxillary—To refer to the maxilla or upper jaw.
maxillary orthopedic appliance (bite guard)—See maxillary orthotic appliance.
maxillary orthotic appliance—An acrylic resin appliance designed to cover the occlusal and incisal surfaces of the maxillary teeth of a dental arch to stabilize the teeth and/or provide a flat platform for unobstructed excursion glides of the mandible.
maxillary tuberosity—An area in the form of a bulge at the posterior end of the maxillary alveolar ridge.
maxillofacial prosthetics—A subspecialty of prosthodontics where prostheses are fabricated to replace missing or damaged head and neck structures; for example, artificial eyes, ears, noses, or obturator dentures.
maxillomandibular relationship—Any spatial relationship of the maxilla to the mandible. Also called jaw relation.
maxillomandibular relationship record or registration—A record of the relationship of the mandible to the maxillae.
maximum intercuspation (MI)—The complete intercuspation of the opposing teeth independent of condylar position.
medial raphe—The fibrous tissue extending along the middle of the hard palate.
median line—
1. An imaginary line extending through the middle of the face.
2. The midline of a cast.

median (medial)—Toward the middle.
median plane—The plane dividing the body in equal left and right halves.
melting point—The point at which a pure metal becomes molten, or changes from a solid to a liquid.

melting range of an alloy—The interval between the temperature at which the alloy begins to melt (solidus) and the temperature at which it is completely molten (liquidus).
mental foramen—A foramen on the facial surface of the mandible near the roots of the bicuspids, through which the mental vessels and nerves pass.
mesial—The surface of a tooth nearest the midline in a normal occlusion.
metal—A substance that, to some degree, is malleable and ductile and conducts heat and electricity.
metal base denture—See cast base.
metal ceramic restoration—A fixed restoration consisting of a metal alloy substructure covered with a veneer of porcelain. Also known as porcelain fused to metal and ceramo-metal restoration.
metamerism—The phenomenon occuring when the color of two objects match in one lighting condition, but do not match in others.
methyl-methacrylate—The chemical name for synthetic acrylic resin. One of its most common uses is as denture base material for complete dentures and RPDs.
metric system—A decimal system of weights and measures. The basic units are the meter for length and grams for weight or mass.
midline—The imaginary line through the middle of an object, dividing the object into equal parts.
milliampere—One-thousandth (1/1000) of an ampere.
millimeter—A unit of length in the metric system equal to 1,000 microns or one-thousandth of a meter.
mill in—

1. The procedure of refining occluding surfaces through the use of abrasive materials.
2. The machining of boxes or other forms in cast restorations to be used as retainers for fixed or removable prostheses.

minor connector—The part of an RPD uniting clasps and rests to the remainder of the framework.
modeling plastic impression compound—A thermoplastic dental impression material.
modulus of elasticity—A complex measure of the elasticity of a material determined by its ratio of stress to strain. As the modulus of elasticity rises, the material becomes more rigid.
molars—The teeth situated in the posterior region of the mouth. The teeth behind the premolars.
mold—

1. The hollow form or matrix in which an object is cast or shaped.
2. The shape of an artificial tooth.

monomer—A chemical compound that can undergo polymerization. The most common is methyl methacrylate liquid.
morphology, tooth—The study of the form and structure of a tooth.
mounting—

1. The laboratory procedure of attaching a cast to an articulator.
2. The relationship of dental casts to each other and the instrument to which they are attached.

mounting plate—The removable metal, resin, or plastic piece that attaches the dental casts to the upper and lower members of the articulator.
mucolabial fold—The junction between the cheek and the alveolar mucosa of the upper or lower jaw.
mucous membrane—The soft tissue outlining the mouth.
mutually protected articulation—An occlusal scheme in which the posterior teeth prevent excessive contact of the anterior teeth in MI and the anterior teeth disengage the posterior teeth in all mandibular excursive movements.
mutually protected occlusion—See mutually protected articulation.
mylohyoid ridge—An oblique ridge on the lingual surface of the mandible that extends from the level of the roots of the last molar teeth and serves as a bony attachment for the mylohyoid muscles forming the floor of the mouth.

nasal bone—The two small bones forming the arch of the nose.
nasolabial fold—The crease between the nose and the upper lip.
noble metal—A metal not readily oxidized at ordinary temperatures or by heating; for example, gold or platinum.
non-noble—A metal that is expected to form oxides or sulfides; for example, silver or tin.
nonanatomic teeth—Artificial teeth that do not conform to the anatomy of natural teeth. Also called flat-plane or zero-degree teeth.
nonprecious—Metals or alloys that are not scarce and do not possess a high intrinsic value. Examples are nickel and chromium. The term "nonprecious" is regarded by many as less technically correct than the preferred term "base metal."
nonworking side—The side of the mandible that moves toward the median line in a lateral excursion. The side opposite the side toward which the mandible moves. Also called balancing side.
nonworking side occlusal contacts—Contacts of the teeth on the side opposite the side toward which the mandible moves in articulation. Also called balancing side occlusal contacts.
oblique ridge—The transverse ridge of enamel crossing the occlusal surface of the upper molars from mesiolingual to distofacial.
obturator—A prosthesis used to close an abnormal opening between the oral and nasal cavities.
occipital bone—The bone forming the posterior portion and base of the skull.
occlude—To bring together; to bring the upper and lower teeth together.
occlusal equilibration—

1. To equalize.

2 To remove high spots and areas of interference. To adjust the contact areas between the upper and lower teeth so each tooth carries an equal share of the occlusal load.

occlusal plane—The plane established by the occlusal surfaces of the bicuspids and molars of both the upper and lower jaws in opposition. May also refer to the same plane established in the occlusion rims.
occlusal rest—The part of the RPD that contacts the occlusal surface of the tooth.
occlusal surface—The biting, grinding, or chewing surfaces of molars and bicuspids.
occlusal vertical dimension—The distance measured between two points when the occluding members are in contact. Also called vertical dimension of occlusion.
occlusion—

1. The act or process of closure or of being closed or shut off.
2. The static relationship between the incising or masticating surfaces of the maxillary or mandibular teeth.

occlusion rim—See record rim.
opaqueing—See masking.
open bite—Slang for open occlusal relationship.
open occlusal relationship—The lack of tooth contact in an occluding position. Also called open bite.
orbitale—The lowest point in the margin of the orbit (directly below the pupil when the eye is open and the patient is looking straight ahead) that may readily be felt under the skin. Can be used as a reference point for making a facebow record.
orientation of occlusal plane—The position the occlusal plane is to occupy between the upper and lower ridges.
origin—The fixed point of attachment of a muscle.
oven, burnout—See furnace.
overdenture—A prosthesis that covers and is partially supported by natural teeth, tooth roots, and/or dental implants.
overjet—See horizontal overlap.

overjet principle—The spruing method used to reduce casting turbulence in an RPD mold. In this system, the sprue leads exit the main sprue below its tip.
ovoid arch form—A dental arch that is oval or round in outline.
oxidation—The process of heating a metal substructure in a porcelain furnace to cleanse the porcelain-bearing surfaces of contaminants and produce an oxide layer for porcelain bonding. Also called degassing.
oxidize—To combine with oxygen; for example, iron rust or brass tarnish.
oxypropane torch—A blowtorch mixing propane gas and pure oxygen to produce a much hotter flame than either natural gas and air or propane and air.
packing a denture—To place the acrylic dough in the mold and close the flask.
palatal bar connector—A major connector of an RPD that crosses the palate and is characterized by being relatively narrow anteroposteriorly.
palate—The roof of the mouth; classified into both hard and soft palate areas.
palatine bone—The paired bones forming the posterior one-third of the hard palate.
pantograph—An instrument used to graphically record in one or more planes paths of mandibular movement and provide information for the adjustment of an articulator.
papillary hyperplasia—Abnormal tissue growth found on the hard palate.
paraffin—A white, waxy hydrocarbon distilled from coal or petroleum and used to compound several dental waxes.
parafunctional mandibular movement—Disordered movement of the mandible; for example, movements associated with tension, emotion, or aggression.
parietal bone—The two quadrilateral bones forming the sides of the skull.
partial veneer crown—A restoration restoring all but one coronal surface of a tooth, usually not covering the facial surface.
Passavant's cushion or pad—A small bulge of soft tissue on the posterior and lateral walls of the nasopharynx at the level of the hard palate. Aids in closing the opening between the nasal and oral cavities when swallowing.
Passavant's ridge—See Passavant's cushion or pad.
passive—

1. Not active or in operation.
2. Resistant to corrosion.
3. Existing or occurring without being active, direct, or open.

passivity—The quality or condition of inactivity or rest assumed by the teeth, tissues, and denture when an RPD is in place, but not under masticatory pressure.
pathogen—Any disease producing agent; for example, a virus, bacterium, or microorganism.
pathogenic—Capable of producing disease.
path of insertion—See path of placement.
path of placement—The specific direction in which a prosthesis is placed on the abutment teeth.
patrix—The extension of a dental attachment system that fits into a matrix. Also called male attachment.
pennyweight—See Troy weight.
periapical—The area around the apex or root tip of a tooth.
periodontics—The branch of dentistry dealing with the science and treatment of the tissues and bone surrounding the teeth.
periodontium—Collectively**,** the tissues surrounding and supporting the tooth.
periosteum—The tough fibrous membrane covering the outer surface of all bone except at articular surfaces.

peripheral roll—See denture border.
petrolatum—A lubricant used as a separator in many dental laboratory procedures.
phonation—Action constituting a source of vocal sound.
phonetics—

1. The science or study of speech sounds and their production, transmission, and reception.
2. The symbols representing the speech sounds of a language. A denture patient's ability to say "s" and "ch" clearly with the appliance in place.

physiology—The branch of biology dealing with the functions and activities of living organisms and their parts, including all physical and chemical processes.
physiologic rest position—The position of the mandible where all the masticatory muscles are in a relaxed state.
pier abutment—See intermediate abutment.
pigment—A finely ground powder used to impart color to a material.
placement—The process of directing a prosthesis to a desired location; the introduction of prosthesis into the patient's mouth. Also called insertion.
plaster of paris—A white, powdery, slightly hydrated calcium sulfate used to make casts and molds when combined with water to form a quick setting paste.
plastic—

1. Capable of being shaped or formed.
2. Pertaining to the alteration of living tissues.
3. Any of numerous organic synthetic or processed materials that are generally thermoplastic or thermosetting polymers. They can be cast, extruded, molded, drawn, or laminated into films, filaments, and objects.

pit—A depression usually found where several developmental lines intersect.
point angle—The angle made on a tooth by the convergence of three planes or surfaces.
polishing agent—Any material used to impart a luster to a surface.
polymer—Compound (powder) composed of smaller organic units. Most common in dentistry is methyl methacrylate powder.
polymerization—The reaction that takes place between the powder and liquid during the curing of acrylic resin. Characterized by joining together molecules of small molecular weights to a compound of large molecular weight.
pontic—The part or parts of a fixed partial denture replacing a missing tooth or teeth, usually restoring function and space occupied by the natural crown.
porcelain—A ceramic material. In dentistry, most porcelains are glasses and are used in the fabrication of teeth for dentures, pontics, facings, metal ceramic restorations, and other restorations.
porcelain fused to metal restoration—See metal ceramic restoration.
porous—Pitted; not dense. Containing voids and bubbles.
porosity—The presence of voids or pores within a structure.
post—

1. A retention mechanism for acrylic resin teeth used on an RPD.
2. The portion of a dowel (post and core) restoration that extends into the root portion of a tooth.

posterior—Situated in back of or behind.
posterior palatal seal—See postpalatal seal
postpalatal seal—An elevation of acrylic resin on the tissue side of the posterior border of a maxillary appliance for the purpose of sealing it against the resilient soft tissue in the palate.
posterior tilt—When a cast is surveyed with the posterior part of the cast lower than the anterior.
posterior teeth—Premolars and molars.

precious metal—A metal containing primarily elements of the platinum group, gold, and silver.
precious metal alloy—An alloy predominantly composed of elements considered precious.
precision attachment—A retainer consisting of a metal receptacle (matrix) and a closely fitting part (patrix). The matrix is usually contained within the normal or expanded contours of the crown on the abutment tooth; the patrix is attached to a pontic or RPD framework.
preliminary cast—A cast formed from the preliminary impression used for the purpose of diagnosis, treatment planning, or the fabrication of a custom tray.
preliminary impression—A negative reproduction made to form a preliminary cast.
process—

1. A prominence or projection of bone.
2. In dentistry, any technical procedure that incorporates a number of steps; for example, the procedure of polymerization of dental resins for prostheses or bases.

prognosis—A forecast of the probable outcome of an illness.
propane—A flammable gas found in petroleum and natural gas.
prophylaxis—The removal of calculus and stains from the teeth.
proportional limit—The amount of stress a metal will stand before it is permanently stretched or bent; a measure of the strength and toughness of an alloy.
prosthesis—An artificial replacement for a lost part of the body. In dentistry, it is used in the more limited sense of a strictly dental replacement. (Plural: prostheses.)
prosthodontics—The branch of dentistry pertaining to the restoration and maintenance of oral function, comfort, appearance, and health of the patient by the restoration of natural teeth and/or the replacement of missing teeth and contiguous oral and maxillofacial tissues with artificial substitutes.
protrude—To project forward.
protrusion—

1. The act of protruding something forward.
2. In dentistry, a position of the mandible anterior to centric relation.

protrusive interocclusal record—A registration of the mandible in relation to the maxillae when both condyles are advanced in the temporal fossa.
protrusive articulation—Occlusal contact relationships between maxillary and mandibular teeth when the mandible moves into a forward position.
protruberance—A projecting part; bulge.
proximal—

1. Situated close to.
2. Next to or nearest the point of attachment or origin—a central point.

proximal tooth surface—The surface of a tooth that lies next to another tooth.
pterygomaxillary notch—The notch formed by the junction of pterygoid hamulus of the sphenoid bone and maxilla. Located just posterior to the maxillary tuberosity. Also called hamular notch.
pulp—The connective tissue found in the pulp chamber and canals and made up of arteries, veins, nerves, and lymph tissue.
pumice—A type of volcanic glass used as an abrasive agent in many polishing procedures.
quadrant—One of the four sections of the dental arches, divided at the midline.
quench—To cool suddenly by plunging into a liquid.
quick cure resin—See autopolymerizing resin.
ramus—The ascending part of the mandible.
rational posterior teeth—See nonanatomic teeth.
rebase—Complete replacement of the denture base, saving only the denture teeth.

reciprocal arm—The rigid arm of the clasp located on the tooth, opposing any pressure exerted by the retentive arm. Acts to stabilize the appliance and resist lateral displacement. Also called bracing arm or reciprocal clasp.
reciprocity—The state of being inversely related or proportioned; opposite.
record base—An interim denture base used to support the record rim material for recording maxillomandibular records.
record rim—The occlusal surfaces fabricated on a record base for the purpose of making maxillomandibular relationship records and/or arranging teeth. Also called occlusion rim.
reducing zone of a flame—The zone of a flame least apt to cause oxidation of the metal when melting or soldering.
reducing investment—A specially made investment that contains fine graphite or copper particles to prevent oxidization of the casting. Also called deoxidizing investment.
refractory cast—A cast made of a heat resisting material. Also called investment cast.
reinforced acrylic pontic (RAP)—An anterior acrylic resin denture tooth attached to a specially constructed retentive site on an RPD framework.
relief—

1. The reduction or elimination of undesirable pressure or force from a specific region; for example, the scraping of a working cast to better fit a facing to the ridge.
2. Material added to a cast to relieve the pressure over specific areas in the mouth. Also added to the master cast before duplicating it to create a raised area on the refractory cast.

reline—The replacement of the tissue surface of the denture to make it fit more accurately.
removable partial denture (RPD)—A dental prosthesis that artificially replaces teeth and associated structures in a partially edentulous dental arch and can be removed and replaced by the patient.
reservoir—

1. An area where extra supply or stock is collected or accumulated.
2. In dentistry, an attachment to the sprue to provide additional molten metal when the casting begins to solidify and shrink.

resin—

1. A gummy substance obtained from various trees used to make many dental materials.
2. A broad term used to describe natural or synthetic materials that form plastic materials after poly-merization.

resin, denture—See acrylic resin.
resin crown—A resin restoration restoring a clinical crown without a metal substructure.
resorption—The loss of tissue substance by physiologic or pathologic processes. The roots of the primary teeth are resorbed naturally.
rest—A supporting device of an RPD lying on the occlusal or incisal surface of a tooth..
rest position—See physiologic rest position.
rest seat preparation—The preparation made on a tooth to accommodate an occlusal or incisal rest.
retainer—Any type of device used for the stabilization or retention of a prosthesis. In RPDs, a clasp is called a direct retainer. In fixed partial dentures, an abutment casting is called a retainer.
retention of a clasp—The property that enables a clasp to resist dislodgement.
retromolar pad—The soft tissue pad at the posterior extremity of the mandibular ridge.
retrusion of the mandible—A backward movement of the mandible.
reverse curve—A curve of occlusion defined by the cusp tips and incisal edges which, when viewed in the sagittal plane, is curved upward or superiorly.

reverse articulation—An occlusal relationship in which the mandibular teeth are located facial to the opposing maxillary teeth. The maxillary buccal cusps are positioned in the central fossa of the mandibular teeth. Also called crossbite.
reversible hydrocolloid—An impression material containing agar that can be softened to a jelly-like consistency and cooled to a solid to make an impression or duplicate a cast. This procedure can be repeated by reheating; hence the name "reversible."
rhomboidal—The shape of an oblique-angled parallelogram with only the opposite sides equal. The occlusal outline of the maxillary molars are rhomboidal.
ridge—

1. An elevated body part; a long, narrow, raised crest.
2. A linear elevation of enamel on the surface of a tooth; for example, a marginal ridge.
3. (Alveolar ridge) The area of the upper and lower jaws formerly occupied by the natural teeth.

ridge contour—The shape of the alveolar ridge with reference to its height, width, and degree of slope.
ridge lap—The area of an artificial tooth that normally overlaps the alveolar ridge. On the inner surface of the denture tooth, it corresponds approximately to the location of the collar on the facial surface.
ridge relationship—The position of the upper and lower ridges relative to each other.
ridge resorption—The resorption of the alveolar bone once teeth are no longer present, resulting in a progressively flatter ridge.
ring—A metal cylinder used to confine the investment when investing the pattern for a fixed wax pattern or an RPD framework pattern.
Roach clasp—See bar clasp.
Rockwell hardness—A measurement of the hardness of metals that are too hard for the Brinell needle.
root—The portion of the tooth covered with cementum.
root canal—The small channel running through the tooth's root, connecting the pulp chamber and the root-end opening.
rouge, jeweler's—A red powder usually in cake form used on a buff or chamois wheel to impart a high luster to metal.
rubber points/wheels—Rubber impregnated with abrasive used for smoothing ground surfaces.
rugae—The elevated folds or wrinkles of soft tissue situated in the anterior part of the palate.
safeside disk—An abrasive disk having one smooth side so it does not damage or scratch adjacent surfaces or structures.
sagittal plane (mid)—The plane dividing the body vertically into two equal halves.
sandpaper disks—Various size disks with different grits of sandpaper on their surface used for smoothing and polishing in the laboratory.
sanitary pontic—See hygienic pontic.
sanitization—A process that removes gross debris and reduces the number of microorganisms on nonliving material.
saturated calcium sulphate dihydrate solution (SDS)—A clear, true solution of water and a maximum amount of dissolved, dihydrate (set) gypsum product.
second half-flasking—Completion of the investing process in the top half of the denture flask.
semirigid fixed partial denture—See interlock fixed partial denture.
separating medium—An agent used between two surfaces to prevent them from sticking together.
serrated—Indented with many shallow crosscuts.
setting expansion—The dimensional increase that occurs concurrent with the hardening of various materials, such as plaster of paris, dental stone, die stone, and dental casting investment.
setting time—The time necessary to harden or solidify.
setup—See tooth arrangement.

shade—A particular hue or variation of a primary hue, such as a greenish shade of yellow.
shelf life—The period of time a material can be stored without losing its useful properties.
shellac base—A record base constructed using a shellac-based wafer that has been adapted to the cast with heat.
sideshift—Articulator simulation of mandibular translation.
slurry—A fluid mixture of a liquid and undissolved solid. Used to accelerate the setting time of dental stone.
soft palate—The movable part of the palatal anatomy posterior to the hard palate.
solder—

1. A fusible metal alloy used to unite the edges or surfaces of two pieces of metal.
2. The act of uniting two pieces of metal by the proper alloy of metals.

soluble—Capable of being dissolved.
solute—In a solution, the dissolved solution is called the solute. In salt water, the water is the solvent and the salt is the solute. See solvent.
solvent—A substance capable of dissolving another substance; for example, water is the solvent of salt. See solute.
spatula—

1. An instrument designed for mixing; a flat, knife-like instrument used for mixing plaster, hydrocal, and investment.
2. An instrument that can be heated for working with wax.

specific gravity—The weight of a substance as compared to the weight of exactly the same volume of water. The standard formula is 1 cm^3 of water at 4 ^oC = 1.
sphenoid bone—The irregular, wedge-shaped bone at the base of the skull.
spindle, surveyor—The perpendicular part of the surveyor containing a chuck that holds the interchangeable tools.
splint—

1. A rigid or flexible device that keeps a displaced or movable part in position.
2. A rigid or flexible material used to protect, immobilize, or restrict motion in a part.

split remounting plate—A device consisting of two machined metal plates. One part is embedded in the cast, and the other is embedded into the articulator mounting. The cast can then be removed from the mounting and accurately replaced.
sprue—

1. The channel or hole through which plastic or metal is poured or cast into a reservoir and then into a mold.
2. The cast metal or plastic that connects a casting to the residual sprue button.

sprue base—See crucible former.
sprue button—The material remaining in the reservoir of the mold after casting.
sprue former —A wax, plastic, or metal pattern used to form the channel or channels to allow molten metal to flow into a mold to make a casting.
square arch form—A dental arch roughly square in outline, particularly in the anterior region.
stability—The property of resistance to tipping and rocking of a prosthesis.
stabilized record base—A record base lined with an impression material to increase its stability.
stent—An appliance, usually of acrylic resin, used to reposition soft tissue.
sterilization—The process by which all forms of life within an environment, including viruses and spores, are totally destroyed.
stock impression tray—A device with a handle used to confine and hold an impression material as it is carried to place in the mouth to make an impression.

stone—See dental stone.
stone cap—See stone core.
stone core—The layer of stone placed over the incisal and occlusal surfaces of the teeth in the top half of the flask to facilitate deflasking. Same as stone cap.
strain—The deformation of a material caused by an external force.
stress—The forces within a substance opposing an external force.
stress breaker—See interlock fixed partial denture.
strut—A name often given to a minor connector.
sublingual—The area under the tongue.
sulcus—

1. A furrow, fissure, or groove.
2. In dentistry, a linear depression in the surface of a tooth, the surfaces of which meet at an angle. A sulcus is always found along the surface of a developmental line.

sulfuric acid—An acid made up of hydrogen, sulfur, and oxygen. Mixed with water in equal parts, it is used as a deoxidizing solution for gold.
superior—Above**.**
supernumerary tooth—An extra tooth; one in excess of the normal number.
support—

1. To hold up or serve as a foundation or prop for.
2. The foundation area on which a dental prosthesis rests.

suprabulge—The area above the survey line on an abutment tooth.
suprabulge clasps—See circumferential clasp.
supraerupted tooth—A tooth that has emerged past the occlusal plane.
surgical guide—Any prosthesis prepared for insertion during a surgical procedure and intended for short use. Also called surgical template and surgical prosthesis.
surveying—

1. To analyze the master cast for favorable and unfavorable undercut conditions.
2. To establish the path of insertion, using a dental surveying instrument.

surveyor—An instrument used to locate and mark the greatest circumference of one or several abutment teeth at a given tilt of the cast. Used to locate soft tissue undercuts at a given tilt.
suture line—A junction line where the bones of the cranium unite.
swage—To shape a piece of metal between a die and counterdie.
symphysis, mandibular—The immovable dense midline junction of the right and left halves of the adult mandible.
T-clasp—A vertical, projection-type clasp formed approximately in the shape of a "T."
tang—The connector between the clasp body and the frame of the appliance.
tapered arch form—A dental arch which, in outline, is between an oval and a square arch.
tapered blockout tool—The tapered, cylindrical-shaped surveyor tool used to carve the undercut wax on the proximal surface of an abutment tooth on the master cast. The taper ensures the rigid part of the metal framework does not enter an undercut adjacent to an edentulous space.
tempering—The procedure of imparting a desired degree of hardness to a metal. Also called heat hardening treatment.
template—

1. A pattern, mold, or gauge used as a guide to form a piece being made.
2. A flattened or curved plate, usually of metal, used as a guide in arranging artificial teeth.

temporal bone—The irregular-shaped bone at the side and base of the skull.

temporomandibular joint—The joint formed by the condyle of the mandible, temporal bone, and associated soft tissues.
tendons—The heavy fibrous bundles attaching a muscle to bone.
tensile strength—A measure of resistance to breakage from a stretching or pulling force.
thermal expansion—The increase in the size of a material when it is heated.
thermoplastic—A material that softens under heat and solidifies when it is cooled without chemical change.
thirty-degree (30°) teeth—An anatomical type of artificial posterior teeth. The manufacturer claims the cusp incline forms a 30-degree angle with a horizontal plane.
three-quarter veneer—See partial veneer crown.
Ticonium Premium 100—An alloy characterized by a lower melting range than any of the other chrome dental alloys—nickel, chromium, and beryllium.
tilt—The position of the cast on the surveyor table relative to a horizontal plane.
tooth arrangement—The placement of teeth on a denture with definite objectives in mind.
tissue-borne—A partial denture where all the masticatory stresses are borne by the soft tissues of the mouth.
tooth-borne—A partial denture where all the masticatory forces are carried by the abutment teeth.
tooth-supported base—A denture base restoring an edentulous region with abutment teeth at each end for support. The tissue it covers is not used as support.
torque—A twisting force.
torus—

1. A smooth, rounded, anatomical proturberance.
2. Torus mandibularis—found on the lingual surface of the body of the mandible. There may be several tori (plural), usually in the area of the midline backward to about the bicuspids.
3. Torus palatinus—found midline on the hard palate.

translatory (sliding) motion—The motion of a rigid body in which a straight line passing through any two points always remains parallel to its initial position. The motion may be described as a sliding or gliding motion.
transverse horizontal axis—An imaginary line around which the mandible may rotate within the sagittal plane. Also called hinge axis.
transverse plane—The plane that divides the top horizontally from the bottom.
transverse ridge—The ridge of enamel formed at the junction of the buccal and lingual ridges on the occlusal surface of a molar or bicuspid.
trapezoid—A four-sided plane figure with two parallel sides. The occlusal surface of the lower first molar is trapezoidal in outline.
trauma—A wound or injury, whether physical or psychic.
treatment partial—See interim prosthesis.
treatment plan—An outline of the various clinical steps in the proper sequence to be followed for restoring a mouth to health and function.
trial packing—The process of filling the mold with acrylic resin dough several successive times before the final closure to ensure an adequate amount of the material is present.
trial record base—See record base.
triangular ridge—The ridge of enamel that extends from the tip of the cusp down onto the occlusal surface of the bicuspids and molars.
trial placement—The process of checking the trial denture in the patient's mouth for accuracy and the suitability and arrangement of the teeth. Also called try-in.
trifurcated—Having three roots.

troy weight—A system of weights used for weighing gold. The basic unit is the grain; 24 grains are equal to 1 pennyweight.
tube tooth—An artificial tooth containing a vertical channel that fits over a metal post and secures the tooth to the appliance.
tubercule—A nodule or small eminence.
tuberosity—See maxillary tuberosity.
twenty-degree (20^o) teeth—A trade name denoting an artificial posterior teeth with 20-degree cusp angles.
undercut—The portion of the surface of an object that is below the height of contour in relationship to the path of placement.
undercut gauge—A tool for the surveyor that is shaped to measure the amount of undercut on a tooth in thousandths of an inch.
undesirable undercut—Any area that cannot be used for retention and may interfere with insertion and removal of the prosthesis.
unilateral balanced occlusion—See group function.
vacuum fired—To bake porcelain in a vacuum.
vacuum mixing—A method of mixing a material in asubatmospheric pressure.
value—The dimension of a color denoting relative blackness or whiteness.
vault—The palate or roof of the mouth.
veneer—A thin layer.
vertical dimension of occlusion—See occlusal vertical dimension.
vertical overlap—

1. The distance teeth lap over their antagonists as measured vertically. May also be used to describe the vertical relations of opposing cusps.
2. The vertical relationship of the incisal edges of the maxillary incisors to the mandibular incisors when the teeth are in maximum intercuspation.

vestibule—The part of the mouth between the cheeks or lips and the alveolar ridge.
vibrating line—An imaginary line in the soft palate marking the junction between the movable and immovable tissues. Also called flexure line.
vibrator—A mechanical device used to remove air pockets from a mix of plaster or stone.
Vicker's hardness—A range of hardness measured by the indentation made by a square-based, pyramidal diamond point under various loads.
viscosity—A measure of a liquid's resistance to flow or its relative fluidity.
vitrification—The process of making a homogenous, glassy substance by heat and fusion.
volatile—To quickly evaporate.
volatility—The ability to become gaseous or vaporize into gas.
volt—The unit of electrical pressure that forces the current through the circuit.
vomer—The bone forming the lower and posterior portions of the septum of the nose.
warpage—The loss of an original shape or contour.
watt—A unit of electrical power obtained by multiplying the voltage by the amperage.
wax—There are many different types of waxes are used in dentistry, and each is compounded to produce certain physical properties for a specific purpose. Wax is manufactured in various forms, such as baseplate, boxing, inlay, and sticky.
wax elimination—The use of heat to remove a wax pattern from the mold.
wax pattern—Wax that has been formed into the size and shape desired in the finished prosthesis and used to form the mold in the investment.
wax-up (noun)—The finished wax pattern for any dental prosthesis.

wax up (verb)—

1. To smooth and finish the wax on a complete denture.
2. To flow and carve a wax pattern for a fixed restoration.
3. To contour the wax for any dental prosthesis.

weld—A process for joining metals, using heat and pressure or pressure alone.

working cast—The cast of an entire dental arch or section of an arch on which the laboratory work is accomplished.

working articulation—Occlusal contacts of teeth on the side toward which the mandible has moved. Also called working occlusion.

working side—The side toward which the mandible moves in a lateral excursion.

xerostomia—Dryness of the mouth caused from the lack of a normal amount of saliva.

yield strength—The amount of stress required to produce a particular offset that is chosen. A value of 0.2 percent plastic strain is often used (called 2 percent offset).

zero-degree (0^o) teeth—See nonanatomic teeth.

zinc oxide—A powder incorporated with eugenol or a similar oil to form a mild antiseptic and analgesic paste; a constituent of most impression pastes.

zygomatic processes, temporal and maxillary—The bony extensions of the temporal and maxillary bones that unite with the zygomatic bone to form the zygomatic arch.

Attachment 2

PREFIXES AND SUFFIXES

A2.1. Prefixes. Prefixes are one or more syllables placed before words or roots of words to show various kinds of relationships. They are never used independently, but, they modify the meaning when they are added to verbs, adjectives, or nouns. Figure A2.1 lists prefixes to help you understand dental terminology.

Figure A2.1. Prefixes of Dental Terms.

Prefix	Translation	Example
a- ("an" before a vowel)	without, lack of	Anemia—lack of blood
ab-	away from	abrade—to wear away
ad-	to, toward, nearer to	adhesion—sticking to
ambi-	both	ambidextrous—ability to use both hands
ante-	before, forward	anterior—situated in front of
anti-	against, opposed to, reversed	antiflux—prevents the flow of solder
bi-	twice, double	bilateral—both sides
circum-	around, about	circumference—surrounding
com-	with, together	compression—pressing together
con-	with, together	condense—pack together
contra-	against, opposite	contralateral—opposite side
de-	away from	dehydrate—remove water from
dia-	through, apart, across, completely	diagnosis—complete knowledge
dis-	reversal, apart from, separation	dissect—cut apart
dys-	bad, difficult, disordered	dysfunction—impaired function

e-, ex-	out, away from	edentulous—without teeth extrude—to elevate
ec-	out from	eccentric—away from center
em-, en-	in	embed—to cover over
endo- within		endodont—within tooth
epi-	upon, on	epidermis—on skin
extra- outside		extracoronal—outside coronal portion
hyper-	over, above, excessive	hyperplasia—abnormal increase in tissue cells
hypo-	under, below, deficient	hypocalcification—reduced calcification
im-	in, into	immersion—act of dipping in
in- not		incompatible—not compatible
infra- below		infraorbital—below eye
inter- between		interocclusal—between occlusal surfaces
intra-	within	intraoral—within the mouth
meta-	beyond, after, change	metamorphosis—change of form
para-	beside, by side	parafunction—beyond normal function
per-	through, excessive	permeate—pass through
peri-	around	periapical—surrounding the apical area
post-	after, behind	posterior—situated behind
pre-	before, in front of	preoperative—before surgery
pro-	before, in front of	prognosis—forecast

re-	back, again, contrary	rebase—replacing base material
retro-	backward, located behind	retrognathic—posterior relationship of the mandible
sub-	under	subgingival—below the gingiva
super-	above, upper, excessive	supernatant—floating above the surface
supra-	above, upon	supragingival—above the gingiva
syn-	together, with	synarthrosis—articulation of joints together
trans-	across	transplant—to remove and plant in another place
ultra-	beyond, in	ultraviolet—beyond violet end of spectrum

A2.2. Suffixes. Suffixes are the one or more syllables or elements added to the root or stem of a word to alter the meaning or indicate the intended part of speech. The suffixes in Figure A2.2 are often used in dental terminology.

Figure A2.2. Suffixes of Dental Terms.

Suffix	Use	Examples
-al, -c	add to nouns to make adjectives expressing relationship, concern, or pertaining to	cervical—pertaining to the cervix, traumatic—pertaining to trauma
-ent	add to verbs to make adjectives or nouns of agency	recipient—one who receives; concurrent—happening at the same time
-form, -oid	add to nouns to make adjectives expressing resemblance	fusiform—resembling a fusion, metaloid—resembling metal
-ia, -ty	add to adjectives or nouns to make nouns expressing a quality of condition	ductility—condition of being ductile

-ible, -ile	add to verbs to make adjectives expressing ability or capacity	flexible—capable of being bent, contractile—ability to contract
-id	add to verbs or nouns to make adjectives expressing state or condition	fluid—state of being liquid
-ist, -or, -er	add to verbs to make nouns expressing agent or person concerned	Prosthodontist—a dentist practicing prosthodontics, connector—the part that connects other parts
-ize, -ate	add to nouns or adjectives to make verbs expressing to use and act like, to subject to, to make into	oxidiz—to form an oxide, impersonate—act like
-ma, -mata, -men -mina, -ment, -ure	add to verbs to make nouns expressing a result of action or an object of action	trauma—injury, foramina—openings, arrangement—position of artificial teeth
-olus, -olum, -culus, -culum, -cule, -cle	add to nouns to make them diminutive	alveolus—bony socket of a tooth, miniscule—very small, molecule—little mass
-ous	add to nouns to make adjectives expressing material	Ferrous—composed of iron, amorphous—not definite form, porous—full of pores
-sia, -y	add to verbs to make nouns expressing an action, process, or condition	Anesthesia—lack of feeling, oily—resembling oil
-tic	add to verbs to make adjectives showing relationships	caustic—referring to burn

Attachment 3

SUBJECT INDEX

A

Abutments, 1.8.

Acrylic resin
- autopolymerizing resin, Volume 1, 2.44
- Dura Lay, 1.25.2
- veneers, 5.1

Acrylic resin nightguard, 7.1

Acrylic resin custom tray, 1.15

Acrylic resin splints, 7.6.3

Alginate impression template method, 1.14, 2.1

Alginate impressions, Volume 1, 2.40.2

All-Ceramics
- preparation requirements, 4.2
- procedures for In-Ceram®, 4.3
- procedures for IPS Empress®, 4.5

Anatomical contouring, 1.4.2

Arch bars, 7.10

Articulator settings, Volume 1, 6.5.5.1

Autopolymerizing resin, Volume 1, 2.44

B

Base metal alloys, Volume 1, 2.64.1

Beryllium hazards, Volume 1, 2.63.1.3

Bonding of porcelain and metal, 2.2.1

Bonding resin bonded FPD, 2.31

Burnout
- base metal alloys, 2.30.4
- metal-ceramic substructures, 2.9

C

Cantilevered pontic, 1.60.1

Casting production
- base metal alloys, 3.7
- cleaning and deoxidizing, 1.57

finishing, 1.58
investing, 1.54
spruing, venting a sprued pattern, 1.53
wax elimination, 1.55
with gas-air torch and centrifugal casting machine, 1.56

Casts
diagnostic, 1.13
mounting, Volume 1, 6.12, 6.13, 7.46
remounting, Volume 1, 7.130
trimming and finishing, Volume 1, 7.23, 7.36
working, 1.16

Ceramic alloys. See *also* Metal-ceramic restorations; Porcelain, Volume 1, 2.62

Cervical porcelain, 2.14.4.1

Chill sets, 1.53

Chill vents, 1.53

Cleaning a casting, 1.57

Cleft palate, 7.13

Color, 2.3

Complete crowns, 1.7.1

Connectors. See *also* Soldering
rigid, 1.8.3
stress breaker, 1.68.2

Copings, 1.25

Crown attachments, 1.8.3

Crowns
com plete, 1.7.1
fitting, 1.58
jacket, 1.7.1.3
m etal, 1.7.1.1
partial, 1.7.2
patterns, 1.3
post, 1.7.1.4
veneered, 1.7.1.2

Cusp-embrasure centric occlusion, Volume 1, 5.9

Cusp-fossa centric occlusion, Volume 1, 5.10

Cusps
shearing, Volume 1, 5.7.2
stamp, Volume 1, 5.7.1

Custom earpiece, 7.18

Custom-fitted masks, 7.11

Custom incisal guide tables, 1.38.4

Custom trays, 1.15

Cutback technique, 2.6.4

D

Dentin porcelain
 application, 2.14.4.3
 effects, 2.14.9

Deoxidizing a casting, 1.57

Diagnostic casts, 1.13

Dies
 definition, 1.16.2
 dowel pin systems, 1.19
 extension access, 1.28
 keyed, 1.16.3
 made from "tube" impressions, 1.17
 matrix band shim method, 1.22
 Pindex instrument and technique, 1.23
 preparation before waxing, 1.33
 removable, 1.18
 saw-out technique, 1.20
 silver-plating impressions, 1.24
 trimming, 1.33.1

Double abutments, 1.60.3

Dowel pin removable die systems, 1.19

Dura Lay acrylic resin, 1.25.2

E

Edentulous fixation splint, 7.6.4

Elastomeric impressions, Volume 1, 2.37

Enamel porcelain, 2.14.4.5.1

Endodontically treated teeth, 1.7.9

Esthetics, 1.34

Extracoronal restorations, 1.6

F

Face form casts, 7.12

Facebow transfer, 1.29.2

Finishing a casting, 1.58

Fixed partial dentures
components, 1.8
connectors, 1.68, 1.83
constructing, 1.61
designs, 1.60
edentulous ridge modifications, 1.33.2.3
interim, 1.10
Maryland bridge, 2.29
materials, 1.62
pattern waxing, 1.61
porcelain application, 2.14
repairing metal castings, 1.76
resin-bonded, 2.30.6

Fixed prostheses. See *also* Fixed partial dentures
articulator settings, Volume 1, 6.5.5.1
cast mounting procedures, Volume 1, 6.12, 6.13, 7.46
cast remounting, Volume 1, 7.130
casting production, 1.50
custom trays, 1.15
definition, 1.1
diagnostic casts, 1.13
dies, 1.19
direct method, 1.2
esthetics, 1.34
indirect method, 1.34
interim, 1.10
post and core construction, 1.79
procedural overview, 1.11
types, 1.4
veneering, 5.1
waxing, 1.47
working casts, 1.16

Fixed splints, 7.6.3

G

Glazing porcelain, 2.24

Gunning splint, 7.6.4

H

Hanau H2 articulator settings, Volume 1, 6.5.5.1

Hand investment technique, 1.54.4.2

Hydrocolloid impressions. See *also* Alginate impressions, Volume 1, 2.40.2
    reversible hydrocolloid impressions, Volume 1, 2.40.1

I

Implants
    components, 6.2
    custom tray, 6.8
    master model, 6.9
    procedures for removable prosthesis, 6.16
    procedures for single tooth cemented restoration, 6.11
    procedures for screw retained restoration, 6.15
    provisional restoration, 6.10
    radiographic stents, 6.6
    surgery, 6.5
    surgical stents, 6.7

Impressions
    alginate, Volume 1, 2.40
    elastomeric, Volume 1, 2.37
    for arch bar fabrication, 7.8
    for obturator fabrication, 7.14
    pickup, Volume 1, 8.64.3
    preliminary, 1.13
    reversible hydrocolloid, Volume 1, 2.40.1
    rubber-base, Volume 1, 2.33.2
    tube, 1.17

Improved stone dies, Volume 1, 2.11

Incisal guide table, Volume 1, 6.9.13

Inlays, 1.4

Interim fixed partial denture, 1.10

Interim fixed restorations, 1.14
    alginate impression template method, 1.14.2.1
    silicone template method, 1.14
    vacuum-forming methods, 1.14

Intermediate abutment, 1.60

Interocclusal record, 1.30.2.1

Intracoronal restorations, 1.44

Investing
base metal alloys, 3.7
metal-ceramic substructures, 2.8
post and core construction, 1.79.3

Irreversible hydrocolloid impressions, Volume 1, 2.40.2

J

Jacket crown, 1.7.1.3

K

Key and keyway, 1.68.2.1

L

Law of beams, 2.11.3.2

M

Margin styles, 1.33.1

Maryland bridge, 2.29

Masks, 7.11

Matrix band shim method for removable dies, 1.22

Maxillary orthopedic appliance, 7.1

Metal casting repair, 1.76

Metal-ceramic restorations. See *also* Porcelain, 2.1
anatomical contouring, 2.16
application and firing, 2.14
burnout, 2.30.4
casting, 2.30.4
finishing, 2.30.5
glazing, 2.24
investing, 2.8
physical characteristics, 2.2
porcelain postsolder, 2.28
presolder, 2.27
pretreatm ent, 2.12
resin-bonded fixed partial dentures, 2.29
spruing, 2.7
staining, 2.23
substructure design, 2.5.4
waxing a pattern, 2.6

Metal conditioning agents, 2.12.7

Metal crowns, 1.7.1.1

MOD (mesio-occluso-distal) inlay, 1.4.2

Modified ridgelap pontic gingival adaptation, 1.64.1

Morphology of anterior teeth, 1.35

Moulage, 7.12

Mounting casts, Volume 1, 6.12, 6.13

Mouth protector, 7.4

N

Negative waxing, 1.41.6.1

Ney Mini-Rest, 1.68.2.4.1

Nickel-chromium alloys, 3.3

Nickel hazards, 3.4

Nobestos, 1.52.5

Nonrigid connectors. See Stress breaker

O

Obturators, 7.14

Occlusion scheme, 1.38

Onlays, 1.6

Opacious dentin, 2.14.4.2

Opaque porcelain, 2.13

P

Partial crowns, 1.7.2

Pickling a casting, 1.57

Pickup impression, Volume 1, 8.64.3

Pier, 1.60.4

Pindex instrument and technique for removable dies, 1.23

Pinledges, 1.5

Polishing a casting, 1.58.7

Polysiloxane impression materials, 2.37.3

Pontics
cantilevered, 1.60.1
construction, 1.65
gingival adaptation to a residual ridge, 1.64.1
hygienic, 1.64.3
occlusion and occlusal surface area, 1.66
types, 1.64
veneered, 5.6

Porcelain. See *also* Metal-ceramic restorations
application and firing, 2.12
complete crown, 4.1
cusps, 2.14.6
dentin effects, 2.14.9
glazing, 2.24
laminate veneers, 4.8
margin technique, 2.14.8
opaque, 2.13
pontics, 2.5.4.4
repair, 2.22
shading, 2.14.4.2
staining, 2.23

Positive waxing, 1.41.6.2

Post and core construction, 1.79

Post crown, 1.7.1.4

Postsolder technique, 2.28

Preliminary impressions, 1.13

Presolder technique, 2.28

Primary abutment, 1.8

R

Remounting casts, Volume 1, 7.130

Removable dies, 1.18

Repair porcelain, 2.22

Repairing metal castings, 1.76

Resin. See Acrylic resin

Resin restorations, fixed
procedures for Targis™, 5.2
procedures for Sinfony®, 5.6

Reversible hydrocolloid impressions, Volume 1, 2.40.1

Rigid connectors. See *also* Soldering, 1.8.3

Rubber-base impressions, Volume 1, 2.33.2

S

Saw-out technique for removable dies, 1.20

Shade selection, 2.4

Shearing cusps, Volume 1, 5.7.2

Shim method for removable dies, 1.22

Silicone putty impression material, 2.6.2

Silver cyanide hazards, 1.21.1

Silver-plating impressions, 1.24

Soldering
- base metal alloys prior to porcelain application, 3.5.6
- fixed prostheses, 1.75
- postsoldering metal-ceramic fixed partial dentures, 2.28
- presoldering metal-ceramic fixed partial dentures, 2.27

Splints
- acrylic resin fixation, 7.6.3
- edentulous fixation, 7.6.4
- Gunning, 7.6.4
- surgical, 7.6

Sprinkle-on technique, 7.1.3.5

Spruing
- base metals, 3.6
- direct, 1.52.4.2
- indirect, 1.52.4.3
- metal-ceramic substructure, 2.7
- venting a sprued pattern, 1.22

Staining porcelain, 2.23

Stamp cusps, Volume 1, 5.7.1

Stone index method of relating fixed partial denture units, 1.75.2.2.1

Stress breaker, 1.8.3

Surgical splints, 7.6

T

Temporo-mandibular joint disorders, 7.1.21

Thermoplastic vinyl mouth protector, 7.4

TiCor® abrasive, 3.9.1

TiHi® abrasive, 3.9.1

Tooth preparation, 1.33.1

Transfer copings, 1.25.2

Tube impressions, 1.25.1

V

Vacuum-forming methods
    custom trays, 1.15.3
    interim fixed restorations, 1.14.1
    mouth protector, 7.4

Veneered crowns, 1.7.1.2

Veneered pontics, 5.6

Venting a sprued pattern, 1.53

W

Wax-added technique, 1.47

Wax elimination. See Burnout

Wax pattern
    anatomic and functional contouring, 1.42
    characteristics of inlay wax, Volume 1, 2.23
    direct, 1.2
    indirect, 1.2
    instruments, 1.39
    materials, 1.40
    metal-ceramic substructures, 2.6.4
    negative waxing, 1.41.6.1
    positive waxing, 1.41.6.2
    post and core construction, 1.79
    steps, 1.49

Whip-Mix articulator settings, 1.29.2.2

Working casts, See *also* Dies, 1.16