A review of 243 errors possible during the fabrication of a removable partial denture: Part II

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In Part II of this series, possible errors 72 through 168, all of which may be committed during the fabrication of a removable partial denture, are presented. Suggestions for avoiding the problems and solutions for correcting them are described. (J Prosthet Dent 2001;86:262-76.)

An asterisk indicates that the error is serious. If the error is committed, new impressions may have to be made.

INDEXING AND MOUNTING CASTS IN AN ARTICULATOR

72. *Error*: Failing to properly index the base of the cast.

Problem: A smooth base cast cannot be remounted accurately to correct processing errors or for other procedures.

Solution: Always use a good indexing procedure for the base of a cast before mounting it in an articulator (see solution to error 73).

73. *Error*: Using 3 semicircular cutouts, 1 at each distal corner and 1 in the anterior midline.

Problem: Index cuts at the periphery of the cast may work sometimes, but when the cast must be reduced in diameter to make it fit into a flask—or when the cast is broken during deflasking—one or more of the indices may be destroyed. Then the cast cannot be seated accurately.

Solution: The best index for mounting a cast in an articulator is one made by cutting v-shaped grooves across the base in the form of a plus sign (+).[1] When the (+) index is used, the cast can be remounted accurately even if more than half of the base is lost.[1,2]

74. *Error*: Failing to mark the casts to ensure unmistakable articulation even though they can be hand articulated.

Problem: Casts that are not mounted in an articulator must be marked by the dentist, even though they can be hand articulated. When the casts are not marked, it may be difficult (if not impossible) for the technician, who has never seen the patient, to articulate them correctly.[1,3]

Solution: The dentist can mark the casts by holding them in occlusion and drawing 3 widely separated vertical lines on the facial aspect of occluding teeth between the maxillary and mandibular casts. The technician can match the 3 lines for the correct occlusion, lute them together, and mount them in an articulator with confidence that the occlusion is correct.[3,4]

75. *Error*: Failing to mount casts in an articulator that cannot be hand articulated before sending them to the laboratory.

Problem: Laboratory technicians cannot possibly know how the casts relate to each other when they cannot be hand articulated. Therefore, when frameworks are made, space may be lacking to set the denture teeth, and it may be necessary to reduce the opposing rests considerably to establish the correct occlusal relationship in the mouth.[3]

Solution: Accurate jaw relation records must be made and the casts mounted in an articulator in the dental office. At minimum, the record should be sent to the commercial laboratory with the casts.

76. *Error*: Failing to use a face-bow to mount a maxillary cast in an articulator.

Problem: If casts are mounted too far anterior or posterior in an articulator and the vertical dimension of occlusion is changed even by a small amount, the artificial teeth and stone teeth on the cast will occlude too hard in the anterior or posterior (whichever the case may be). This inaccuracy will be more apparent in the mouth.[4] This may happen even with an accurate jaw relation record when a face-bow is not used.

Solution: An accurate face-bow recording must be made and used to mount the maxillary cast in an articulator either in the dental office or in the laboratory.

77. ***Error*: Failing to use an accurate jaw relation record to mount the mandibular cast against the maxillary cast in an articulator.

Problem: Restorations made on incorrectly mounted casts require considerable adjustments in the mouth to correct the occlusion and may necessitate a remake of the restoration.

Solution: An accurate jaw relation record can save considerable time and may be as essential for removable restorations as for fixed restorations in some cir-

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cumstances.[5] Check the accuracy of the jaw relation record before the patient leaves the office (Note 1).[2,6,7] With the use of light and magnification, examine the record for flaws (see Part I, error 36). Use a sharp surgical knife blade (No. 25) to trim the record, leaving only cusp tips of teeth and/or stable, firm edentulous alveolar ridge surfaces. The cut edge of the record must be sharp and well defined. Seat the record on each cast independently to verify the fit of the record to each cast. The record must seat completely without rocking, and there must be no visible space between the cut edge of the record and the cast. If space exists, the reason for it must be ascertained and corrected. If the reason for the space cannot be discovered, the record must be remade.

Note 1. Procedure for verifying jaw relation records

After the casts have been mounted in an articulator, check the accuracy of the jaw relation record by inserting a piece of 0.0005-in. shim stock between 2 opposing teeth of the casts. Close the articulator, and feel how firmly the shim stock is held when it is pulled. Repeat this procedure between the same teeth in the mouth. Check several other occluding teeth on each side of the arch in the same way. If the resistance to the pull of the shim stock feels the same in the mouth as it does on the casts, the jaw relation probably has been transferred correctly to the mounted casts. If the resistance is not the same, remake the jaw relation record, and remount the mandibular cast.[2,6]

78. *Error*: Failing to securely lute the casts into the jaw relation record.

Problem: If casts simply rest in the jaw relation record or are held by hand during mounting, some movement may occur during application of the mounting stone or while the stone sets. Consequently, the mounting will be inaccurate.

Solution: With the maxillary cast mounted in the articulator, seat the jaw relation record on the maxillary cast, seat the mandibular cast in the record, and hold the assembly firmly together. Place at least 3 small metal rods (in areas widely separated from one another) from the sides of one cast to the sides of the other and lute them in place with sticky wax, impression compound, or another appropriate nonporous, rigid, strong material. Mount the mandibular cast (see error 79 and solution). Alternatively, when not using a facebow, seat both casts in the jaw relation record, hold them firmly together, place at least 3 widely separated small metal rods from one cast to the other, and lute them in place. Proceed to mount both casts in the articulator.

79. *Error*: Using wood or another porous material to help lute casts together before mounting.

Problem: If wood (such as tongue blades, cotton-tipped applicator handles, paper, and cardboard) or another porous material is used to secure casts together before mounting, the material may absorb water and expand. This swelling may increase the dimension between the maxillary and mandibular casts. The change in dimension is likely to be vertical or uneven bilaterally. When the sticks are removed after the stone sets and the articulator is closed to tooth contact, the anterior teeth may contact before the posterior teeth, resulting in an incorrect mounting.

Solution: Always use metal to secure casts when luting them into jaw relation records in preparation for mounting the casts. Old burs, sections of coat hangers, and other rust-resistant materials are good choices.

80. *Error*: Disregarding proper powder-to-water ratios when mixing mounting stone.

Problem: Gypsum stone expands as it sets. Using improper powder-to-water ratios when mixing mounting stone can cause excessive expansion. This can result in a vertical increase of the distance between the maxillary and mandibular casts. An error in the mounting of the casts, similar to that possible when wood mounting sticks are used (see error 79), may result.

Solution: Use a proper powder-to-water ratio as recommended by the manufacturer. Plaster has a very high setting expansion, so although it may be inexpensive, it can exacerbate mounting inaccuracies. Some manufacturers make special mounting stone formulated for low expansion and sold in preweighed packages to maximize convenience and accuracy.

81. *Error*: Failing to wet the cast with slurry water before mounting it in an articulator.

Problem: If the cast is not wetted before it is mounted in the articulator, the dry cast will absorb water from the mix of mounting stone, and a dry wafer of stone between the cast and the rest of the mounting stone will form. This soft layer may make the mounting index inaccurate.[6,8]

Solution: After indexing the base of the cast, place the base in approximately ½ in. of slurry water for 5 minutes immediately before the mounting procedure (Note 2). Blot excess slurry water from the base of the cast.

82. *Error*: Failing to properly coat the bottom of the base of the cast with a separating medium.

Problem: Neglecting to use separating medium on the bottom of the base of the cast will make it very difficult to separate the cast from the articulator mounting. Attempts to separate the cast may result in broken and destroyed indices.[1,8]

Solution: Paint only the bottom surface of the cast with clear stone-separating medium. Petroleum jelly also will work, but it must be used sparingly.[6,8]

83. *Error*: Using excessive stone separator on the cast.

Problem: Excessive or improper application of sepa-

Note 2. Slurry concentrate formula

To make slurry concentrate, catch the slurry (grindings) from the cast trimmer when grinding a piece of set dental stone. Do not use a cast that has been in contact with an intraoral impression to avoid contamination with pathogens. Fill a container with the grindings, and allow them to settle. Decant the liquid and save the grindings. The leftover sediment is the slurry concentrate or thick slurry used to accelerate the setting of the stone. Add some of this slurry concentrate to the water used to mix stone for mounting the casts in an articulator. Depending on the amount of slurry concentrate used, the setting time of the stone mix can be reduced and controlled.[2]

rating medium can cause the cast to separate prematurely from the mounting stone in the articulator. It also can make it difficult to accurately reorient the cast to the mounting stone.

Solution: The separating medium must be applied in a thin coat only to the bottom surface of the base; the mounting stone must lap over approximately ¼ in. on all sides of the base.[1]

84. *Error*: Inappropriate use of slurry concentrate.[6,7]

Problem: Although slurry concentrate is useful for mounting casts, it may result in reduced strength of the stone after it has set. When slurry concentrate is used to pour impressions, the user (knowing that it will set faster) may make a thinner mix to allow the impression to be poured before the stone sets. This will result in a softer cast. Mixing the slurry concentrate with stone to pour casts in impressions would be satisfactory only if some procedure were instituted to ensure use of the normally recommended water-to-powder ratio.

Solution: Use slurry concentrate when hardness is not as critical as time.[8]

SURVEYING, DESIGNING, AND BLOCKING-OUT CASTS

85. *Error*: Failing to survey and design diagnostic casts.[9]

Problem: The dental laboratory generally does not have detailed diagnostic and examination findings about the patient. Even if dental laboratory technicians have access to the information, they do not have the training to properly evaluate it and determine the appropriate treatment. Without a thorough understanding of biologic and physiologic principles, laboratory personnel could unknowingly place harmful forces on the patient's dentition.

Solution: It is the dentist's responsibility to survey and draw the design on diagnostic casts[7] before sending them to the laboratory as a part of the work authorization order.[1] If the dentist abdicates his responsibility by delegating the authority to design the removable partial denture (RPD) to the laboratory, it could be argued that the dentist is allowing the laboratory to decide treatment for the patient.[7,9] The dentist must design the partial denture (Note 3).

Note 3. RPD design

Designing an RPD is much more than a mechanical exercise in which selection is made from a list of clasps, rests, major connectors, and other components that are then assembled into a framework. An RPD is a part of the comprehensive treatment of the patient. The designer must have an in-depth knowledge of the patient's oral condition, including:

1. The health of the periodontium, the length of the tooth roots, and the crown-to-root ratio; whether a tooth can stand alone, should be splinted to another tooth by a double clasp or fixed restoration, should be avoided altogether, or should be extracted; and where the long-term prognosis of individual teeth is poor and allowances need to be made for their future loss and replacement. The designer must know the mobility of the teeth to determine which and how many teeth need to be supported by the RPD and how many and what kind of clasps should be used.[5]
2. The character of supporting soft tissue on the ridges and the underlying bone to determine the best type of bases to use; the health and condition of the adjacent soft tissues; whether the ridges are well healed; whether the soft tissue is firm or flabby; and whether there is movable tissue that should be avoided by rigid RPD components.
3. The nature and strength of the teeth, including the kind of restorative materials used in restorations currently in the mouth[7]; the health of the natural tooth structure; and the location and condition of amalgam, composite, gold, and/or ceramic restorations. On a cast, all materials used for restorations look alike.[9] It may be desirable to clasp abutments that have been restored with gold crowns but avoid abutments restored with all-ceramic crowns or large resin composite restorations.[5]
4. Whether the patient will accept some or any display of metal components.
5. The treatment priorities for the particular patient when compromises must be made.
6. Whether the patient has any special psychologically and/or physically limiting conditions that may influence the choice of design. The dentist should consider such conditions during the diagnosis and planning phase of treatment. The dental laboratory rarely has this information unless the dentist has specifically communicated it.

86. *Error*: Dentists drawing the design on the definitive cast.

Problem: Most laboratories have a particular color and symbol coding system for designs drawn on the definitive cast. The system informs each technician about the specifics of the design. When the dentist designs or draws on the definitive cast, it becomes cluttered with marks that may confuse the technician at the working level.

Solution: The dentist should mark only on the diagnostic cast. A good laboratory technician can easily transfer the design to the definitive cast. The only exceptions are that the dentist should mark the location of the floor of the mouth, frenum attachments, or other features (perhaps tripod locations) that cannot be identified on the cast.

87. *Error*: Dentists failing to tripod the designed diagnostic cast (Note 4).[9,10]

Problem: When the dentist designs a diagnostic cast, it must be tripoded to accurately record the selected tilt. Without tripod marks, laboratory technicians cannot precisely duplicate the tilt that the dentist used and cannot be blamed for using a different tilt.

Solution: The dentist must determine the tilt to be used to take advantage of guide planes, to avoid or place undesirable undercuts appropriately, and for proper functioning of the selected clasping system.

Note 4. How to tripod a cast[1]

1. Place the diagnostic cast on the surveying table, usually with the occlusal plane parallel to the tabletop.
2. Lock the cast securely on the surveying table.
3. Fasten the analyzing rod in the surveying arm.[1]
4. Loosen the tilt-adjusting knob on the surveying table.
5. Adjust the tilt of the table/cast assembly; select the tilt most suitable for the path of insertion desired for the RPD. The path of insertion is parallel to the analyzing arm when the surveying table/cast assembly is locked in any given position.
6. After selecting the tilt, lock the tilt-adjusting knob to hold the cast in this position.
7. Replace the analyzing rod in the surveying arm with the carbon marker.
8. Adjust the height of the surveying arm to allow the tip of the carbon marker to touch the cast in 3 widely separated places as the surveyor table/cast assembly is moved around (but always in contact with the surveyor base and with the cast locked in the position selected in step 6).
9. Lock the surveying arm in this position.
10. Slide the surveyor table/cast assembly on the surveyor base, and make 3 small, widely separated marks on the cast with the tip of the carbon marker.
11. Use a pencil to draw a short line at right angles across each of the marks made by the carbon marker. This will make a plus (+) mark. Draw a small circle around the area where the lines intersect to distinguish the index marks from other marks that may be on the cast. The marks must be made in places on the diagnostic cast that will be present on the definitive cast as well as on all casts made or used in place of the definitive cast (namely, the working cast, the refractory cast, and all duplicate casts of the definitive cast). A good technician can easily transfer the tilt, marked on the diagnostic cast, to the definitive cast if the diagnostic cast has been tripoded.[10]

88. *Error*: Dentists failing to indicate the degree of block out that laboratory personnel should use on the definitive cast for fabrication of the framework.[1]

Problem: In the absence of instructions, most laboratory technicians will use either a 2- or 6-degree taper[4] when blocking out undesirable undercuts around the abutment teeth. A positively tapered block out speeds production in the laboratory by reducing the time and care required to fit the framework to the cast after casting. This preparation also reduces complaints from dentists about frameworks not fitting in the mouth when the dentists have provided inaccurate impressions or poor quality casts. However, a tapered block out produces excessive space between the framework and the teeth; this space engenders food trapping, decreases the stability of the RPD, and negates the effects of the guide planes carefully prepared by the dentist.[7] The purpose of a guide plane is to guide the framework into place in the mouth and stabilize the teeth while the retentive clasp tips spring into the undercut.[7] Without proper guide planes to stabilize the abutment teeth and reciprocate the force of the retentive clasps when a framework is placed or removed from the mouth, the rocking forces created may damage the abutment teeth.

Solution: The dentist must request a 0-degree block out when he/she has developed parallel guide planes on the teeth in the patient's mouth.[2,11,12]

89. *Error*: Failing to ledge the block out at the tips of the retentive clasps or inaccurately locating the retentive undercuts.

Problem: Ledges created in the block out wax as it is applied to the cast indicate the proper location of the retentive tip of the clasp when the framework is waxed. Inaccurately placed ledges can have a deleterious effect.

Solution: During the design transfer, the technician must accurately measure the desired undercut with an undercut gauge and carefully mark the location. During block out, the mark must be easily identifiable to create the ledges. The quality control monitor in the laboratory should inspect and correct any block out errors before approving the next step.

DUPLICATING CASTS

90. *Error*: Failing to protect the design drawn on the definitive cast.

Problem: If the design is not covered with a light coat of sealer, it will be washed off of the definitive cast when the cast is wet with slurry water in preparation for duplication. When transferring the design to the refractory cast, the technician will have difficulty determining the original design.

Solution: Cover the design with a light coat of cast sealer to maintain the design[2,13] (Note 5).

91. *Error*: Failing to use slurry water (see Part I,

Note 5. Formula for homemade sealer

Mix 1 part white shellac with 16 parts methanol to create an inexpensive sealer that can be painted over the design drawn on the cast. Use a small brush to paint a thin coating over the design; it will dry almost immediately. The sealer can be stored in a small bottle with an air-tight cap to prevent the alcohol from evaporating. Buy only a small can of white shellac, which is available at most paint stores. Shellac can be stored under normal conditions for approximately 1 year but should not be used after the expiration date on the original container. Old shellac will not set.

Note 10) to wet definitive casts when preparing to duplicate them.

Problem: When a cast is submerged in tap water to wet it, some of the cast's surface will dissolve. In less than 5 minutes, the loss can be significant. The longer the cast is in the water, the more it will dissolve. When the framework is completed, it will be too tight (small).

CAUTION: A set stone cast is soluble in tap water at the rate of 1 to 500 (1 part of stone is soluble in 500 parts of water).[6,12] If a cast is placed in a large amount of water, it will dissolve until the water becomes saturated.[12] Casts cannot be left in slurry water indefinitely. Even in slurry water, the solution exists in a dynamic equilibrium, with small amounts of stone continually being dissolved and deposited on the surface of the cast. Although the cast will not lose mass after dynamic equilibrium is reached, the surface will be constantly rearranged, resulting in an etched surface on the cast. Casts that have less dense surfaces (which result when the proper procedures for forming the cast are not followed) are more susceptible to etching and dissolution.

Solution: Soak the cast in slurry water rather than tap or distilled water. Leave the casts in slurry water no longer than is necessary to thoroughly wet them. Use a dense stone (type 4 dental stone, for example).[14]

92. *Error*: Failing to ensure the cast is thoroughly wet immediately before it is duplicated.

Problem: If some air remains in the cast when hot duplication material (130-135°F) is poured over the cast, the contained air will expand and collect around the teeth on the cast, causing voids in the fluid duplicating material. This will translate into nodules on the cast.[2] If the definitive cast is completely submerged in water to wet it, 8 or more hours may be required for the water to completely soak through and eliminate all the air.

Solution: To thoroughly wet a cast and expel all of the air cells in the stone, a part of the cast must be left out of the slurry water.[7] The water will be pulled through the cast by capillary action.[6]

93. *Error*: Leaving the cast in slurry water too long even though the anatomic portions of the cast are not submerged and not subject to etching.

Problem: If the base of the cast is immersed in slurry water and the anatomic portion of the cast is exposed to air, slurry water will be drawn to the exposed portion of the cast, where the water will evaporate and deposit stone salts on the surface of the cast.

Solution: Do not leave casts in slurry water any longer than necessary to thoroughly wet them. Put the casts and slurry water in a container with an air-tight lid to minimize evaporation.

94. *Error*: Failing to eliminate undercuts on the cast even though they are not involved within the borders of the casting.

Problem: Gross undercuts, such as those on the lingual aspect of the most distal portion of the mandibular cast and the facial aspect of the maxillary cast above the anterior teeth, engage the gelled duplicating material, making it difficult to remove the stone cast from the duplicating material. If the duplicating material is stretched beyond its elastic limit, it will either tear or distort as the definitive cast is separated. A distortion is more difficult to detect than a tear.

Solution: Use wax or clay to block out large undercuts on the cast, even when they are not directly involved in the area of the casting. Block out all undercuts around the periphery of the cast, making certain not to cover a part of the framework design.[12]

95. *Error*: Using duplicating material that is past its prime.

Problem: The process of repeatedly melting duplicating material, as it is reused, gradually deteriorates the material, which may cause it to tear easily. This problem usually is detected when the material is observed to crumble or mash around the undercuts as the cast is separated from the mold.[13]

Solution: Establish a log to monitor the number of times the hydrocolloid has been liquefied and the age of the material. It is best to replace the duplicating material with a new batch when even the slightest tearing or crumbling is evident. The life of the material is affected by such factors as the liquefying procedure, type of hydrocolloid storage and holding unit used, age of the material, cleansing and storage of the material between liquefying procedures, and amount of dehydration. Experience will establish the useful life of the material.[14]

96. *Error*: Failing to seal the definitive cast to the bottom of the duplicating flask before pouring the duplicating material.

Problem: If the definitive cast shifts and lifts slightly when the duplicating material is introduced into the flask, separation of the cast without distortion of the duplicating material will be very difficult.

Solution: Seal the cast to the bottom of the flask with at least 3 pea-sized pieces of modeling clay pressed against the cast and the flask base.[13,15,16]

97. *Error*: Having type 1 (reversible) duplicating material[15] too hot when it is poured over relief wax.[13,16]

Problem: If duplicating material that is too hot is poured over the blocked out cast, it can soften the wax relief enough to allow the relief to loosen from the cast and to permit bubbles to form under the wax.

Solution: Use calibrated sheet casting wax that is specifically made for this purpose. It is available in several thicknesses, the most popular being 20 gauge (American wire gauge 0.810 mm thick) and 30 gauge (American wire gauge 0.254 mm thick). Manufacturers supply the sheets in several colors to differentiate waxes with different consistencies and handling characteristics. Gauged sheet wax is also supplied with adhesive backs.[13] Be certain that the duplicating material is at the manufacturer's recommended pouring temperature or select a wax with a higher melting range.

98. *Error*: Pouring reversible duplicating material over a room-temperature cast.[13]

Problem: If the definitive cast is at or below room temperature when reversible duplicating material[15] is poured over it, the duplicating material may chill enough to form a thin film over some portions of the cast. At this point, the duplicating material will not be hot enough to coalesce with the thin film of gelled material; lines of demarcation may form, or some detail of the definitive cast may be lost.[13]

Solution: Warm the definitive cast to between 125°F and 130°F before pouring the duplicating material. This will allow the duplicating material to flow evenly over the cast before it starts to gel.

99. *Error*: Pouring the duplicating material around the definitive cast too rapidly.

Problem: Air voids can be trapped in the duplicating material if it is poured too rapidly or in too large of a stream. The cast made in the mold will not be useable.[16]

Solution: With the cast fastened to the base of the duplicating flask, pour a thin stream of bubble-free duplicating material in the center of the palate or tongue space. Allow the material to flow slowly until the entire cast is covered and the flask is filled.

100. *Error*: Improper cooling of type I duplicating material.[15]

Problem: Immersing the flask in room temperature or colder water cools the duplicating material but also causes it to shrink in an uncontrolled and erratic manner. Duplicate casts made with improperly cooled material will be distorted and larger than the definitive cast in some areas.[13,16] Type I duplicating materials[15] shrink toward the part that cools first, and thick sections shrink more than thin sections.

Solution: Cooling should be accomplished only through the base of the duplicating flask. Regulate the depth of the cooling water so that it contacts only the base of the flask. The material near the base and the cast will gel first, causing the duplicating material to shrink toward the cast. Distortion thus will be limited.[13,16,19]

101. *Error*: Failing to cool the duplicating material adequately as directed by the manufacturer.[16,19]

Problem: If the definitive cast is separated too soon and some of the material is not completely gelled, a distorted mold may result. This distortion may not be detected until the framework is fitted.

Solution: Most manufacturers are specific about the cooling time. It is better to leave the flask to cool a little longer than to rush the separation process.

102. *Error*: Failing to use continuously moving cooling water for type I duplicating material.[15]

Problem: If the cooling water is static rather than continuously moving past the flask, the water in contact with the flask will warm, and inadequately gelled material may result.[15]

Solution: Use a water-cooling system that provides continuous movement of the water to prevent hot spots around the flask.

103. *Error*: Failing to control the temperature of the cooling water.[15]

Problem: If the cooling water is below 55°F, the duplicating material will cool too rapidly at the base of the flask, causing distortion of the mold.[17]

Solution: The cooling system must be capable of keeping the water between 55°F and 60°F. Use an accurate thermometer to monitor the water temperature.

104. *Error*: Improperly removing the definitive cast from the duplicating material mold.[17]

Problem: The mold will be distorted if the cast is removed slowly or with a rocking motion. Slow or rocking removal will exceed the duplicating material's elastic limit in some areas, which will not recover their original shapes.[18] The resultant refractory cast will be distorted.

Solution: Remove the base of the duplicating flask and the clay used to stabilize the definitive cast. Insert the points of 2 knives, one on each side of the definitive cast. Using the walls of the body of the flask as fulcrums, pry up quickly to remove the cast with a quick snap. Do not lift one side at a time.

105. *Error*: Delaying the pouring of stone or investment into the mold.

Problem: As with irreversible hydrocolloid, (see Part I, errors 43 and 44) the longer the delay before the mold is poured, the more the mold will distort, translating into a distorted duplicate cast.[16] Some operators recommend covering the mold with a moist towel to minimize the escape of moisture from the duplicating material while preparing the mix of investment. The

same moist towel may be used to cover the investment-filled mold while the investment sets (see error 115 and solution). Using a moist towel in this case is permissible because the metal of the duplicating flask surrounds the reversible duplicating material. This is not the same as wrapping an impression in a wet towel (see Part I, error 46).

Solution: Vibrate the stone or investment mix into the duplicating material mold as soon as it is separated from the definitive cast,[19] as the moist towel will not prevent distortion of the mold from syneresis (see Part I, error 43).

106. *Error*: Failing to remove all of the excess liquid after rinsing the mold upon separating the definitive cast.[2]

Problem: Any excess liquid left in the mold when the mix of investment or stone is introduced will unite with the mix, making the teeth on the duplicate cast soft (see Part I, error 47).

Solution: It normally is not necessary to rinse the mold unless debris has fallen into it. Carefully shake the excess liquid from the mold and remove liquid with a gentle stream of air. If any liquid remains in the impressions of the teeth, remove it by blotting it with a cone of cleansing tissue.[18] Be especially careful not to excessively dry the material or dislodge the mold from the flask.

107. **Error*: Leaving the definitive cast in the mold too long before separation.

Problem: Color left on the surface of the mold indicates that the definitive cast was left too long before separation. The color is a thin layer of the definitive cast left in the mold. The color must be removed during the washing of the mold, or the duplicate cast will have a soft surface. Such a definitive cast is damaged and cannot be used for further duplications.

Solution: If stone residue is left in the mold, use the procedure described in the solution to error 106 (and in Part I, Note 5) to clean the mold.

108. *Error*: Failing to protect the bulk investment powder from moisture.

Problem: Moisture contamination will affect the accuracy and delay the setting time of the investment.[18]

Solution: Keep investment sealed in an air-tight container between uses.

109. *Error*: Failing to prepare the mix of investment according to the manufacturer's recommended water-to-powder ratio by weight (mass to mass).[13]

Problem: Manufacturers use the water-to-powder ratio to control the expansion of the investment to compensate for metal shrinkage during casting. One gram of powder or 1 mL of water can make a significant difference in the expansion of the refractory cast. Altering the water-to-powder ratio will result in a casting that fits either too tightly or too loosely.

Solution: Weigh the investment powder on accurate scales, and accurately measure the water according to the manufacturer's directions (see Part I, Note 7).

110. *Error*: Failing to use room-temperature distilled water or special liquid to make the investment mix.

Problem: Liquids expand or contract with changes in temperature. Liquid that is significantly too warm or cool may not measure accurately when a volumetric measure is used. Inconsistent liquid temperatures will result in inconsistent measurement of the liquid volume and create inconsistent expansions of the refractory cast.

Solution: Always use room-temperature liquid to mix investment powder.

111. *Error*: Failing to use distilled water for the investment mix or duplicating material mix.

Problem: Most communities treat their water supply with various chemicals, including chlorine and/or fluoride. Laboratory personnel have noticed a pronounced difference in the behavior of both investment and duplicating materials when tap water is used to mix them.

Solution: Use only distilled water or liquid supplied by the manufacturer to mix investment and duplicating materials.[17]

112. *Error*: Overvibrating the mold to make the investment flow faster.

Problem: Heavy, harsh vibration and prolonged vibration of the mold to make the investment or stone mix flow into the mold may loosen it from the duplicating flask. The mold may be distorted and result in an inaccurate duplicate cast.[2,14]

Solution: Use a vibrator that has light, sharp vibrations to make the investment mix flow into the mold (see Part I, Note 8).

113. *Error*: Adding the mix to the mold too rapidly.

Problem: Adding the investment too rapidly and in large amounts can result in voids (caused by trapped air) in critical places around the teeth.[17]

Solution: Add small increments of the mix, allowing it to flow smoothly around the mold. Keep the leading edge of the mix thin so that it does not jump across the space and trap air.[17]

114. **Error*: Allowing investment to overflow the mold and set while touching the metal rim of the flask.[9]

Problem: Investment that touches the flask cannot expand freely as it sets. This interference with the desired setting expansion may result in a distorted cast.

Solution: Try not to overfill the mold when pouring the mix. If some of the mix inadvertently overflows,

wipe the excess away after filling the mold so that the mix does not reach the metal rim of the flask.

115. *Error*: Failing to prevent dehydration of the filled duplicating flask while the investment sets.

Problem: If poured investment is exposed to ambient air while it is setting, water will evaporate from the investment and the duplicating material. The reduced moisture will prevent the investment from reaching its complete desired expansion and will permit the mold to dehydrate and shrink.[1,17]

Solution: As each duplicating mold in a flask is filled with investment, set the mold aside and drape a damp (but not dripping wet) paper or cloth towel over the filled flask. Leave the towel in place until the investment has set and is ready to separate from the mold. An even better procedure may be to place each filled flask in a sealed container to maintain a 100% humid environment.[8]

116. *Error*: Failing to allow the investment or stone to set for the proper length of time.[17]

Problem: Removing the cast from the mold before 1 hour may cause the investment cast to have a loose, powdery surface.

Solution: Use a timer to accurately measure the 1-hour setting time. The setting of the investment should be timed from completion of the pour.

117. *Error*: Leaving the cast in the mold too long.

Problem: If the investment remains in contact with the water-rich mold longer than 1 hour, the moisture in the mold may dissolve some of the surface of the investment cast.

Solution: The cast must be separated from the mold 1 hour after the mix was poured into the mold. If circumstances arise that prevent separation at 1 hour, it is best to let the mix set a slightly longer rather than shorter time.

118. *Error*: Using stone or investment that is not compatible with the duplicating material.[18]

Problem: Not all brands of gypsum materials are compatible with all duplicating materials.[19] If the materials are incompatible, the surface of the cast will be soft and poorly defined and/or a thin film of investment or stone will be left in the mold (Note 6).

Note 6. Cleaning gypsum from equipment

A 25% solution of sodium citrate sometimes is used to remove the film of stone and investment from equipment such as flasks and sprue formers. It is an effective agent, but it must be used with caution. After use, the equipment must be rinsed thoroughly with distilled water before it is used again. If sodium citrate comes in contact with stone or investment, it will seriously retard the setting time of the mixed material and cause the duplicate cast to develop a powdery surface. Pits will appear on castings made on the investment casts.[17]

Solution: Use only duplicating material that the manufacturer states is compatible with the specific brand of investment or stone being used.[14,18,19] If the manufacturer makes no recommendation, test the materials by preparing them according to the directions, and pour a cast to evaluate the results.

119. *Error*: Improperly removing the duplicating material from the flask and the cast.[17]

Problem: Severe damage to the cast may occur if it is handled too soon after it is separated from the mold.

Solution: After the investment has been in the mold for 1 hour, remove the duplicating material and cast from the flask in 1 piece. Carefully break the duplicating material away from the cast in small pieces. Because the investment has reached only its initial set and is still very soft, it can be damaged easily. Handle the cast very carefully to avoid marring or breaking the teeth. At this time, the teeth should not be touched by an instrument or even one's fingers.[13,17]

120. *Error*: Delaying rinsing and storage of the pieces of duplicating material.

Problem: If used pieces of reversible duplicating material lose or gain any liquid, the material's elastic properties will deteriorate and thus affect the accuracy of the resulting casts.

Solution: Rinse the pieces of duplicating material in clear water, making certain to remove all traces of stone and investment. Shake off the excess water and place the pieces in a container that can be tightly sealed. Rinsing replenishes the liquid that has been lost through vaporization.[16]

121. *Error*: Storing the duplicating material submerged in water.

Problem: If duplicating material is stored in water, it will absorb water, changing the water-to-gel ratio. This imbalance will cause the material to rapidly lose accuracy and strength.[17]

Solution: Rinsing the pieces in water adds enough water to maintain the balance of gel and water. If a strict practice of rinsing and storing the material immediately after use is followed, it will not be necessary to add more water or to pour out any liquid that may accumulate in the bottom of the sealed container.

WAXING AND INVESTING

122. *Error*: Drying the investment (refractory) cast with the teeth oriented up.

Problem: If the cast is dried with the teeth up, white material will be deposited around the teeth. This white material consists of salts deposited during the drying, when water vapor rises as it leaves the investment. The salt deposits will form a positive layer that cannot be removed without scraping and damaging the cast.[2]

Solution: To prevent the accumulation of salts on the teeth of the cast, place the refractory cast in the drying oven with the teeth down to allow the salts to

accumulate on the base of the cast, where they can be removed without damage to the teeth.[2] Use extreme care to prevent damage to the teeth as the cast rests on them.

123. *Error*: Drying the refractory cast in an unvented drying oven.[17]

Problem: An unvented drying oven can cause the refractory cast to crack. Heating the cast to a higher temperature than recommended or for a prolonged period may destroy the cast.

Solution: Always use the manufacturer's recommend drying procedure. Normally, this means placing the investment cast in a vented drying oven set at 200°F (93°C) for approximately 1 hour.[17]

124. *Error*: Using dirty beeswax to seal the investment cast.

Problem: Impurities such as chips of investment can accumulate in beeswax and may be stirred up when the wax is heated. This debris may adhere to the investment cast, become incorporated into the wax-up, and lodge in the casting, thus creating rough areas, especially inside the clasps.

Solution: Clean beeswax often by pouring the melted wax through a very fine mesh strainer. Use only refined beeswax.[1]

125. *Error*: Failing to heat the dipping wax to an appropriate temperature.

Problem: If wax is visible on the surface of the investment cast, the dipping wax may not have been hot enough. Wax that is too cool will not penetrate well into the cast. More importantly, the wax will not be as fluid as it should be and will not drain from the cast; a wax coating will remain. Any casting made on this cast will have fins as the molten metal fills the space left by the wax film.

Solution: Heat beeswax to between 280°F and 300°F (138°C-149°C). Take the hot cast directly from the drying oven, and use a cast carrier to submerge the cast in the wax. After a few seconds, the wax will start to foam. After the foaming starts, leave the cast submerged for 15 seconds. If these steps are followed properly, the dipping wax will completely soak into the refractory cast or will drain off, leaving the cast with a dry appearance.[17]

126. *Error*: Leaving the refractory cast improperly on its end to drain.

Problem: Visible wax on the investment cast also may indicate that the refractory cast was placed on end to drain but was not moved.[17] As wax drains, it can accumulate at the lower part of the cast and form a buildup of wax as it cools.

Solution: Before placing the investment casts in the drying oven, trim the backside (heel) of each one so that the cast can stand on its heel to let the hot beeswax drain. When removing each cast from the hot wax, stand the cast on its heel on a piece of absorbent paper so that the excess wax will drain. After a few seconds, move the cast to another clean place on the paper so that the drained wax will not solidify around the cast.[17] It may be necessary to blow residual foam from the cast before it cools. Use short, strong puffs of air. After the cast cools, it will appear to be wax free. Allow it to cool to room temperature before proceeding to the next step.

127. *Error*: Inaccurately transferring the design from the definitive cast to the refractory cast.

Problem: If the design is not correctly transferred to the investment cast, the waxing technician will not be able to correctly wax the framework. Because the refractory cast is a uniform color, the waxing technician will not be able to tell which areas have been blocked out or to accurately discern the design.

Solution: Quality control in the laboratory should include inspection of the transferred design onto the investment cast.

128. *Error*: Marking the investment casts with graphite pencils.

Problem: If the design is placed on the refractory cast with a graphite pencil, the final casting may be pitted. Graphite acts like antiflux.[17]

Solution: Always use crayon (wax-based) pencils for design transfer.

129. *Error*: Using dirty wax and dirty preformed plastic patterns.

Problem: Dust and dirt in the laboratory often contain particles that will not burn out during wax elimination. Contaminates such as polishing compound, graphite, and metal grindings can cause pits in the finished framework.

Solution: Keep wax and preformed plastic patterns clean and use them in a relatively dust-free environment. Store them in a closed container. Particularly avoid exposing these materials to grindings from the lathe and handling them with dirty hands.[17]

130. *Error*: Failing to seal preformed plastic patterns to the cast.[17]

Problem: Preformed plastic clasp shapes will curl away from the refractory cast at their tips when they are applied to form the framework. The patterns have elastic memory and will tend to return to their original, flat shape even after they have been properly adapted to the cast.

Solution: Paint the design outline on the wax-dipped investment cast with tacky liquid, and then apply the plastic forms. Before investing, carefully inspect the applied forms. If the tips of the forms have lifted, either paint more tacky liquid directly on the cast side of the tip of the preformed plastic pattern and reseat it, or tack the tip of the pattern down with a small drop of soft wax.

131. *Error*: Attaching the sprue lead to a thin section of the waxed framework.

Problem: Attaching sprue leads to thin sections of the waxed framework may result in casting failures.

Solution: Never cast a thick section through a thin section; always sprue to a bulky section of the pattern. The ideal pattern will get progressively smaller in volume from the attachment of the sprue leads to the extremities of the pattern.

132. *Error*: Failing to securely attach the sprue leads to the sprue cone.

Problem: If the sprue leads are not attached securely to the sprue cone and to the pattern, a seam will form at the attachment. Small amounts of the investment mix may enter cracks or imperfections during the investing procedure. After burn out, these imperfections will be unsupported, and during casting, small pieces of investment may break off as the molten metal enters the mold. The metal will carry the pieces of investment into the casting.

Solution: During spruing, make certain that all sprue leads are attached firmly and smoothly at both ends. All sides of each joint must be sealed.

133. *Error*: Trimming the sprue hole in the investment cast after wax dipping to enlarge or smooth it.

Problem: Using a sprue cone that is too small in diameter for the amount of metal to be cast, placing the sprue cone former improperly or in a haphazard manner, or using a dirty sprue cone former will leave rough areas on the investment mold around the sprue hole. These areas will require that the hole created in the investment cast be trimmed to make it large enough or to make a smooth transition into the sprue leads.[17] If the surface of the investment is disturbed, it will be rough and allow the molten metal to carry some of the refractory material into the body of the casting.[14]

Solution: Use a clean sprue cone former of the proper size as recommended by the manufacturer so that the investment will not require modification. The sprues must be attached to the sprue former and the framework pattern with wax contoured to make a smooth transition after the wax is eliminated.

134. *Error*: Failing to use surface tension reducer correctly on the waxed patterns.

Problem: Correctly mixed paint-on investment will not cover the patterns well if surface tension reducer is not used on the pattern. Because it has difficulty flowing, the paint-on mix often will trap air, creating metal nodules and rough areas on the cast framework.[17]

Solution: Use a surface tension reducer (as recommended by the manufacturer) or any other appropriate detergent solution to improve the wettability of the wax and plastic surfaces.

135. *Error*: Failing to allow the surface tension reducer to dry before applying the paint-on investment.

Problem: If the surface tension reducer is not allowed to dry before the paint-on investment is applied, the completed casting will have fins and rough areas in it.

Solution: Paint surface tension reducer over the wax and/or plastic pattern, or dip the entire pattern in surface tension reducer as applicable. Gently shake or blow the excess solution from the waxed pattern, being careful to avoid making bubbles, and allow the pattern to air dry completely before proceeding with the investing.

136. *Error*: Failing to mix the paint-on investment according to the manufacturer's directions as recommended for some procedures.[17]

Problem: Some casting procedures require the investment cast to have 28 mL of water to 100 g of powder and the paint-on and outer investments to have 30 mL of water to 100 g of powder.[17] These ratios permit the outer investment to expand slightly less than the cast to eliminate the fins that would occur if they expanded the same amount. If the paint-on investment layer is too thin, it will not cover the pattern to the depth required; the paint-on layer will be weak and subject to breaking away during casting. If the paint-on layer is too thick, this dense layer will impede the escape of gasses as the molten metal flows into the mold. Fins, roughness, and incomplete castings indicate that the manufacturer's directions for mass-to-mass proportions for the paint-on mixes were not followed. The completed casting may require an unusual amount of finishing.

Solution: Because such a small difference in the powder-to-liquid ratio can affect expansion, the powder must be weighed on accurate scales, and the liquid must be measured very precisely[2,17] (see Part I, Note 7).

137. *Error*: Failing to allow the paint-on investment to set before soaking the assembly in slurry water before placing the outer investment.[17]

Problem: Rushing the paint-on investment and not allowing time for it to set thoroughly before placing it in slurry water may soften the investment and cause it to lift slightly from the cast. This may cause the metal casting to be thicker, have fins, and require more finishing.

Solution: Follow the manufacturer's recommendations, and allow ample setting time for the paint-on investment.

138. *Error*: Allowing the mold (flask) with the invested pattern to be loose in the casting machine during casting.[17]

Problem: If the mold moves in the casting machine as the casting arm starts to spin, molten metal may partially miss the sprue hole, and some molten metal may spill outside of the mold. The casting may be porous or incomplete because of insufficient metal.[17] If the mold is faced after the outer investment has set to

make the ends flat and parallel, an excessive amount of investment may be removed, making the mold shorter than normal and less secure in the casting cradle.

Solution: Make certain that the investment mold is stable in the machine before spinning the casting arm.

CASTING AND FINISHING

139. *Error*: Placing a dry investment mold in the burn out furnace.

Problem: If the investment surrounding the wax pattern is dry as the temperature increases, the molten wax and plastic will soak into the surrounding investment. Some of the residue may solidify and prevent the molten metal from entering the smaller portions of the mold. Moreover, if the investment mold is allowed to dry excessively, the mold may crack during burn out and cause fins on the casting.

Solution: Place molds with invested patterns in a pan of water deep enough to cover the mold half way. Allow the investment to become soaked before placing it in the burn out oven.[17] As the mold is heated, the moisture will create steam to flush the plastic and wax out of the mold.

140. **Error*: Carelessly locating the investment molds in the burn out oven.

Problem: If molds touch the floor, walls, or each other or are not evenly spaced in the furnace, some parts of the molds will be colder or hotter than others. This may cause warping of the framework even as it is cast.

Solution: Place the molds in the furnace so that they do not touch the walls or floor of the furnace or each other. This will allow circulation of the hot air during burn out and prevent the formation of hot and cold spots in the molds. Porcelain denture teeth or small pieces of ceramic material may be used as spacers.[17] Some ovens have vent holes. Be certain that the vent holes are open to ensure good circulation, and keep the inside of the oven clean.[17]

141. *Error*: Failing to place the investment molds in the burn out oven with the sprue holes down.

Problem: If the sprue hole faces upward during burn out, it will be more difficult for the wax to flow out of the mold. Any retained wax will carbonize and may inhibit the flow of the molten metal to all parts of the pattern when it is cast. This may result in an incomplete casting.

Solution: Always load molds in the burn out oven with the sprue holes down so that the wax can easily drain and be flushed out by the steam generated inside the mold as the temperature rises.

142. *Error*: Failing to use accurate burn out temperatures and times.

Problem: If the burn out temperature is too low and the burn out time is too short, the investment will not experience enough thermal expansion.[17] As a result, the casting may fit the definitive cast too tightly. If the burn out temperature is too high, the investment will decompose and cause the casting to be pitted and rough.[17]

Solution: Use the recommended burn out temperature. Accurately set the equipment for time and temperature, and calibrate the equipment on a regularly scheduled basis.

143. *Error*: Improperly positioning the mold in the casting machine.

Problem: If the mold is positioned in the casting machine so that the thinner sections of the framework are toward the rotating direction of the spinning machine, a negative pressure may cause some parts of the pattern to miscast.

Solution: Take advantage of the centrifugal force. Orient thin sections away from the rotating direction of the casting arm (toward the trailing edge). Additional centrifugal pressure will be placed on the molten metal when it enters the mold.[17] When investing the framework, mark the position of the thin framework sections so that they can be identified easily when the mold is placed in the casting machine.

144. *Error*: Failing to heat the metal to the specified temperature before casting.[17]

Problem: If the metal is slightly below the casting temperature, a cold melt will result, and the clasp tips and thin sections will not cast completely. If the metal is slightly overheated, the casting will be porous.

Solution: Verify that the temperature gauge reads the correct temperature and that the casting machine has been correctly set and properly calibrated. In the absence of an expensive casting machine that measures the temperature of the metal, the operator must have the knowledge to judge when the molten metal is within the casting range.

145. *Error*: Failing to allow the metal to cool to room temperature in the investment.[17]

Problem: Quenching the mold to speed up cooling after casting may cause serious warping of the metal casting and make the investment more difficult to remove.[17]

Solution: Allowing the mold to cool to room temperature on its own will result in uniform cooling and is a form of tempering the metal. When the mold is cool enough to handle with bare hands, pick it up and tap the sides of the mold lightly with the handle of a plaster spatula. Much of the investment will break away. Then grasp the button firmly with sturdy pliers and tap on the end of the sprue button with a hammer. Most of the remaining investment will fall off easily. An air-abrasion machine with walnut shell is recommended for removal of the remaining investment.[2] The oxide can be removed with 50-μm-grit aluminum oxide.

146. *Error*: Improperly using an air-abrasion machine to clean the casting.

Problem: The air pressure at the nozzle of the air-abrasion machine is about 100 psi. Thin areas of a framework, especially a thin horseshoe major connector, can be warped easily if the framework is held too closely to the nozzle.[2]

Solution: Hold the framework approximately 5 to 7 inches away from the orifice of the nozzle so that the aluminum oxide can spread out and the force of the air can dissipate.

147. *Error*: Carelessly cutting off the sprue leads.

Problem: A large separating disk can quickly destroy vital parts of the framework, especially if the operator is inattentive or if the disk is too large to allow easy access to the sprue leads.

Solution: Normally, a large separating disk can be used to cut off the sprues, but for places that are inaccessible to the larger disk, smaller disks are available. The large disk cuts faster but can be dangerous to the metal and the operator. When removing the sprue leads, observe the edge of the disk opposite to the edge doing the cutting as well as the edge cutting. It is possible to be so intent on cutting the sprue that the opposite side of the disk is forgotten and cuts a groove in a clasp or nicks a major connector. Cut close to the framework, but be careful not to nick the metal parts of the framework.[18]

148. *Error*: Allowing a thick carborundum disk to bind in the cut and throw the framework out of the operator's hands.

Problem: A large disk turning at 24,000 rpm can be a dangerous tool.[17] If a disk binds in the cut, it may break and throw debris unpredictably, or it may throw the framework and bend the clasps or the major connector. More importantly, the operator may be seriously injured.[17]

Solution: Be alert. Use light pressure to make the cut a little wider than the width of the disk to prevent binding. The deeper the cut, the greater the danger of binding. If the cut is getting too deep, consider cutting from the opposite side to meet the first cut halfway.

149. *Error*: Using the wrong mandrel in a high-speed lathe.[17]

Problem: High-speed lathes operating at 24,000 rpm can cause the shank of a regular mandrel to bend at a right angle where it is clamped in the chuck. This distortion occurs in the first few revolutions of the lathe, before the operator can react, and may seriously injure the operator's hands before they can be withdrawn.

Solution: Make certain that the mandrels used in the lathe are reinforced between the clamping mechanism of the lathe and the disk or stone. The disks and heatless stones must be rated for use in a high-speed lathe.

150. *Error*: Using heatless (heat-free) stones of a larger diameter than ½ in. on a high-speed lathe.

Problem: With or without a mandrel with a reinforced shank, some larger heatless stones used at high speeds may fly apart and/or bend the mandrel and injure the operator.

Solution: Always use the shatterproof glass shield that comes with the high-speed lathe. Always wear shatterproof glasses or other safety eyewear when using rotary instruments.[17] Know the instruments being used, and use them within their design specifications.

151. *Error*: Skipping from course-grit grinding and cutting wheels to fine polishing wheels and points.

Problem: Establishing smooth contours and eliminating deep scratches in the metal without using progressively finer grit wheels, stones, and points to shape clasps and remove oxide from the outside of the casting is an impossible task. More time is spent when steps are skipped because one must work harder to use finer grits when the proper sequence has not been followed.[2]

Solution: Complete all work with a course-grit stone before changing to a finer-grit stone. Changing back and forth only wastes time.

152. **Error*: Carelessly grinding the inside of clasps.

Problem: Injudiciously relieving the inside of clasps to speed the seating process may remove too much metal. As a result, the clasps will not fit the abutments as planned, and adverse forces will be placed on the teeth, plaque-trapping spaces will remain between the clasp and the tooth, and the required retention will be reduced.

Solution: With the use of fine-grit tapered stones and rubber abrasive points inside the clasps, remove only the oxide layer. Removal of any other metal inside the clasps must be accomplished deliberately and carefully with the use of a proper disclosing medium to show where the unfavorable binding must be relieved.[17]

153. *Error*: Using large stones or burs to remove nodules in tight places and inside clasps.

Problem: When large stones or burs are used to try to eliminate imperfections in limited-access places, the tendency is to overgrind and remove too much metal.[17] The result is open spaces between the metal and tooth and loss of planned stability for the RPD.

Solution: Use a No. 1 or No. 2 round carbide bur in a high-speed handpiece or lathe to remove any nodules present in places that have limited access. In extremely tight and critical areas such as marginal ridges or cingulum rests, it may be necessary to use even smaller carbide burs (½ or even ¼ round).

154. **Error*: Carelessly shaping and air-abrading the framework.

Problem: Removing too much metal from the framework may cause it to fit inaccurately or retentive

clasps to be weak and subject to breakage.[2] An improperly tapered clasp or one that has thin places or nicks encourages breakage by concentrating the strain of opening and closing as the clasp springs into the retentive undercut at the narrow, weak spot in the clasp arm. The result is metal fatigue and fatigue fracture at that spot. On the other hand, a clasp that is properly tapered and has no weak spots causes the stress to be distributed over the full length of the clasp arm so that the clasp can spring indefinitely without fatigue.

Solution: When shaping clasps with stones and wheels, maintain the general shape of the plastic pattern. For best results, a retentive clasp should taper uniformly, from the rest or attachment to the framework to the tip. After all shaping has been completed, use 50 μm aluminum oxide to lightly abrade the framework. This will prepare the framework for electropolishing by establishing a clean, oxide-free surface. Abrading should be performed carefully, especially inside the clasps, to prevent removal of an excessive amount of metal.

155. *Error*: Failing to follow the manufacturer's instructions when electropolishing the metal.[17]

Problem: Electropolishing for a longer time or at a higher amperage than recommended may result in the removal of too much metal. Thin areas will be disproportionately affected, potentially making them weak and subject to failure.

Solution: Electropolishing is a deplating process; that is, it removes a layer of metal from the surface of the framework. For best results, be certain to use the proper amperage and time.[17] If the framework is placed in a cool solution, the amperage will rise as the solution warms. Periodically check the amperage during the process. Reset the amperage each time another framework is electropolished.

156. **Error*: Indiscriminately using carborundum-impregnated rubber abrasive wheels and points over the entire surface of the casting.

Problem: Abrasive rubber wheels and points can build up heat in the framework very quickly. If this heat is concentrated in a thin area, such as the palate or other thin major connectors, the polishing may cause the framework to warp.[17]

Solution: Use a brush wheel and cutting or high-shine compound to polish thin areas. Use these products sparingly and with no more pressure than necessary.

157. *Error*: Polishing the intaglio surface of the framework with rubber wheels.

Problem: Polishing removes a definitive layer of metal. The goal is to adapt the metal as closely as possible to the tissue to prevent space for food accumulation and to provide for thermal stimulation of the tissue. A highly polished surface has had a significant layer of metal removed and therefore cannot fit as well to the tissue as an unaltered frame.[17]

Solution: Carefully remove any metal nodules and artifacts, then shine the intaglio surface slightly with a brush wheel and polishing compound to enhance the shine left by the electropolishing (see solution to error 155). Do not use rubber abrasive wheels.

158. *Error*: Polishing any part of the retentive area for acrylic resin.

Problem: Polishing the resin retention area wastes time and may weaken the retentive network. Electropolishing leaves a bright metal surface without additional polishing. Regardless, the retention area will be covered with resin.[17]

Solution: Spend time highly polishing only those areas of the framework that will be exposed after resin processing.

159. *Error*: Carelessly using felt or cloth wheels while polishing the framework.

Problem: Clasps and other parts of the framework can easily catch in the polishing wheel. If they catch, the framework may be pulled from the operator's hands and thrown. The force usually distorts the framework and may injure the operator.

Solution: Be careful to avoid catching the cloth or felt polishing wheels and points on the clasp tips or other parts of the framework. The wheel should be applied so that it rotates away from clasp tips and other projections.

160. *Error*: Indiscriminately applying cutting compound inside the clasps.

Problem: Cutting compound, such as tripoli for gold or gray cutting compound for base metals, can remove a considerable amount of metal. When cutting compound is applied to critical areas such as the inside of clasps or under rests, the close adaptation of the metal to the tooth may be jeopardized.

Solution: Use cloth or felt wheels or points on a high-speed lathe with discretion. Polish the outside of clasps and other components with these tools, but reserve prophy brushes for polishing the inside of clasps.[17]

161. *Error*: Failing to clean the cutting compound from the framework before starting the next step.

Problem: Cutting compound left on the casting will be transferred to the wheels and points used for the next step, which is the use of a red or white polishing compound. If such residue remains, it may not be possible to develop a high luster on the framework.[17]

Solution: Use a solution of tincture of green soap and ammonia on a brush to clean the cutting compound from the casting. This process will work faster if the solution is warmed and is excellent if used in an ultrasonic cleaner (see solution to error 163 and Part III, solution to error 234).

162. *Error*: Using the same felt wheels, points,

cloth wheels, and brush wheels for both cutting compound and high-shine compound.

Problem: If the compounds are transferred from one polishing instrument to another, the finish will not develop its full shine.

Solution: Wheels and points should be dedicated to the use of only 1 type of polishing compound. Each should be stored separately from those used for other compounds. The polishing materials can be separated by keeping them in small boxes marked for easy identification (see Part III, solution to error 234).

163. *Error*: Failing to clean the framework after completing polishing procedures.

Problem: Soap and detergent by themselves do not do a good job of removing cutting and polishing compound from castings. Leftover residue will dull the framework and prevent it from achieving its full luster.

Solution: Use the tincture of green soap and ammonia solution (see solution to error 161 and Part III, solution to error 235) with a brush or in an ultrasonic cleaner to bring out the full luster of the polished metal.[2]

FITTING THE FRAMEWORK TO THE CAST AND MOUTH

164. **Error*: Laboratory fitting the casting to the definitive cast rather than to a duplicate of the definitive cast.

Problem: If the technician fits the casting to the definitive cast, the cast will be scarred and scratched. If the casting does not fit the mouth, the cast cannot be used again to remake the framework. A new impression and cast must be made.

Solution: The advantage is with the dentist if the framework has been fitted to a duplicate of the definitive cast in the laboratory and the framework has never been on the definitive cast. The dentist has the opportunity to evaluate the casting and the unscarred cast and to compare them with the mouth. If the casting does not fit, the dentist can decide whether to remake the impression and make a new cast or send the original definitive cast back for a remake. Without the unscarred cast, there is no choice but to remake the impression and make a new cast. There are some disadvantages to this procedure. Additional costs are incurred if the laboratory makes a duplicate definitive cast.[2] Moreover, if the duplicate cast is not accurate, the casting may fit the duplicate cast and still not fit the definitive cast or the mouth. Some laboratories may have a tendency to excessively relieve areas of the framework where it contacts the blocked out areas in an effort to seat it quickly and completely.

165. *Error*: Failing to fit the framework to the mouth with the use of disclosing wax.

Problem: Thin disclosing materials such as white shoe polish, machinists' dye, rouge dissolved in chloroform, or spray-on indicator only indicate the presence or absence of contact between the casting and the teeth; they do not indicate the magnitude of the space. In other words, they are 2-dimensional indicators and are inefficient for evaluating fit.

Solution: Use a thick disclosing material such as white disclosing wax.[7] With disclosing wax, hard contacts show as bright metal. Where the wax looks gray, a small space exists between the casting and tooth surface. Where the wax is white, a significant space exists between the casting and the tooth. These differences enable the operator to read the degree of contact and arrive at a 3-dimensional evaluation of the fit of the casting. With thin disclosing materials that show only the hard points of contact, the only way to judge the fit is to note the number of hard contacts. Presumably, the more contacts that show, the better the fit. Time is spent chasing point contacts without really knowing how much adjustment is required.[7]

166. **Error*: Accepting a partial denture framework that rocks in the mouth and cannot be seated firmly.

Problem: A framework that does not fit solidly in the mouth will damage the teeth and soft tissues and will annoy the patient.[12]

Solution: If one side of the framework is seated and the other side pops up slightly as pressure is applied to a rest, the framework is not seating correctly and must be refitted. Flow a thin layer of disclosing wax inside the clasps. Seat the framework in the mouth, carefully applying even hand pressure to seat all clasps at the same time. Do not rock the framework, as this will displace the wax in the wrong places and lead you to make adjustments in the wrong places. Repeat the seating and relieving procedures in places where bright metal shows through the wax until all rests seat at the same time and the casting does not rock.[12] If the framework is still unstable after considerable fitting, it must be remade.

167. *Error*: Failing to mount the casts in an articulator before setting the teeth.

Problem: If the casts could be hand articulated and the dentist elected not to mount them before the framework was made (see error 74), they must be mounted before the teeth can be properly arranged.

Solution: Do not try to mount the casts in an articulator without accurate jaw relation records because it is not possible to do so without error.[2] Mount the casts with a face-bow and jaw relation records as described earlier[7] (see solutions to errors 76 through 78).

168. *Error*: Dentists failing to select type, shade, and mold of the denture teeth to be used.[7]

Problem: Selection of the type of artificial teeth is the dentist's responsibility. Laboratory personnel have not seen the patient and cannot know the treatment parameters to the degree that the dentist does.[7]

Solution: The dentist must select the type, shade,

and mold of teeth based on esthetic and functional requirements. The dentist must at least select the occlusal scheme, establish priorities for esthetics versus functional compromises, and choose the composition of the artificial teeth (plastic, porcelain, or metal, for example). This information must be included as a part of the laboratory work authorization order.

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