Direct Gold Restorations

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Direct Golds and Principles of Manipulation

Several types of dental restorative materials are currently available. Generally, they are grouped into categories such as amalgam, cast gold, tooth-colored material, dental porcelain, porcelain-fused-to-metal (PFM), and direct gold. Direct gold is a gold restorative material that is manufactured for compaction directly into prepared cavities. Two types of direct gold are manufactured for dental use: gold foil and powdered gold. These gold materials differ in their metallurgical structure.

Pure gold has been in use in dentistry in the United States for more than 100 years. Various techniques have been advanced for its use in the restoration of teeth. It is generally agreed that this noble metal is a superior restorative material for treatment of many small lesions and defects in teeth, given sound pulpal and periodontal health. Success is achieved with direct gold restorations if meticulous care is given to an exacting technique in tooth preparation design and material manipulation. Direct gold restorations can last for a lifetime if attention is paid to details of restorative technique and to proper home care. The longevity of direct gold restorations is a result of the superb biocompatibility of gold with the oral environment and its excellent marginal integrity.

This chapter discusses the various forms of direct gold presently available and explains the principles required for their manipulation. The principles of tooth preparation are reviewed as they are applied to direct gold restorations. Class I, V, and III preparations and their restoration are considered in detail.

Materials and Manufacture

Several physical types of direct-filling gold have been produced. All are “compactable” in that they are inserted into tooth preparations under force and compacted or condensed into preparation line and point angles and against preparation walls.

Gold foil is manufactured by beating pure gold into thin sheets. The gold foil is cut into 4 × 4 inch (10 × 10 cm) sheets and sold in books of sheets, separated by pages of thin paper. The books contain 1/10oz or 1/50oz of gold. The sheet of foil that weighs 4 g is termed No. 4 foil; the sheet weighing 3 g is termed No. 3 foil; and the sheet weighing 2 g is termed No. 2 foil. Because the 4 × 4 inch sheets are too large to be used in restorative procedures, they are rolled into cylinders or pellets before insertion into tooth preparations. (The gold foil referred to in the restorative sections of this chapter is in pellet form.)

Pellets of gold foil are generally rolled from 1/12-inch, 1/14-inch, 1/16-inch, or 1/28-inch sections cut from a No. 4 sheet of foil. The book of foil is marked and cut into squares or rectangles (Online Fig. 22-1, A). Each piece is placed on clean fingertips, and the corners are tucked into the center (see Online Fig. 22-1, B and C), and then the foil is lightly rolled into pellet form (see Online Fig. 22-1, D). In addition, cylinders of gold foil may be rolled from the segments of a sheet (see Online Fig. 22-1, A). After pellets of gold are rolled, they may be conveniently stored in a gold foil box (Online Fig. 22-2), which is divided into labeled sections for various sizes of pellets. Cylinders of foil and selected sizes of other types of gold also may be stored in the box. Preferential contamination is suggested by placing a damp cotton pellet dipped into 18% ammonia into each section of the box. This serves to prevent deleterious oxides from forming on the gold until it is used.

Powdered gold is made by a combination of chemical precipitation and atomization, with an average particle size of 15 mm (Online Fig. 22-3, A). The atomized particles are mixed together in wax, cut into pieces, and wrapped in No. 4 or No. 3 foil (see Online Fig. 22-3, B). Several sizes of these pellets are available. This product is marketed as Williams E-Z Gold (Ivoclar-Williams, Amherst, NY).

Cohesion and Degassing

Direct gold is inserted into tooth preparations under force. The purpose of the force is to weld the gold into restorations containing minimal porosity or internal void spaces. Welding occurs because pure gold with an absolutely clean surface coheres as a result of metallic bonding. As the gold is forced and compressed into a tooth preparation, succeeding increments cohere to those previously placed. For successful welding to occur during restoration, the gold must be in a cohesive state before compaction, and a suitable, biologically compatible compacting force must be delivered.
Degassing is accomplished by heating the gold foil on a mica tray over a flame or on an electric annealer or by heating each piece of gold over a pure ethanol flame (Online Fig. 22-4).

The advantage of the technique involving use of the pure ethanol flame is that each piece of gold is selected and heated just before insertion, and waste of gold is avoided. A careful technique is needed to degas an increment of gold in the flame correctly. The gold is passed into the blue inner core of the flame on the tip of a foil-passing instrument and held just until the gold becomes dull red, and then the instrument is withdrawn from the flame. After a few seconds are allowed for cooling, the gold is placed in the preparation. Although any of the three degassing procedures is satisfactory for gold foil, this is not the case for E-Z Gold. The E-Z Gold pellet must be heated 12 to 1 inch above the ethanol flame until a bright flame occurs (caused by ignition of the wax) and the pellet becomes dull red for 2 to 3 seconds, then it is withdrawn from above the flame.

Principles of Compaction

Direct-filling gold must be compacted during insertion into tooth preparations.12 With the exception of E-Z Gold, the compaction takes the form of malleting forces that are delivered either by a hand mallet used by the assistant or by an Electro-Mallet (McShirley Products, Glendale, CA) or a pneumatic mallet used by the dentist. E-Z Gold, because of its powdered form, may be compacted by heavy hand pressure delivered in a rocking motion with specially designed hand condensers.13,14 Successful malleting of the gold foil may be achieved with any of the currently available equipment. Some operators prefer the Electro-Mallet or the pneumatic mallet because a dental assistant is not required for the procedure.

A technique preferred by many clinicians uses a hand mallet to deliver light blows to a condenser held by the dentist (Online Fig. 22-5, A). This technique allows great control of malleting forces when variations are called for, and it allows for rapid change in condenser nips, or tips, when a multitude...
**Online Fig. 22-3** Scanning electron micrographs of direct-filling golds. **A**, Spheres of E-Z Gold. **B**, Wrapped E-Z pellet that contains spheres. (Courtesy of Ivoclar-Williams Company, Inc., Amherst, NY.)

**Online Fig. 22-4** **A**, Pellet of gold foil is degassed in pure ethanol flame. **B**, Mica tray mounted over alcohol lamp for degassing several increments of gold simultaneously. **C**, Gold foil degassed on an electric annealer. (Courtesy of Terkla and Cantwell.)

**Online Fig. 22-5** **A**, Hand mallet and condensers used for hand mallet compaction of direct gold. **B**, Selection of variously shaped nibs. Left to right, three round-faced nibs, oblique-faced nib, foot condenser, and rounded rectangular nib. (A, Courtesy of Terkla and Cantwell.)
of condensers is required. In any case, a suitable condenser must be stepped over the gold systematically to achieve a dense, well-compacted restoration (see Online Fig. 22-8).

Condensers are designed to deliver forces of compaction to direct gold. Condensers used in the handpieces of the Electro-Mallet or pneumatic mallet consist of a nib, or working tip, and a short shank (approximately 1 inch [2.5 cm] in length) that fits into the malleting handpiece. Condensers used with the hand mallet are longer (approximately 6 inches [15 cm]) and have a blunt-ended handle that receives light blows from the hand mallet.

Condenser nibs are available in several shapes and sizes (see Online Fig. 22-5, B). All have pyramidal serrations on the nib faces to prevent slipping on the gold. Condensers described in this chapter are (1) the round condensers, 0.4 to 0.55 mm in diameter; (2) the Varney foot condenser, which has a rectangular face that is approximately 1 to 1.3 mm, and (3) the parallelogram condensers, which are used only for hand pressure compaction and have nib faces that measure approximately 0.5 to 1 mm.

Condenser shanks may be straight, monangled, or offset, and their nib faces may be cut perpendicular to the long axis of the handle or perpendicular to the end portion of the shank (Online Fig. 22-6). The smaller the nib face size (i.e., area), the greater the pounds per square inch delivered (given a constant malleting force). If the nib diameter is reduced by half, the effective compaction force in pounds per square inch is four times greater (because the area of a circle is proportional to the square of the diameter). For most gold, the 0.4- to 0.55-mm diameter nibs are suitable. Smaller condensers tend to punch holes in the gold, whereas larger ones are less effective in forcing the gold into angles in the tooth preparation.

Two fundamental principles involved in compaction of cohesive gold are to (1) weld the gold into a cohesive mass and (2) wedge as much gold as possible into the tooth preparation.15 Welding takes place primarily as a result of the coherence of the noble metal to itself. Wedging results from careful compacting technique. Regardless of the technique used, some bridging occurs, resulting in void spaces not only in the compacted gold but also along the preparation walls. Success depends on minimizing these voids, particularly on the surface of the restoration and at the cavosurface interface, where leakage to the internal aspects of the restoration may begin.

Gold foil compacts readily because of its thin form and produces a mass with isolated linear channels of microporosity (Online Fig. 22-7). Because the thin folds of the gold pellet weld to each other, the remaining channels of microporosity do not appear to be entirely confluent with one another.

It is recommended that compaction of E-Z Gold be done by hand pressure. As compaction is performed, the bag of atomized gold is opened, and the spheres of gold powder move over one another and against the preparation walls. Heavy and methodic hand pressure with the condensers is required to compact this form of gold effectively.

**Compaction Technique for Gold Foil**

Compaction begins when a piece of gold is placed in a tooth preparation. The gold is first pressed into place by hand, then a condenser of suitable size is used to begin malleting in the center of the mass (often this is done while this first increment is held in position with a holding instrument). Each succeeding step of the condenser overlaps (by half) the previous one as the condenser is moved toward the periphery (Online Fig. 22-8). The gold moves under the nib face of the condenser, effecting compaction as malleting proceeds.

The most efficient compaction occurs directly under the nib face.15 Some compaction also occurs by lateral movement of the gold against surrounding preparation walls. The result of compaction is to remove most of the void space from within each increment of gold, to compact the gold into line and point angles and against walls, and to attach it to any previously placed gold via the process of cohesion.16

The line of force is important when any gold is compacted. The line of force is the direction through which the force is delivered (i.e., the direction in which the condenser is aimed) (Online Fig. 22-9). Specific instructions regarding line of force are given in subsequent sections as they relate to the restorations.

Research has shown that a biologically acceptable pulpal response occurs after proper direct gold procedures.17 Care is required when condensing forces are applied to preclude pulpal irritation. The Electro-Mallet is an acceptable condenser if the manufacturer’s instructions for mallet intensity
are followed. Correct hand-malleting technique requires a light, bouncing application of the mallet to the condenser, rather than delivery of heavy blows.

Compaction Technique for E-Z Gold

Using an amalgam condenser or a gold foil condenser, the first pellet of E-Z Gold is pressed into the depth of the tooth preparation and tamped into position. A small condenser is selected to thrust and wedge the gold into opposing line angles and against opposing walls, to secure the mass in the preparation. Additional pellets are added (one at a time, banking against the preparation walls) until the entire preparation is filled. To avoid creation of large void spaces in the restoration, a dense, fully condensed surface is obtained with each pellet before subsequent pellets are added.

Principles of Tooth Preparation for Direct Gold Restorations

Fundamentals of Tooth Preparation

The principles of tooth preparation for all direct gold restorations demand meticulous attention to detail for success. Failure to give attention to outline form may result in an unsightly restoration or, at the least, one in which cavosurface deficiencies are immediately obvious. Poor resistance form can result in tooth fracture; inadequate retention form may result in a loose restoration that is frustrating to the dentist. Lack of detailed convenience form may render an otherwise excellent tooth preparation unrestorable. The preparation must be smoothed and debrided to permit the first increments of gold to be stabilized.

The margins in outline form must not be ragged. They are established on sound areas of the tooth that can be finished and polished. The outline must include all structural defects associated with the lesion. The marginal outline must be designed to be esthetically pleasing because the final restoration may be visible.

Resistance form is established by orienting preparation walls to support the integrity of the tooth, such as a pulpal wall that is flat and perpendicular to occlusal forces. All enamel must be supported by sound dentin. Optimally placed axial or pulpal walls promote the integrity of the restored tooth, providing a suitable thickness of remaining dentin.

The retention form is established by parallelism of some walls and by strategically placed converging walls (as described in detail for each tooth preparation). In addition, walls must be smooth and flat, where possible (to provide resistance to loosening of the gold during compaction), and internal line angles must be sharp (to resist movement). Internal form includes an initial depth into dentin, ranging from 0.5 mm from the dentinoenamel junction (DEJ) in class I preparations to 0.75 mm from cementum in Class V preparations.

Optimal convenience form requires suitable access and a dry field provided by the rubber dam. Access additionally may require the use of a gingival retractor for Class V restorations or a separator to provide a minimal amount of separation (0.5 mm maximum) between anterior teeth for Class III restorations. Sharp internal line and point angles are created in dentin to allow convenient “starting” gold foil as compaction begins. Rounded form is permitted when E-Z Gold is used to begin the restorative phase. Removal of remaining carious dentin, final planing of cavosurface margins, and debridement complete the tooth preparation for direct gold.

Indications and Contraindications

Class I direct gold restorations are one option for the treatment of small carious lesions in pits and fissures of most posterior teeth and the lingual surfaces of anterior teeth. Direct gold also is indicated for treatment of small, cavitated Class V carious lesions or for the restoration, when indicated, of abraded, eroded, or abfractions areas on the facial surfaces of teeth (although access to the molars is a limiting factor). Class III direct gold restorations can be used on the proximal surfaces of anterior teeth where the lesions are small enough to be treated with esthetically pleasing results. Class II direct gold restorations are an option for restoration of small
cavitated proximal surface carious lesions in posterior teeth in which marginal ridges are not subjected to heavy occlusal forces (e.g., the mesial or distal surfaces of mandibular first premolars and the mesial surface of some maxillary premolars). Class VI direct gold restorations may be used on the incisal edges or cusp tips. A defective margin of an otherwise acceptable cast gold restoration also may be repaired with direct gold.

Direct gold restorations are contraindicated in some patients whose teeth have very large pulp chambers, in patients with severely periodontally weakened teeth with questionable prognosis, in patients for whom economics is a severely limiting factor, and in handicapped patients who are unable to sit for the long dental appointments required for this procedure. Root canal–filled teeth are generally not restored with direct gold because these teeth are brittle, although in some cases gold may be the material of choice to close access preparations (for root canal therapy) in cast gold restorations.

**Tooth Preparations and Restorations**

This section presents the preparation and the restoration of Class I, V, and III lesions. The preparations described may be restored entirely with pellets of gold foil, or E-Z Gold may be used. If powdered gold is selected, heavy hand pressure compaction may be substituted for hand mallet or automatic mallet techniques. Class I and V E-Z Gold restorations may be veneered with gold foil pellets, if desired. The Class III tooth preparation discussed in this chapter is recommended by Ferrier, and only pellets of gold foil are used for the restoration. All tooth preparations and restorative procedures are accomplished after a suitable field of operation has been achieved (usually by application of rubber dam).

**Class I Tooth Preparation and Restoration**

**Tooth Preparation Design**

The marginal outline form for the Class I tooth preparation for compacted gold is extended to include the lesion on the tooth surface treated and any fissured enamel. The preparation outline may be a simple circular design for a pit defect, or it may be oblong, triangular, or a more extensive form (if needed to treat a defective fissure) (Online Fig. 22-10, A). Preparation margins are placed beyond the extent of pits and fissures. All noncoalesced enamel and structural defects are removed; the outline is kept as small as possible, consistent with provision of suitable access for instrumentation and for manipulation of gold.

For Class I tooth preparations, the external walls of the preparation are parallel to each other. In extensive occlusal preparations, the mesial or distal wall (or both) may diverge slightly occlusally, however, to avoid undermining and weakening marginal ridges. The pulpal wall is of uniform depth, parallel with the plane of the surface treated, and established at 0.5 mm into dentin. The pulpal wall meets the external walls at a slightly rounded angle created by the shape of the bur. Small undercuts may be placed in dentin if additional retentive features are required to provide convenience form in beginning the compaction of gold (see Online Fig. 22-10, B). Undercuts, when desired, are placed facially and lingually in posterior teeth (or incisally and gingivally on the lingual surface of incisors) at the level of the ideal pulpal floor position. These undercut line angles must not undermine marginal ridges. A slight cavosurface bevel may be placed to (1) create a 30- to 40-degree metal margin for ease in finishing the gold and (2) remove remaining rough enamel. The bevel is not greater than 0.2 mm in width and is placed with a white rotary stone or suitable finishing bur.

**Instrumentation**

For description and illustration, the preparation of a carious pit on the mandibular first premolar is presented (Online Fig. 22-11, A). By use of a high-speed handpiece with air-water spray, the No. 330 or No. 329 bur is aligned, and the outline form (which includes the limited initial depth) is established (see Online Fig. 22-11, B). When the preparation is extensive because of the inclusion of fissured enamel, a small hoe (\(6^{1/2}-2^{1/2}-9\)) may be used to complete the desired degree of flatness of the pulpal wall. With a No. 33\(^{1/8}\) bur at low speed, small retentive undercuts are prepared into the dentinal portion of the external walls at the initial pulpal wall depth; these also may be prepared using a \(6^{1/2}-9\)-angle former chisel. Round burs of suitable size are used to remove any infected carious dentin that remains on the pulpal wall. The preparation is completed by finishing the cavosurface with an angle former, a small finishing bur (e.g., No. 7802), or a flame-shaped white stone (see Online Fig. 22-11, C through E).

**Restoration**

The restorative phase begins with the insertion of a pellet of E-Z Gold or gold foil. The gold is first degassed in the alcohol flame, cooled in air for a few moments, and inserted into the preparation with the passing instrument. The gold is pressed into place with the nib of a small round condenser. In larger preparations, a pair of condensers is used for this initial stage. Next, compaction of the gold begins with a line of force directed against the pulpal wall (Online Fig. 22-12, A). Hand pressure is used for E-Z Gold; malleting is used for gold foil. The gold is compacted into the pulpal line angles and against the external walls, and the line of force is
changed to a 45-degree angle to the pulpal and respective external walls (to compact the gold best against the internal walls) (see Online Fig. 22-12, B). Additional increments of gold are added, and the procedure is repeated until the preparation is about three quarters full of compacted gold. If E-Z Gold is to be the final restoration surface, compaction is continued until the restoration is slightly overfilled.

If gold foil is selected to veneer this restoration, pellets of suitable size are selected; in larger preparations, large pellets are convenient, whereas for small pit preparations, the operator should begin with 1/4-size pellets (Online Fig. 22-13). The pellet is degassed and carried to the preparation. First, hand pressure compaction is used to secure the pellet against the compacted E-Z Gold and spread it over the surface; next, mallet compaction is used. Likewise, each succeeding pellet is hand compacted, and then is compacted with the mallet. The condenser point is systematically stepped over the gold twice as malleting proceeds. Generally, the line of force is perpendicular to the pulpal floor in the center of the mass and at a 45-degree angle to the pulpal floor as the external walls are reached. At this stage and during all building of the restoration, the compacted surface should be saucer shaped, with the compaction of gold on the external walls slightly ahead of the center. The surface should never be convex in the center because this may result in voids in the gold and poor adaptation of the gold along the external walls when the condenser nib is “crowded out” along the wall by the center convexity. The operator continues building the restoration until the cavosurface margin is covered with foil (Online Fig. 22-14). One needs to exercise extreme care that gold is always present between the condenser face and the cavosurface margin; otherwise the condenser may injure (i.e., fracture) the enamel margin. The central area of the restoration’s surface is filled in...
to the desired level. Tooth surface contour of the gold is created to simulate the final anatomic form, and a slight excess of gold is compacted on the surface to allow for the finishing and polishing procedures.

The first step in the finishing procedure is to burnish the gold (Online Fig. 22-15, A). A flat beaver-tail burnisher is used with heavy hand pressure to harden the surface gold. A cleoid-discoid carver is used to continue the burnishing process and remove excess gold on the cavosurface margin. The cleoid, always directed so that a portion of the working edge is over or resting on enamel adjacent to or near the margins, is pulled from gold to tooth across the surface. This is done to smooth the surface and trim away excess gold (see Online Fig. 22-15, B). If considerable excess gold has been compacted, a green stone may be necessary to remove the excess in Class I restorations. Care must be taken at this stage to avoid abrading the surface enamel. After use of the cleoid-discoid, a small round finishing bur (No. 9004) is used to begin polishing (see Online Fig. 22-15, C). It is followed by the application of flour of pumice and tin oxide or white rouge (see Online Fig. 22-15, D). These powdered abrasives are applied dry, with a webless, soft rubber cup in a low-speed handpiece. Care is taken to use light pressure. Gentle blasts of air cool the surface during polishing. The completed restoration is illustrated in Online Figure 22-16.

Class V Tooth Preparation and Restoration

Operating Field

As with all direct gold restorations, the rubber dam must be in place to provide a suitable, dry field for a Class V restoration. For lesions near the gingiva or that extend into the gingival sulcus, it is necessary to provide appropriate access to the lesion by placing a No. 212 retainer or gingival retractor. The punching of the rubber dam is modified to provide ample rubber between teeth and to provide enough rubber for coverage and retraction of the soft tissue on the facial side of the tooth. The hole for the tooth to be treated is punched 1 mm facial of its normal position, and an extra 1 mm of dam is left between the hole for the treated tooth and the holes for the immediately adjacent teeth.

Several modifications may be made to the No. 212 retainer to facilitate its use. If the notches that are engaged by the retainer forceps are shallow, they may be deepened slightly with a large, carbide fissure bur to provide a more secure lock for the forceps (Online Fig. 22-17, A). If the tips of the retainer jaws are very sharp, they may be slightly rounded with a garnet disk, then polished to avoid scratching cementum during placement. For application to narrow teeth (e.g., mandibular incisors), the facial and lingual jaws may be narrowed by grinding with a heatless stone or carborundum disk, after which they are polished with a rubber wheel. To expedite placement on rotated teeth, the jaws may be modified by

Online Fig. 22-14 Compaction of gold foil has proceeded sufficiently to cover all the cavosurface margins.

Online Fig. 22-16 Completed restoration.

Online Fig. 22-15 Steps in finishing Class I direct gold restoration. A, Burnisher work-hardens the surface gold. B, The cleoid-discoid instrument removes the excess gold from the cavosurface margins. C, A No. 9004 bur is used to begin the polishing phase. D, Polishing abrasives are applied with a rubber cup.
grinding suitable contour to the tip edge (see Online Fig. 22-17, B). The jaws may be bent for use on teeth where gingival access to lesions is difficult. This is done by heating the jaws to a cherry-red color in a flame, then grasping the entire facial jaw with suitable pliers and slightly bending the jaw apically. The procedure is repeated for the lingual jaw, bending it slightly occlusally (Online Fig. 22-18).

The No. 212 retainer must be applied carefully to avoid damage to soft or hard tissue. The retainer is secured in the retainer forceps and carried to the mouth after the rubber dam has been placed. The lingual jaw is positioned just apical to the lingual height of contour, and the index finger is placed against the jaw to prevent its movement. The retainer is rotated faciogingivally with the forceps, while the thumb retracts the dam; the facial jaw is set against the tooth (Online Fig. 22-19, A). Next, a ball burnisher is placed into one of the retainer notches and used to move the facial jaw gingivally (without scraping the jaw against the tooth) to the final position (i.e., 0.5–1 mm apical of the expected gingival margin) (see Online Fig. 22-19, B). Gentle pressure is used to position the facial jaw so that only the free gingiva is retracted, and the epithelial attachment is not harmed. The retainer is supported and locked into this desired position with the compound, which is softened, molded by the fingers, and placed between the bows and the gingival embrasures (see Online Fig. 22-19, C). The compound also serves to distribute compaction forces among all the teeth included in the retainer application.

**Tooth Preparation Design**

The typical Class V tooth preparation for restoration with direct gold is trapezoidal (Online Figs. 22-20, 22-21, and 22-22). This outline form is created to satisfy esthetic needs and the requirements for the retention and convenience forms in the treatment of lesions in the gingival third of the clinical crowns of teeth. The straight occlusal margin improves the esthetic result, and by virtue of its straight design, excess gold is readily discerned and removed in the final stages of the restorative process. The gingival outline is shorter than the occlusal route because the tooth narrows in the gingival area. In addition, it is prepared parallel with the occlusal margin for easy identification in the finishing phases. The mesial and distal margins connect the gingival margin to the occlusal margin.

The occlusal margin is straight and parallel with the occlusal plane of the teeth in the arch (see Online Fig. 22-20 and 5-21); it is extended occlusally to include the lesion. (When several adjacent teeth are restored, some additional extension is permissible to create a uniform level that may be more esthetically pleasing.) Often, the mesiodistal extension to the line angles of the tooth places the junction of the occlusal and mesial and distal margins gingival to the crest of the free gingiva, rendering the most esthetic result. The gingival margin is also straight, parallel with the occlusal margin, placed only far enough apically to include the lesion, and extends mesiodistally to the line angles of the tooth.

The mesial and distal margins are parallel to the proximal line angles of the tooth (see Online Fig. 22-22, A) and usually are positioned sufficiently mesially and distally to be covered by the free gingiva. The mesial and distal margins are straight lines that meet the occlusal margin in sharp, acute angles and meet the gingival margin in sharp, obtuse angles, both of which complete the trapezoidal form.

The depth of the axial wall varies with the position of the preparation on the tooth. The axial wall is approximately 1 mm deep in the occlusal half of the preparation. As the outline approaches the cervical line, the axial wall depth may decrease from 1 to 0.75 mm. The axial wall must be established in dentin, and occlusogingivally it should be relatively flat and parallel (approximately) with the facial surface of the tooth (see Online Fig. 22-22, B). Mesiodistally, the axial wall also is prepared approximately parallel with the surface contour of the tooth. This contour may create a slight mesiodistal curvature in the axial wall in convex contoured teeth and where the preparation is extensive proximally. Mesiodistal curvature of the axial wall prevents encroachment of the tooth preparation on the pulp. Excessive axial curvature results in a preparation that is either too shallow in the center or too deep at the proximal extensions, and it further complicates restoration by failing to provide a reasonably flat wall against which to begin compaction. A subaxial wall may be created within
the axial wall to remove infected caries that has progressed deeper than the ideal axial wall placement.

The occlusoaxial internal line angle is a sharp right angle. The occlusal wall also forms a right angle with the external enamel surface, precluding undermining of the enamel. The gingivoaxial internal line angle is a sharp, acute angle, created at the expense of the gingival wall (see Online Fig. 22-22, B). The mesioaxial and distoaxial internal line angles are sharp, obtuse angles. These obtuse line angles are created to prevent the undermining of the mesial and distal enamel, although still providing some resistance to movement of the gold during compaction. They must never be acute angles.

The mesial and distal prepared walls are flat and straight. They meet the occlusal wall in a sharp, acute line angle and meet the gingival wall in a sharp, obtuse line angle. The mesial and distal walls provide resistance for gold compaction, but they provide no retention.

The orientation of the gingival wall is the key to the retention form of the preparation. It is straight mesiodistally, meeting the mesial and distal walls in sharp line angles. Retention is provided by sloping the gingival wall internally to meet the axial wall in a sharply defined acute line angle. Retention is provided by the facial convergence of the occlusal and gingival walls. Gold wedged between these two walls is locked into the tooth. If the gingival margin is established on enamel, the cavosurface is beveled slightly to remove unsupported enamel (see Online Fig. 22-26, E). When placed on cementum, the gingival cavosurface is not beveled (see Online Fig. 22-24, B).

The outline of the preparation may be modified. In clinical situations demanding reduced display of gold, such as in anterior teeth, the incisal outline may be curved to follow the contour of soft tissue mesiodistally (Online Fig. 22-23). This modification is made only when required because preparation instrumentation and finishing of gold are more difficult than when a straight marginal outline is created. A similar modification may be made in the occlusal outline when caries extends more occlusally as the proximal extensions are reached. Also, the mesiodistal extension (i.e., dimension) of a preparation may be limited when caries is minimal, conserving intact tooth structure. When access requires, the gingival wall may be modified also to curve mesiodistally to include the gingival extent of advanced caries. The entire axial wall should not be extended pulpally to the depth of the lesion when deep cervical abrasion, abfraction, or erosion is treated; rather the axial wall is positioned normally, leaving a remaining V notch at its center to be restored with gold. When failing restorations are removed and restored with direct gold, the preparation
Outline is partially dictated by the previous restoration (Online Fig. 22-24).

**Instrumentation**

The No. 33½ bur is used to establish the general outline form of the preparation. The end of the bur establishes the distal wall (Online Fig. 22-25, A); the side establishes the axial depth and the occlusal, gingival, and mesial walls (see Online Fig. 22-25, B). When access permits, the end of the bur may be used to establish the mesial and gingival walls (see Online Fig. 22-25, C and D). The gingival and mesial walls may be prepared with the side of the bur if access so dictates (see Online Fig. 22-25, E and F). The end of the bur is used to place the axial wall in dentin (see Online Fig. 22-25, G).

The 6½-2½-9 hoe or the larger 10-4-8 hoe is useful for planing preparation walls, establishing sharp internal line angles (Online Fig. 22-26, A), and finishing margins. The Wedelstaedt chisel is used to finish the occlusal cavosurface margin (see Online Fig. 22-26, B) and may be used to plane the axial wall. The acute axiogingival angle is established with the 6½-2½-9 hoe, cutting from the cavosurface to the axial wall in a push-cut stroke (see Online Fig. 22-26, C). The chips of dentin produced at the axiogingival angle may be removed with the tip of an explorer (see Online Fig. 22-26, D) or the point of a 6½-(90)-2½-9 small angle former. Care must be taken not to gouge the axial wall. When its use is indicated, the gingival bevel is prepared with the Wedelstaedt chisel or a hoe (see Online Fig. 22-26, E).

**Restoration**

Restoration of the Class V preparation begins with application of cavity varnish (if desired), after which a piece of degassed E-Z Gold is placed into the preparation. The gold is degassed in the alcohol flame and carried to its place in the preparation with the passing instrument. Parallelogram foil condensers or other suitable serrated condensers are used to force the gold firmly against the axial wall and to wedge it into the line angles. One instrument may be put aside (and the other is
Online Fig. 22-24  
A, Failing Class V amalgam restoration.  
B, Replacement direct gold restoration.

Online Fig. 22-25  
Use of No. 33½ bur in straight handpiece for initiating Class V preparation.  
A, The end of the bur is used to establish the distal wall.  
B, The side of the bur is used to establish the occlusal wall.  
C, The end of the bur prepares the mesial wall, if access permits.  
D, The end of the bur is used to establish the gingival wall, if access permits.  
The use of a No. 33½ bur in the straight handpiece for initiating Class V preparation.
used as a holding instrument to prevent movement of the entire piece of gold), and compaction can begin by delivering heavy compacting forces to the gold.

After stabilization of the gold, completion of compaction of the initial mass of gold begins in the center of the mass with a 0.5-mm-diameter, round, serrated condenser nib. Careful, methodical stepping of the gold proceeds outward toward the external walls (to wedge the gold in the tooth and remove internal voids). As soon as the gold is stabilized, a holding instrument is no longer necessary. As the walls are reached, a line of force of 45 degrees to the axial wall is used to drive the gold into the line angles and against the external walls. The entire surface of the gold is condensed twice to complete the compaction of the gold. Additional increments of E-Z Gold are added until the preparation is filled to at least half its depth. E-Z Gold pellets are used to complete the restoration, covering the margins first, and to complete compacting in the center of the facial surface. Pellets of gold foil also may be used to complete the outer one half of the restoration (see Online Fig. 22-27, A).

If gold foil is used for the outer half of the restoration, compaction proceeds with medium-sized pellets at the mesio-occlusal or disto-occlusal line angle and then across the occlusal wall. The entire wall and occlusal cavosurface margin are covered with compacted gold foil (see Online Fig. 22-27, A). To ensure that gold protects the margin from blows of the condenser face, care should be exercised when the condenser approaches any enamel margin. Next, the gingival, mesial, and distal walls are covered, which leaves the restoration concave (see Online Fig. 22-27, B). It is essential that all cavosurface margins be covered at this time, before the final convex surface of the restoration is formed.

Medium and large pellets (sizes \( 1/4 \) and \( 1/2 \)) are compacted in the center of the restoration to complete the formation of the appropriate contour. A slight excess contour is developed and is removed later when the gold is finished and polished. Any small remaining deficiencies in the surface contour are filled with small pellets. A Varney foot condenser (or other large condenser) is malleted over the entire surface to make it smooth and assist in detection of any poorly compacted areas (see Online Fig. 22-27, C).

Finishing begins with application of a beaver-tail burnisher to work-harden and smooth the surface (Online Fig. 22-28, A). Petroleum jelly may be applied to the dam to avoid abrasion from disks; it also may be applied to the disks. Gross excess contour, if any, is removed with a fine garnet disk applied with a Sproule or other suitable mandrel in a low-speed handpiece (see Online Fig. 22-28, B). Excess gold is removed from the cavosurface margins with the cleoid–discoid instrument (using pull-cut strokes) or the gold knife (using only push-and-cut strokes from the gold to the tooth) (see Online Fig. 22-28, C and D). When removing the excess gold over the gingival margin, care is exercised not to remove cementum or “ditch” the root surface (especially when using rotary instruments).

When the final contour has been obtained, cuttle disks may be used in decreasing abrasiveness (i.e., coarse to medium to fine) to ready the surface for final polishing. These disks and the cleoid are helpful in removing very fine fins of gold from margins. Polishing is performed with fine pumice followed by
Completion of compaction where gold foil is used to overlay the E-Z Gold. A, Condensation of foil proceeds to cover the cavosurface margins. A slight excess of gold has been condensed over the mesial half of the occlusal cavosurface margin. B, All cavosurface margins are covered with a slight excess of gold. The restoration, at this stage of insertion, is concave. C, After additional foil pellets are compacted in the central area to form a convex restoration surface with slight excess, a foot condenser is used to confirm condensation.

Finishing the Class V Restoration. A, Burnisher work-hardens surface. B, A small, fine garnet disk removes the excess gold contour. C, The gold knife’s secondary edge used with push-stroke (arrow) removes excess gold from the gingival margin. D, After final surfacing with a cuttle disk, any remaining marginal excess is removed with the cleoid carver.

Class III Tooth Preparation and Restoration

Many styles of Class III preparations are advocated for use with direct gold. Some preparations are based on the lingual approach and are restored with E-Z Gold. Others may be...
Online Chapter 22—Direct Gold Restorations

Viewed from the lingual aspect, the lingual margin generally parallels the long axis of the tooth (Online Fig. 22-32). It may diverge slightly proximally from the long axis, however, to parallel more nearly the proximal contour. It meets the gingival margin in a sharply defined angle that is nearly 90 degrees when viewed from the lingual aspect (Online Fig. 22-33), but it is acute when viewed from the proximal aspect. The lingual margin is straight in its gingival two thirds, but then it curves abruptly to meet the incisal margin.

To provide a suitable resistance form, the internal aspects of the preparation are precisely instrumented. The gingival margin is crucial to the entire preparation. Its faciolingual length dictates the remainder of the preparation. Where possible, the gingival margin is established just apical to the crest of the free gingiva to enhance the esthetic result. It is straight faciolingually and is approximately at a right angle to the long axis of the tooth. It meets the facial margin in a sharply defined obtuse angle that may be rounded slightly (as previously described), and it meets the lingual margin in a sharply defined acute angle.
wall is flat faciolingually. The axial wall is flat faciolingually and incisogingivally, and it is established 0.5 mm into dentin. The resistance form also is created by establishing sharp, obtuse axiofacial and axiolingual line angles in dentin. The facial and lingual walls diverge only enough to remove undermined enamel, and yet they provide firm, flat walls against which the gold can be compacted.

As in the Class V restoration, retention form is provided only between the gingival and incisal walls. In the Class III preparation, the dentinal portion of the gingival wall (as in the Class V gingival wall) slopes apically inward to create an acute axiogingival line angle. In the Class III preparation, the incisal portion is undercut (Online Fig. 22-34). This undercut is placed in dentin but does not undermine enamel.

The finishing of enamel walls requires placement of a facio-inciso-lingual cavosurface bevel, which determines the final marginal outline. This bevel is made with hand instruments and is established totally in enamel. It is designed to create maximum convenience form, to remove all surface irregularities and any unsupported enamel, and to establish a more esthetically pleasing result (Online Fig. 22-35; see also Online Fig. 22-30).

**Modifications of Class III Preparations**

The distal surface of maxillary canines may require a modification in preparation design for convenience in gold compaction. Because a highly convex surface is generally present, it is often desirable to create a “straight-line preparation” in which the facial outline appears as a slice. This modification provides clearance from the mesial marginal ridge of the first premolar and provides considerable convenience form to allow compaction of gold on the gingival wall directly from an incisal position. This type of preparation also is appropriate for the distal surface of highly contoured lateral incisors (Online Fig. 22-36).

The mandibular incisors require a modified Class III preparation because of their small size and because access from a lingual position may be exceptionally difficult. The lingual wall is created in one plane, and extension of the lingual and the incisal walls is limited. The axiolingual line angle is a right or slightly obtuse angle. Care is taken to avoid lingual overextension of the lingual wall because this can result in the removal of dentinal support for lingual enamel, rendering the preparation unrestorable by direct gold. The outline form is extended lingually only far enough to include the lesion and to allow access for finishing of the gold. Incisal extension is restricted because the proximal contact area between mandibular incisors is often near the incisal angle. Extension incisally past the contact may weaken this critical area of the tooth; a mechanical separator may be necessary to obtain clearance between teeth. This provides access for tooth preparation and gold compaction. Facial extension is similar to the maxillary preparation (Online Fig. 22-37).

Internally, the incisal retentive angle for the mandibular Class III preparation is placed directly incisally, rather than condenser directed toward the gingival wall), by adequate clearance of all margins from the adjacent tooth, and by placement of sharp internal point angles suitable for beginning compaction of gold. The facio-axio-gingival and linguo-axio-gingival point angles may be enlarged slightly to assist in initial stages of foil compaction, if desired.19

The finishing of enamel walls requires placement of a facio-inciso-lingual cavosurface bevel, which determines the final marginal outline. This bevel is made with hand instruments and is established totally in enamel. It is designed to create maximum convenience form, to remove all surface irregularities and any unsupported enamel, and to establish a more esthetically pleasing result (Online Fig. 22-35; see also Online Fig. 22-30).
Online Fig. 22-35 Class III preparation internal form and facial marginal outline. A, Incisal view of cross-section of preparation in plane x shown in B. Facial and lingual cavosurface bevels are shown placed in enamel. B, Facial view of the facial marginal outline of the preparation. (From Stibbs GD: Direct golds in dental restorative therapy: Oper Dent S:107, 1980.)

Online Fig. 22-36 Direct gold restoration of a clinical Class III preparation of straight-line design on the distal portion of the maxillary lateral incisor.

Online Fig. 22-37 Mandibular Class III preparation. A, Facial view. The facial margin is similar to that in the maxillary preparation. B, Lingualproximal view.
facioincisally as in maxillary teeth. This modification is made to conserve the thickness of the tooth structure at the facioincisal angle, where wear of mandibular anterior teeth frequently occurs. Lingual approach Class III restorations may be made using E-Z Gold. In such cases, the lingual “slot” type of preparation is made with rounded internal line angles.

**Separation of Teeth**

Separation of teeth frequently is needed for instrumentation or finishing procedures performed on Class III direct gold restorations. The Ferrier separator is a convenient instrument for accomplishing this separation. It is applied and stabilized with compound (similar to stabilization of a No. 212 retainer) (Online Fig. 22-38). The jackscrews of the separator are activated with the separator wrench to draw the teeth slightly apart, creating a maximum space of 0.25 to 0.5 mm. It is desirable to provide only this minimum separation and to remove the separator as soon as possible (preventing damage to periodontal structures).

**Instrumentation**

The No. 33½ bur (or a suitable Wedelstaedt chisel) is used to begin the preparation (Online Fig. 22-39). The bur is angled from the facial to position the gingival outline and the facial wall. A Wedelstaedt chisel establishes the lingual extension, and the No. 33½ bur defines the linguogingival line angle.
(Online Fig. 22-40) and completes the gingival floor preparation. The outline form is completed by beveling the cavosurface areas with a Wedelstaedt chisel. Next, the dentinal part of the gingival, lingual, facial, and incisal walls is planed. A small hoe (i.e., 6½-2½-9) is used for the lingual and gingival walls (Online Fig. 22-41). An angle former is used to plane the facial dentinal wall (Online Fig. 22-42). An axial plane (i.e., 8-1-23) smooths the axial wall, and a bi-beveled hatchet (i.e., 3-2-28) establishes the incisal retentive angle with a chopping motion (Online Fig. 22-43). Small angle formers are used to complete the sharp facio-axio-gingival and linguo-axiogingival point angles and the slightly acute axiogingival angle (Online Fig. 22-44). The point angles may be enlarged further with the No. 33S bur (i.e., end-cutting bur) for additional convenience form. The Wedelstaedt chisel may be used again to complete the final planing of the cavosurface margins (Online Fig. 22-45).

**Restoration**

The separator is used to obtain a separation of 0.25 to 0.5 mm. Compaction of gold foil begins at the linguo-axio-gingival point angle (Online Fig. 22-46). A small (i.e., 0.4 mm) monangle condenser is used to compact the gold, which is held by a small holding instrument. Pellets size 1/64 or 1/32 are used in the beginning of the restorative phase. The line of force is directed over the facial surface of the adjacent tooth and into the linguo-axio-gingival point angle (see Online Fig. 22-46, B). As soon as ample gold has been compacted into the linguogingival area to cover the linguogingival shoulder, compaction...
The next step is the restoration of the incisal portion of the preparation, referred to as “making the turn.” It is accomplished in three phases. First, sufficient gold is built up on the lingual wall so that the gold is near the incisal angle (Online Fig. 22-51). Second, the incisal area is filled by compacting \( \frac{1}{38}\)-size pellets with the right-angle hand condenser (Online Fig. 22-52). Third, pellets of foil are compacted into the incisal area with the offset condenser. This fills the incisal portion, making a complete turn from lingual to facial (Online Fig. 22-53, A). The entire incisal cavosurface is covered with gold (see Online Fig. 22-53, B).

Additional gold compaction finishes the facial one third of the restoration, and then the Varney foot condenser is used to “after-condense” over the contour of the restoration. More separation is generated by slight activation of the separator, before finishing and polishing the restoration. A sharp, gold foil knife is used to remove excess in the contact area, permitting a fine finishing strip or steel matrix strip to pass through. A pull-cut Shooshan file or gold knife may facilitate removal of excess gold facially (Online Fig. 22-54). Initial contouring of the contact area is performed with long, extra-narrow,
Online Fig. 22-44  

A, Angle former before use in the preparation.  
B, The angle former is moved faciolingually (a) to establish an acute axiogingival line angle (b).  
C, The offset angle former thrust faciogingivally establishes an acute facio-axio-gingival point angle.  
D, Completed incisal, gingivoaxial retention form.  

(From Stibbs GD: Direct golds in dental restorative therapy. Oper Dent 5:107, 1980.)

Online Fig. 22-45  

A, The Wedelstaedt chisel may be used again to plane margins.  
B, Completed facial margin of Class III tooth preparation viewed from the facial position.
Online Fig. 22-46 A, The first pellet of the gold foil is placed from the facial aspect into the preparation. Note the separation of teeth by 0.25 to 0.5 mm. B, Compaction of the pellet into the linguo-axio-gingival point angle. The line of force is directed linguo-axio-gingivally, while the holding instrument is placed from the lingual position. C, The holding instrument (a) prevents dislodgment of foil during compaction.

Online Fig. 22-47 The holding instrument (a) remains in position as the gold foil is condensed across the gingival wall toward the facial portion of the preparation.

Online Fig. 22-48 A, Offset condenser before placement in the cavity preparation. B, Compacted gold foil covering the gingival wall and the cavosurface.

Online Fig. 22-49 Lingual view. The monangle condenser confirms compaction of gold at the linguo-gingival aspect of the restoration.
Online Fig. 22-50  A, The monangle condenser is used to build the bulk of gold in the gingival half of the preparation. B, Gingival half of the restoration in longitudinal section. The line of force (a) is directed axiogingivally during compaction of gold to prevent dislodgment of the restoration.

Online Fig. 22-51  A, The condenser is directed over the facial surface of the adjacent tooth, while the gold is built toward the incisal aspect. B, The gold is compacted from the facioincisal aspect to cover the lingual cavosurface; however, compaction direction must continue to have a major vector (arrow) toward the axial wall to prevent dislodgment. At this stage, the compacted foil on the axial wall must be well ahead (incisally) of the “growing” proximal surface.

Online Fig. 22-52  A, The right-angle hand condenser begins to press the gold into the incisal retention. B, This condenser forces the gold deeply into the incisal retentive undercut.

Online Fig. 22-53  Completing the compaction of gold into the incisal region of the preparation. A, The offset bayonet condenser condenses the gold into the incisal retention with mallet compaction. B, The incisal cavosurface is restored with gold foil condensed with the small monangle condenser.
Direct-filling gold is useful in restorative dentistry. If carefully manipulated by a dentist, this restorative material may provide lifetime service to patients and promote their oral health (Online Fig. 22-57). Direct-filling gold contributes to the art and the science of restorative dentistry.

Summary

Direct-filling gold is useful in restorative dentistry. If carefully manipulated by a dentist, this restorative material may provide lifetime service to patients and promote their oral health (Online Fig. 22-57). Direct-filling gold contributes to the art and the science of restorative dentistry.

References


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