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Cervical margin design with contemporary esthetic restorations

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The contemporary dentist has a wide variety of options to use in the restoration of extensively damaged or previously restored teeth. Metal-ceramic and all-ceramic crowns are used frequently to restore esthetics and function. One of the essentials for success with either option is proper tooth preparation, which includes proper selection and preparation of the cervical margin of the preparation [1,2].

Regardless of the margin geometry, proper placement of the prepared gingival margin in relation to the free gingival margin, the epithelial attachment, and the alveolar housing is imperative. Wherever the esthetic demands permit it, margins should be placed in a supra-gingival location [3–6]. In many patients, margins must be placed in an intra-crevicular position to hide those margins with healthy gingival tissue and thus provide an acceptable esthetic result. Clinicians need to understand that placing a cervical margin in an intra-crevicular position is an exercise in precision. If the margin is placed a short distance from the free gingival margin, a minor amount of gingival recession may result in exposure of the margin and esthetic failure. A margin placed too deep in the sulcus risks the possibility of biologic width violation and concomitant chronic gingival inflammation (Fig. 1) [7,8].

There are two potentially useful landmarks to guide the clinician in accurate margin placement. A generally useful guideline is to place cervical margins 0.5 mm apical to the healthy free gingival margin [9]. A more precise method is to sound through the attachment to probe the crest of the alveolar bone and to place cervical margins at least 4 mm coronal to that alveolar crest [10]. With either landmark, it is critical that the prepared cervical margin follow the scalloped anatomy of the alveolar bone, the attachment, and the

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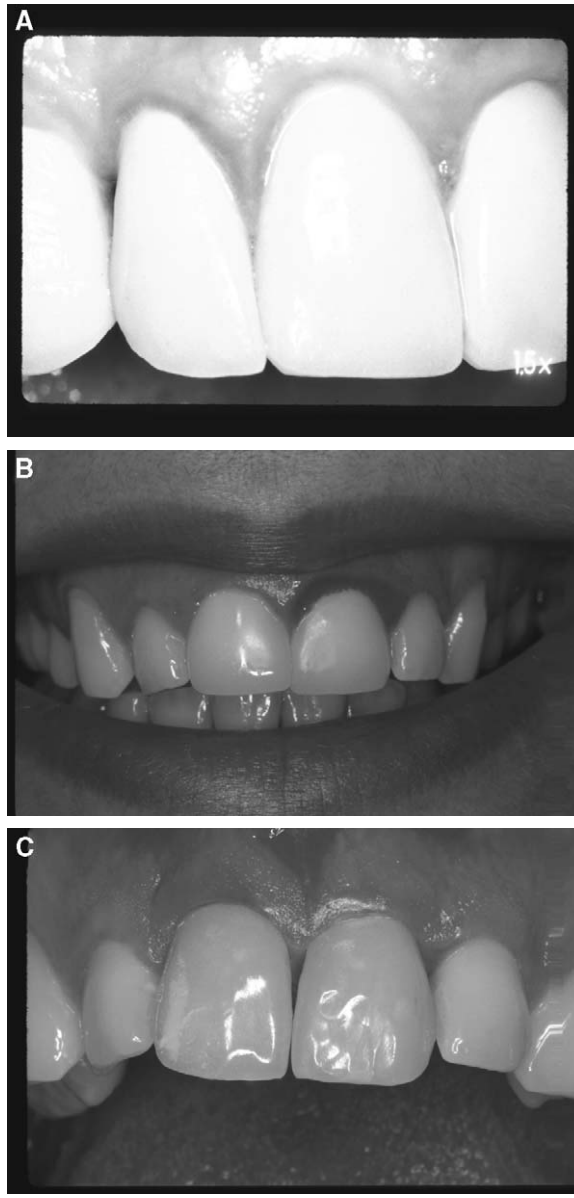

Fig. 1. (*A*–C) When cervical margins are placed too close to the epithelial attachment, biologic width is violated. This results in a typical chronic inflammatory response.

gingival tissues. The most common error made by clinicians is to flatten the cervical margin in the inter-proximal areas, thereby violating biologic width and eliciting a chronic inflammatory response (Fig. 2).

Several geometric margin designs are available for consideration with metal-ceramic crowns. Different margin designs are indicated in different clinical situations [11]. Specific criteria must be used to assist the clinician in determining which margin design is optimum for a given clinical situation. The following criteria for margin selection seem reasonable:

1. The selected margin must provide a predictable level of marginal integrity.
2. To minimize plaque accumulation, the selected margin must present smooth materials to the gingival sulcus.
3. In some situations, the margin also must provide acceptable esthetics.

Not all designs meet all of these criteria. Selection of an inappropriate cervical margin design can have deleterious consequences.

There are many problems that can result from improper preparation and placement of cervical margins. These include biologic width violation, metal margins showing through thin marginal gingiva, recession exposing the tooth/restorative interface, opacity in the cervical third of the restoration, and roughness of the cervical margin, which contributes to plaque accumulation. Biologic width violations are primarily a function of margin placement and are independent of margin design. Gingival recession is primarily a result of improper soft tissue management and is independent of margin design [5,6]. The other problems can be resolved by proper selection and preparation of the appropriate cervical margin.

With metal-ceramic crowns, there are five potential cervical margins to consider. These include the knife-edge, the chamfer, the shoulder or butt joint, the beveled shoulder, and the slant shoulder or disappearing margin

Fig. 2. The biologic width has been violated in the inter-proximal area because the cervical margin does not follow the scalloped anatomy of the attachment and the underlying alveolar housing.

(Fig. 3). Each of these cervical margin configurations is considered relative to the three criteria listed previously.

One of the most important considerations in selecting a cervical margin design is the ability to consistently and predictably provide excellent marginal integrity. The termination of knife-edge margins is often difficult to read on the gypsum die, so "fit" is often compromised inherently with this design. The thin metal margins are also prone to distortion during the firing of the ceramic veneer, further reducing marginal fidelity. Such margins also have the potential for metal display and hence inherently lack esthetics. Thus, knife-edge margins should not routinely be used with metal-ceramic restorations [12]. Their use should be limited to situations where a root has been amputated due to periodontal disease or with cusp fractures where a knife-edge margin cannot be avoided.

The chamfer margin should also be avoided with metal-ceramic crowns due to the relative inherent lack of specificity of depth and due compromised marginal integrity as a result of distortion of the metal framework during porcelain firing [13,14]. Distortion of cervical margins is a complex phenomenon that relates to the composition of the metal alloy and the cervical geometry of the margin. It is generally believed that the lower the melting temperature of the alloy, the greater the marginal distortion.

With high gold alloys it has been demonstrated that chamfer margins distort considerably more than shoulder or shoulder-bevel margins. Many clinicians prefer to use such gold colored alloys for single-unit restorations in the anterior area because the oxide layer with these alloys is readily masked with a thin layer of opaque porcelain. Gold-palladium alloys, which are recommended for fixed partial dentures and posterior restorations, do not display similar differences in distortion with different margin designs [15].

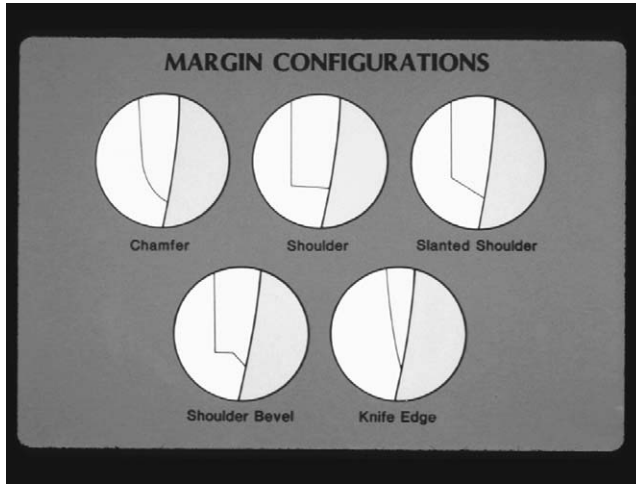

Fig. 3. Various cervical margin configurations.

Although there is conflicting evidence regarding the etiology of the distortion, it is generally believed that the majority of the distortion occurs during the degas cycle and is primarily the result of the release of strains that develop during the casting and cooling process [16,17]. Whatever the cause, chamfered margins should be avoided with porcelain-metal crowns because of their lack of prescribed depth and because of this fundamental compromise in marginal integrity with high gold alloys.

There are three cervical margin designs that seem to meet the criterion related to acceptable marginal integrity. These include the shoulder, the shoulder-bevel, and the slant shoulder. Although definitive studies related to the slant shoulder and distortion are not available, the shoulder and shoulder-bevel margin seem to resist distortion due to the inherent bulk of metal at the margin.

The shoulder and shoulder bevel also meet the criterion related to the use of smooth materials in the gingival crevice. This is critical to long-term periodontal health because rough materials accumulate and retain plaque more readily than do smooth materials [18–20]. The shoulder can be used with a metal margin, which can be highly polished, or with a porcelain margin, which results in glazed porcelain in the sulcus. The shoulder-bevel margin has a collar of metal 1 mm or more in width and thus places highly polished metal in the sulcus (Figs. 4, 5) [21].

The slant shoulder can be used with a metal collar or with the so-called disappearing margin [22]. If a metal collar is used, it can be highly polished and thus can be acceptable as it relates to plaque accumulation. However, the disappearing margin is inherently rough due to the presence of three different materials at the terminus of the margin [11]. This margin design places oxidized metal, opaque porcelain, and body porcelain in the vicinity of the marginal terminus, and each of these materials has an inherent lack of smoothness [23]. Oxidized metal is approximately 75 times rougher than polished metal. Opaque porcelain is substantially rougher than glazed porcelain, and the body porcelain in this position is often porous because it tends to shrink toward the greater mass of porcelain coronal to the margin (Fig. 6). These different rough materials with their inherent interfaces present a rough surface to the gingival sulcus and may predispose the patient to increased plaque accumulation and retention.

The third criterion to be considered when selecting a cervical margin design is the esthetic potential of the design. When used appropriately, the shoulder-bevel margin has a polished metal collar of 1 mm or more. This is because a steep bevel of approximately 60° should be used to maximize the slip-joint effect and close the margin [21]. This steep bevel results in a substantial metal collar. This provides the best initial fit before firing the porcelain; this fit is maintained through all of the ceramic firing cycles [24–27]. The metal can be highly polished; however, the problem with this design is esthetics.

It once was believed that adequate esthetics could be achieved by hiding the metal collar in the sulcus, but experience has proved this to be

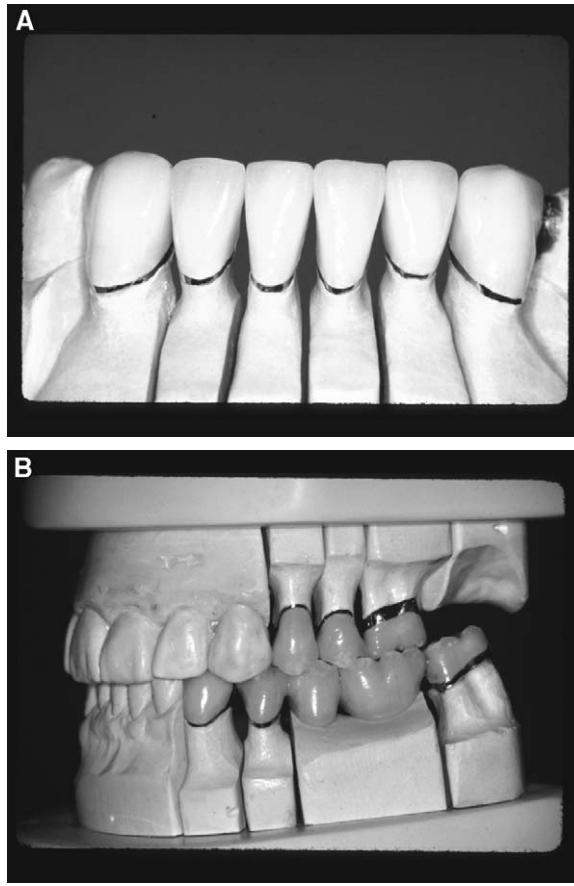

Fig. 4. (*A*, B) These restorations have used a shoulder-bevel margin that provides optimum marginal integrity and a smooth, polished surface.

unpredictable at best. Thus, the shoulder-bevel margin should be used only in situations where esthetics is not important (Fig. 7). The margin can be placed partially in the sulcus, in an equi-gingival position, or a supra-gingival position. With the metal display inherent with this margin, it is recommended that the patient give informed consent when it is indicated.

In situations where esthetics is important, the clinician has three options. The first is to use an all-ceramic crown. Although the potential life span of most all-ceramic options has improved in recent years, metal-ceramic crowns may provide a longer service [28,29]. However, several all-ceramic systems provide excellent esthetics with improved longevity and can be used with relative confidence on anterior teeth. All-ceramic alternatives should be avoided on posterior teeth.

Although there are several all-ceramic systems available, the cervical margin design with all the systems is similar. A shoulder margin with

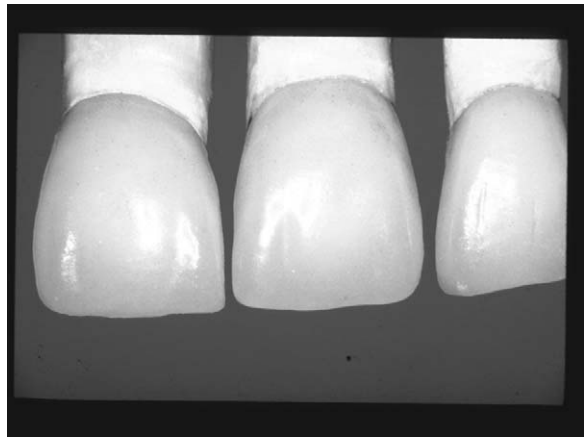

Fig. 5. The use of a shoulder margin with a porcelain labial margin results in smooth, glazed porcelain in the gingival crevice.

a rounded internal angle should be prepared to end at approximately 90° to the external angle of the labial or buccal surface. A slight slant of no more than 5° is acceptable. The margin should be as smooth as possible, and, to provide optimum esthetics and strength, should be between 1.2 and 1.5 mm in depth (Fig. 8). This design provides adequate bulk for esthetics and strength and places the cervical margin in compression during function. It also permits the restoration to be glazed without rounding of the terminal ceramic margin. If a more pronounced slant is produced, tensile forces occur in function, which can result in half-moon fractures in the cervical area. It is

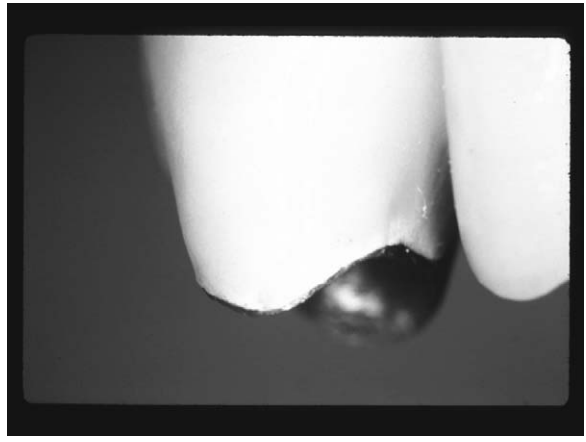

Fig. 6. The disappearing margin design results in multiple materials and interfaces at the marginal terminus that are inherently rough and may have a deleterious effect on plaque accumulation and retention.

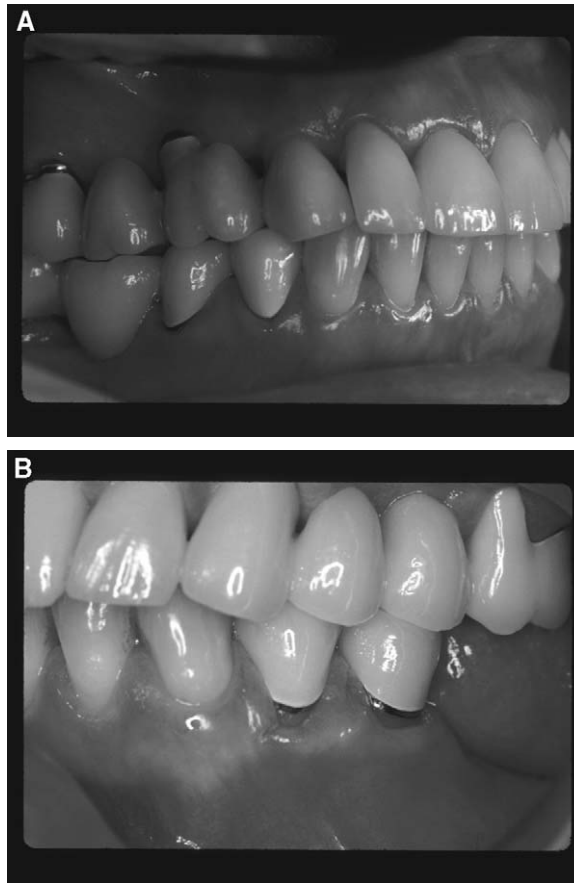

Fig. 7. (*A*, *B*) These restorations are not visible with a normal or exaggerated smile and the shoulder-bevel margin was used, providing optimum fit with a smooth, polished surface.

also difficult, if not impossible, to avoid rounding of the thin wedge of porcelain during glazing when a pronounced slant is prepared.

When a metal-ceramic restoration is indicated, the porcelain labial margin (shoulder) and the disappearing margin (slant shoulder) can be used. Because of the inherent roughness of the disappearing margin, the slant shoulder should be used only where indicated, and that is when the cervical margin of the restoration must be placed a considerable distance down the root surface [30]. In this position, excess tooth structure would have to be removed to accommodate a classic shoulder margin.

In patients with a low smile line, the slant shoulder with a metal collar should be considered. However, if the smile exposes the cervical portion of the restoration, a disappearing margin is the margin of choice. This design hides the metal but, due to the relative lack of bulk of porcelain in the cervical area, results in an opacious appearance due to the proximity of the opaque to

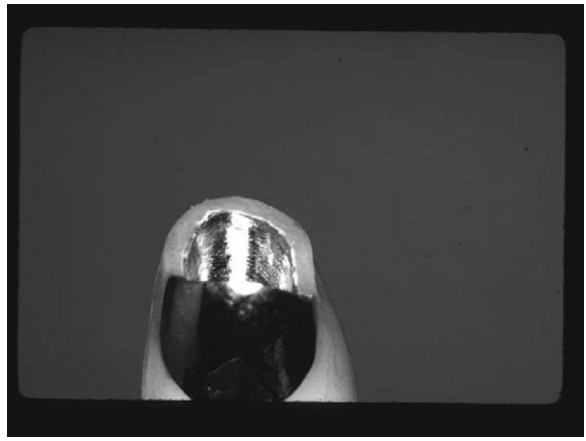

Fig. 8. All-ceramic margins should provide a shoulder with a rounded internal angle and should be between 1.2 and 1.5 mm in width.

the surface (Figs. 9, 10). This can be masked with intrinsic coloration by some master ceramists but often is an esthetic deficiency of this margin design.

The margin of choice in esthetic situations when using metal-ceramic crowns is a shoulder design with a porcelain labial margin. This design allows for an adequate thickness of ceramic material at the margin so that a predictable esthetic result is assured, provides excellent strength, and places glazed porcelain in the gingival sulcus (Figs. 11, 12) [31].

Several techniques have been described for fabricating porcelain margins, and all seem to provide acceptable results if the margin has been prepared properly and the technician pays meticulous attention to detail [32–42]. It

Fig. 9. The disappearing margin effectively hides the metal margin but often results in cervical opacity.

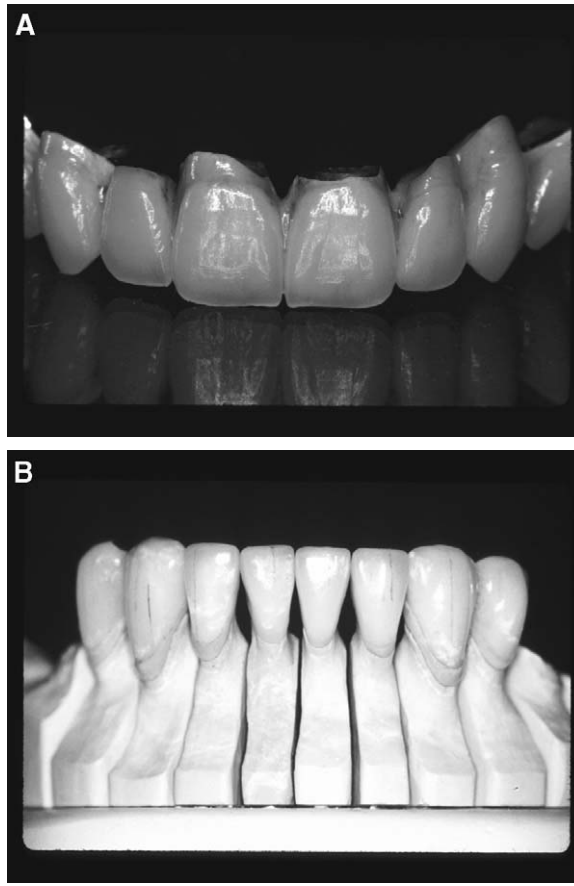

Fig. 10. (*A*, *B*) If patients accept characterization, cervical opacity can often be masked with internal coloration.

has been shown theoretically and experimentally that shoulder margins can be fabricated with acceptable fits. Sufficient expansion is achieved with casting investments, or internal expansion is achieved with the appropriate thickness of die spacer [43,44]. With proper technique, marginal gaps of 6 to 34 μm can predictably be achieved, which is well within the realm of clinical acceptability [45–47].

The preparation of the porcelain labial margin is identical to that of the all-ceramic crown, with the exception that the shoulder margin is prepared only on the labial or buccal surfaces. The shoulder margin is carried interproximally to the proximal-lingual line angle, and a chamfer or beveled shoulder margin is prepared on the lingual half of the tooth (Fig. 13). The shoulder should be at 90° to the external surface and 1.2 mm in width. It should be smooth, and hand instrumentation is generally recommended to achieve a planed surface [48].

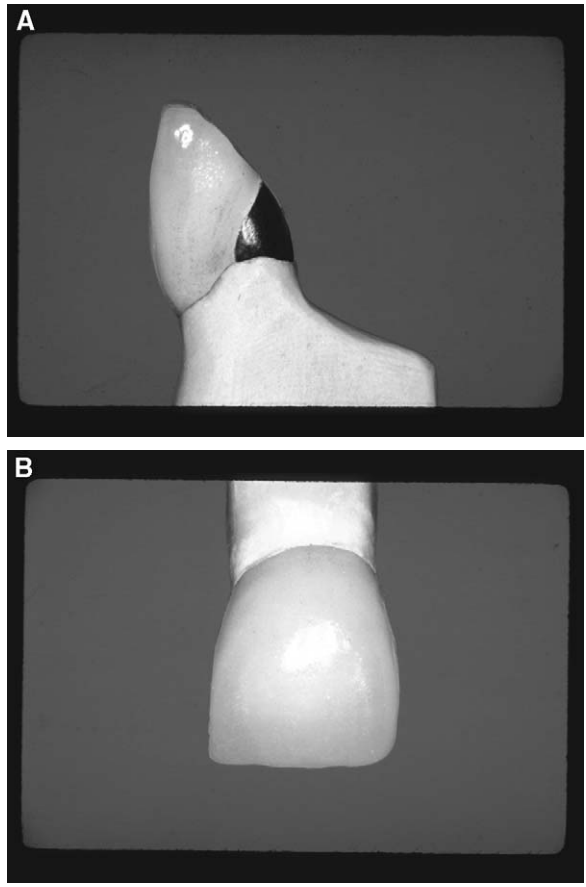

Fig. 11. (*A*, *B*) The porcelain margins illustrated combine good marginal integrity with excellent esthetics.

Some authorities recommend the use of a 360° porcelain margin. This approach is proposed because it theoretically permits improved light transmission and improved esthetics. In the opinion of the authors, this unnecessarily complicates the laboratory phase of fabrication and provides, at best, minimal benefit.

Another issue that has generated controversy in recent years is where the gingival extension of the metal substructure should terminate relative to the shoulder margin. The classic technique extends the metal framework to the axio-gingival line angle. Technicians have recently advocated shortening the metal framework and terminating it anywhere between 1 and 3 mm from the shoulder margin. A recent study has demonstrated that light transmission is improved with the metal cut back 1 mm from the shoulder and that increased cutbacks do not result in significant improvement in light

Fig. 12. These metal-ceramic restorations with porcelain labial margins provide acceptable esthetics when the margins are hidden with healthy gingival tissues.

transmission [49]. The same study found that a cutback of 2 mm or more resulted in significant weakening of the restoration. Based on this information, it is recommended that the metal framework be cut back 1 mm from the shoulder margin.

Summary

When preparing teeth for esthetic crown restorations, the clinician must determine which cervical finish line is appropriate for each specific clinical

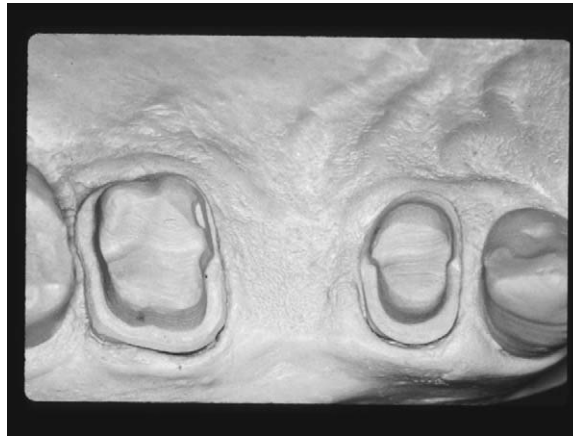

Fig. 13. The preparation for porcelain labial or buccal margins mandates a shoulder margin on the buccal half of the tooth and a shoulder bevel or chamfer on the lingual half. The premolar has been prepared for a porcelain shoulder margin, and the molar has been prepared for a shoulder-bevel margin.

situation. All cervical margins must be placed in the correct position relative to the free gingival margin, the epithelial attachment, and the alveolar housing.

With all-ceramic crowns, the optimum finish line is a shoulder margin with rounded internal angle with a width of 1.2 to 1.5 mm. This depth may have to be reduced to 1.0 mm with triangular-shaped teeth. It should meet the external surface of the tooth at an angle of 90°.

With metal-ceramic crowns, knife-edge margins and chamfer margins should generally be avoided due to concerns with fit. Shoulder-bevel margins are the margins of choice in situations where esthetics is not important because of their documented ability to provide optimum fit and the ability to polish the inherent metal collar.

Shoulder margins with a labial or buccal porcelain margin are indicated in situations where esthetics is paramount. These margins should be prepared at 90° to the external tooth surface, should be exceptionally smooth, and should have a width of 1.2 mm. The metal substructure should be finished 1.0 mm from the shoulder margin to permit optimum light transmission without sacrificing strength.

Slant shoulder margins are necessary when the tooth preparation extends some distance on the root surface. In situations where these margins are not visible, they should use a metal collar. In situations where the smile exposes these margins, the disappearing margin approach should be used.

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