One of the prime goals of restorative therapy is to establish a physiologic periodontal climate and facilitate the maintenance of periodontal health. Crown contour, margin placement, and pontic design all affect periodontal health. This article reviews the current theories of all three of these.

CROWN CONTOUR

The contours for full and partial coverage restorations play a supportive role in establishing a favorable periodontal climate. Three prominent theories of crown contour have evolved: (1) gingival protection, (2) muscle actions, and (3) access for oral hygiene.

Gingival protection theory

The gingival protection theory advocates that contours of cast restorations be designed to protect the marginal gingiva from mechanical injury (Fig. 1). The concept of protecting the gingiva has been with dentistry for many years. A number of dental anatomy textbooks, periodontal textbooks, and respected clinicians advocate the concept of gingival protection with little or no supporting scientific evidence. Statements in support of gingival protection appear to be primarily empirical. Wheeler has stated, “The gingiva is apt to be stripped or pushed apically through lack of protection and consequent overstimulation.” The axiom of gingival protection has become so ingrained in the dental literature and teaching that for years this concept was seldom challenged. Some dentists and laboratory personnel apparently have reasoned that, if a little gingival protection is good, then more is better. This theory and the increased use of full coverage veneer crowns have produced an era of overcontoured restorations. Wheeler has remarked that, when molars have curvatures in excess of normal, the gingiva will be overprotected and will suffer from lack of proper stimulation. Wheeler’s warning was based on “protection” of the gingiva.

The gingival protection theory has been defended primarily on the basis of three elements: protection of gingival margins, gingival stimulation, and self-cleansing contours.

Protection of gingival margins. This concept implies that undercontouring of the clinical crown will cause deflection of masticated food onto the gingival margin, forcing it into the sulcus, thus initiating gingivitis.

This concept may have originated from the observation that interproximal food impaction occasionally can initiate acute inflammation. However, numerous studies have demonstrated a cause-and-effect relationship between plaque and gingivitis, and in comparison, the interrelationship of periodontal disease and food impaction appears slight. Many authors have
reported situations where crowns or temporary fixed partial dentures have been lost or removed for long periods of time with no apparent ill effects to the surrounding gingiva (Fig. 2). Schluger et al\textsuperscript{18} stated, in discussing crown contours, “the so-called protective cervical bulge that hypothetically protects the human gingival crevice protects nothing but the microbial plaque.”

Koivumaa and Wennstrom\textsuperscript{19} studied the histologic effects of crown contour on human gingiva. They found that there was an increase in inflammation adjacent to bulbous artificial crowns but that properly contoured artificial crowns exhibited no such increase at the adjacent gingiva.

Perel\textsuperscript{20} in studying dogs, cut Class V preparations 0.5 mm above the buccogingival crest. He then overcontoured some restorations and undercontoured other restorations. After 9 weeks, he found no clinical or histologic changes with the undercontoured restorations; but with the overcontoured restorations, he reported evidence of inflammation and hyperplasia both clinically and histologically. Thus, there appears to be no evidence to support crown contours designed to “protect the gingival margins.”

**Gingival stimulation.** This concept reasons that, as food is masticated, it will pass over the gingiva, stimulating it and causing increased keratinization of the epithelium. The keratinized epithelium would be more resistant to periodontal breakdown.

Several authors\textsuperscript{21–24} have shown that the gingival margin is not in the path of masticated food. Even if the food passing over the teeth were to increase keratinization (there is little evidence to back this assumption),
this stimulation would only occur at the buccal and lingual surfaces, leaving the interproximal tissues without proper stimulation. It appears that, under normal circumstances, the mechanics of mastication has very little effect on gingival health.

**Self-cleansing contours.** This concept asserts that, as food passes over the tooth during mastication, the tooth will be cleansed. While certain prominent buccal and lingual surfaces of teeth do not accumulate plaque even in neglected mouths, numerous authors\(^\text{21,22,24}\) have shown that mastication does not remove plaque at the gingival margins of teeth. Neither does mastication have any effect on the progress of gingivitis.\(^\text{22}\) Thus, self-cleansing crown contours apparently are nonexistent at the gingival margins of the teeth (Fig. 3).

**Muscle action theory**

Morris\(^\text{15,16}\) was one of the first to question the rationale of the gingival protection theory. He and others\(^\text{25-28}\) have suggested that overcontouring prevents the normal cleansing action of the musculature and allows food to stagnate in the overprotected sulcus.

Lindhe and Wicen,\(^\text{22}\) Loe,\(^\text{11}\) and others\(^\text{29}\) have all demonstrated that, in the absence of oral hygiene, “self-cleansing” mechanisms do nothing to prevent gingivitis. Even if there were some cleansing of the buccal and lingual surfaces from muscle action, interproximal cleansing still would be impossible.

Some proponents of the gingival protection theory also concur with the muscle action theory.\(^\text{5,6,14,27,28}\) These authors strive for an intermediate design of crown contour which allows for both gingival protection and muscular action.

**Theory of access for oral hygiene**

This theory is based on the concept that plaque is the prime etiologic factor in caries\(^\text{30-32}\) and gingivitis.\(^\text{11,29,33}\) Thus crown contour should facilitate plaque removal, not hinder it.\(^\text{18}\) When crowns were overcontoured experimentally, 64.3% of the test sites demonstrated an increase in periodontal inflammation. This was attributed to decreased access for oral hygiene.\(^\text{34}\)

The four guidelines to contouring crowns with emphasis on access for oral hygiene will be described.

**Buccal and lingual contours—flat, not fat!** (Fig. 4). Numerous authors\(^\text{17,18,21,25}\) have demonstrated that plaque retention on the buccal and lingual surfaces occurs primarily at the infrabulge of the tooth. Reduction or elimination of the infrabulge would reduce plaque retention.\(^\text{18}\) Perel\(^\text{20}\) demonstrated that in actuality undercontouring may promote gingival health. Ramfjord,\(^\text{35}\) Yuodelis et al,\(^\text{17}\) and an increasing number of other authors have come to the realization that overcontouring is a greater periodontal hazard than undercontouring.

The normal buccolingual contour of teeth without caries is quite flat. Most authors who have studied normal tooth contours\(^\text{2,4,9,36,37}\) have reported that rarely is the buccolingual width of these teeth more than 1 mm wider than the cementoenamel junction (CEJ). Thus, a normal tooth at the buccocervical bulge is usually ≤ 0.5 mm wider than the CEJ.

**Open embrasures.** If plaque is a primary etiologic factor in gingivitis,\(^\text{18,33,38}\) then every effort should be made to allow easy access to the interproximal area for plaque control.\(^\text{18,35,39}\) Open embrasure spaces will allow for this easy access (Fig. 5). An overcontoured embrasure will reduce the space intended for the gingival papilla. The result is a broadening of the col area, causing pressure and irritation on the papilla. This also
inhibits effective oral hygiene. Several authors have suggested or implied that an interproximal space that is slightly larger than normal may be desirable since it provides adequate room for the gingival papilla and is a more accessible area to clean. Some authors have reported the fear of creating an environment which promotes “lateral food impaction” when open embrasures are employed. Townsend has observed that, even with grossly undercontoured, open embrasure spaces, lateral food impaction rarely occurs as long as interproximal tooth contacts are properly maintained. Several authors have demonstrated that the most effective method of interproximal plaque control in gingival recession is the use of an interproximal brush. When the interproximal brush is used, the space between two adjacent proximal surfaces must be wide enough to allow it to pass through with relative ease.

**Location of contact areas.** Contacts should be high (directed incisally) (Fig. 6) and buccal in relation to the central fossa (except between maxillary first and second molars) (Fig. 7). Several authors have demonstrated that the contact areas on natural teeth occur at the incisal one third of the tooth. Many agree that natural teeth are straight or slightly concave interproximally from the CEJ to the contact area. This tends to open the embrasure, particularly if the contact area is high (in the incisal direction). Many authors have pointed out that the contact area of all teeth, except between the maxillary first and second molars, should be buccal to the central fossa. This creates a large lingual embrasure for optimum health of the lingual papilla. Hazen and Osborne have warned of the consequences of an “oversized” col resulting from broad (buccolingual) contacts. The col is a nonkeratinized area which is thought to be more susceptible to plaque. The broad contact produces a larger col, thereby leading to increased chance of inflammation. Ramfjord recommends placement of contact areas as far occlusally as possible to facilitate access for interproximal plaque control.

**Furcations involvement.** Furcations that have been exposed owing to loss of periodontal attachment should be “fluted” or “barreled out” (Fig. 8). The concept of fluting into molar furcations is based on the desire to eliminate “plaque traps” and facilitate plaque control. Yuodelis et al., in discussing molar furcations, warn that the final restoration should not follow the anatomy of the original clinical crown but should be an extension of the contours of the periodontally exposed roots. When this approach is properly executed, the triangular
region that is created by the roots and the cervicular bulge is eliminated (Fig. 9). This triangular region is the most difficult area to maintain in a plaque-free condition with conventional brushing techniques. We have found that by recontouring the furcation to eliminate the triangle, plaque control with normal brushing is greatly facilitated (Fig. 8).

**MARGIN PLACEMENT**

The concept of subgingival margins is a natural outgrowth of G. V. Black’s “extension for prevention” and the “caries-free zone.” Locations for marginal placement for cast restorations have included: (1) the base of the gingival crevice; (2) half the distance between the base of the gingival crevice and the gingival margin; (3) slightly below the gingival margin; (4) the crest of the gingival margin; and (5) supragingivally. With each of these margin locations, the authors have reported clinically healthy periodontal tissues when quality restorations were combined with effective plaque control.

As early as 1941, Orban proposed supragingival margins for improved periodontal health. Orban and other researchers discovered that the “caries-free” or “clean” subgingival zone, which had been observed previously on extracted teeth, was nothing more than the location of the epithelial attachment. This epithelial attachment will not attach to the margin of a cast restoration. Thus the concept of routine subgingival margins was questioned as more scientific evidence appeared (Fig. 10).

Plaque accumulation, inflammation, and gingivitis are reported to occur more frequently in teeth with subgingival crown margins than in those with supragingival margins. Oral hygiene instructions do not seem to alter this pattern.

Few incidences of new caries associated with supragingival margins have been reported because of improved access for plaque control. Christensen has
demonstrated that the visually accessible margin (supragingival) can be, and is, fitted more accurately than the visually inaccessible margin (subgingival).

Based on these and other findings, subgingival margins should be avoided except for the following specific situations: (1) esthetic demands, (2) caries removal, (3) subgingival tooth fracture, (4) to cover existing subgingival restorations, (5) to gain needed crown length, and (6) to provide a more favorable crown contour (that is, furcation involvement).

**PONTIC DESIGN**

The design of pontics for fixed partial dentures has been clouded by empirical judgment. The so-called “sanitary pontic” is not new to dentistry. The “bullet-shaped” pontic has been advocated by some authors as a desirable design to reduce food accumulation. Nearly all authors agree that the “ridge-lap” pontic is undesirable from the point of view of tissue health (Fig. 11).

Numerous investigators have reported that inflammation of the edentulous mucosa adjacent to pontics is probably a response to plaque accumulation.
on the surface of the pontics. Many authors\(^5,7,8,2,88\) feel that glazed porcelain is the material of choice for contact against the edentulous ridge. Other investigators\(^7,8,7,8,8,89\) have shown that there is no clinical or histologic difference in the response of the mucosa to pontics properly constructed of cast gold, acrylic resin, or glazed or unglazed porcelain.

Stein’s\(^8,1\) classic article on pontic design was largely responsible for a change in philosophy from a “sanitary” or “bullet-shaped” design to what is now commonly called a “modified ridge-lap” design. The modified ridge-lap design in the posterior region (Fig. 12) and the ridge-lap facing design in the anterior region (Fig. 13) offer minimal tissue contact, acceptable cosmetic value, proper cheek support, and accessibility for adequate oral hygiene.\(^1,4,8,1,4,4,4\) It has now been established that the design of the pontic may be the most important factor in preventing inflammatory reactions,\(^8,1,8,9\) not the material used in the pontic.

In addition to properly designing the undersurface of pontics, it is imperative to open embrasure spaces adjacent to abutments to allow room for interproximal tissue and access for oral hygiene (Figs. 12 and 13, part B).\(^1,5,8,1,4,6,7,8,8,9,9,1,9,1\) The occlusal surface should not be narrowed arbitrarily\(^1\) since this may create a food impaction and/or plaque retention situation similar to that of malposed teeth (Fig. 14).\(^5,8,1\) The embrasure space between two adjacent pontics usually is closed to provide added strength, reduce food and plaque retention, and facilitate oral hygiene procedures under pontic areas (Fig. 15).\(^9,2\)

Basic guidelines for the access-for-oral-hygiene theory of crown contour, margin placement, and pontic design can be applied to nearly all fixed restorative procedures. These guidelines apply to full porcelain coverage restorations (Figs. 12, B, 14, and 15, B), precision attachments (Figs. 12, B, 14, and 15, B), coping reconstructions (Fig. 17). Occasionally tooth preparations must be modified to allow for the added bulk needed for

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**Fig. 16.** A, Modification (m) of tooth preparation to allow for placement of attachment system within the normal contour of the tooth. B, Castings with precision attachments for patient in Fig. 15, a. Note the open embrasures, high contacts, flat-not-fat contours, and the intracoronal attachments are within the confines of the normal crown contour.

**Fig. 17.** The coping approach to reconstruction can be designed to facilitate the access for oral hygiene guidelines. A, Copings in place. B, Suprastructure cemented onto copings. Note the open embrasures, flat buccolingual contours, and fluted molar furcations.
SUMMARY

Crown contours which promote favorable tissue response follow these guidelines: (1) buccal and lingual contours are flat; (2) embrasure spaces should be open; (3) contacts should be high (incisal one third) and buccal to the central fossa (except between first and second molars); and (4) furcations should be "fluted" or "barreled out." Margins should be supragingival where possible. The pontic design of choice is the modified ridge lap for posterior spaces and the ridge-lap facing for anterior spaces.

REFERENCES

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