# TOPICS OF INTEREST

# The Esthetic Width in Fixed Prosthodontics

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**With the evolution of adhesive dentistry and the increasing use of porcelain veneers, single-unit crowns generally are restricted to the replacement of pre-existing full-coverage crowns and the restoration of nonvital and/or severely damaged teeth. Porcelain-fused-to-metal restorations are still widely used to generate single-unit crowns and fixed partial dentures. Collarless metal-ceramic restorations represent the most successful evolution among efforts to meet maximum esthetic requirements using porcelain-fused-to-metal restorations. Extended metal frameworks and opaque aluminous ceramic cores are associated with unpleasant optical effects in the soft tissues surrounding such restorations. This problem is particularly evident in the presence of the upper lip, which can generate an "umbrella effect" characterized by gray marginal gingivae and dark interdental papillae. Based on the concept of the biologic width, a systematic approach is proposed for the elaboration of an "esthetic width," including: 1) positioning of preparation margins; 2) reduction of the metal framework; and (c) appropriate marginal design of porcelain-fused-to-metal restorations. Strategic features of pontics and a specific interdental design are suggested to compensate for deficient anatomical features of the soft tissue and the edentulous ridge.**

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**INDEX WORDS: esthetics, porcelain-fused-to-metal, porcelain shoulder, framework design, pontics, interdental design**

FOR THE RESTORATION of single vital teeth, a contemporary approach generally includes adhesively luted porcelain veneers.[1-3] Techniques for bonding ceramic facings have been in use for more than 15 years, and numerous clinical evaluations[4-9] have reported excellent performance in terms of fracture rates, microleakage, debonding, and soft tissue response when such restorations are compared with traditional complete-coverage restorations.[10] The combination of ceramics and composite luting materials permits optimal integration of the materials' physical, biological, and esthetic properties. Among these, adhesive properties, tissue preservation, esthetics, and longevity are critical. Most important, the definitive tooth-restoration complex seeks to approach the natural tooth condition from esthetic, functional, and biomechanical perspectives.[11-14] As the indications for porcelain laminates continue to be expanded,[15-17] the use of traditional cemented full-coverage crowns tends to be limited to two specific situations: 1) restoration of severely damaged teeth; and 2) replacement of existing full-coverage restorations (Figs 1A-1C, 2A-2B). The quest for the ideal system continues, with all-ceramic restorations competing with traditional metal ceramics. The success and integration of extended prosthetic rehabilitations, however, is not simply a matter of technical choice (porcelain-fused-to-metal versus all-ceramic). It is also related to the diagnostic and provisional restoration phases,[18-23] the importance of which is often overshadowed by the development of new ceramic systems.

Fixed partial dentures also may be fabricated using either ceramic or metal-ceramic technologies. Metal-ceramics remain the esthetic standard for fixed partial denture applications. The technical aspects of metal-ceramic fixed partial dentures have been significantly improved (eg, refinement of framework design, interdental morphology, and an extended porcelain margin combined with translucent luting agents). Novel approaches have been developed for framework fabrication such as capillary

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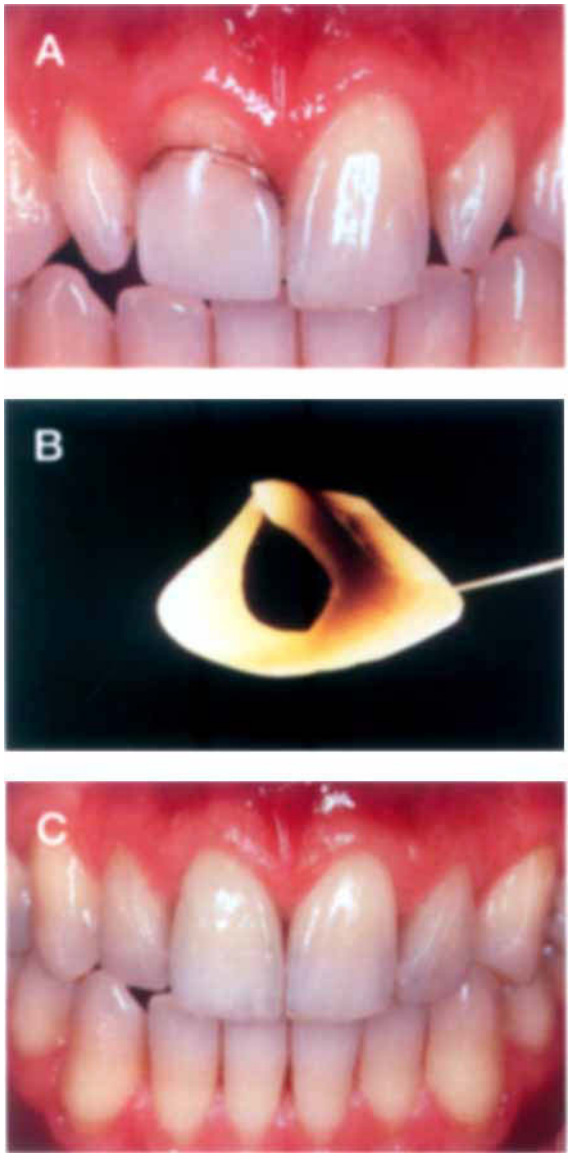


**Figure 1.** The patient exhibits peg-shaped maxillary lateral incisors and a resin crown on the right maxillary central incisor (*A*). The existing crown was replaced by a porcelain-fused-to-metal crown with an advanced design—an extended porcelain margin and reduced metal framework, providing the margin of the restoration with maximum light transmission (*B*). The crown, as well as the two porcelain laminates on the lateral incisors, were luted with a composite resin (C).

technology and composite metals (platinum filler and high-gold-content matrix).[24]

When properly constructed, metal-ceramic restorations can be used in a variety of applications. Furthermore, esthetically pleasing results can be obtained with proper integration of metal-ceramic pontics and associated ridge crests. Key aspects of this integration are presented in the following sections. The importance of metal framework design in light of biological considerations is discussed. Strategic features of pontics and specific interdental designs are suggested that will compensate for deficient anatomical characteristics of soft tissues and edentulous ridges.

## Biological Framework Design

The morphology and dimension of supracrestal periodontal tissues undoubtedly represent the most important parameters to be taken into consideration in designing a fixed prosthesis. This fact has been widely accepted since the definition of the "biological width". This original concept initially addressed the length of the dentogingival unit.[25] Respect for the biologic width and proper placement of preparation margins not only contribute to optimization of gingival health,[26,27] but also enhance the esthetic design of the prosthesis. The rational use of these principles

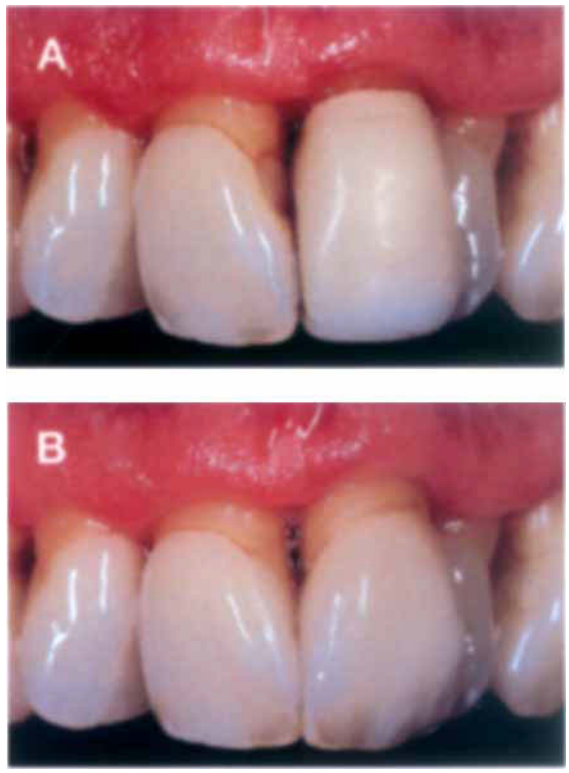


**Figure 2.** Despite a supragingival margin, the periodontal tissues are inflamed around this resin crown on the left central incisor (*A*). Periodontal health and esthetics were restored following improved oral hygiene and the placement of a PFM crown with an intrasulcular margin (*B*).

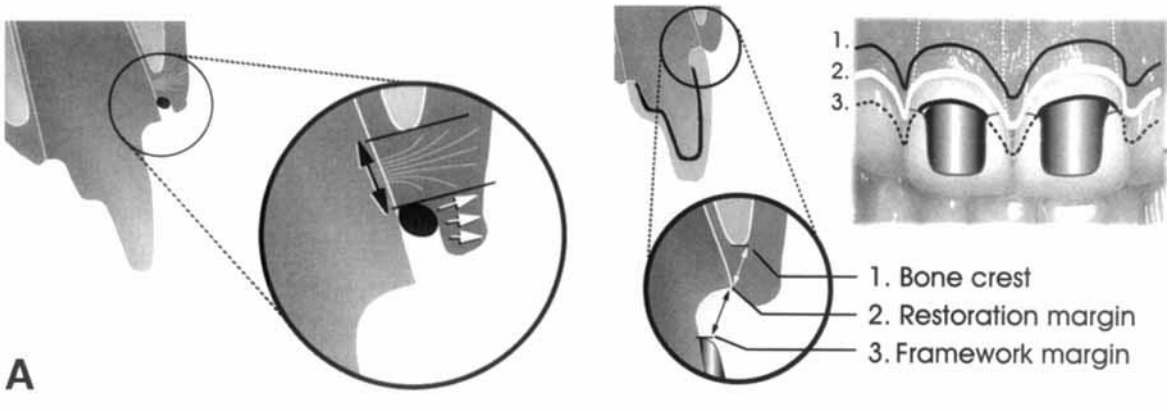


**Figure 4.** A similar distance (respecting the biologic width) should be reproduced when reducing a metal framework for the placement of porcelain margins.

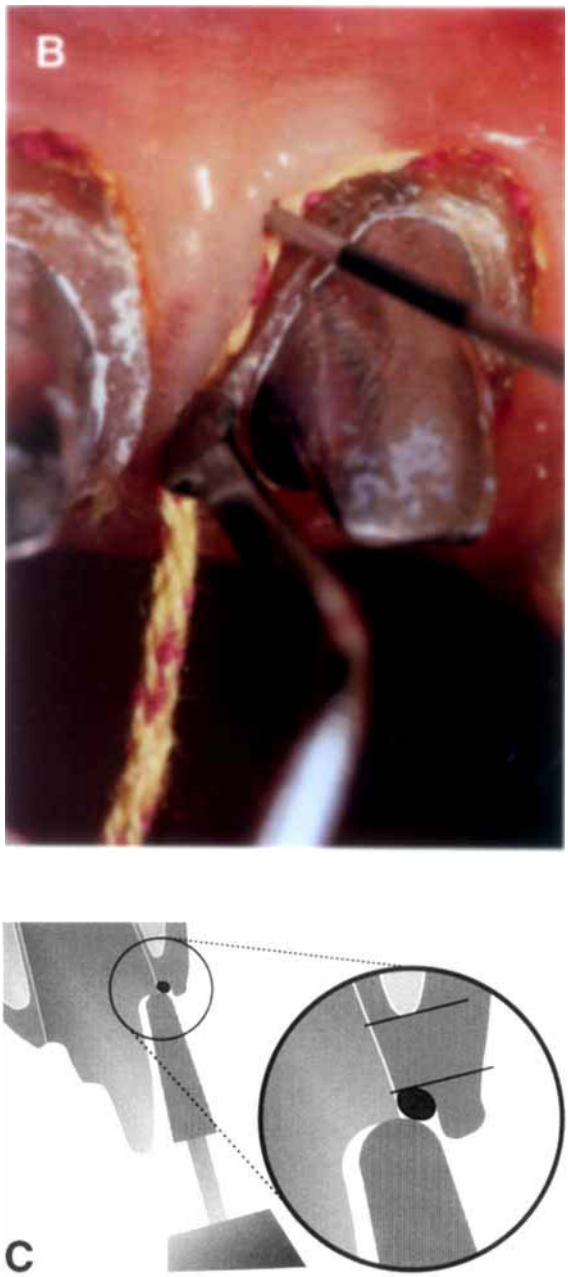


**Figure 3.** The placement of retraction cord should not damage the connective tissue attachment (*A*). Traumatic forces can be avoided by using a bimanual insertion technique: the cord is stabilized with a periodontal probe on the site of insertion, while a spatula is used to position the cord in the sulcus (*B*). The related placement of the margin is made accordingly, the tip of the bur being guided by the surface of the cord (*C*).

leads to the introduction of the concept of the "esthetic width."

### *The Esthetic Width*

Understanding the concept of esthetic width requires consideration of the tooth preparation itself and, in particular, placement of preparation margins.[28,29] The biologic width, which describes the location and dimension of the connective tissue attachment, should first be respected when placing the retraction cord. The exposed surface of the deflection cord will serve as a reference to the bur for the margin placement (Fig 3A-3C). In this context, pressure and trauma should be minimized during cord placement.[30] The combined use of a spatula and a periodontal probe (bimanual insertion technique) may facilitate this step by better distributing forces during insertion (Fig. 3B). Respect for the biologic width upon placement of the finish line aids in the fabrication of a restoration that will favor periodontal health.

Well-adapted and well-contoured provisional restorations are key elements in this process, permitting the conditioning of the edentulous ridges and the surrounding abutment teeth. While palatal and facial contours must be consistent with the emergence profile of the abutment tooth, proximal contours

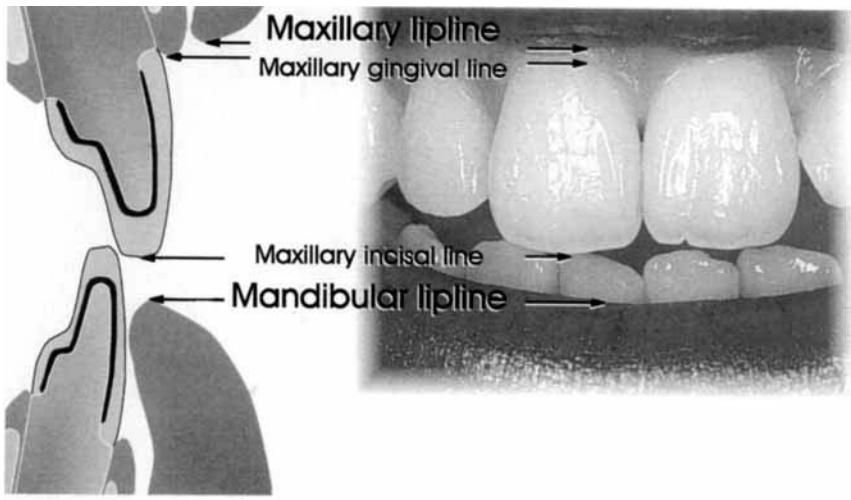


**Figure 5.** The presence of the lips, especially the upper lip, is determinant in the distribution of light into the adjacent soft tissues.

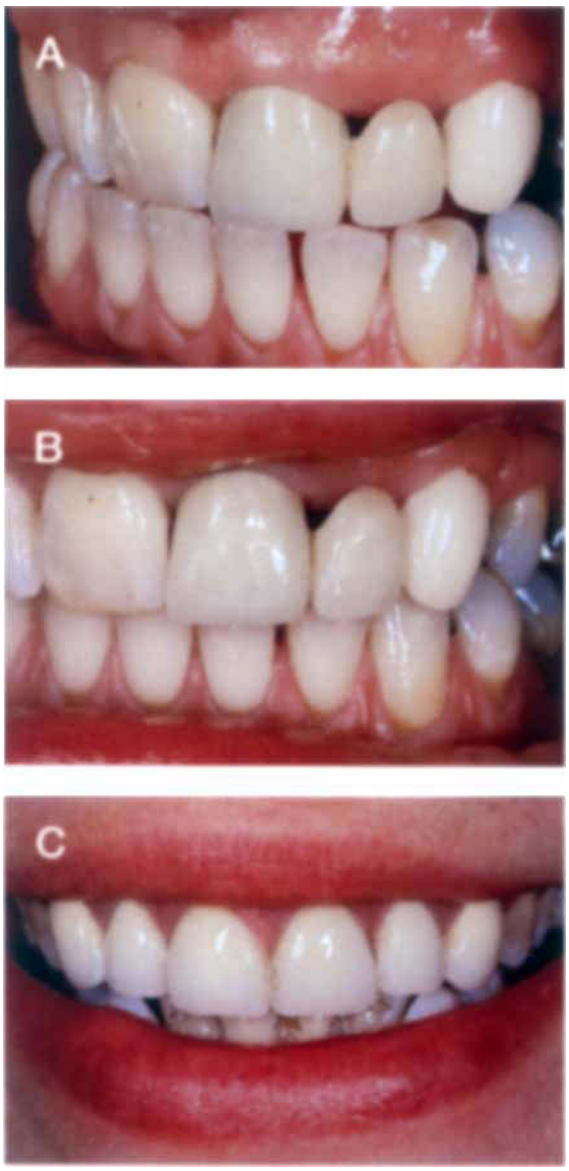


**Figure 6.** This preexisting metal-ceramic fixed partial denture presents an extended metal framework on abutment tooth 9, but no metal is exposed on the margin (*A*). The interaction of the lip with the cervical area gives rise to very dark marginal soft tissues that simulate cervical metal exposure (*B*). Interdental papillae are extremely sensitive to this "umbrella effect" of the lip as illustrated in another case of six preexisting maxillary porcelain-fused-to-metal crowns (*C*).

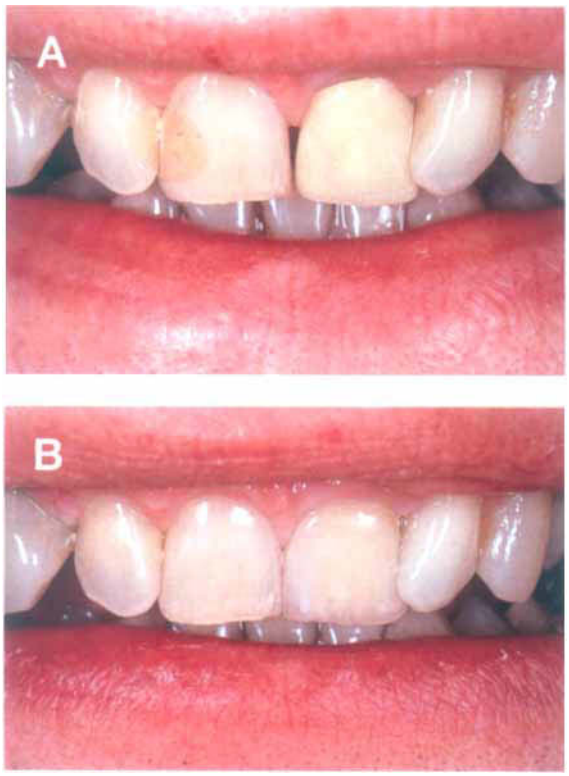


**Figure 7.** The presence of an old resin crown luted with an opaque cement also creates an "umbrella effect" around tooth 9 (*A*). After the replacement of Class III composite restorations on teeth 7 and 8, good illumination of the tissues around tooth 9 was provided by placing a porcelain-fused-to-metal crown with porcelain margins (*B*).

often must be modified to compensate for the flattening of the interdental papillae (see Interdental Design). As the supracrestal connective tissue attachment is respected during tooth preparation, so should the esthetic width be respected when designing the prosthetic framework (Fig 4); a distinct space is necessary between the coronal border of the gingiva and the cervical margin of the framework to provide adequate room for the application of specific shoulder porcelains.[31] Collarless metal-ceramic crowns have been shown to resist the same axial pressures as those restorations with complete metal support.[32,33] In addition, the optical consequences of extended metal frameworks are considerable, resulting in lack of brightness in the area of the marginal soft tissues even in the presence of vital abutments (ie, the "umbrella effect" discussed below).

### *The Umbrella Effect*

A careful analysis of clinically relevant optical phenomena should always include the effects produced by the lips, particularly the upper lip (Fig 5), because this feature will significantly influence the interaction of light with the teeth and their supporting tissues (Figs 6 and 7). When the lips are retracted (as is the case during intraoral photography), the apical extension of the framework generally will not have a strong impact on the optical behavior of the crown,

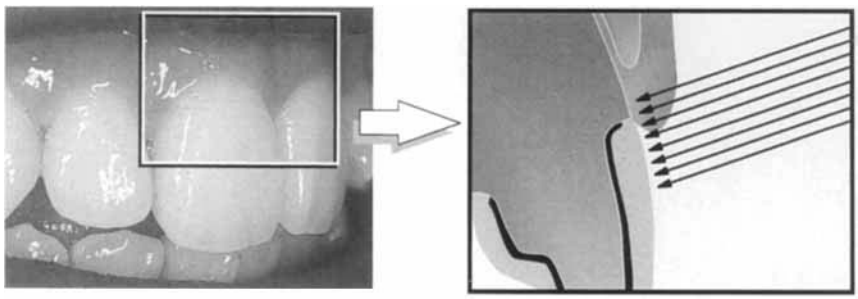

**Figure 8.** In the presence of a high lip line or during intraoral photography with retracted lips, the light penetrates directly to the soft tissues, regardless of the extension of the framework. No shadows are evident in the soft tissues (see also Fig. 6A).

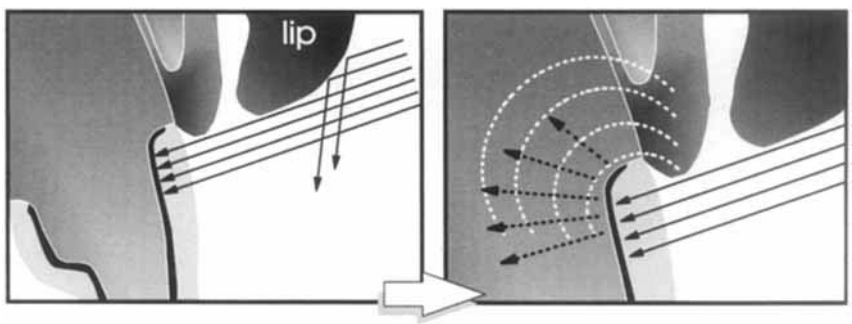


**Figure 9.** The "umbrella effect" is produced by the absence of indirect light penetration into the soft tissues (*dotted lines*). Either an extended metal framework or an opaque ceramic core may cause this phenomenon.

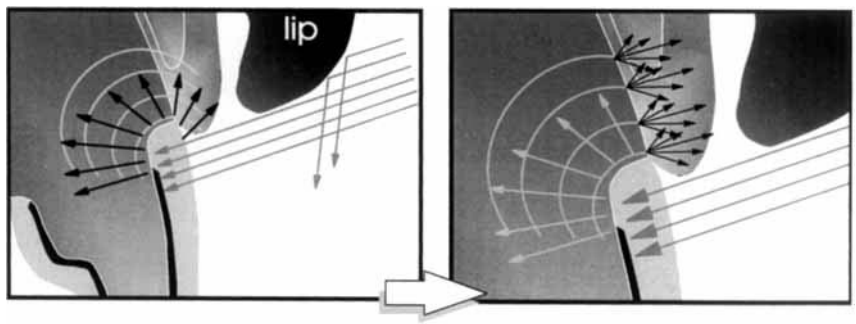


**Figure 10.** Indirect light-transmission phenomena can occur when the natural root is used as a guide for light redistribution. Reduced metal frameworks and extended porcelain margins are imperative to permit transillumination of the gingiva.

because the light can be directly distributed into the tissues (Figs 6A, 8). When the upper lip is in its normal position, however, the difference becomes significant, because direct penetration of light into the surrounding periodontal tissues is prevented (Figs 6B, 6C, 9). In contrast, an adequately reduced framework does not demonstrate the so-called "umbrella effect," even in the presence of the lip, because indirect penetration of light is permitted by the porcelain shoulder (Figs 7B, 10). This allows transillumination of the gingiva, which may otherwise be totally lacking in three common situations: 1) in the presence of apically overextended frameworks (Fig 9); 2) when using insufficiently translucent restorations or opaque cements (Fig. 7A); and 3) in the presence of cast dowel-and-core restorations or endosseous, root-form implants and related abutments. The root portion of a natural tooth is a very luminescent area. The fluorescence of the radicular dentin contributes to the brightness of the root and the illumination of

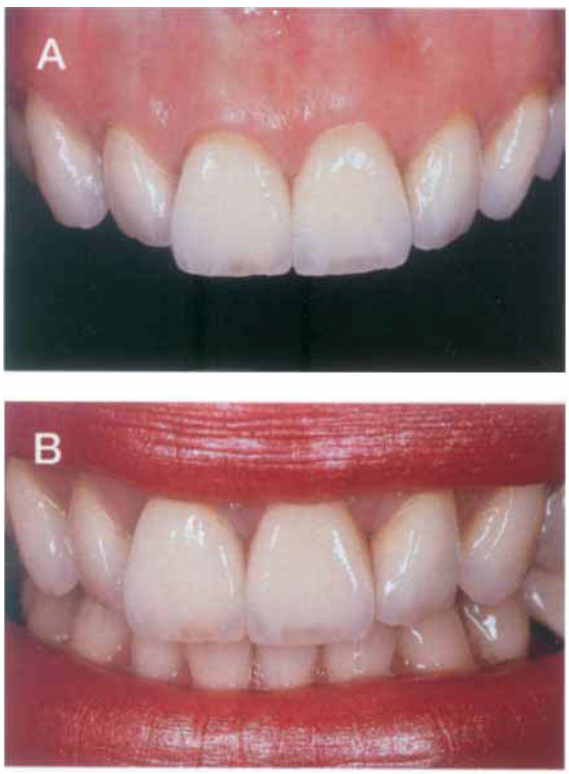


**Figure 11.** These six anterior InCeram crowns (teeth 6-11) allow acceptable illumination of the soft tissues when considered in an intraoral view with retracted lips (*A*). Nevertheless, gray papillae are observed in the presence of the upper lip (*B*).

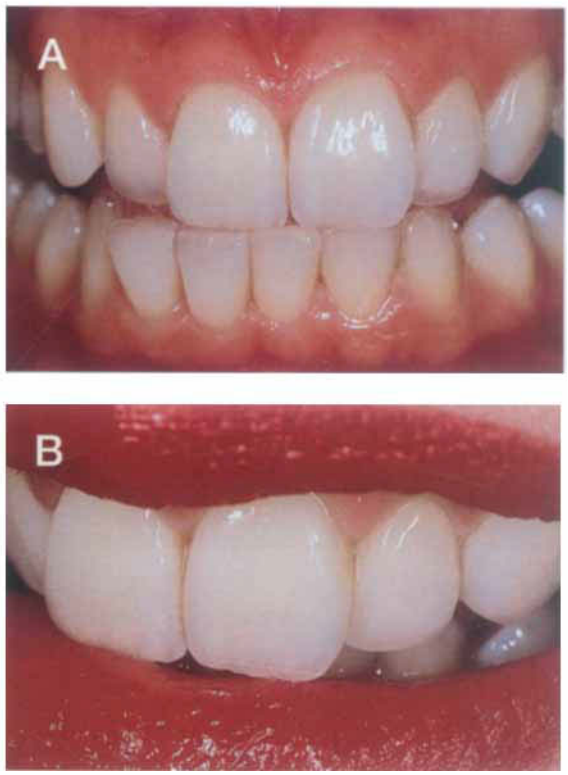


**Figure 12.** Porcelain laminate veneers were placed on teeth 8 through 11 (*A*). The periodontal tissues appear healthy and naturally illuminated even in the presence of the lips (*B*).

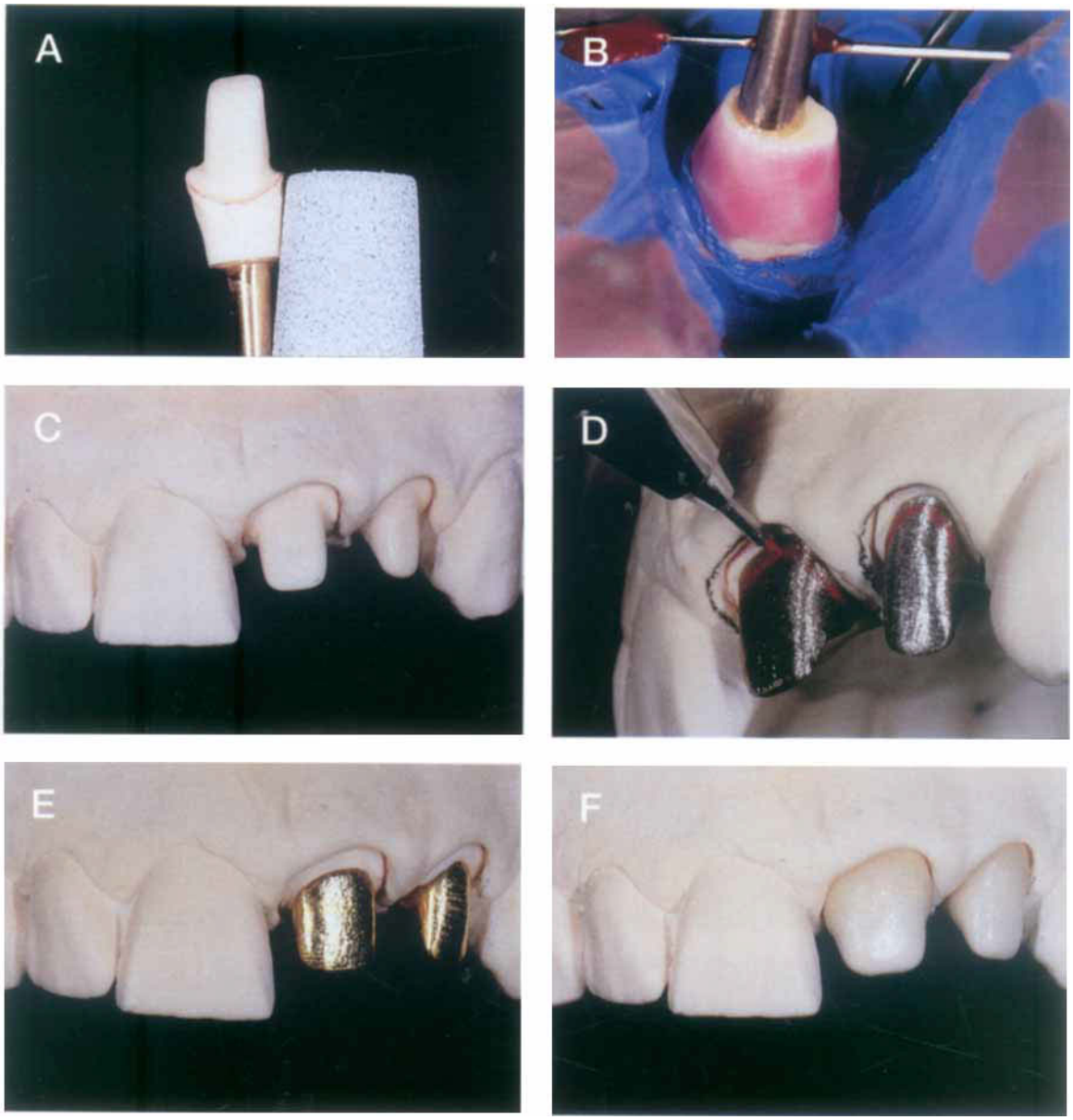


**Figure 13.** Preparation of a master cast with accurate soft tissue reproduction (modified according to Geller): single dies are equipped with metal pins and trimmed conically to simulate the coronal portion of the root (*A*). Individual dies are repositioned in the impression and stabilized with a pin stuck in the impression material; the axial surface of the stone is coated with a thin layer of wax (*B*). The base is poured in two increments to allow the elimination of additional stabilization pins. The resultant cast exhibits removable dies and an intact stone gingiva (*C*). The direction the upper lip is projected on the metal framework (*red line*) using the hard stone gingiva as a guide (*black line*) (*D*). The framework is reduced to the level of the projected gingiva and coated with gold film to enhance the color of the metal before porcelain application (*E*). The first bake is made for the porcelain shoulder and the opaque porcelain (*F*).

periodontal tissues. The use of fluorescent porcelain margins is imperative to simulate this phenomenon. Extended cast dowel-and-core restorations present significant challenges to luminosity, because porcelain margins can never fully compensate for the resulting lack of light penetration at the root level. One might assume that full-coverage ceramic crowns would permit the optimal distribution of light. This is certainly true for ceramic systems in which the core is not fabricated from an opaque ceramic. However, clinicians should remain observant when placing InCeram crowns. The nontransparent and nonfluorescent reinforced alumina framework[34] must be extended to the margin for mechanical purposes. Consequently, in terms of optical effect, InCeram units may resemble metal-ceramic units with overextended metal frameworks (Fig 11A-11B). The area of the interdental papilla is very sensitive to the *umbrella effect*, because adjacent teeth prevent the penetration of light into the interdental tissues (Figs 6C, 11B). Similar effects can be seen with porcelain-fused-to-metal and InCeram crowns (Figs 6C, 11B). In light of these considerations, one may easily recognize that bonded porcelain laminates exhibit excellent optical behavior and promote a more natural appearance of the marginal soft tissues (Fig 12A-12B).

### *Technical Application of the Esthetic Width*

The first requirement in the application of the esthetic width is the most accurate possible reproduction in the final impressions of the surrounding soft tissues. As is the case when placing finish lines, a minimally traumatic retraction method is essential. Polyvinylsiloxane impression materials are recommended because they provide accuracy for multiple pours.[35] The optimal use of final impressions requires 3 or 4 consecutive pours, including the fabrication of an additional master cast that accurately reproduces the soft tissues, as advocated by Geller. To create this cast, individual dies should be trimmed (Fig 13A) and carefully repositioned in the impression (Fig 13B). The subsequent pour of the cast base should result in a cast with gingival contours recorded in stone (Fig 13C). The framework may be objectively reduced using the hard stone gingiva as a reference, together with the approximately estimated direction of the upper lip (Fig 13D-13E). The same cast should be used during the ceramic layering process, beginning with the placement of the porcelain shoulder (Fig 13F). However, this cast should not be considered to be a precise duplicate of the dental arch and should not be used for adjustments of occlusion. Instead, occlusal adjustments should be made using a nonsegmented cast that represents the most accurate reference for intertooth relationships. Surface finishing procedures should be accomplished after the try-in. Finishing procedures include glazing and final correction of the porcelain margin on an intact die using the porcelain-wax technique.[36,37] It is important to note that try-in procedures and occlusal adjustments are complicated by the presence of a porcelain shoulder, which remains extremely fragile as long as the restoration is not definitively cemented. During try-in, careful control of occlusion using articulating paper can be accomplished intraorally. However, extraoral grinding and reshaping is recommended to avoid cracking of the ceramic margin. In fact, while the crown is seated intraorally on its abutment (not cemented), vibrations generated from rotary instrumentation can create marginal microfracture of the ceramic shoulder.

### *Modified Pontic Designs*

All the foregoing statements apply when considering fixed partial dentures in the esthetic zone (Fig 14). As far as specific requirements for pontics are concerned, the ideal crest would provide an adequate geometry for an ovate design (Fig. 15A). This may be obtained if the clinician can successfully influence the external soft tissue healing pattern of the fresh extraction site by means of appropriately designed

**Figure 14.** The framework is similarly reduced at the level of the abutments and under the pontics to allow the same ceramic stratification. The final case is shown in Fig 16A-16C.

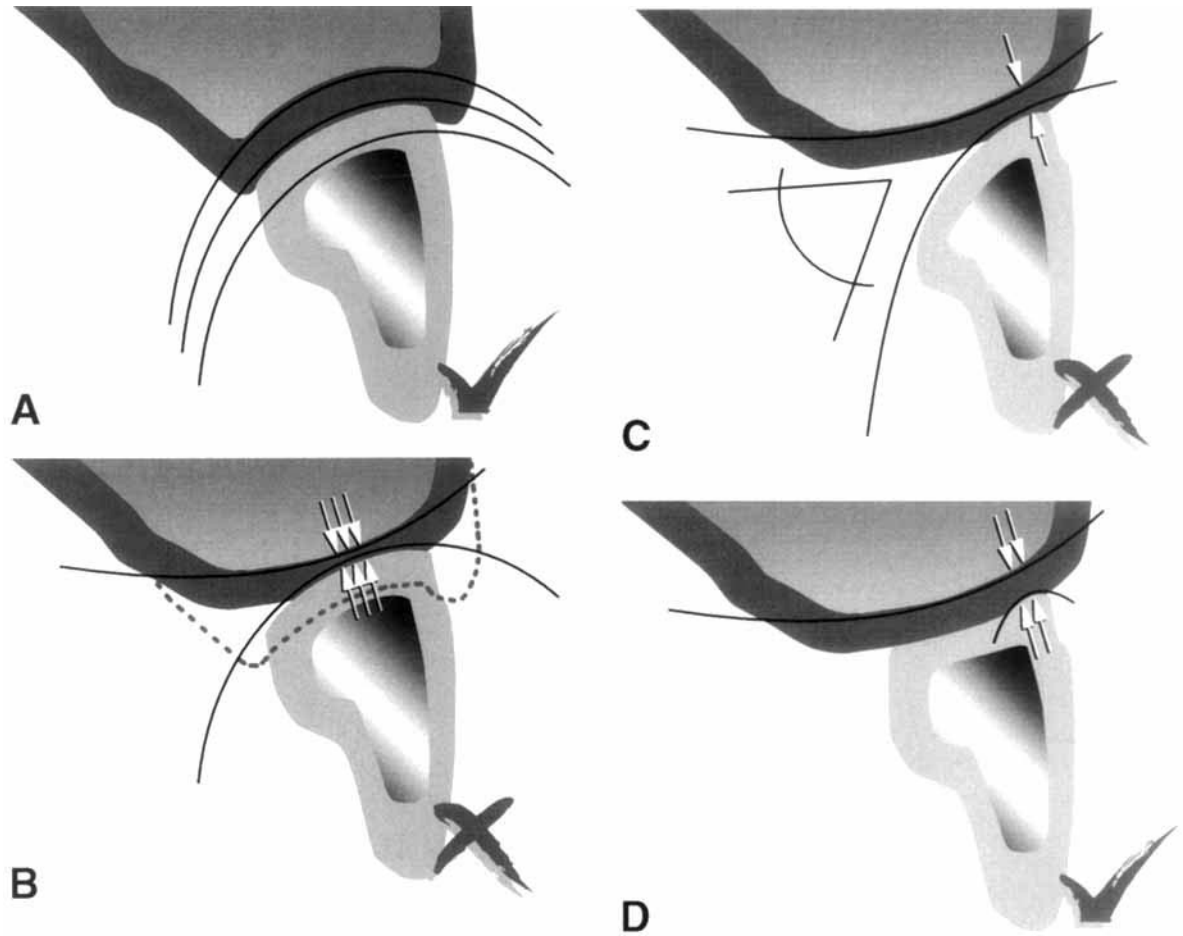


**Figure 15.** The ovate pontic requires a concave morphology of the bone crest (*A*). The presence of a collapsed ridge is not compatible with an ovate pontic design because of the bone proximity (*B*). A sanitary pontic form is most compatible with function and hygiene. However, when placed on a convex crest, it will generate the undesirable result of wide space between gingiva and tooth in the palatal aspect of the prosthesis (*C*). A ridge-lap pontic is easily placed on a convex crest, a slight pressure being maintained only at the facial level of the contact with the gingiva (*D*) (see also Fig 16A-16C).

provisional restorations. Nevertheless, the resulting clinical situation frequently features a collapsed and convex ridge (Fig 15B) that prevents selection of an ovate pontic unless corrective surgical procedures are performed.[38] To avoid the problem of proximity between the bone crest and the pontic without resorting to corrective surgery, the design of the pontic must be modified. Creation of a classical sanitary pontic (Fig 15C) is recommended for posterior segments. In anterior regions, only a ridge-lap pontic with a delicate and selective pressure distributed on the facial aspect of the crest will provide the patient with optimal comfort as well as esthetically pleasing results with minimal surgical intervention (Figs 15D, 16A-16C). This design requires a specific hygiene method using floss (Superfloss, Oral-B, Belmont, CA) and a soft filament brush in a "cross-movement" (Fig 17). This technique may be easily applied in anterior areas of the mouth.

## Interdental Design

The interdental morphology of a restoration provides an additional parameter that can be easily controlled by the operator and will significantly enhance the esthetic outcome of treatment. When the soft tissue architecture of a patient is compared with an intact dentition, it becomes apparent that the interdental papillae of the prosthodontics patient are flattened, leading to unsightly black interdental triangles (Fig

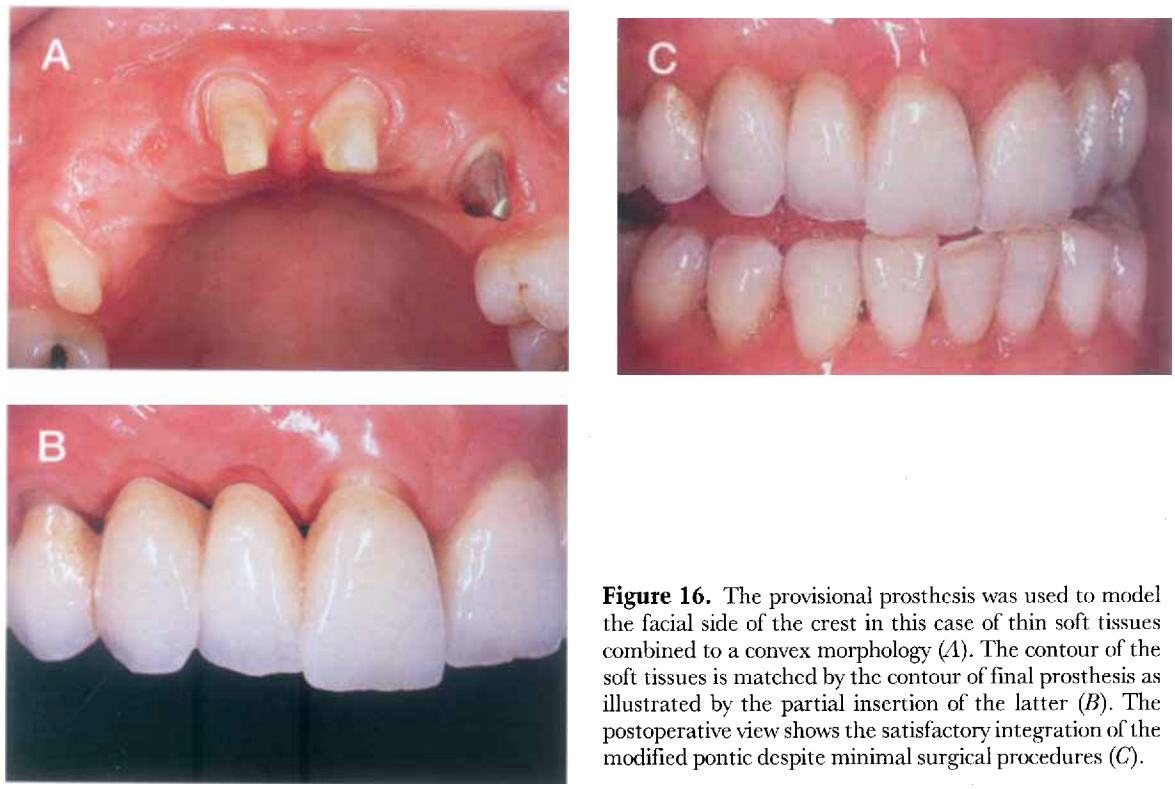


**Figure 16.** The provisional prosthesis was used to model the facial side of the crest in this case of thin soft tissues combined to a convex morphology (*A*). The contour of the soft tissues is matched by the contour of final prosthesis as illustrated by the partial insertion of the latter (*B*). The postoperative view shows the satisfactory integration of the modified pontic despite minimal surgical procedures (*C*).

18). This problem has captured the interest of numerous periodontists and led to the development of various sophisticated preprosthetic surgical procedures.[39] It appears that the presence of interdental bone is certainly a major prerequisite for the long-term success of such procedures. However, these situations may also be alleviated using the rational, nonsurgical approach described below.

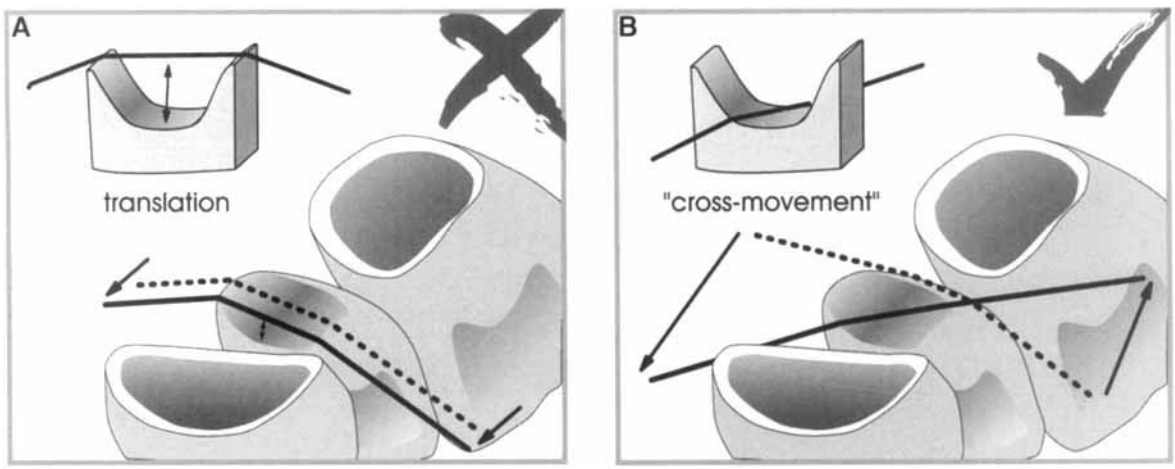


**Figure 17.** Hygiene under a ridge-lap pontic can be inefficient and painful if floss (*black and dotted lines*) is stretched and moved laterally within the available space (translational movement [*A*]). The floss is best guided to the bottom of the concavity when first pulled mesio-palatally and disto-facially (then pulled disto-palatally and mesio-facially), defining the so-called "cross-movement" (*B*).

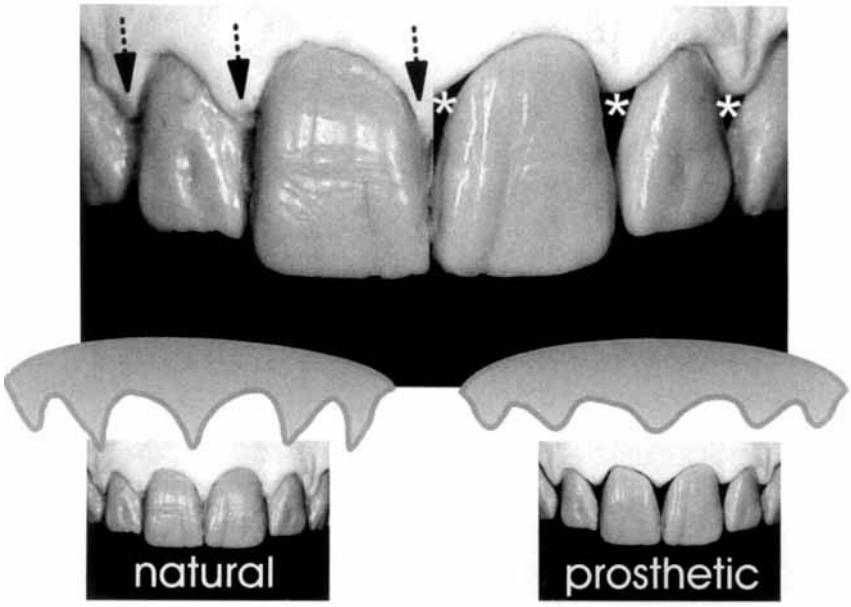


**Figure 18.** A natural and intact periodontium can be easily distinguished from a "prosthetic" periodontium because of the unavoidable flattening of the papillae.

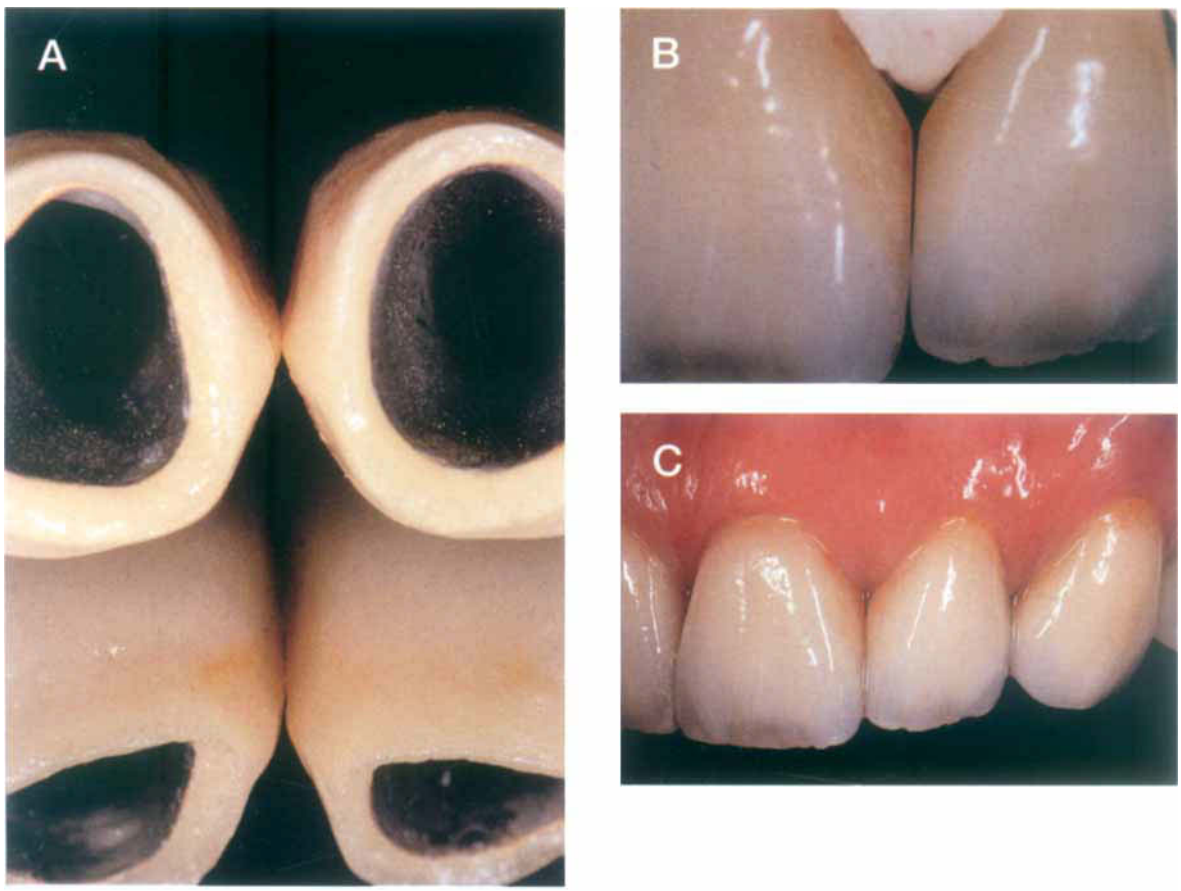


**Figure 19.** Adjacent porcelain-fused-to-metal crowns show the interdental mini-wings compensating for the deficient volume of the papillae (*A*). Local extension of ceramic is made with a porcelain of higher chroma to prevent the appearance of a bulky tooth (*B*). The shape of the anatomic crown is unchanged, but the proximal contact point is replaced by a proximal contact line extending from the incisal edge to the papilla (*C*).

### *The Concept of Interdental "Mini-wings"*

Prosthetic teeth may reasonably compensate for deficiencies in the soft tissues at the interdental level. However, the natural convex proximal surface of the tooth must be modified. To accomplish this, slight interdental extension is made, still respecting the emergence profile of the crown (Fig 19A). The interdental contact point becomes an interdental contact line (Fig 19B). On the master cast, small black triangles may still be visible, but the intraoral try-in often will reveal intimate contact between such crowns and the associated interdental papillae (Fig 19C). Here again, the special master cast (ie, soft tissue cast), which provides the ceramist with the complete morphology of the gingiva in stone, is critical. It is important to note that a ceramic of a higher chroma must be used in the interdental area. This precaution is even more critical when designing interdental mini-wings. If the color and saturation of the interdental extension differs from the remainder of the crown (Fig 19C), the form of the anatomic crown can be "optically" preserved despite the presence of the interdental extension. The gingival fiber apparatus is not affected by such modification of the interdental design, and a long-term esthetic success can be established. This same concept also is applicable to laminate veneers, especially when considering closure of diastemata. Traditional laminate preparations, however, must be modified: a more extended interdental preparation (penetration of the interdental space) is required to allow the ceramist to create the progressive emergence of the interdental zone of extension.

## Conclusions

As a result of the development of adhesive dentistry, the metal-ceramic single unit has tended to be replaced by bonded ceramic restorations. Porcelain-fused-to-metal restorations, however, remain the technique of choice for the realization of FPDs. Optimized concepts in metal-ceramics have brought new, more esthetic solutions through reduced metal frameworks and extended porcelain shoulders. Resultant restorations feature improved "esthetic widths," permitting optimal interaction of light with anterior teeth and their supporting tissues, and by preventing the "umbrella effect" of the lip. In the presence of collapsed and convex anterior edentulous ridges, ridge-lap pontics are recommended. These pontics provide optimal comfort and esthetics, while minimizing the need for surgical intervention. In the interdental zone, the concept of interdental mini-wings represents a simple answer to the problematic soft tissue architecture of prosthetic cases (flattening of papillae and black interdental triangles).

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