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Contemporary crown-lengthening therapy

A review

Timothy J. Hempton, DDS; John T. Dominici, DDS, MS

In contemporary dentistry, dentists are confronted on a daily basis with clinical decision making regarding dentition affected with significant caries or subgingival fractures. The dentist weighs the clinical findings and patients' concerns in the balance to determine if the tooth or teeth should be extracted or restored. We are, of course, in an age of dental implants, an era in which heroic efforts to salvage extensively

damaged teeth are waning. This, however, does not mean that dentists should abandon tools commonly used to preserve the natural dentition, tools such as complex restorative treatment, pos-

sible concomitant endodontic therapy and periodontal therapy. Moreover, if the patient wishes to retain part or all of his or her own dentition, providing the outcomes of these treatment options are predictable, the dentist should consider honoring those wishes.

When caries or fractures are extensive and subgingival, a dentist may opt to use crown-lengthening therapy to expose solid tooth structure and thus to facilitate restorative therapy. Our purpose in this article is to review the goals, basic surgical principles and wound healing associated with crown-lengthening surgery. In addition, we discuss potential positive and negative outcomes of this therapy. In addition, we present a report of a clinical case followed for eight years to illustrate the concepts outlined in this review.

We used PubMed and Google Scholar search engines to identify pertinent literature regarding crown lengthening and res-

ABSTRACT

Background. The authors conducted a literature review regarding the rationale, basic surgical principles, contraindications and wound healing associated with periodontal crown-lengthening surgery. They present a report of a clinical case illustrating crown lengthening with osseous resection.

Types of Studies Reviewed. The authors evaluated clinical and radiographic studies, as well as literature reviews. They selected only publications that pertained to the surgical exposure of the natural dentition to facilitate restorative therapy, esthetic concerns or both.

Results. Periodontal crown lengthening can be used for esthetic enhancement in the presence of delayed passive eruption. Moreover, for teeth with subgingival caries, fractures or both, this treatment can establish a biological width and, if needed, a ferrule length facilitating prosthetic management. Crown-lengthening surgery involves various techniques, including gingivectomy or gingivoplasty or apically positioned flaps, which may include osseous resection. Authors of wound-healing investigations have reported that an average of 3 millimeters of supragingival soft tissue will rebound coronal to the alveolar crest and can take a minimum of three months to complete vertical growth.

Clinical Implications. Initiation of final prosthetic treatment should wait at least three months and possibly up to six months for esthetically important areas, as the free gingival margin requires a minimum of three months to establish its final vertical position. Dentists must be aware that osseous resection could affect periodontal stability and may pose a contraindication to crown-lengthening therapy.

Key Words. Crown lengthening; gingivoplasty. *JADA* 2010;141(6):647-655.

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toration by using the key words “ferrule,” “posts,” “endodontic dowel core,” “post retention,” “root fracture,” “endodontics,” “core restoration,” “post designs,” “fracture resistance” and “post-core.”

RATIONALE FOR CROWN-LENGTHENING SURGERY

Esthetic and functional concerns. The indications for crown-lengthening surgery include esthetic enhancement, exposure of subgingival caries, exposure of a fracture or some combination of these. Crown-lengthening surgery has been categorized as esthetic or functional. The term “functional” relates to exposure of subgingival caries, exposure of a fracture or both. Often, the discussion of crown lengthening in the anterior sextants is presented in the context of esthetic surgery. Excess gingival display can occur when passive eruption has been delayed. The result is the appearance of short clinical crowns. In the presence of a medium or a high lip line, this condition is more noticeable. If the patient desires an anterior dentition that is more normal in tooth length, resective treatment that exposes the anatomical crowns may be warranted.^{1,2}

Indeed, functional and esthetic therapy can converge in the esthetic zone when subgingival caries does not extend greatly or at all to the root. In these cases, the dentist may need a surgical stent as a guide to determine the position of the new crown margins. If the interdental tissue needs to be removed during surgery, the potential for an esthetic compromise can be reduced or eliminated via compensating prosthetic crown contours. The dentist can conceal or correct widened embrasure areas that may result after healing from the surgical procedure by lengthening and widening the crown contact areas to accommodate the new morphology of the interproximal papillae.

A caveat that the dentist must address for crown lengthening in areas of the dentition visible during smiling is the potential for an esthetic compromise relative to the gingival framework. In an esthetically important area in which the free gingival margin may be located significantly coronal to the cemento-enamel junctions (CEJs) of the dentition, resection of these excess tissues may not pose a high risk of developing a problematic situation. This is true, even if full-coverage restorations are not planned, as long as the interdental tissues are not involved in the process of resection.³ Resective therapy, however, may result in facial root

exposure if the free gingival margin already approximates the CEJs of the dentition in an esthetic area. Moreover, an altered morphology of the anterior dentition’s interdental papillae after healing also is a concern. Black triangles may develop if the postresection distance between the contact area and the interdental osseous crest is greater than 5 millimeters.⁴

The biological width. In addition to exposing supragingival tooth structure for restorative therapy, dentists excise tissues so that crown margins do not impinge on the so-called biological width. A review of the literature reveals differing opinions regarding the occlusoapical length of the biological width. Gargiulo and colleagues⁵ described the dimensions of the dentogingival junction. They reported the average length of the dentogingival junction to be 2.04 mm. They identified the subcomponents of the dentogingival junction as the connective-tissue attachment (mean value: 1.07 mm) and the epithelial attachment (mean value: 0.97 mm). Vacek and colleagues⁶ also investigated the dimensions of the dentogingival junction in human cadaver specimens. They reported mean values of 0.77 mm for the connective-tissue attachment and 1.14 mm for the epithelial attachment. Ingber and colleagues⁷ suggested that the term “biologic width” relates to the average value of the dentogingival junction—that is, approximately 2 mm. They suggested that an additional 1 mm be added coronal to the 2 mm dentogingival junction as an optimal distance between the bone crest and a restorative margin. The authors reasoned that “adding the 1 mm to the average 2 mm of the biologic width establishes a minimum dimension of 3 mm coronal to the alveolar crest that is necessary to permit healing and proper restoration of the tooth.”⁷ Nevins and Skurow⁸ also described the importance of a 3-mm biological dimension separating the osseous crest by a safe distance from the plaque associated with crown margins.

In contemporary practice, it generally is accepted that a 3-mm distance would significantly reduce the risk of periodontal attachment loss induced by subgingival restorative margins. Placing the restoration in close proximity to the osseous crest has been demonstrated in a human clinical study to induce chronic inflammation.⁹

ABBREVIATION KEY. CEJs: Cemento-enamel junctions.

Moreover, results from an animal investigation involving histologic evaluation indicated that restorative margins impinging on the osseous crest may result in bone resorption.¹⁰

Ferrule length. A ferrule is a metal ring or cap intended for strengthening. The Journal of Prosthetic Dentistry's 2005 Glossary of Prosthodontic Terms defines a ferrule as a metal band or ring used to fit the root or crown of a tooth.¹¹ Sorensen and Engelman¹² redefined the ferrule effect as "a 360-degree metal collar of the crown surrounding the parallel walls of the dentine extending coronal to the shoulder of the preparation." Figure 1 illustrates a prepared and restored tooth with a ferrule and a prepared and restored tooth without a ferrule.

For better understanding of the concept of the ferrule, we should examine the dynamics related to full-coverage restorations used as a restorative option when tooth structure has sustained severe damage. Often, the dentist replaces the lost tooth structure with a foundation restoration before making the final preparation for a full-coverage restoration. Furthermore, if the breakdown in tooth structure has impinged on the pulp or if little residual supragingival tooth structure remains, endodontic therapy and concomitant placement of a post and core may be necessary to allow intracanal retention of the restoration. The placement of the foundation restoration results in an increase in clinical crown height, width or both, thereby increasing the retention of the full-crown restoration. Under these circumstances, however, supragingival crown preparation may result in a margin that is partially or entirely seated on foundation restorative material.

A basic prosthetic concept is that the greatest amount of retention and resistance to dislodgement of the restoration occurs at the apical one-third of the preparation. It is in this location that parallelism is most critical. In this situation, after placement of a full-coverage restoration, the forces of occlusion generally may be transmitted to the foundation restoration.

When a post-and-core restoration is placed to retain the core foundation, the occlusal forces may be transmitted to the interface between the internal aspect of the root and the post. The den-

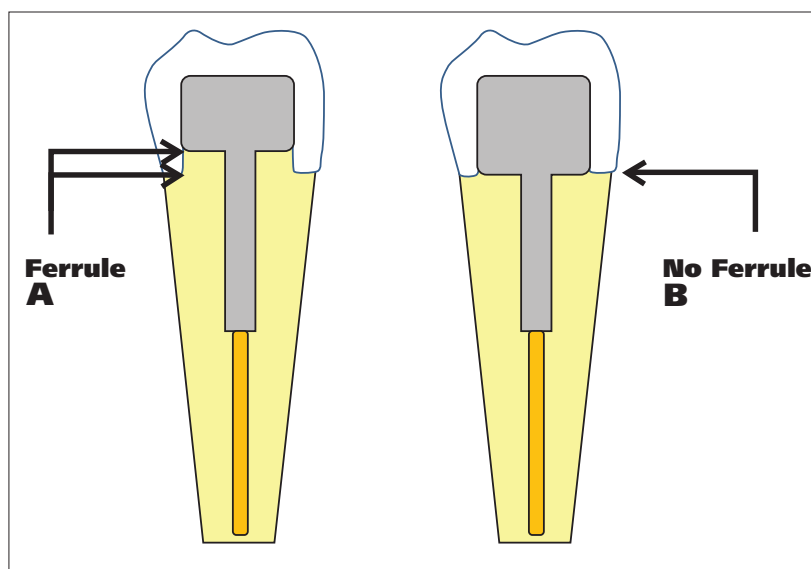


Figure 1. A. A tooth prepared for a full-coverage crown with a ferrule. **B.** A tooth prepared for a full-coverage crown without a ferrule.

tist fills this area with cement to facilitate retention of the post. The physical properties of the cement become critical. Fatigue of the cement under occlusal stress could result in dislodgement of the post and core or, worse, fracture of the tooth.

The advantage of exposing additional tooth structure in this clinical scenario is that the tooth preparation can extend in a more apical direction for 1 to 2 mm. This additional surgically exposed tooth structure is provided in addition to exposure of the biological width so that the crown does not invade the attachment apparatus; thereby, a more predictable prosthetic outcome is facilitated.¹³

This added disclosure of tooth structure can contribute to the formation of a ferrule. In other words, the restorative margin is circumferentially 1 to 2 mm apical to the most apical extent of the foundation restoration or core buildup. This ferrule height—the length of solid tooth structure engaged by the full-coverage restoration—may permit the forces of occlusion to be dispersed onto the periodontal ligament rather than concentrating stresses at the post and core intraradicularly, which can increase the likelihood of failure of the tooth or the restoration. Libman and Nicholls¹⁴ recommended a ferrule of at least 1.5 mm. Some investigators have reported that a ferrule is not necessary.^{15,16} They argued that the length of the post and the type of cement used negate the concern about obtaining a ferrule. Morgano and Brackett¹⁷ advised that the pros-

thetic principle of establishing a ferrule should not be abandoned.

As a result of the concern regarding obtaining a ferrule, lengthening the crown of a tooth with minimal supragingival tooth structure may involve additional surgical removal of tissue. In other words, the dentist may be required to excise both hard and soft tissue to facilitate development of a biological width of 3 mm, as well as a ferrule length of 1.5 mm.

Attempting to obtain a ferrule with additional resection is not without its problems. Gegauß¹⁸ pointed out that an attempt to gain an adequate ferrule via a crown-lengthening procedure may result in compromise of tooth and biomechanical leverage. He noted that the more apical relocation of the crown margin after crown-lengthening procedures resulted in a preparation with a thinner cross section. This reduction combined with the altered crown to root ratio could result in a weakened tooth. Orthodontic extrusion may be another option to expose tooth structure in some clinical situations. Any method used to increase the ferrule length will reduce the root length invested in bone and possibly make the crown to root ratio unfavorable. Furthermore, surgical and orthodontic procedures add to the cost of restoring the tooth and prolong treatment.

Most research investigating the ferrule has taken the form of in vitro studies of single-rooted teeth. The influence of the ferrule effect on multi-rooted teeth is an area for further research. Also, without supporting clinical research or prospective data, the clinician must question whether appropriate restorative treatment still can be performed when a ferrule is absent or shorter than that advocated in the in vitro studies.

BASIC SURGICAL CROWN-LENGTHENING PROCEDURES

Soft tissue. To plan a crown-lengthening procedure, a dentist must think in three dimensions. In addition, he or she should be concerned about the quantity and quality of residual gingival tissues left behind after the resected tissue has healed completely.

As a result, the first concern in flap design or excision is the height of gingiva present on the facial and lingual aspects of the involved tooth or

teeth. The dentist can accomplish a tissue excision via a gingivectomy by means of a scalpel, an electrosurge, a radiosurge or a laser. Lasers have made their way into conventional dental therapy for use in performing gingivectomy or gingivoplasty.¹⁹ Laser tissue ablation can result in adequate exposure of tooth structure with minimal or no bleeding. This type of tissue removal can result in a dry field, thus allowing the clinician to place a restoration immediately.

The clinician, however, should not ignore the concern regarding the width of gingiva in an occlusal apical height. Maynard and Wilson²⁰ recommended a minimum of 3 mm of attached gingiva in the presence of subgingival restorative therapy. A gingivectomy, no matter what tool the dentist uses to accomplish the excision, could

result in complete removal of attached gingival tissue.

If soft-tissue excision via a gingivectomy would result in a postoperative gingival width of less than 3 mm, one should consider the apically positioned flap as an alternative to a simple gingivectomy.^{21,22} If the pretreatment level of gingiva is minimal, the dentist could make a sulcular incision and position the

flap apically to the osseous crest.²³ This not only would preserve the amount of gingiva but also would increase the width of the attached gingiva after healing.

Another parameter to consider is the need to visualize the bone. If the underlying bone crest is less than 3 mm from the level of gingival resection, then the dentist should consider using an elevated flap procedure for access. A simple excision of tissue probably would result in regrowth of soft tissue if the osseous crest is less than 3 mm apical to the existing free gingival margin. In addition, access to the bone yields the opportunity to perform additional resection of bone if the dentist also intends to expose a ferrule.

Osseous management. Regarding esthetic implant dentistry, Garber and colleagues²⁴ stated, "The tissue is the issue, but the bone sets the tone." In fact, this concept also is true for outcomes of periodontal surgery. The key to success is a three-dimensional analysis of the clinical objectives associated with the osseous component of the proposed crown-lengthening surgery. The first dimension is the occlusoapical dimension,

Lengthening the crown of a tooth with minimal supragingival tooth structure may involve additional surgical removal of tissue.

the second is the mesiodistal dimension and the third is the buccolingual dimension.

Two terms that describe osseous resection are “ostectomy” and “osteoplasty.” “Ostectomy” refers to removal of supporting bone; “osteoplasty” refers to removal of nonsupporting bone. Regarding tools used for bone resection, a dentist can use hand chisels, high-speed rotary instrumentation or a piezoelectric cutting device. No matter what tool the dentist uses, he or she should ensure that the treated bone is moistened constantly during the procedure to prevent desiccation and associated postoperative pain and delayed healing.

When resective osseous surgery is performed to eliminate osseous deformities or reshape healthy bone for exposure of tooth structure, the final contours of the underlying osseous structure influence the overlying gingival tissues.²⁵ When the bone has positive architecture after therapy, wound healing results in scalloped gingival architecture with minimal sulcus depth. The achieved reduction in probing depths can be maintained in the long term for nonsmokers and former smokers who practice proper oral hygiene and compliance with a professional maintenance program.²⁶

If reverse architecture remains after a tooth with a surrounding healthy periodontium has undergone crown lengthening, excess gingival tissue may rebound in the healing phase. This rebound would result in inadequate exposure of the treated dentition. If periodontal disease and associated intrabony defects are present in conjunction with the need to lengthen a tooth's crown, the dentist should eliminate those deformities and establish positive architecture. Failure to eliminate osseous deformities poses a risk of pockets' being present after surgery.^{27,28}

The extent of bone resection. In deciding which and how much bone should be removed, the dentist's first concern is determining whether the lesion associated with the tooth requires Class V, Class II or full-coverage restorative treatment. If the lesion is located solely on the facial aspect, then the dentist can perform the needed osseous removal solely on the facial or lingual aspect. Moreover, the resection would be limited to altering the bone in the occlusoapical dimension, thereby attaining a 3-mm dimension of supra-crestal tooth exposure (distance for a biological

width). The flap for this procedure could be a one-tooth flap with two adjacent vertical releasing incisions.

When the tooth will be treated with a Class II restoration or a full-coverage crown, the interproximal bone may need to be resected. In this event, the dentist resects interproximal bone to establish a distance associated with health between the restorative margin and the new, more apical level of bone. As a result, the interproximal bone is apical to the facial and lingual bone. The dentist, having created reverse architecture, needs to evaluate the second dimension, the mesiodistal dimension. To reestablish positive architecture, the dentist would need to resect facial and lingual bone mesial and distal to the interproximal area.

In an esthetic crown-lengthening procedure, bone removal plays an important role in the final location of the free gingival margin after healing.

The third dimension to osseous resection is the buccolingual dimension. Periodontal biotype is related to thickness of periodontal tissues. Thick biotypes may consist of thick bone, thick soft tissue or both. After elevating the flap, the dentist may note an osseous ledge or exostosis. Thick bone often occurs on the palatal aspect of the maxillary molar dentition.²⁹ It also can be present on the lingual border of the

mandible.³⁰ Horning and colleagues³¹ examined 52 modern skeletal specimens and reported buccal alveolar bone enlargements associated with 25 percent of all teeth examined. Reduction of osseous ledging or an exostosis via osteoplasty was recommended originally by Schluger³² in 1949 and subsequently by Friedman³³ in 1955. It is our opinion that reduction of alveolar bone enlargements reduces the risk of postoperative rebound of soft tissue.

In an esthetic crown-lengthening procedure, bone removal plays an important role in the final location of the free gingival margin after healing. Coslet and colleagues³⁴ described the clinical circumstance known as “delayed passive eruption.” In this condition, excess gingiva covers the anatomical crown, thereby resulting in a short clinical crown. The classification system described by the authors indicated that in some cases, when gingiva is significantly coronal to the CEJ, the osseous crest may be located at or within close proximity to the CEJ. For a predictable outcome in these cases, flap elevation with access to the facial osseous crest enables the dentist to visu-



Figure 2. Tooth no. 4 prepared for a full-coverage crown. Supragingival tooth structure is not visible, and there is no ferrule.



Figure 3. Pretreatment radiograph of tooth no. 4. Teeth nos. 3 and 4 had undergone endodontic therapy.



Figure 4. After flap elevation and before resection, the buccal osseous morphology is exposed.



Figure 5. Buccal view after osseous resection. Tooth structure is exposed to establish a biological width and ferrule length.

alize and resect an appropriate amount of bone.

Altered passive eruption also can be observed in the posterior sextants. The clinical crowns of the posterior dentition can be significantly shorter than the anatomical crowns. In cases in which fixed prosthetic therapy is needed, repositioning the free gingival margin to the level of the CEJ may be all that is necessary to expose caries and establish cleansable gingival embrasure areas.³⁵ The effect on periodontal support is negligible in these cases, as the resection of soft tissue and bone essentially is the resection of excess periodontal tissues.

Contraindications to osseous resection.

Ostectomy becomes a liability when the stability of the treated dentition may be affected. Generally, dentists should refrain from excessive osseous removal if it will compromise the crown to root ratio. In addition, removal of bone in the furcation region associated with the root trunk is a concern.³⁶ The dentist also should avoid removing bone in the furcation area.³⁷

Wound healing. After the surgical procedure concludes, the healing phase begins. Research has shown that when the clinician creates an apically positioned flap with an osseous resection procedure, the biological width reestablishes itself at

an apical level.³⁸ Researchers have observed that if the margin of the flap is positioned at the level of the osseous crest, a postoperative vertical gain or rebound in supracrestal soft tissues occurs that averages 3 mm.^{39,40} If the flap margin is placed at a level more coronal to the newly established osseous crest, less vertical gain or rebound in supracrestal soft tissues has been observed.⁴¹

After a crown-lengthening procedure, a common question pertaining to restorative or prosthetic treatment regards when the final tooth preparation can begin and when impressions, if needed, can be taken. A key determinant for initiating prosthetic therapy is the final position of the free gingival margin. This is particularly true in cases in

which the treated dentition is of esthetic concern to the patient.

Lanning and colleagues⁴² demonstrated that coronal advancement of the healing tissues from the osseous crest averages 3 mm by three months' time after surgery. They also determined that six months after surgery, no further significant changes in the vertical position of the free gingival margin were apparent. Brägger and colleagues⁴³ also noted that during a six-month healing period after crown lengthening, periodontal tissues were stable, with minimal changes in the level of the gingival margin. From these findings, one can conclude that regarding final prosthetic treatment in the esthetic zone, the waiting period after a crown-lengthening procedure should be six months.

DISCUSSION

Crown-lengthening surgery is a resective procedure used to induce recession surgically. To do so, the clinician either excises or apically positions soft tissues. In addition, the underlying osseous structure plays a critical role in the final wound healing. When osseous deformities already are present, osseous resection and apically positioned flaps would have the dual advantage of reducing probing

depths and exposing tooth structure for restorative therapy. Modification of the morphology of the underlying bone must be evaluated in three dimensions. With respect to proximal lesions or full-coverage restorations, crown-lengthening surgery involves changes in the mesiodistal dimension to establish positive architecture. As a result of the need to dissipate the changes in the hard and soft tissues of the adjacent teeth, lengthening the crown of one tooth with a proximal lesion essentially becomes a three-tooth surgery.

With respect to prosthetic therapy, crown lengthening results in more cleansable gingival embrasure areas adjacent to full-coverage crowns. Moreover, this procedure can enable the clinician to establish a biological width and a ferrule length. Obtaining adequate exposure to establish both of these parameters should be weighed against the possibility of compromising the osseous support of the tooth undergoing crown lengthening, the osseous support associated with the adjacent teeth or both.

Regarding initiation of final prosthetic treatment, researchers have observed an average vertical growth of 3 mm of supraosseous gingiva.^{39,40} The final position of the free gingival margin can occur at three months after surgery but may occur as long as six months after surgery. For treated areas in the esthetic zone, a waiting period of six months is advisable.

CASE REPORT

A 58-year-old woman in good health had a subgingival foundation restoration associated with tooth no. 4 (Figure 2). A preoperative radiograph



Figure 6. Bone architecture after elevation of a palatal flap and before osseous resection.



Figure 7. Palatal view of osseous morphology after osseous resection. Positive architecture is established at an apical level.



Figure 8. View of apically positioned buccal flap sutured with periosteal sutures.



Figure 9. Buccal view eight weeks after crown-lengthening surgery. Periodontal tissues still are healing. Plaque-control measures need to be reviewed with the patient.



Figure 10. Buccal view of the maxillary right posterior sextant eight years after periodontal and prosthetic treatment. Teeth nos. 3 and 4 have been restored with porcelain-fused-to-metal restorations.

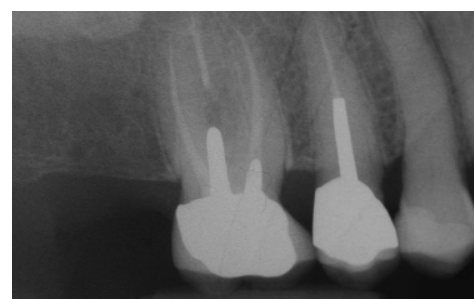


Figure 11. Radiograph of teeth nos. 3, 4 and 5 eight years after treatment with a crown-lengthening procedure and placement of full-coverage crowns.

indicated that endodontic therapy had been performed in conjunction with placement of a post-and-core foundation restoration. A periapical radiograph indicated that the root length associated with tooth no. 4 appeared to be adequate to allow for osseous resective therapy (Figure 3).

As adequate root length was available, and a ferrule was not present, the clinician decided to perform a crown-lengthening procedure. Figures 4 and 5 show the flap extending from the distal aspect of tooth no. 3 to the mesial line angle of tooth no. 6. These images display the osseous levels before osseous resection. The clinician noted that the length of supraosseous tooth structure

was inadequate for establishment of a biological width or ferrule.

The clinician performed osseous resection, establishing 4.5 mm of supraosseous tooth structure on the buccal and palatal aspects of tooth no. 4. In addition, the clinician attained positive osseous architecture that extended from the distal aspect of tooth no. 3 to the mesial aspect of tooth no. 5. Figures 6 and 7 show the area after the osseous resection. After completing osseous therapy, the clinician positioned the flaps apically by means of periosteal sutures (Figure 8). This type of sutured closure attaches the flap at an apical level to connective tissue still present on the facial aspect of the buccal bone (as described by Kramer and colleagues⁴⁴).

Figure 9 shows additional exposure of tooth structure at eight weeks after the procedure. At three months after surgery, the patient returned to the restorative dentist for fabrication of full-cast restorations associated with teeth nos. 4 and 3. Figure 10 is a photograph and Figure 11 a radiograph of the restored area eight years after treatment.

CONCLUSION

Crown-lengthening surgery can be a viable option for facilitating restorative therapy or improving esthetic appearance. When planning a crown-lengthening procedure, the dentist should evaluate the patient's complete periodontal condition and disclose all possible treatment options to the patient. In cases involving the possibility of a negative esthetic outcome, compromise to the support of the dentition involved in the surgical procedure or both, extraction and implant therapy or conventional prosthetic therapy may be a more compelling solution. ■

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