

Determining Osseous Resection During Surgical Crown Lengthening in the Esthetic Zone with the Use of a Radiographic and Surgical Template

Luca Landi, DDS, CAGS*

Paolo F. Manicone, DDS**

Stefano Piccinelli, DDS***

Roberto Raia, DDS***

Fabio Marinotti, CDT****

Fabio Scutellà, DDS, MS*****

Surgical crown lengthening is defined as a procedure used to expose sound tooth structure with or without removal of alveolar bone for restorative purposes.¹ Whenever the crown extension includes removal of supporting bone, the principles of osseous resective surgery should be applied. The objectives of osseous resective surgery include (1) elimination of alveolar bone alterations due to periodontal disease activity²; (2) establishment of a physio-

logic supracrestal gingival tissue (SGT) in cases of violation of the biologic width³; and (3) correction of unesthetic soft and hard tissue aberrations.⁴

While alveolar bone deformities resulting from periodontal disease dictate the degree of osteoplasty and ostectomy needed to achieve a positive architecture,⁴ the same cannot be applied to surgical crown-lengthening procedures. In such instances, alveolar bone anatomy retains its physiologic contour and the periodontist relies only on the proposed restoration finish line to determine adequate ostectomy to achieve a physiologic SGT. Recently, Scutellà et al⁵ introduced the use of a surgical template to guide the bone resection. Their device was primarily indicated in those cases where the amount of residual crown did not allow fabrication of a retentive provisional restoration, such as with severe tooth breakdown as a result of caries or extensive tooth abrasion subsequent to bruxism or bulimic disorders.

Because of the invasive and irreversible nature of surgical crown lengthening, several factors

*Private practice, Studio di Odontoiatria Ricostruttiva, Rome, Italy; University of Modena & Reggio Emilia (Italy).

**Private practice, Studio di Odontoiatria Ricostruttiva, Rome, Italy; Catholic University of Sacred Heart, Rome, Italy.

***Private practice, Studio di Odontoiatria Ricostruttiva, Rome, Italy.

****Dental laboratory technician, Rome, Italy.

*****Private practice, Rome, Italy.

Correspondence to: Dr Luca Landi, Studio di Odontoiatria Ricostruttiva, Via della Balduina 114, 00136 Rome, Italy. Fax: 39-06-35403508. E-mail: studio.ric@tin.it.

should be considered before osseous resective surgery is performed: crown-to-root ratio, amount of keratinized gingiva, root alterations or furcation defects, esthetic concerns of both the patient and the clinician, and altered passive eruption. The expected residual periodontal attachment after surgical bone recontouring seems to be the most critical factor for long-term tooth stability. In some instances, the roots are extremely short, either congenitally or as a consequence of resorption resulting from previous orthodontic therapy. Therefore, the feasibility of the proposed surgical procedure should be evaluated well in advance and weighed against other available treatment alternatives.

Bragger et al⁶ showed that surgical crown lengthening might be less predictable than the profession currently anticipates. One possible explanation may be the lack of guidance provided during bone resection resulting either in excessive or inadequate bone resection. Carnevale and Pontoriero⁷ recently pointed out that even in those cases where the principles of osseous resective surgery have been correctly applied, the amount of crown extension after 1 year of healing might have been less than adequate. They attributed this phenomenon to “soft tissue rebound.” On the other hand, the bone removal may exceed the amount actually needed. In these cases, the achievement of a physiologic SGT may have been obtained by an excessive reduction of the attachment apparatus, **[Au: has editing retained your meaning?]** thus jeopardizing the long-term stability of the tooth.

In esthetic areas, surgical treatment cannot be focused only on the achievement of an adequate SGT or a more retentive restoration preparation. Conversely, the surgical plan should account for all of the variables that may play a role in the final outcome. In this article, the authors present a technique that may help to guide the periodontal and restorative team to formulate an accurate diagnosis and therefore more precisely predict the feasibility of surgical crown lengthening in the esthetic zone.

CASE PRESENTATION

Diagnostic Procedure and Template Fabrication

A 32-year-old female patient presented in our clinic complaining about the poor esthetics of an existing fixed partial denture in the maxillary anterior region (Fig 1). The existing prosthesis had been delivered more than 2 years previously, and since that time the patient had experienced recurrent gingival inflammation. Porcelain had chipped soon after prosthesis insertion and was never repaired (Fig 2).

A complete intraoral examination including full-mouth radiographs, periodontal probing, study casts mounted on an articulator with a facebow registration and intraoral and extraoral photographs was accomplished. Based on the clinical and radiographic data, the patient was diagnosed as having an altered passive eruption (type II A, according to Coslet et al⁸) in the maxillary arch, a violation of the SGT resulting from faulty restorations, uneven gingival margin architecture (Fig 3), and a lesion of endodontic origin on the right lateral incisor and canine (Fig 4).

Analysis of the smile line revealed a moderate display of gingival tissues (Fig 5). A diagnostic soft tissue contour cast was developed, and a template was fabricated. The goals of the proposed therapy were to re-establish a physiologic SGT, increase the clinical crown length, correct the altered passive eruption, and improve the gingival display and the gingival margin architecture.

Following endodontic treatment and reconstruction of all maxillary anterior foundation restorations, a first set of provisional restorations was delivered (Figs 6 and 7). At this point, an ideal proposed contour cast of the anterior sextant was again developed to determine the correct proportion of the clinical crowns to the gingival architecture and smile line (Figs 8 and 9).

A clear acrylic resin template duplicating the diagnostic contours was then fabricated. Once the device was made, a 0.2-mm-diameter orthodontic wire was adapted and bonded at the cervical margin of the teeth (Figs 10a to 10c). The template

Initial Presentation



Fig 1 Frontal view of the patient's maxillary anterior sextant at the initial consultation. Poor esthetics are clearly visible. The marginal periodontal tissues are erythematous and edematous and display loss of physiologic architecture.

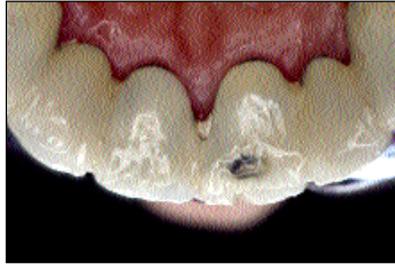
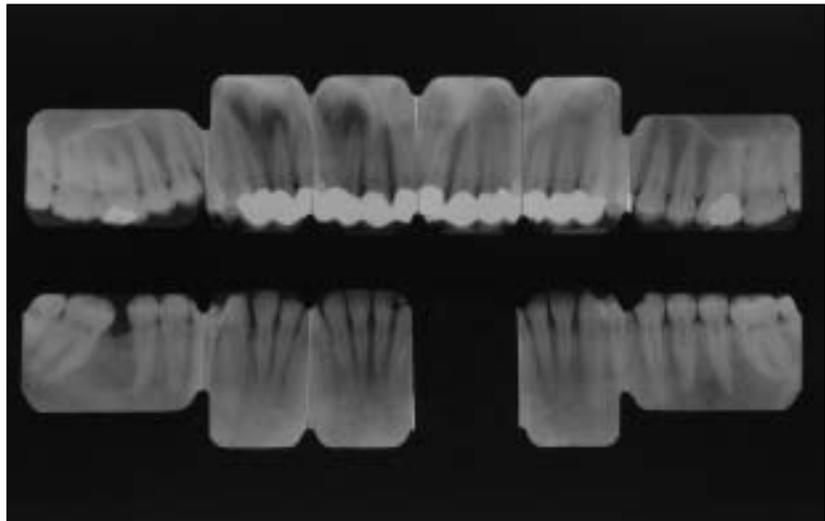


Fig 2 The porcelain on the lingual surfaces is chipped.



Fig 3 The previous restorations have been removed. The cervical margins of both lateral incisors are more apical than those of the other teeth, creating an obvious discrepancy of the gingival margin.

Fig 4 Periapical radiographs reveal a lesion of endodontic origin, as well as recurrent decay, on the right lateral incisor and canine. All the crown margins display discrepancies. Residual enamel is apparent on the right central incisor and both lateral incisors. The interdental crestal bone tissues approximate the cementoenamel junction (CEJ) in all of the interproximal spaces, suggesting an altered passive eruption.



was tried in and relined on the posterior teeth with autopolymerizing acrylic resin to ensure adequate stability during the planned periodontal surgery (Figs 11a to 11d). The template was fabricated in such a way that the cervical margin would compress the gingiva to minimize the discrepancy between the position of the template and the bone crest. This was done to overcome one of the major drawbacks the authors had previously experienced with the templates⁵: that is, because of the horizontal discrepancy between the soft and hard tissue, it was difficult to complete the bone reshaping according to the contour of the template.

Standard periapical radiographs using an XCP Rinn device (Dentsply Rinn, Elgin, IL) were also made (Fig 12); this facilitates identification of the position of the cervical margin on the buccal surface of the teeth in the proposed surgical site. With this information, the surgeon can ideally move the bone crest in an apical direction to achieve an adequate SGT. As a consequence, the residual gingival attachment position can be anticipated more consistently. Once the diagnosis was confirmed, the surgical procedure was planned and performed.

Diagnosis and First Provisional Restoration



5

Fig 5 The patient's smile reveals an uneven gingival architecture concurrent with unacceptable prosthodontic restorations. Mismatched shade and inadequate tooth contours are the dominant features of the smile. A certain degree of excessive gingival display is also evident. Considering the presence of an altered passive eruption and looking at the location of the gingival margin in the posterior sextants, it is possible to visualize the physiologic appearance of the anatomic crowns.



Fig 6 Following endodontic treatment and abutment reconstruction, an initial, under-reduced preparation of the teeth is performed to accommodate the provisional restorations. The quality of the soft tissue margin shows a marked improvement.



Fig 7 A set of provisional restorations is fabricated and delivered to improve the esthetics and create a more healthy environment for the soft tissue interface.



Fig 8 The location of the apex of the parabola at the future crown and soft tissue margin is marked with a red pencil. The most apical gingival margin is used as the landmark, and from that point, a proposed ideal contour of the other margins is outlined.

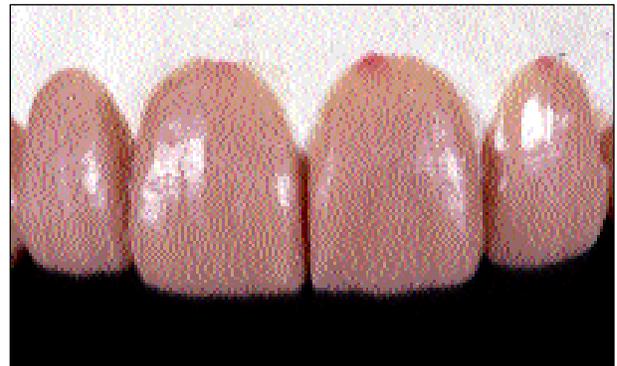
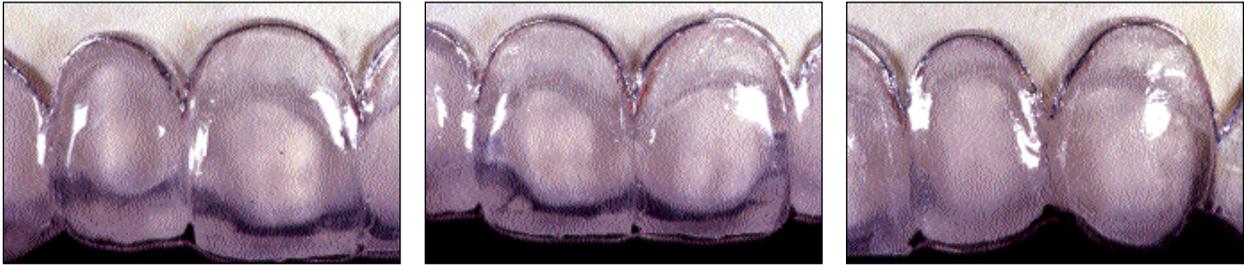


Fig 9 A diagnostic soft tissue contours cast is then developed based on the indicated new crown length. Because the gingival margin of the right lateral incisor is located more apically than that of the other incisors, a rather flat architecture may result at the end of treatment in this region.

Template Fabrication



Figs 10a to 10c Stainless steel wire is adapted to the cervical margin of the template. The wire is then bonded to the acrylic.



11a



11b



11c



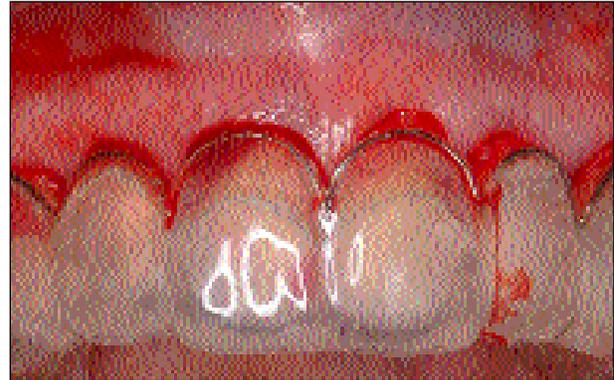
11d

Figs 11a to 11d The template is tried in to evaluate the fit and adaptation. The cervical margin of the template is positioned as close as possible to the gingiva to reduce the horizontal discrepancy between the template and the alveolar crest once the flap is reflected.

Fig 12 Standard periapical radiographs show the relationships between the template and the anatomic landmarks, including the interproximal osseous crest, the CEJ, the restoration margin, and the root length. Because of radiographic projection, only one tooth is evaluated in each radiograph.



Surgery



Figs 13a and 13b Surgical incisions are made according to the information provided from the template. In this case, the amount of keratinized gingiva allows a submarginal, beveled, full-thickness incision.



14a



14b



14c

Fig 14a The alveolar bone crest immediately after flap reflection and degranulation. The palatal flap has not been elevated, and the residual enamel confirms an altered passive eruption.

Fig 14b The osteotomy procedure is performed using the surgical template as a guide to create the desired scalloped architecture. Because of the very thin buccal bone plate, minimal osteoplasty is performed. The periodontal probe indicates the distance achieved between the highest convexity of the buccal soft tissue parabola and the CEJ, about 4.5 mm. This dimension could not be achieved without the use of a surgical template.

Fig 14c The anterior sextant after osseous surgery.

Surgical Procedure

The surgical site was infiltrated with local anesthetic supplemented with epinephrine 1:100,000 to ensure sufficient hemostasis. The tissue was thin and scalloped, and the defective restorations further altered the physiologic architecture. Particularly, the gingival margin of the maxillary right lateral incisor was more apical to that of the other anterior teeth. An adequate band of keratinized

gingiva was clinically present. With these factors in mind, the template was positioned, and a full-thickness submarginal beveled incision was made labially outlining the margin of the surgical template (Figs 13a and 13b). After the template was removed, [Au: ok to add this step?] the flap was fully reflected, and the secondary flap tissue was eliminated by surgical thinning. The surgical template was reinserted and the amount of osteotomy reevaluated.

Figs 15a to 15c The flap is sutured into position with 4-0 silk continuous vertical mattress sutures. The template is again positioned to verify flap adaptation.



15a



15b



15c

Because of the thin buccal bone, minimal osteoplasty was accomplished. Hand chisel instruments (Ochsenbein Nos. 1 and 2, Hu-Friedy, Chicago, IL) were used for the bone resection procedure. At each step of the resection, the template was repositioned and the amount of osteotomy rechecked until the desired crown extension was achieved (Figs 14a to 14c). The buccal flap was placed into proper position to achieve passive closure, and vertical mattress sutures, using 4-0 silk suture material, were made to insure soft tissue

adaptation. The surgical guide was once again used to verify that the flap position was consistent with the margin of the surgical template (Figs 15a to 15c).

The patient was instructed to refrain from brushing, and a 0.2% chlorhexidine mouthwash was prescribed for use twice a day until mechanical tooth cleaning was resumed. A nonsteroidal anti-inflammatory drug was administered immediately after surgery and then again every 12 hours for 48 hours.

Tissue Healing and Second Provisional Restorations



16a

Figs 16a and 16b Clinical view 6 weeks postsurgery. The tissue maturation is monitored using the template as a reference. Since the position of the flap in relationship to the bone crest was determined just after surgery, [Au: is this what you meant?] it is easy to evaluate the development of the SGT.



16b



Fig 17 Twelve weeks postsurgery, the tissue is still maturing. The teeth are more definitively prepared, 0.5 to 1.0 mm away from the gingival margin to protect the development of the SGT. The provisional restorations are again relined.



Fig 18 Occlusal view of the provisional restorations on the master cast. Six months postsurgery a new set of provisional restorations is delivered. A polyvinyl siloxane impression is made, and the provisional contours are modified to create an appropriate emergence profile to further guide the soft tissue maturation.

Healing

Sutures were removed after 7 days, and the healing was uneventful. Follow-up appointments occurred weekly until adequate patient hygiene was demonstrated. At each appointment, the template was reinserted to monitor the tissue posi-

tion and maturation as healing progressed (Figs 16a and 16b).

Twelve weeks after the surgical procedure, the teeth were prepared and the provisional restorations were relined. Care was taken to prepare the teeth 0.5 to 1.0 mm coronal to the soft tissue margins to avoid any violation of the SGT in order to



19a



19b

Figs 19a and 19b The provisional crowns are seated on the abutments. Shape, length (frontal view), and incisal edge position (lateral view) are greatly improved over the presurgical contours. The emergence profile was customized to allow physiologic tissue development.



20a



20b

Figs 20a to 20c Soft tissue maturation is evident prior to making the final impression. The interdental papilla between the central incisors is fully developed, while those at the lateral incisors have a lower profile. The lateral views also show the physiologic position of the prosthodontic margins within the gingival sulcus. The tissue is stable and adequately supported by the provisional restoration's emergence profile.



20c

facilitate tissue maturation (Fig 17). Three months after surgery, tissue maturation was again evaluated using the surgical template as a guide, and a polyvinyl siloxane impression was made for a second set of provisional restorations (Figs 18 and 19).

Nine months after surgery, findings at the recall appointment revealed that a physiologic SGT was

fully developed, and final prosthodontic therapy proceeded as planned (Figs 20a to 20c). Auro Galva Crown (Wielan, Pforzheim, Germany) restorations were fabricated and delivered shortly thereafter (Figs 21 to 24).

Tissue Healing and Second Provisional Restorations (continued)



Fig 21 Occlusal view of the prepared teeth prior to try-in of the definitive restorations. [Au: Please explain the gold coating on the teeth.]



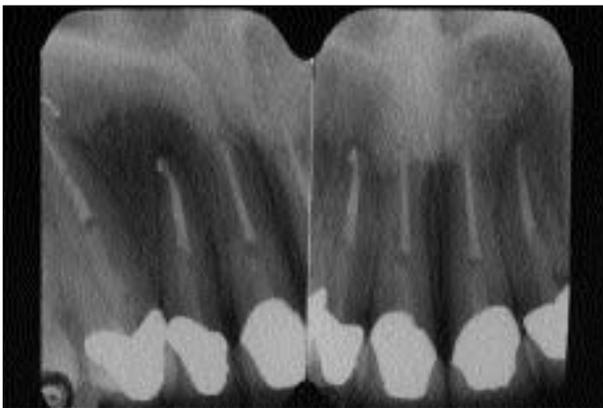
Fig 22 Crown shape and form of the definitive restorations closely resemble those of the second set of provisional restorations (see Fig 19a), with the parabolas of the central and lateral incisors lying almost on the same level. Nevertheless, the alignment of the free gingival margins and the resultant symmetry create an esthetically pleasing architecture.



23a



23b



24

Figs 23a and 23b The incisal length of the definitive crowns has been lengthened approximately 1 mm. The texture of the ceramic surface can be better evaluated with the use of black and white photography.

Fig 24 Radiographic evaluation 3 months postcementation. The marginal fit of the restorations to the teeth, the physiologic bone crest position, and the anatomy are acceptable. Healing of the periapical lesion is also remarkable.

DISCUSSION

Surgical crown-lengthening procedures are generally performed using the parameters first introduced by Gargiulo et al⁹ in 1961. These concepts, based on autopsies of 30 dry human skulls and additional histologic findings, defined average measurements for sulcus depth (0.69 mm), junctional epithelial attachment (0.97 mm), and connective tissue attachment from the CEJ to the alveolar bone crest (1.07 mm). The sum of the linear measurements for junctional epithelium and connective tissue (2.04 mm) was later termed by Cohen¹⁰ as *biologic width*.

Since its introduction, the biologic width has been widely discussed in dental journals and used by clinicians as a reference point in periodontal-restorative procedures. However, some comments about the earlier studies of Gargiulo et al⁹ can be made. The anatomic measurements used were the averages between 30 different human skulls and were not representative of all individuals, all teeth, or all sites around one specific tooth. Furthermore, the sulcus depth (0.69 mm) was obtained from cadavers, while clinical depths in living bodies range from 1 to 3 mm,¹¹ depending on prevailing inflammation, probing force used, and the location measured on a given tooth. With these observations in mind, it would seem that sulcus depth represents the greatest variance in the old concept of biologic width, whereas the least variance is that of the true biologic width (junctional epithelium and connective tissue attachment).

Some authors¹²⁻¹⁵ have challenged the measurements for the junctional epithelium and connective tissue attachment **[Au: is this what you meant?]**, proposing a more generous bone resection for prosthetic purposes. However, those studies provided no scientific-based evidence on how much bone tissue should be removed in the case of surgical crown lengthening. Recently, Kois¹⁶ and Smukler and Chaibi³ have introduced new concepts of biologic width, respectively called *dentogingival complex* and *supracrestal gingival tissue*, which are characterized by in-

terindividual and intraindividual variability and in which the sulcus depth is a predominant factor. According to these concepts, individual tooth and site measurements rather than average measurements should be used. This may partly explain why it is sometimes not possible to predictably achieve adequate crown extension using average measurements.^{6,17}

Several factors other than those related to the patient (such as SGT, tissue biotype, and plaque control) also can affect treatment outcomes. The selected surgical technique and its application may be also important for the end result.⁷ Careful osseous resection, in conjunction with positioning of the flap margin apical to the osseous crest (and not a more coronal positioning), leads to an initially greater crown extension. Carnevale and Pontoriero,⁷ using osseous surgery and repositioning of the flap apical to the bone crest, were able to achieve crown extension 4.1 mm buccally and 3.7 mm interproximally. However, after 12 months of healing, 2.9 mm buccal and 3.2 mm interproximal tissue regrowth was registered, leaving a final crown lengthening of 1.2 mm buccally and 0.5 mm interproximally.

On the other hand, Bragger et al⁶ applied the concept of osseous resective surgery in a different manner, positioning the flap over the osseous crest. The mean crown extension resulting at the end of that surgery (1.3 mm) remained stable at 6 months. This may be due to the fact that flap thickness over the crest was already accommodating a physiologic SGT and therefore very little tissue regrowth would be expected. However, it is noteworthy that at the completion of the healing phase, 22.5% of the cases reported had gingival margins located at or coronal to the preoperative soft tissue levels. Furthermore, 30% of the teeth exhibited increased gingival recession, while 33% showed growth in a coronal direction. All of these results indicate poor tissue stability and an uneven gingival margin. **[Au: words were missing here. is this what you meant?]** Therefore, tissue regrowth or maturation should be expected in relation to the surgical technique selected and biometric characteristics of the tissue.⁷

It is commonly accepted that a long period of time should pass before the restorative phase of treatment is completed following surgery. This allows the tissue to stabilize and a physiologic SGT to be reestablished via a development of a clinical sulcus. It is known that tissue regrowth occurs up to 12 months after surgery.^{7,18,19} The prosthetic preparation should not be placed subgingivally during tissue maturation, as this may violate the SGT. Three months after healing, the finishing line may be outlined, and then the residual regrowth will determine the most physiologic location of the tissue margin.

The template previously described by Scutellà et al⁵ was mainly indicated for cases in which provisional restorations could not be delivered because of severe tooth wear. In the present case, provisional restorations were delivered, but several considerations led the authors to use a diagnostic tool to plan the surgical procedure. The surgical goals of this case were to reestablish a physiologic SGT, increase the clinical crown length, correct the altered passive eruption, and improve the gingival tissue display. It may sometimes be difficult to address all of these issues through surgery alone. The restorative margins cannot be considered a landmark by which to conduct the osteotomy because they do not provide reliable information on where the final crown margins will be placed according to esthetic parameters. Therefore, rather than rely on the ability of the periodontist to foresee the shape and proportion of the definitive restorations, the authors believe that a surgical template, representing the final restorative goal, would increase the chances of predictable results.

This treatment aid can also be used to monitor tissue development during healing. If the presurgical SGT and the postsurgical position of the osseous crest are known, the degree of coronal displacement of the gingival margin can be determined more predictably at any given time.

For this case, the definitive restorations were delivered about 9 months after surgery. This time-

frame was guided by the information gathered from the template and by the fact that, for thin gingiva, about 90% of the regrowth had already taken place.⁷

CONCLUSIONS

A surgical template provides a simple and reliable method of relaying critical information necessary in complex treatment strategies. It provides the periodontal-restorative team with the ability to anticipate the treatment outcome and improves communication between the various care providers involved. The indications for its use in the clinical setting are broader than those previously presented⁵ and may be divided into both presurgical and postsurgical uses. Presurgically the template is indicated when provisional restorations cannot be delivered (as when extreme tooth wear is exhibited), for situations with short or resorbed roots, and when provisional restorations can be delivered (such as in esthetic areas and for cases of excessive display of gingival tissues, violation of SGT, altered passive eruption, and uneven gingival architecture.) Postsurgically the template can be used to determine the degree of tissue maturation and to more critically determine the timing of the delivery of the definitive restorations.

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