Flap Advancement: Practical Techniques to Attain Tension-Free Primary Closure

Gary Greenstein,* Benjamin Greenstein,† John Cavallaro,* Nicholas Elian,* and Dennis Tarnow*

Background: Primary and tension-free closure of a flap is often required after particular surgical procedures (e.g., guided bone regeneration). Other times, flap advancement may be desired for situations such as root coverage.

Methods: The literature was searched for articles that addressed techniques, limitations, and complications associated with flap advancement. These articles were used as background information. In addition, reference information regarding anatomy was cited as necessary to help describe surgical procedures.

Results: This article describes techniques to advance mucoperiosteal flaps, which facilitate healing. Methods are presented for a variety of treatment scenarios, ranging from minor to major coronal tissue advancement. Anatomic landmarks are identified that need to be considered during surgery. In addition, management of complications associated with flap advancement is discussed.

Conclusions: Tension-free primary closure is attainable. The technique is dependent on the extent that the flap needs to be advanced. J Periodontol 2009;80:4-15.

KEY WORDS
Alveolar ridge augmentation; oral surgical procedures.

Flap advancement is required as part of certain surgical procedures (e.g., ridge augmentation) to attain tension-free primary closure along the incision line. Flap advancement may also be an integral part of other surgical procedures, such as root coverage. When coapting flaps, coronal positioning of mucogingival tissues facilitates healing by primary intention, which is superior to healing by secondary intention.1 Primary closure results in decreased discomfort and faster healing and is critically important in attaining desired objectives (e.g., bone regeneration). Failure to attain tensionless closure may result in a soft tissue dehiscence along the incision line that can cause a poor outcome and/or postoperative complications. Numerous investigators2-6 have made contributions with regard to procedures and the understanding of biologic benefits derived from coronally advanced flaps. This article builds on that information and describes several techniques to achieve predictable tension-free primary closure of surgical wounds. In addition, the following subjects are discussed: histology of incised tissues, concerns about anatomic structures in specific sections of the mouth, basic surgical principles, and complications associated with these procedures.

HISTOLOGY OF INCISED TISSUES
The term “oral mucous membranes” refers to the lining of the oral cavity that communicates with the outside.7 Mucous
membranes consist of two layers: surface epithelium and an underlying lamina propria. Below the lamina propria is the submucosa that attaches the lamina propria to the underlying subjacent structures. During oral surgical procedures, epithelium and connective tissue are usually incised from the oral epithelium inward. In contrast, when releasing flaps to attain primary closure, the tissues are penetrated in reverse order. First, the periosteum is surgerized, followed by the submucosa and possibly part of the muscle layer. Incision into the epithelium is avoided.

When executing flap advancement, it is advantageous to think microscopically with respect to the tissues being incised. The first layer to be penetrated is the periosteum, which is like a cellophane covering that surrounds the bone. It is a thin wrap of dense connective tissue that consists of two layers. The inner cambium stratum contains progenitor cells and Sharpey’s fibers, which insert into the bone. The outer fibrous layer is innervated and contains blood vessels. The periosteum is several cells thick (up to 0.375 mm); it is bound down and is not very flexible because of the lack of elastic fibers.

The next tissue stratum to be entered is the submucosa, which consists of varying densities and thicknesses of connective tissue. Within the submucosa there are strands of densely grouped collagenous fibers and loose connective tissue containing adipose, small mixed glands, blood vessels, and nerves. In general, the submucosa is loosely textured and contains numerous elastic fibers. It is firmly attached to the buccinator muscle in the cheek area and the orbicularis oris adjacent to the lips. In the fornx, the mucosa is loosely attached to the underlying structures. When flaps are advanced, gingiva and lining mucosa (e.g., cheek and vestibule) are coronally positioned.

**REGIONAL ANATOMIC CONSIDERATIONS WHEN EXECUTING FLAP ADVANCEMENT**

**Posterior Maxilla**

Flap advancement in the posterior maxilla is a relatively safe procedure that can be accomplished with minimal complications. Branches of the infraorbital artery emerge from the infraorbital foramen and anastomose with subdivisions of the facial and buccal arteries. These blood vessels are located within the tissue of the cheek, which is 10- to 19-mm thick (mean thickness, 15 mm). The posterior superior alveolar artery is surrounded by a lot of tissue, and the transverse facial artery courses anteriorly between the parotid duct and the inferior border of the zygomatic arch and rests on the masseter muscle. It is improbable that these blood vessels, which are located within the tissues, would be damaged during properly executed flap-advancement procedures. The parotid duct (Stensen’s duct) traverses anteriorly over the masseter muscle and turns at a right angle at the second molar to pierce the buccinator into the mouth. The duct is distant to the flap release site and is unlikely to be injured during flap releases. In general, branches of the facial (motor nerves) and trigeminal nerve (sensory nerves) are located deep within the tissues and are not prone to being damaged when coronally positioning tissues. However, prior to flap advancement in the maxillary premolar region, it is prudent to palpate the inferior aspect of the infraorbital ridge and determine the location of the infraorbital notch. The infraorbital canal is ~5 mm inferior to the notch, and an imaginary straight line drawn vertically through the pupil helps to identify the usual location of the infraorbital canal. Flap release must remain distant to this structure to avoid injuring the infraorbital nerve and its terminal branches. If surgical procedures are close to the foramen, it is prudent to isolate the nerve prior to creating releasing incisions into the submucosa to avoid it. Accessory infraorbital foramina have been detected in 11.5% of patients. In general, it is advisable not to incise too deeply into the tissues, because it is unknown precisely where branches of the blood vessels and nerves reside.

Concerning the palatal aspect of the posterior maxilla, the anatomic structures that need to be respected during palatal surgery are the greater palatine foramen and the greater palatine artery. The artery emerges from the foramen and crosses the palate anteriorly. The foramen is found halfway between the osseous crest and the median raphe and is usually located palatally in the maxillary second- and third-molar region. Therefore, when extending a flap with partial-thickness dissections on the palatal aspect, it is advisable to operate mesial to the second molar. Furthermore, when doing procedures in this region, the height of the palatal vault should be evaluated to determine how large a flap can be elevated without encroaching on the palatal artery. It is prudent to leave 2 mm between the artery and the depth of the surgical incision. The following information has been reported with respect to the location of the artery in relation to the cemento-enamel junction: low vault (flat) = 7 mm; average palate = 12 mm; and high vault (U-shaped) = 17 mm.

**Anterior Maxilla**

In the anterior region of the mouth, the superior labial artery is located between the mucous membrane and the orbicularis muscle. It is not apt to be injured during flap-advancement procedures.

**Posterior Mandible**

The buccal artery is found on the outer wall of the buccinator muscle and is not usually in danger of being incised during routine flap advancement. Similarly,
other nerves (e.g., motor and sensory nerves) lie deep within the tissue and are not in jeopardy of being damaged. Conversely, the three branches of the mental nerve emerge from the mental foramen and must be managed carefully to avoid harming them during flap manipulations. If the flap needs to be advanced in the mental foraminal region, the location of the mental foramen needs to be identified radiographically.

Flap advancement adjacent to the mental foraminal area can be accomplished in several ways. Once a full-thickness mucoperiosteal flap is elevated past the mucogingival junction, wet gauze can be used to push back the flap (a periosteal elevator can be used to push the gauze) until the roof of the mental foramen is exposed. The use of gauze helps to avoid nerve damage. Flap elevation results in two muscles (depressor anguli oris and depressor labii inferiorus) being reflected. After the roof of the foramen is located, the periosteal elevator is used mesially and distally to the foramen to push the flap several millimeters apically past the inferior border of the mental foramen. The periosteal elevator is used to release the full-thickness flap apical to the mental nerve, thereby totally isolating it. At this juncture, the base of the flap can be released without injuring the nerve. It is also possible to execute a split-thickness flap in this region to isolate the mental nerve prior to advancing the flap. However, with this technique there is increased risk for injuring branches of the nerve within the soft tissue. Another method for advancing the flap in this region that is preferred by the authors is presented when incision designs are described.

With regard to flap release on the lingual side of the mandible, if buccal flap advancement is inadequate to attain primary closure over a graft site, then additional coverage can be obtained by releasing the lingual flap to the mylohyoid muscle. Wet gauze can be pushed with the periosteal elevator to accomplish blunt displacement of the tissue. If additional flap advancement is needed, the mylohyoid muscle can be dislodged from its origin on the mylohyoid ridge. Starting at the distal aspect of the flap, a finger can be inserted under the periosteum to push part of the mylohyoid muscle off the bone.

When operating on the lingual aspect of the mandible, the flap needs to be carefully retracted to avoid lingual nerve damage and transient pressure-traction injuries. The lingual nerve is usually found 2 mm horizontally away from the lingual plate of bone and 3 mm apical to the bony crest. However, its position varies: the nerve was reported to contact the cortical plate 22% of the time, and it was at or coronal to the crest of bone lingual to the mandibular third molar 15% to 20% of the time. Accordingly, it is prudent not to create vertical releasing incisions on the lingual aspect of the posterior mandible. Furthermore, to avoid injuring the lingual nerve distal to the second molar, it may be advantageous to release the flap in this region on the buccal side of the retromolar pad area.

**Anterior Mandible**

In the buccal region, nerves and blood vessels (e.g., inferior labial nerve and artery and mental nerve and artery) are within the tissues and are protected by the submucosa. However, on the lingual aspect, caution must be exercised when reflecting or releasing a flap, because the submental and sublingual arteries may enter accessory foramina through the lingual plate. Bleeding can be excessive if these vessels are damaged.

### MEDICATION ASSESSMENT PRIOR TO SURGERY

A thorough medical history should be taken prior to oral surgical procedures. Any medications that the patient is ingesting that can interfere with clotting should be reviewed (e.g., aspirin, antiplatelet medication, and warfarin). After consultation with the patient’s physician, if possible, aspirin and antiplatelet medication should be stopped 7 days before surgery, and other non-steroidal anti-inflammatory drugs (e.g., ibuprofen) ought to be discontinued 2 to 5 days before procedures. It is prudent to have a patient stop using these products prior to surgery to eliminate their effect on platelets, whose turnover time is 7 to 11 days. However, surgical procedures are often performed when patients are taking antiplatelet medication or aspirin on a daily basis. If there are concerns about a patient’s clotting ability, then an international normalized ratio should be obtained. Warfarin should also be stopped 3 days prior to surgery. In addition, several herbal drugs and vitamins may increase bleeding time: garlic, ginseng, gingko biloba, ginger, fish oils, and vitamin E. Patients should refrain from using herbal drugs before surgery. In general, prior to altering a patient’s medications, it is advisable to consult with their physician to determine that this can be done safely.

### BASIC SURGICAL PRINCIPLES

**(10 BASIC RULES)**

There are a number of important surgical tenets that apply to flap-advancement procedures.

1. Plan the flap design in advance of all procedures. In this regard, it is suggested that flaps be reflected at least one tooth beyond what is necessary to facilitate altering the surgical plan if required. Bear in mind that long incisions heal as rapidly as short ones.

2. Flap design simplicity should be a key goal, and unnecessary complexity should be avoided.
3. If possible, the base of the flap should be wider than its coronal aspect to maintain optimal vascularity.

4. When vertical releasing incisions are used, the incised tissue is actually a pedicle flap. This pedicle contains the flap’s vascular supply; therefore, when created, it should always include submucosa, which contains blood vessels. To ensure that the flap has adequate vascularity, its length-to-width ratio should not be >2.5:1.25 In addition, vertical releasing incisions, when used to mobilize a flap, can help to avoid inducing recession in adjacent healthy areas.

5. The time that tissues are exposed and desiccated affects the amount of postoperative edema. Therefore, procedures should be performed efficiently to reduce operative time.

6. Attain primary closure without tension on the incision line. In this regard, an advanced flap that has been properly prepared for closure should be able to lie passively 3 to 5 mm beyond the original incision line.

7. Keep the tissues moist at all times; after a long procedure, hydrate the flap and stretch it out.

8. Manage tissues gently; it results in less swelling and discomfort. Keep the periosteal elevator on the bone at all times; suctioning should be done on bone in a sweeping motion to avoid irritating the soft tissues.

9. Be mindful of vital structures at the site undergoing surgery and the adjacent tissues.

10. Snug sutures into place, but do not tie them tightly, because it can result in pressure necrosis. Use a combination of mattress and interrupted sutures to ensure optimal closure. Mattress sutures are used to resist muscle forces on the flap. Use a modified surgeon’s knot for the interrupted sutures (two throws clockwise, one counterclockwise, and one more clockwise knot). A surgeon’s knot does not ordinarily have the third throw.26

**AMOUNT OF Buccal Flap Advancement Required Is Based on Complexity of the Surgical Procedure**

**Minor Flap Advancement (several millimeters)**

Elevate a full-thickness flap (periosteum included) apically to the buccal vestibule and extend the release mesially and distally under the periosteum beyond the boundaries of the flap (Figs. 1A through 1C). This allows some advancement of the elevated tissues. However, it usually does not permit positioning the flap many millimeters over the lingual or palatal incision line. This technique works well in the buccal vestibule. A split-thickness dissection beyond the apical and lateral extent of the original full-thickness mucoperiosteal flap can be used as an alternative technique to advance a flap in areas where vital structures are not present (e.g., mental nerve) or when decortication is not required as part of a guided bone regeneration (GBR) procedure.

**Moderate Flap Advancement (3 to 6 mm)**

In conjunction with a horizontal incision across the edentulous area, create two vertical releasing incisions on the buccal aspect: one mesial and one distal to the field of surgery as part of the initial flap design (Figs. 2A and 2B). Elevate a full-thickness flap and extend it apically to the vestibule (Fig. 2C). In the premaxilla area, tissue elevation is usually extended to the anterior nasal spine (piniform rim) when doing a GBR procedure. The vertical releasing incisions will facilitate flap advancement. However, this still may not release the flap enough to achieve coronal positioning of several millimeters over the lingual or palatal incision line. To test the extent of the flap release, use a toothed tissue forceps and stretch the flap to determine whether it can be lengthened to attain tensionless closure. A simple test to ascertain if there is no tension on the advanced tissues is to extend it onto the palatal or lingual tissue and release it, if it remains in place then the flap is tension-free.

If vertical incisions do not facilitate optimal tissue advancement, hold the flap under tension with a tissue forceps (e.g., Adson tissue forceps), and score the periosteum with a new scalpel blade close to the base of the flap from the distal to mesial aspect, laterally across the whole flap (Fig. 2C). It is important to maintain direct vision of the surgical field when executing incisions to ensure their effectiveness. Use the scalpel blade to cut into the periosteum 1 mm deep (Fig. 2C). The bevel on a #15 blade is 1 mm wide, and the periosteum is <0.5 mm thick; therefore, the bevel of the blade can be used as a guide as to how far to insert the scalpel blade. When the flap is held under tension, release of the flap will be felt upon incising the periosteum. To attain further tissue advancement, insert a closed blunted scissor (e.g., Metzenbaum scissor) or a hemostat into the incision line (Fig. 2D). The instrument is held vertically, and it is opened ~5 mm, thereby stretching apart the two sides of the incision line. Once again, the tissue forceps are used to advance the flap to determine whether it can be positioned past the incision line (Fig. 2E). Scoring the periosteum can be repeated 3 to 5 mm away from the initial periosteal fenestration (this can be done several times) to achieve additional flap movement. The scissor or hemostat can be used along each incision line. Because this surgical manipulation can result in additional bleeding, it is advantageous to accomplish flap advancement prior to placement of graft materials and barriers.

**Major Flap Advancement Required (≥7 mm)**

If buccal vertical releasing incisions and periosteal fenestrations do not provide enough flap advancement to achieve tensionless primary closure, it is necessary to cut deeper into the submucosa. In this regard, clinicians should also be aware that once the muscle layer...
**Figure 1.**  
A) Minor flap advancement. Initial photograph of teeth #20 and #21. Periosteum has been elevated mesially and distally beyond the width of the sulcular incision. B) Envelope flap advanced several millimeters. C) Healing after 8 weeks. Roots are covered, and there is a band of attached keratinized gingiva adjacent to the teeth.

**Figure 2.**  
A) Moderate flap advancement. Initial photograph of teeth #6 through #11. B) Full-thickness buccal mucoperiosteal flap with vertical releasing incisions elevated teeth #6 through #11. C) Periosteal fenestration executed several millimeters coronal to the base of the flap. D) Hemostat used to stretch apart the incision line. E) Tissue forceps used to hold the flap and advance it palatally. F) Collagen barrier placed over the bone graft. G) Primary tension-free closure of the flap. H) Healing after 12 weeks.
is incised, the patient experiences increased morbidity with regard to swelling, hemorrhage, and discomfort. Therefore, this is done only when necessary. Furthermore, if the decision to cut deeper into the submucosa because of the extent of the required tissue advancement was made prior to initiating the procedure, then the 1-mm-deep periosteal fenestrations are replaced by the following technique.

Figure 3 illustrates major flap advancement as part of a GBR procedure. After the initial incisions and a full-thickness mucoperiosteal flap is elevated, the following steps are used to attain ≥7 mm of flap advancement. Hold the flap in tension with toothed tissue forceps or college pliers. Then, on the distal aspect of the flap, several millimeters coronal to its base, insert a new scalpel blade 3 to 5 mm into the tissue.
penetrating the periosteum into the muscle layer. A releasing incision is made in a single sweeping motion, cutting distal to mesial across the whole flap. The blade (use a new blade) is inserted, and the tissues are incised with a motion that parallels the bone, thereby avoiding perforating the flap on the buccal aspect, i.e., the incision is not made perpendicular to the flap, it is oblique to the outer surface of the flap. Determine if adequate tissue advancement has been achieved. If it has not achieved the desired objective, then additional flap release must be provided using either of the following methods. Stretch the incision apart with a scissor or hemostat. If that does not supply desired flap advancement, then incise deeper into the muscle tissue in the first incision line or create another incision 3 to 5 mm coronal to the first one. When doing a large GBR augmentation, the second incision is often required to attain primary closure. If extensive flap release is necessary (incising more deeply into the muscle layer), place your finger on the epithelial surface of the skin so that you can feel if the scalpel blade is approaching the skin surface. In addition, further extension of vertical releasing incisions can help to attain additional flap advancement. However, the authors prefer not to create “cut back incisions” because it is desired to keep the base of the pedicle flap as wide as possible to maintain an optimal blood supply.

Some clinicians use incisions at the end of the vertical releasing incisions to enhance flap advancement. Sclar recommended cut back incisions at the base of the vertical incisions, thereby creating 45° to 60° horizontal incisions toward the center of the flap (Fig. 4). In addition, curvilinear releasing incisions were used. He made the following recommendations: start the vertical releasing incision in the muco-buccal fold one tooth width away from the surgical site; a split-thickness dissection should be executed; and when the mucogingival junction is reached, a full-thickness flap is elevated, and the incision courses over to the surgical site.

In contrast, Fugazzotto placed horizontal incisions, 3 to 4 mm in length, at the apical extent of the vertical releasing incision (in the buccal vestibule), which were directed away from the vertical incisions. Cranin created a split-thickness flap past the muco-gingival line as they proceeded apically to release the flap. He avoided incising the periosteum, which does not have a lot of give, and attempted to take advantage of the submucosa, which has many elastic fibers that facilitate flap advancement. However, it may be advantageous not to create a split-thickness flap in areas where decortication of bone will be performed because it will dictate that the connective tissue be perforated multiple times.

SUPPLEMENTAL TECHNIQUES FOR FLAP ADVANCEMENT

A practical technique to advance a flap in the posterior mandible that avoids dissecting apical to the mental foramen or developing a split-thickness flap is illustrated in Figure 5. First, a full-thickness mucoperiosteal flap is elevated exposing the roof of the mental foramen. Then, starting on the distal internal aspect of the flap, periosteal fenestration and incision into the submucosa are initiated as described above. However, in the region of the mental foramen, a dome-shaped...
incision is created around the foramen (Fig. 6). Approximately 3 mm distal to where the nerve emerges, the incision is curved coronally to within 3 mm of the flap margin. The incision at this coronal level is extended mesially 3 mm beyond the mental foramen, before it is carried apically to the level of the initial incision. As a rule of thumb, if the measurement from the base of the flap to within 3 mm of the coronal margin is called distance A (e.g., 6 mm), then the width of the dome-like incisions initiated on each side of the foramen is 1/2 A (e.g., 3 mm) (Fig. 6). It is recognized that the exact position of the branches of the mental nerve are unknown; therefore, the incisions coronal and mesial to the mental foramen should not be made very deep into the tissue.

Figure 6.
In the area of the mental foramen, a dome-shaped incision is made around the foramen. If the distance from the base of the flap to within 3 mm of the coronal margin is 6 mm (A), then the dome-like incisions made on each side of the foramen is 1/2 A (e.g., 3 mm).

Figure 7 demonstrates a technique for expanding the volume of palatal tissues to provide primary coverage after a GBR procedure in the posterior maxilla. Palatal manipulation of tissues can be done independently or as a supplement to buccal flap repositioning. For large ridge augmentations, palatal expansion of tissue reduces the need to greatly advance the buccal flap to attain primary closure. Thus, it may avoid decreasing the buccal vestibule when the buccal flap is advanced and circumvents the need for a secondary procedure (e.g., free gingival or a connective tissue graft) to reconstruct the vestibule.

This type of flap was described and diagrammed by Fugazzotto28 (Fig. 8). The palatal-advancement procedure involves splitting the palatal tissues (bucco-palatal width in the edentulous area) and rotating out a pedicle graft. Therefore, caution must be exercised not to proceed too far apically on the palate, because the greater palatine artery can be damaged. Furthermore, it is prudent to use the following procedure mesial to the second molar, because inadvertent severing of the artery close to the foramen could result in its retraction into the foramen, making it impossible to ligate or directly compress it.

First, an incision is made mid-crestally on the edentulous ridge, and the buccal flap is elevated as described previously (Fig. 8A). Then the tissue covering the ridge is elevated, and a full-thickness flap is extended toward the median raphe. The amount of extension is dictated by the size of the vault, which reflects the position of the artery. Then, on the internal aspect of the flap, close to its base, coronally directed vertical incisions are made (mesial and distal of the desired length of the pedicle flap that extend halfway through the flap (bucco-palatally) (Fig. 8). The apical extension of the two incisions is connected by a horizontal incision, which also extends halfway though the flap (Fig. 8B). Next, starting at the horizontal incision, the scalpel blade is brought incisally, splitting the flap, leaving the coronal 2 mm of palatal gingiva intact (Fig. 8C). The dissected tissue (inner flap) is rotated to the buccal aspect, thereby providing a large segment of tissue to cover the surgical site (Fig. 8D). This procedure should only be performed when the palatal tissue is thick (≥4 mm).

SUTURING
Prior to suturing, the midline of an elevated flap should be positioned to ensure the tissue is being properly placed. For instance, in the premaxilla, the midline of the flap should line up with the nasopalatine papilla. Initially, it is advantageous to place a stitch (interrupted or a horizontal mattress suture) at the midpoint of the flap to maintain its orientation. Then the vertical releasing incisions, at their junction with the horizontal incision, are brought together with an interrupted
stitch. Next, the horizontal incision is closed with a few interrupted or mattress sutures. Mattress sutures can be used to provide resistance to muscle pull (e.g., orbicularis oris, mentalis, or buccinator). Subsequently, interrupted stitches are used to attain primary closure along the horizontal suture line. Finally, the remainder of the vertical releasing incisions are closed with interrupted stitches. The authors prefer to use polyglactin 910 sutures‡ because they maintain 40% of their tensile strength at 21 days. Expanded polytetrafluoroethylene sutures§ also can provide prolonged tensile strength. After suturing, apply pressure for 10 minutes (bleeding time is between 2 and 9 minutes) to obtain a fibrin clot; this prevents pooling of blood under the flap.

**POSTOPERATIVE MEDICATIONS**

After large augmentation procedures, the patient usually is prescribed an antibiotic (e.g., amoxicillin, 500 mg, three times a day for 1 week), a mouthrinse (e.g., 0.12% chlorhexidine gluconate), and an analgesic. If there is a high degree of concern that a patient may swell excessively, consideration is given to providing a dose pack of methylprednisolone (4-mg tablets, #21). The patient takes six tablets on the day before surgery and subsequently takes one less pill each day for the following 5 days. The major disadvantage of prescribing a steroid is that it may mask an infection. Furthermore, the use of this drug is not recommended if the patient has a fungal infection. Other medical conditions in which steroids may be contraindicated include heart disease, liver disease, kidney disease, human immunodeficiency virus infection, high blood pressure, peptic ulcer, osteoporosis, myasthenia gravis, herpes eye infection, low levels of thyroid hormone (hypothyroidism), diabetes, tuberculosis, mental/mood disorders, seizures, recent infection, allergies, pregnancy, and breastfeeding.31

**HEALING TIME**

The time for wound repair subsequent to surgery is tissue-specific: epithelium, after a 12-hour lag time: 0.5 to 1 mm daily;32 connective tissue: 0.5 mm daily,33 and bone: 50 μm daily (1.5 mm per month).34 After suturing, a mucoperiosteal flap adheres to bone (or soft tissue flap) by a fibrin clot (0 to 24 hours).

‡ Vicryl sutures, Biosense Webster, Diamond Bar, CA.
§ Gore-Tex sutures, W.L. Gore & Associates, Flagstaff, AZ.
After 1 week, the clot is replaced by granulation tissue. In 2 weeks, the flap is attached to bone via immature collagen fibers. However, healing may be delayed because the barrier can interfere with vascularization of the flap. If a particulate graft was placed, 4 to 6 months is needed for graft calcification before an implant should be placed, and following a cortical block graft, 4 to 5 months is needed for healing.

It is possible that biologics, such as platelet-rich plasma, may enhance results with regard to the rapidity of soft tissue healing. However, it was decided to limit this technique article to discussions about soft tissue management and not to address agents that may affect results.

COMPLICATIONS

**Undersizing Flap Advancement**

When doing a procedure such as a ridge augmentation, a common error is to underprepare the flap, which results in failure to achieve tensionless closure. If the tissue is not adequately released, primary closure will not be attained or too much tension will need to be placed on the sutures in an attempt to close the wound. This can result in suture necrosis and a dehiscence along the suture line. To avoid this dilemma, it is advantageous to prepare the flap for advancement prior to placing bone grafts and barriers. The size of the projected augmentation in width and height determines how far the tissue needs to be advanced. In general, the buccal flap should be able to be displaced 3 to 5 mm over the palatal/lingual tissue before even starting a large GBR procedure. To accommodate the augmentation, additional flap advancement may be required, and the final releasing of the tissue should be done if needed after the bone and barriers are in place.

Shrinkage of the augmented ridge after a GBR procedure is commonplace. Clinicians should expect non-uniform shrinkage in height and width, ranging from 39.1% to 76.3%. Therefore, the augmentation must be initially overbuilt. Furthermore, the height of the augmentation should be dictated by the desired height of the interproximal tissue at the future restored site and not by the anticipated mid-buccal contour.

**Ecchymosis and Edema**

Swelling can begin minutes to hours after surgery and continue for 48 to 72 hours before it peaks. Edema may not extend equally in all directions from the injured site. A possible reason for this is that muscle attachments, fascia, and structures, such as bone, guide swelling. The above tissue alterations can cause discomfort and reduced function. After surgery, patients should apply ice for 10 minutes on and 10 minutes off until retiring that evening. Ecchymosis may appear adjacent to the surgery, or it may be found at the inferior aspect of the jaw or even on the chest. Ecchymoses do not affect the results and do not require therapy. They may be disconcerting to the patient, and reassurance may be needed. In general, avoidance of penetrating too far into the submucosa when making incisions to facilitate flap advancement helps to reduce the amount of postoperative swelling and bleeding.

**Bleeding**

A good medical history helps to avoid untoward bleeding due to drug-related coagulopathy. Intraoperative hemostasis is usually not a problem if tissues are managed gently. Exuberant bleeding can usually be controlled with pressure, epinephrine in the anesthetic, and sutures. After surgery, too much activity should be avoided. Postoperative bleeding along the suture line may be due to the epinephrine in the anesthetic wearing off. Pressure for 5 minutes usually results in clotting (bleeding time is 2 to 9 minutes). Failure to achieve hemostasis dictates that the flap be reopened. The soft and hard tissues need to be inspected for bleeding points. Bleeding vessels within the flap need to be ligated, and bleeding from nutrient vessels within the bone should be obtunded. The incision needs to be resutured, and coaptation of the flaps should be checked by gently rubbing a periodontal probe across the suture line. If a hematoma develops during the first 24 hours after therapy and causes discomfort or distorts the flap, it should be evacuated and the wound resutured.

When doing a split-thickness palatal flap, the clinician must be prepared to manage accidental damage to the greater palatine artery. If the artery is injured, apply pressure to control hemorrhaging, then take a curved hemostat(s) and clamp the palatal flap adjacent to where the split of the palatal tissue was made. If the bleeding vessel is visible, ligate it or apply electric cautery. Additional deep sutures may be needed if the bleeding vessel is not visible.

**Infections**

After the first 72 hours, erythema, edema, tenderness, and exudation are indicative of infection. If there is suppuration, a culture should be taken and an antibiotic prescribed. The presence of fluctuance dictates that the area should be incised and a drain placed for several days.

**Dehiscence**

The main cause of wound dehiscences is failure to provide tensionless closure. Other reasons for a dehiscence are infection, trauma from opposing den- tition, irritation from a removable prosthesis, and hematoma development. If a patient brushes on the sutures prematurely it can result in a dehiscence. If
a dehiscence develops, the chance of a successful augmentation is reduced. Do not attempt to resuture a dehiscence. Let it heal by secondary intention and monitor the patient.

**Necrosis**
If the blood supply to the flap is compromised, it can result in ischemia and, subsequently, tissue necrosis. If this occurs, it may be due to sutures that were too tight, paracrestal incisions, or poor flap design resulting in thin tissue margins, thereby excluding an adequate blood supply. Increased wound tension could also induce necrosis of the flap margins, resulting in a soft tissue dehiscence.

**Loss of the Vestibule**
Flap advancement to cover a large bone regeneration procedure may result in partial or total loss of the vestibule adjacent to the surgical site. Coronal positioning of the tissue often distorts the topography of the vestibule and alters the mucogingival line with the adjacent tissues (Fig. 3H). In extreme cases, the patient may also feel that the lip is tethered (tied down). After the augmentation has healed, the vestibule needs to be reconstituted. This can be accomplished in different ways: a split-thickness flap with tacking of the flap at the level of the vestibule; a subepithelial connective tissue graft or a free gingival graft may or may not be placed over the connective tissue bed created by the split-thickness flap; or laser therapy. It is appropriate to inform patients in advance that multiple revisions may be part of the treatment.

**CONCLUSIONS**
One of the important factors in achieving successful GBR is providing tensionless primary closure over surgical sites. The extent of the bone augmentation is the critical determinant dictating the distance that tissues need to be coronally positioned. This article reviewed several techniques that can achieve this objective. The simplest technique that can provide tensionless primary closure should be selected, because it will be associated with the least amount of morbidity. Inability to attain closure with a simpler method does not preclude using more advanced outlined methods. However, careful consideration needs to be given to the merits of each technique prior to initiating incisions to avoid creating unnecessary wounds. Clinicians need to make a judgment call as to which technique they believe will provide the optimal result. This decision should take into account the size of the augmentation, elasticity of the patient’s tissue, oral musculature, size of the vestibule, operator experience and preference, and the patient’s willingness to undergo these procedures as opposed to a prosthetic solution with pink porcelain.

**ACKNOWLEDGMENT**
The authors report no conflicts of interest related to this study.

**REFERENCES**


Correspondence: Dr. Gary Greenstein, 900 W. Main St., Freehold, NJ 07728. Fax: 732/780-7798; e-mail: ggperio@aol.com.

Submitted June 24, 2008; accepted for publication August 3, 2008.