PRESERVING THE SOCKET DIMENSIONS WITH BONE GRAFTING IN SINGLE SITES: AN ESTHETIC SURGICAL APPROACH WHEN PLANNING DELAYED IMPLANT PLACEMENT

Tassos Irinakis, DDS, MSc; Moe Tabesh, DDS

Recent advancements in barrier membranes, bone grafting substitutes, and surgical techniques have led to a predictable arsenal of treatment methods for clinicians who practice implant dentistry. The contemporary clinician is supplied with proven knowledge, substantiated materials, and instrument inventory that allows implant placement in cases that used to be reserved for the specialist in the past because of their complexity. Nowadays, postextraction alveolar ridge maintenance can be a predictable procedure and can certainly aid the clinician in preventing ridge collapse, thereby allowing for implant placement in a position that satisfies esthetics and function. Extraction socket maintenance for future implant therapy does not rule out immediate implant placement but rather provides an additional option when treatment planning implant patients. This article will focus on the concept of extraction socket preservation using regenerative materials. It will describe a technique suggested by the authors to resist bone resorption and soft tissue shrinkage following tooth extraction.

Key Words: socket, extraction, socket preservation, ridge preservation, bone grafting, Implants

INTRODUCTION

Different etiologies may be associated with tooth loss. Such examples are endodontic pathology (root fractures, root perforations); periodontal pathology (combined endodontic-periodontic lesions, periodontal disease); advanced caries lesions; and facial injuries. Alveolar bone loss can also occur as a result of iatrogenic trauma from aggressive maneuvering while extracting teeth or as a result of natural postextraction socket healing. Whatever the reason for tooth extraction, postextraction socket healing commonly results in deformities of the alveolar ridge.[1] In most cases, the extractions are performed without a thought as to what may happen to the underlying ridge. Therefore, the practitioner may just wait to see where the healing patterns lead prior to deciding on the choice of restoration, underestimating the likelihood that the residual ridge might heal in an unesthetic fashion. The severity of this problem becomes even more apparent if one considers that, in the United States alone, more than 20 million teeth are extracted on an annual basis by dental practitioners.[2]

Because the healing patterns of human sockets are unpredictable (with likely detrimental effects to the

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local alveolar architecture), then such common procedures as extractions may lead to intraoral situations in which the remaining healed ridge does not allow for an esthetic and functional solution without the aid of significant bone grafting. A satisfying end result for the patient may not even be attainable. However, it is possible to prevent such problems by simply performing ridge preservation procedures in extraction sockets that employ replacement grafting materials with or without barrier membranes.[3] The authors carefully studied the literature on this topic and will describe a flapless approach to assist clinicians in treating their patients, with an emphasis on maintaining esthetics.

Histology of the Postextraction Alveolus

There are 5 different stages in osseous socket healing:

- Stage 1: The initial clot forms almost immediately as a ''coagulum'' of red and white blood cells.
- Stage 2: Granulation tissue replaces the clot over a 4- to 5-day period. Angiogenesis begins through cords of endothelial cells and capillary formation.
- Stage 3: Connective tissue (collagen fibers, spindle-shaped fibroblasts) gradually replaces granulation tissue over a period of 14 to 16 days.
- Stage 4: Calcification of osteoid is apparent, commencing at the base and periphery of the socket by 7 to 10 days. Bone trabeculae almost completely fill the socket by 6 weeks. Maximum osteoblastic activity, seen as a proliferation of cellular and connective tissue elements with osteoblasts laying down osteoid around immature islands of bone, occurs between 4 and 6 weeks after extraction. After 8 weeks, the osteogenic process appears to slow down.
- Stage 5: Complete epithelial closure of the socket is achieved after 4 to 5 weeks. Substantial bone fill occurs between 5 and 10 weeks. By 16 weeks, bone fill is complete, with little evidence of osteogenic activity at this time.[4–7] Although bone fill in the socket will continue for several months, it does not reach the bone level of the neighboring teeth.[8]

Alveolar Ridge Resorption

Various classic studies in the 1960s showed that the resorption process of the postextraction alveolus in both jaws was significantly more pronounced on the buccal aspect. This comes as no surprise, as the buccal surface of the anterior alveolar ridge is commonly thin and fragile. The maxilla tends to exhibit greater reductions in width than in height. The loss of tissue contour takes place mostly during the first 1 to 3 months following tooth extraction.[9–11] Most of the statements in these original studies have been supported by the results of newer studies.[8,12]

In a recent prospective study,[8] single postextraction alveoli were followed up with subtraction radiography on a monthly basis for 1 calendar year. No regenerative materials were used. The sockets were allowed to heal naturally. At the end of the study it was found that the remaining socket/ridge was reduced to 50% of its original width. More than 65% of this reduction occurred within 3 months. A comparison of nonmolar sockets that healed naturally with nonmolar sockets covered with a resorbable membrane (primary closure was not necessarily attained) found that by 6 months, the first group had an average reduction in alveolar width of 4.56 mm, compared to a reduction of 1.50 mm in the membrane group.[13] A procedure that uses membranes alone to cover sockets can prove to be technique sensitive for the inexperienced surgeon. The use of a bone graft in the socket would provide support to the barrier membrane, preventing its collapse and possible compromised regenerative result of the surgery. Wanting to investigate further the combined use of grafts and membranes, Iasella et al[14] studied the socket healing of nonmolars with and without regenerative materials. The first group of sockets was allowed to heal naturally, while the test group used freeze-dried bone allograft and a resorbable membrane. The first group showed a reduction in ridge width of 2.7 mm, versus 1.2 mm in the grafted group. Similarly unfavorable results for sockets that healed naturally have been shown when examining the loss of vertical postextraction alveolar height.[13,14]

Overview of Grafting Materials

Choosing the appropriate grafting materials and membranes requires knowledge of the properties of the available regenerative inventory in the current market. The ability to recognize the advantages and disadvantages of these products will aid clinicians in the decision of which materials to use. The purpose of this study is not to investigate these properties in detail; therefore, only a brief overview is offered.

Bone grafts in general are divided into 4 major categories.

1. Autogenous bone grafts: Grafts harvested from one site to another site within the same individual,

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2. Allografts: Bone grafts that are transferred between members of the same species, for example, from one human (cadaver donor) to another (patient recipient),
3. Xenografts: Bone grafts where the donor is a different species from the recipient, for example, grafts of bovine origin, which are commonly used in dental patients (humans),
4. Alloplasts: Grafting materials of synthetic origin.

Although in almost any case, the gold standard is the autogenous graft, in socket preservation it may be considered excessive or aggressive to harvest autogenous bone for such contained defects. Studies have clearly proven the reliability and functionality of using either allografts or xenografts (in socket healing and implant placement), which avoids the creation of an additional surgical site for bone harvesting.[14–18]

Membranes can be divided into 2 major categories based on their ability to become absorbed: resorbable versus nonresorbable. For the novice surgeon, we strongly recommend the use of resorbable membranes, which are more forgiving if they become exposed during healing and lead to a significantly smaller number of complications.

ESTHETIC APPROACH

When treatment planning for the extraction of one single-rooted tooth and subsequent implant placement, many pieces of information are needed to decide on the route of action. First, certain clinical parameters/criteria must be investigated to determine whether the case is acceptable for implant therapy.

These criteria include but are not limited to:

- mesiodistal space available for implant placement,
- buccolingual space available for implant placement,
- interarch space available (for potential implant-supported crown),
- smile line (high, equigingival, or low),
- gingival biotype (thick, average, or thin),
- whether the case is a distal-extension situation, or whether teeth are present mesial and distal to the site of treatment,
- opposing dentition (natural teeth or a denture),
- occlusion,
- presence of parafunctional habits, and
- general medical and local surgical concerns.

If it is decided that implant placement will be delayed[19] (not performed at the time of extraction or within 6 weeks of extraction), then it is prudent to take steps to maintain the alveolar bone dimensions to whatever extent possible. Socket preservation for a nonmolar tooth can become quite demanding and technique sensitive, unless a thorough surgical protocol is in place for the clinician to follow. Knowledge of the materials and their properties is necessary, along with the appropriate scientific background for their usage. As with any procedure, some techniques are easier than others, and some are more warranted than others.

Classic technique

There are three main steps in the procedure of socket preservation on a single-rooted tooth: (1) extraction of the tooth, (2) placement of grafting materials, and (3) primary tissue closure.

Traditionally, when it is known that a bone grafting procedure will take place following an extraction, the surgeon may elect to raise a mucoperiosteal (full-thickness) flap, which will simplify removal of the tooth in question. The flap design will include 1 or 2 vertical releasing incisions at the line angles of the adjacent teeth. A particulate bone graft is routinely placed to fill the empty socket. A membrane then covers the socket and the bone graft (Figure 1), and the flap is advanced coronally to achieve primary closure (Figure 2).

The potential problems associated with this flap design are:

- loss of interdental papilla height once the papillary attachment has been severed,
- recession at the adjacent teeth,
- difficulty in adequate coronal displacement of the flap and subsequent inability to achieve primary closure,
- scar tissue formation along the vertical incisions, which could become visible in patients with a high smile line, and
- coronal displacement of the keratinized tissue, which reduces the amount of keratinized attached tissue on the facial aspect of the alveolus.

Flapless esthetic technique

This technique in its original design was first described by Landsberg and Bichacho[20] when they developed their ''socket seal surgery'' technique. Their technique was later improved by modifying the soft tissue component of the surgery.[21] The surgery described in this article is a slight modification of the original technique, which aims to improve it, primarily by the addition of a barrier membrane.

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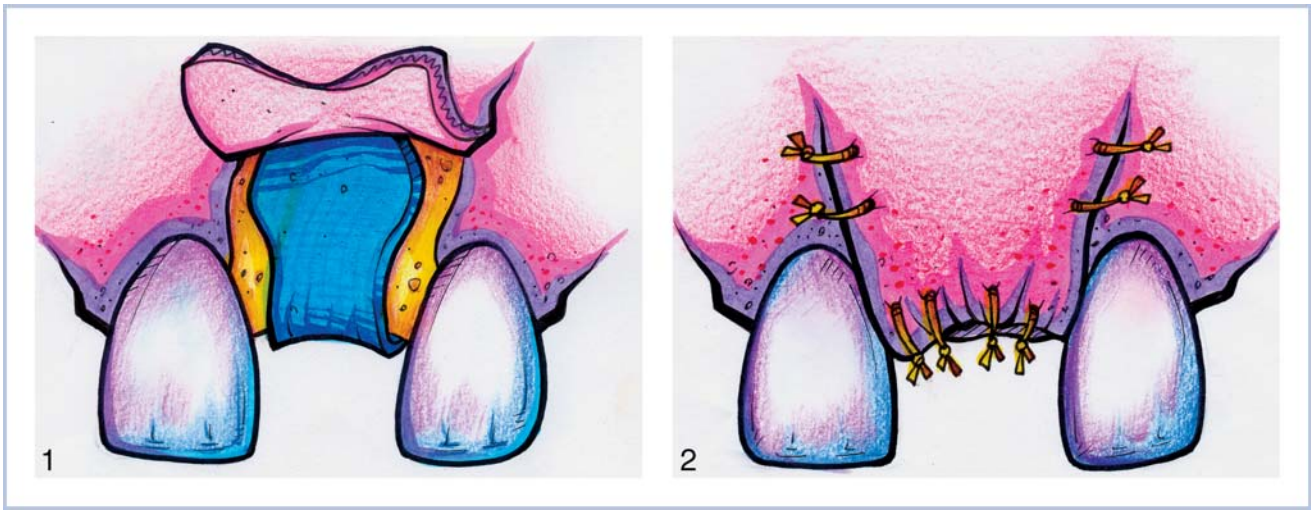

FIGURES 1 AND 2. FIGURE 1. Diagram of a typically viewed flap design with 2 vertical incisions on the line angles of the adjacent teeth. A collagen membrane can be seen covering the socket. FIGURE 2. Diagram showing how the full-thickness flap has been coronally advanced and secured into place with multiple sutures.

Step 1: Extraction of the Tooth

After adequate local anesthesia is administered, the surgeon places a 15C blade along the circumference of the tooth for an intrasulcular incision. The blade tip severs the supracrestal fibers down to the osseous crest. The papillae remain entirely intact and are still attached to the cementum of the adjacent teeth. The next main instrument is the periotome (Figure 3). Periotomes come in various designs. They are used by wedging the instrument into the periodontal ligament space and severing the subcrestal and partially the subcrestal fibers. At the same time, they luxate the tooth and allow for its atraumatic removal from the socket (Figure 4). Removal of all debris from the socket is performed with a surgical spoon or curette.

Step 2: Placement of Grafting Materials

At this stage, the surgeon may proceed with transfer of the particulate graft (Figure 5). The placement of grafting material into a well-contained socket (ie, with all 4 walls intact: buccal, lingual, mesial, distal) is quite simple. The occlusal aspect of the grafted socket is then covered with a resorbable membrane. The membrane is tucked under the facial and lingual aspects of the socket soft tissue walls, which have been undermined with the periotomes or an Orban periodontal knife.

Step 3: Primary Tissue Closure

Because no vertical incisions have been made and the papillae have not been severed, it would be unfortunate to proceed with such a concession (ie, creating incisions at this stage of the procedure for coronal displacement of the buccal soft tissue). Primary tissue closure can be achieved without compromising the blood supply of the surgical area by placing an autogenous free soft tissue socket seal. Basically, the grafted site can be covered with a small free autogenous gingival graft (FGG). The surgeon must first carefully measure the dimensions of the occlusal opening by means of a periodontal probe, or more accurately with a sterile aluminum foil template. Then the surgeon can take this template to the palatal premolar (preferably) or the first molar area and harvest an FGG (Figure 6). Caution must be exercised to ensure that the outline of the FGG is slightly larger than the aluminum foil template, since it is known that once an FGG is harvested from the palate, it shrinks to varying degrees, depending on its thickness.[22,23] This FGG socket seal is then sutured and secured in place over the grafted socket (Figure 7). The patient is then put on anti-inflammatories, analgesics, a chlorhexidine rinse, and antibiotics. The waiting period prior to implant placement is typically 4 to 6 months or more, depending on the grafting material used.

CLINICAL EXAMPLE

This is a clinical example of this modified esthetic approach advocated by the authors.

A 33-year-old man was referred to his dental practitioner for a crown-lengthening procedure on the maxillary right first premolar. After the radiograph

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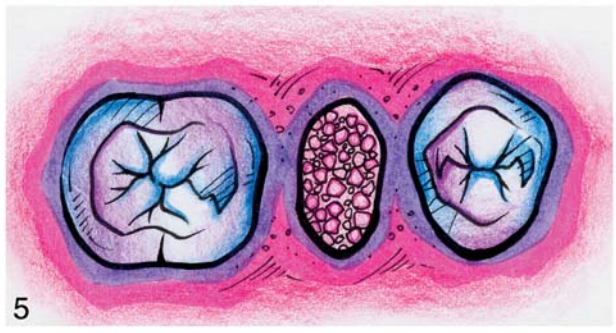

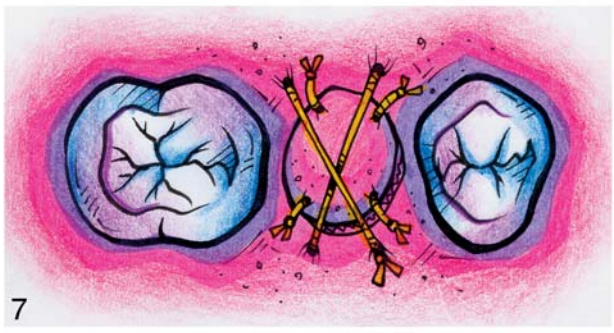

FIGURES 3–7. FIGURE 3. Photo of angled and straight periotomes that are used by means of wedging this instrument into the periodontal ligament space, thus severing the periodontal fibers and luxating the tooth. FIGURE 4. Flapless and atraumatic removal of the tooth leads to preservation of the papillae and their fibrous attachment to the roots of the adjacent teeth. The facial tissue profile remains constant. FIGURE 5. Diagram showing particulate bone graft material filling the socket. FIGURE 6. Diagram exhibiting the harvest of the autogenous free gingival plug that will cover the grafted socket and protect the graft during its initial healing stages. FIGURE 7. Diagram showing the free gingival graft socket seal sutured securely in place with 4 interrupted sutures and 1 cross-mattress suture.

and the clinical appearance of this tooth (Figures 8 and 9) were carefully evaluated and all options were discussed with the patient, the decision was made to proceed with a socket preservation procedure for the purpose of future implant placement. The flapless approach discussed previously was implemented with atraumatic removal of the tooth without compromising the attachment of the papillae (Figures 10 and 11). A particulate bovine-derived bone graft was placed in the socket after being mixed with the patient's blood to wet the bone graft and facilitate its transfer into the socket (Figure 12). The graft was carefully placed in the socket without being forcefully packed down to avoid destroying the graft's granular architecture. The graft filled up the socket to the most coronal edges of the alveolus walls but not beyond them (Figure 13). The socket soft tissue walls were then undermined carefully to allow a resorbable membrane to be tucked under the periosteum of the facial and palatal aspects and thus completely covering the bone graft particles in the socket. After the dimensions of the socket (which is covered by the membrane) were measured, an FGG plug was harvested from the palate (Figure 14) and

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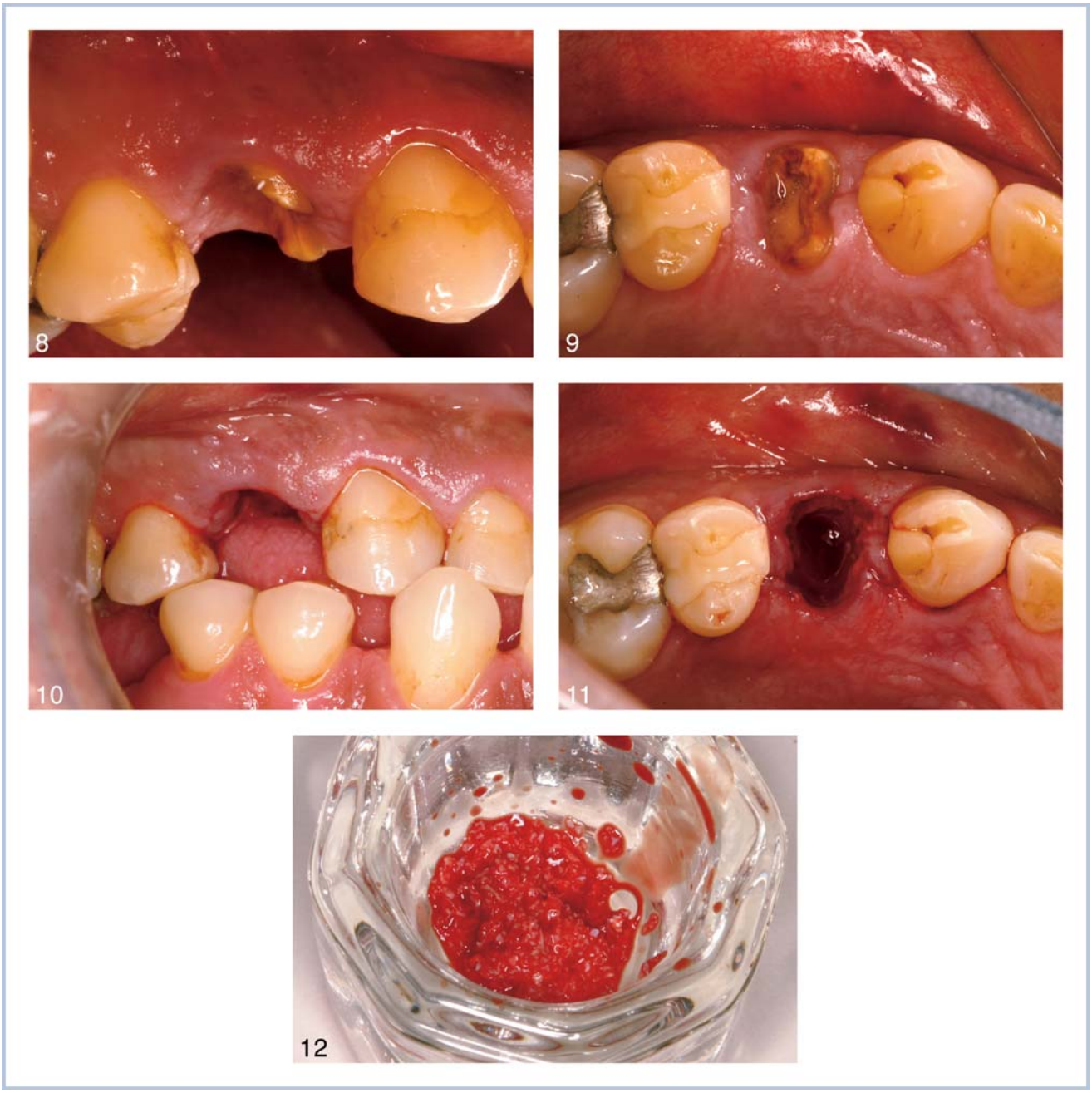

FIGURES 8–12. FIGURES 8 AND 9. Initial clinical presentation of the buccal and palatal aspects of the maxillary right first premolar. FIGURES 10 AND 11. Atraumatic and flapless extraction of the first premolar. This was achieved by means of periotomes that severed the periodontal ligament fibers and luxated the tooth without damaging the osseous housing of the alveolus. FIGURE 12. A particulate xenograft was used to fill the socket. The graft was first wet with blood from the socket to facilitate (by making it sticky) the graft's transfer from the dampened dish to the alveolus.

secured over the filled socket with interrupted (Figure 15) and cross-mattress sutures (Figure 16).

At the 3-month postoperative visit, the esthetic result of this surgical approach was clearly seen. The facial profile of the tissues was practically intact, with the papillae still in their original position (Figure 17).

The authors would like to mention at this time that during the initial post-operative healing phase, "gingival graft sloughing" is most commonly seen at the socket preservation site. When the FGG socket seal is placed upon the membrane (covering the underlying bone graft particles), the only source of

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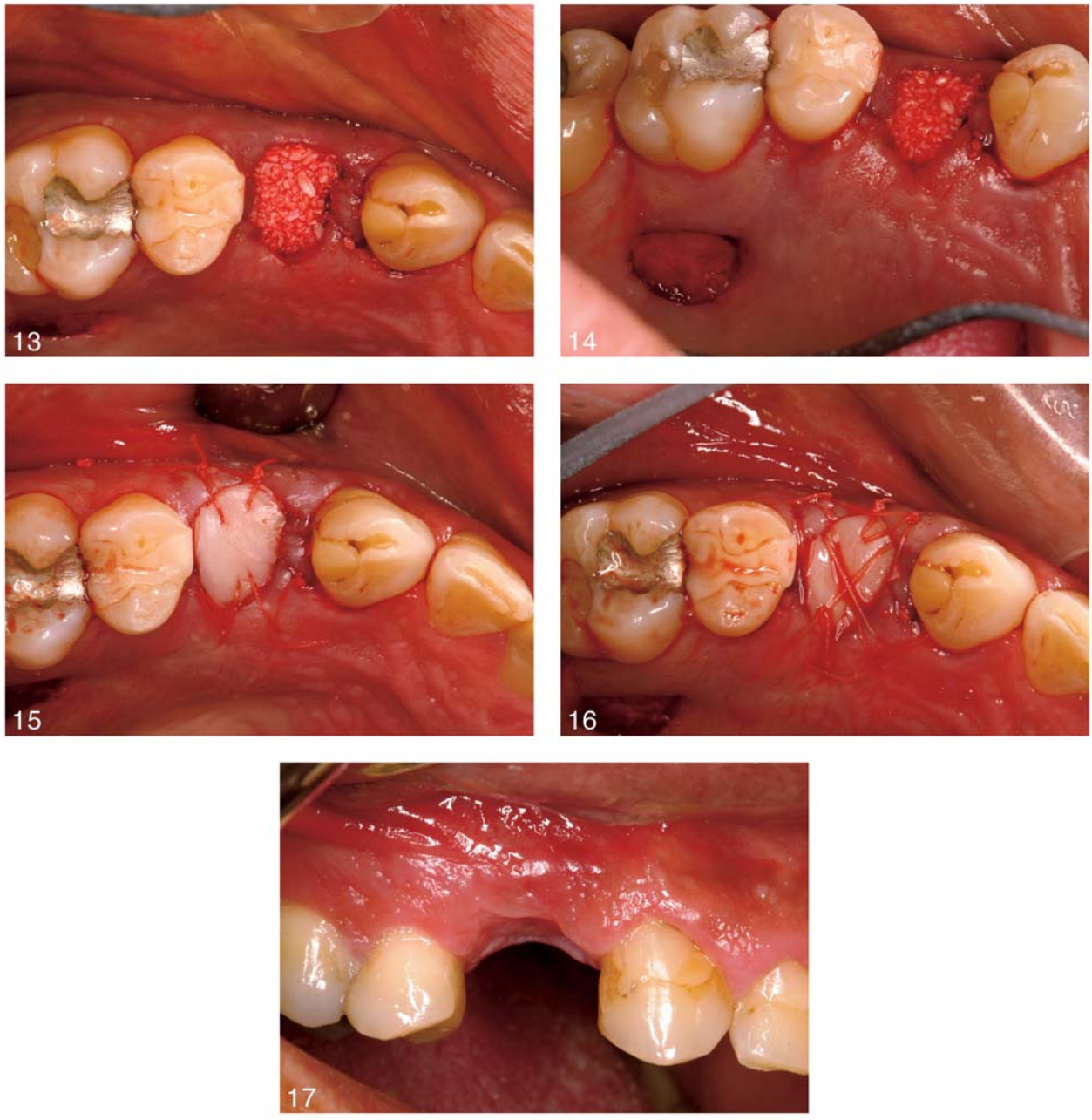

FIGURES 13–17. FIGURES 13 TO 16. After the socket was filled with bone graft and covered with a resorbable membrane, a free gingival plug was harvested from the palate to seal the socket. This gingival socket seal was secured in place with 5-0 vicryl sutures. FIGURE 17. The esthetically pleasing result was readily visible 3 months after the original procedure, even though the patient declined to wear a provisional prosthesis, which would have helped maintain the positions of the papillae.

nutrients for this graft is the surrounding "gingival lip" of the socket aperture. A fibrin clot may form between the edges of that lip and the deep connective tissue cells of the FGG. However, this source of nutrition alone will not be adequate to sustain the integrity of the gingival graft in its entirety. Nature will take over, and the FGG will begin sloughing (turning white) as the surface epithelial cells degenerate and slough. Under this sloughing FGG, the cells from the gingival lip margin will begin to horizontally proliferate to cover the underlying membrane with soft tissue. This lateral migration of cells under ideal conditions may

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reach even 0.5 mm per day. The clinician may decide to remove the sloughing part of the graft weekly as he/she deems fit. Usually by the fourth week the socket is covered by new soft tissue that seals the opening.

Conclusion

This procedure can be applied only to carefully selected cases in which the tooth can be removed without surgical intervention and when most of the facial bone is still present. There are various reasons why a surgeon may decide to proceed with socket preservation instead of immediate implant placement, although it is not the intention of this article to explore them. Regardless of the reasons for socket preservation, there seems to be a consensus that sufficient alveolar bone volume and favorable alveolar ridge architecture are essential to obtain ideal functional and esthetic prosthetic reconstruction following implant therapy.[1] Preservation and/or reconstruction of the extraction socket of a failed tooth according to the principles of guided bone regeneration enhance the clinician's ability to provide esthetically pleasing restorations to patients without violating the predictability and function of those prostheses.

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