Flapless Alveolar Ridge Preservation Utilizing the "Socket-Plug" Technique: Clinical Technique and Review of the Literature

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It has been documented that after every extraction of one or more teeth, the alveolar bone of the respective region undergoes resorption and atrophy. Therefore, ridge preservation techniques are often employed after tooth extraction to limit this phenomenon. The benefits of a flapless procedure include maintenance of the buccal keratinized gingiva, prevention of alterations to the gingival contours, and migration of the mucogingival junction that are often experienced after raising a flap. The purpose of this article is to review the literature concerning flapless ridge preservation techniques with the aid of collagen plugs for occlusion of the socket. The term “socket-plug” technique is introduced to describe these techniques. The basic steps of the “socket-plug” technique consist of atraumatic tooth extraction, placement of the appropriate biomaterials in the extraction site, preservation of soft tissue architecture employing a flapless technique, and placement and stabilization of the collagen plug. A case example is presented that illustrates the steps used in this technique.

Key Words: ridge preservation, tooth extraction, dental implants, collagen plug

INTRODUCTION

It is well documented in the literature that following every tooth extraction, resorption of the alveolar bone is triggered in the respective region.1,2 Alveolar ridge resorption is a chronic, irreversible phenomenon, which is estimated to lead to a reduction in width ranging between 2.6 and 4.6 mm and in height between 0.4 and 3.9 mm post extraction.3–5 The vast percentage of the alveolar bone resorption process occurs within the first 3 to 6 months post extraction, but this procedure is chronic, and the alveolar bone continues to resorb even 25 years after the extractions.6 Resorption rate varies among individuals and may even fluctuate for the same individual within different periods of time. Additionally, there is a marked difference on the resorption patterns between the maxillary and the mandibular bone, with sockets in the mandible being resorbed up to 4 times faster than those in the maxilla.4,6 If no actions are employed for the prevention of this phenomenon, 40%–60% of the total alveolar bone volume is lost during the first 2–3 years post extraction, and this phenomenon continues incessantly with a rate of 0.25%–0.5% loss per year7 (Figure 1).

The aim of this paper is to review the data from the literature that involves flapless ridge preservation procedures employing the use of collagen plugs.
plugs and report their efficacy in preserving alveolar ridge dimensions. The authors have introduced the term “socket-plug” technique to include all variations of this commonly used technique, which are used by many clinicians in everyday practice.

**Review of the literature**

The first attempts to study the alveolar ridge resorption phenomenon started in the early 1960s, whereby the submerged root concept was introduced as a ridge preservation technique. Contemporary socket preservation techniques involve the placement of different biomaterials in the socket. The choice of biomaterials that will be used is correlated to the purpose for which the technique is going to be used (Figure 2).

Bartee proposed 3 categories of ridge preservation based on the resorbability pattern of the graft material that was employed.

1. **Long-term ridge preservation**: In this case the technique is used either for pontic site development or to improve the stability of removable appliances. Nonresorbable materials are used for this indication, and as a result, the placement of implants in these sites is not favored.

2. **Medium-term or transitional ridge preservation**: Slowly resorbable bone graft materials are used in ridge preservation allowing for the preservation of the alveolar ridge for a protracted period of time while enabling the placement of an osseointegrated implant in the site after an initial healing period, even in the presence of some unresorbed graft particles. Transitional ridge preservation is indicated in cases where it is still undetermined whether the patient is going to restore the edentulism with an implant, or in cases where the patient has chosen to have an implant placed but will be unable to return and place the implant for a substantial amount of time.

3. **Short-term ridge preservation**: The objective of this technique is to maintain the postextraction alveolar dimensions during the initial healing phase in order to allow for the placement of an implant in the shortest possible timeframe.

As far as the coverage of the graft is concerned, primary soft tissue coverage with or without a membrane, sealing of the socket with a free...
gingival graft or a connective tissue graft, and placement of a collagen plug for socket occlusion have all been proposed.13–16 Barrier membranes have been employed showing good results in ridge preservation in a manner similar to guided bone regeneration.17–19 The main drawback associated with this technique is that it requires primary soft tissue closure. Flap advancement for primary closure causes repositioning of the mucogingival junction, displacement of the keratinized mucosa towards the crestal region, and increased postoperative swelling and discomfort.20 Furthermore, if the membrane undergoes secondary exposure, there is a risk for infection of the graft, thus jeopardizing the outcome of the preservation procedure.21 The "socket seal surgery" technique is a ridge preservation procedure that does not require flap advancement and was introduced to counter these technique-inherent drawbacks.22 This minimally invasive ridge preservation procedure involves bone and soft tissue grafting. The extraction socket is filled with the bone graft of choice, and then a soft tissue graft of adequate size is harvested from the palate and is placed over the graft in order to seal the socket.23 Even though the "socket seal surgery" technique was novel in introducing a ridge preservation procedure that would not require primary flap closure, it still did not minimize the postoperative discomfort due to the soft tissue graft harvesting.

The "BioCol" technique was introduced shortly afterwards using the same principles as the "socket seal surgery," but specifically used anorganic bovine bone mineral as a bone substitute and replaced the soft tissue graft with a collagen plug that was stabilized with a horizontal mattress suture to occlude the socket. Cyanoacrylate was placed over the collagen to harden the material and decrease permeability of this barrier.24 This new concept reduced postoperative discomfort to a minimum, as there was no need for flap elevation or graft harvesting. After the introduction of this technique, many modifications were proposed in the literature, differing either in the graft that was used ("allo-plug" technique, "Nu-mem" technique) or in the placement of the collagen plug ("modified BioCol" technique).25–27

The modified Bio-Col technique suggested an alternative approach to the handling and stabiliza-
tion of the collagen plug. Only the terminal one fifth of the collagen plug is utilized to cover the graft, rather than layering the bulk of it to the level of the free gingival margin. The horizontal mattress suture was eliminated, and a fixed or removable interim prosthesis with an ovate pontic was fabricated to cover the collagen plug to aid in retention and formation of an esthetic soft tissue profile at the site.26 Recently, the "allo-plug" technique was introduced, where the authors substituted the use of bovine xenograft with a human mineralized bone allograft.27 The rationale behind shifting from one bone graft to the other was the large number of remaining bovine xenograft particles observed even after a significant healing period of time.19,27 According to the previous authors’ views, freeze-dried bone allograft (FDBA) may provide a better potential for osteoconductivity than anorganic bovine xenograft. In this technique, a cross-mattress suture was placed over the collagen plug for stabilization rather than placing cyanoacrylate or other tissue adhesive. The term "socket-plug" technique is coined by the authors in this paper to encompass all variations of this socket preservation technique.

**"Socket-plug" technique**

The "socket-plug" technique consists of 4 distinct steps.11,28

1. Atraumatic extractions after careful surgical preparation of the soft and hard tissues using periotomes as illustrated in Figure 3: Several authors propose that a sulcular incision is done with the aid of a number 15 or 15c scalpel in order to dissect the crestal fibers.11 Careful curettage and debridement of the socket is performed. If residual inflammatory tissue is left in the socket, the bone graft may be resorbed because of the low pH environment, and the bone regeneration process may be compromised.29 It is important that clinicians do not apply bicortical pressure on the alveolar ridge after the extraction of the tooth.30

2. Placement of the appropriate biomaterial: Autogenous grafts are said to be the "gold standard" in bone grafting because of their osteogenetic characteristics and biocompatibility.31 Common intraoral donor sites are the external oblique line, mental protuberance, and maxillary tuberosity. As far as ridge preservation is concerned, the autologous graft has not been found to display any osteoinductive or osteogenetic effects.32,33 It is
rapidly resorbed and replaced by vital bone without diminishing the resorptive procedure. A major disadvantage of autologous bone grafting is patient discomfort, and any advantage associated with the use of this type of graft should always be weighed against this disadvantage.

Allografts have also been employed in ridge preservation procedures, contributing positively in the dimensional stability of the postextraction socket. Allografts are slowly absorbed in socket preservation applications. Allografts that contain calcium and phosphorous salts (FDBA) are resorbed more slowly than those that have been demineralized. For the first 3–6 months after the placement of the graft in the socket, particles of the graft are still found in the socket surrounded by connective tissue and newly formed bone.35

Xenografts are employed by many clinicians for ridge preservation. An animal study reported that 3 months after the use of Bio-Oss in surgically created jaw defects that resembled postextraction resorption defects, residual graft particles remained occupying approximately 30% of the defect posthealing. Moreover, no osseointegration was achieved for implants placed in the regenerated defects 3 months after the placement of the xenograft. In another paper by Artzi et al, 15 sockets were filled with inorganic bovine graft. Nine months following the graft placement, satisfactory ridge dimensions were observed, but histologic study revealed graft particles in connection with the newly formed bone at a constant 30% across the socket. Interestingly, the histomorphometric measurements revealed that the coronal part of the socket consisted predominantly of loose connective tissue (52.4%), followed by woven bone (15.9%) and remaining graft particles (30%). Descending from the coronal to the apical third of the socket, there was a marked shift of the proportion of connective tissue to the newly formed bone, with the bone being better trabeculized and occupying 63.9% of the socket volume, while connective tissue was decreased to 9.5%. Throughout the whole socket dimension, the percentage of nonabsorbed graft remained constant at about 30%. The use of osseointegrated implants was predictable at 9 months after socket grafting. On the other hand, it has been documented that even though the graft’s particles remain at the implantation site for a protracted period of time, they are surrounded by vital, newly formed bone. In an animal study, vital host bone was found to separate the remaining xenograft particles from the implant surface, and it was suggested that the remaining particles may have no negative effect on the osseointegration of implants. It can be concluded that xenografts can be used for transitional ridge preservation because of their slow resorption rate, with remaining particles being found in the socket even after 4 years.

Alloplastic materials are a large and diverse group of bone substitutes that include hydroxyapatite, calcium phosphate, bioactive glass, and calcium sulfate. Each category of alloplastic materials has a different resorption pattern ranging from the rapidly resorbing calcium sulfate that is used for short-term ridge preservation to condensed hydroxyapatite that is practically nonresorbable and is suitable for long-term ridge preservation. Recently, there is an interest in the clinical application of new alloplastic graft materials that have unique distribution characteristics in comparison to the traditional bone substitutes that come in the form of particles. One such material will be discussed in the case example below (Figure 4).

(3) Flapless design: Many authors have suggested various flap designs in order to establish primary closure of the socket. There is not adequate research data to clearly demonstrate that flapless socket preservation techniques are superior to techniques that involve raising a flap, but an animal study reported that the detachment of the periosseum from the buccal site of the ridge leads to an increase of the resorption rate, resulting in an increase of the ridge resorption of approximately 0.7 mm. Consequently, there seems to be evidence to promote the idea that the use of socket preservation techniques that do not require the opening of a flap may be superior to putting effort in achieving primary closure of the socket, wherever they are indicated. Moreover, it has been shown in the literature that where a connective tissue graft, a collagen sponge, or a collagen membrane was left to heal without primary closure, excellent preservation of the vertical dimension of the ridge was achieved or even an increase in height was noted, which could be attributed to an increase in the soft tissue volume. The use of a collagen sponge has particularly been found to not only protect the bone substitute but to present
hemostatic properties as well as to minimize discomfort during the postsurgical period. In addition to stabilizing the blood clot, collagen plugs act as chemotactic agents for fibroblasts.47

(4) Suturing: The collagen plug has a dual purpose. It is placed to prevent the wash out of the bone graft and to induce blood clot formation and stabilization of the clot by stimulation of the platelet aggregation.27,47 For the collagen plug to be stabilized over the socket, suturing is done without tension in order to secure the plug without distorting the gingival architecture. Preferably, a single horizontal mattress suture is executed (Figure 5).

**CASE PRESENTATION**

A 30-year-old nonsmoking male patient presented with a nonrestorable maxillary left second premolar due to extensive decay (Figure 6). Extraction and ridge preservation were scheduled. The patient was in good general health and had no contraindications regarding this treatment plan. After informed consent was obtained from the patient, he was instructed to rinse with a chlorhexidine 0.12% solution for 1 minute (Chlorhexil, Intermed, Athens, Greece). Following administration of local anesthesia, the width of the alveolar bone was measured at 5 and 7 mm below the line connecting the cementoenamel junction (CEJ) of the 2 neighboring teeth with the aid of a bone caliper. The measurement was 9.3 mm and 8.9 mm, respectively. Subsequently, extraction of the involved tooth was performed asatraumatically as possible (Figures 7 and 8). Care was given not to raise a flap in order to maintain the vascularization of the socket walls. After thorough debridement of the socket, a calcium phosphosilicate (CPS) putty graft was injected into the socket (NovaBone Dental Putty, NovaBone Products LLC, Alachua, Fla) (Figure 9). The graft was placed up to the crest of the bone and a collagen plug (CollaPlug, Zimmer Dental, Carlsbad, Calif) was trimmed and adapted over the graft in order to occlude the socket (Figure 10). The plug was stabilized with a single mattress suture. Effort was made to avoid applying any pressure with the suture to preserve the gingival architecture. The healing process was uneventful and the patient was recalled at 6-month intervals for prophylaxis and evaluation of the healed site. Implant placement was to be scheduled when the patient could financially afford the treatment.

At the 6-month appointment, the bone width measurement was repeated and revealed a reduction of 1.1 mm at 5 mm below the reference point and 1.0 mm at the 7-mm point.

Eighteen months post extraction, the measurement of the bone width at 5 and 7 mm below the line connecting the CEJ of the 2 neighboring teeth revealed minimal ridge resorption with measurements of 8.1 and 7.7 mm, respectively (Figures 11 and 12).

It appears that the major percentage of the resorption of the ridge occurred within the first 6 months following the extraction, which is in agreement with previously published data.7,17 The measurements were taken at 5 and 7 mm from the reference point because a smaller distance may have involved the sulcus of the tooth instead of the alveolar bone. Simon et al48 performed similar measurements using a ridge mapper to determine the width at 3 and 5 mm apical to the alveolar crest. In another study,49 bone width was estimated 4 mm apical to the CEJ of the neighboring teeth as measured in cone-beam computerized tomography. The authors chose to measure at least 5 mm below the line connecting the CEJ of the 2 neighboring teeth because of the possibility that in cases with a slight resorption of the buccal plate, a 3-mm measurement may stop on the cementum of the root instead of the buccal plate. Therefore, 2 measurements at 5 and 7 mm were taken in order to minimize measurement error and verify the validity of the measurements. Additionally, the exact distance between the site of measurement and the root surface of the nearest tooth was recorded to ensure that the follow-up measurement would be standardized and reproducible.50

At the 18-month recall appointment, the patient was able to proceed financially with implant placement, thus we were able to harvest a 3.0 × 6.0 core and preserve it in (10%) neutral buffered formalin. Upon receipt in the Hard Tissue Research Laboratory, the core was sectioned in half through the area of interest and immediately dehydrated with a graded series of alcohols for 9 days. Following dehydration, the specimen was infiltrated with a light-curing embedding resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). Following 20 days of infiltration with constant shaking at...
normal atmospheric pressure, the specimen was embedded and polymerized by 450 nm light with its temperature never exceeding 40°C. The specimen was then prepared by the cutting/grinding method of Donath and Breuner. The specimen was cut to a thickness of 150 μm on an EXAKT cutting/grinding system (EXAKT Technologies, Oklahoma City, Okla). Following this, the core was polished to a thickness of 45–60 μm using a series of polishing sandpaper discs from 800 to 2400 grit using an EXAKT microgrinding system followed by a final polish with 0.3-micron alumina polishing paste. The slides were stained with Stevenel’s blue and Van Gieson’s picrofuchsin and were evaluated. Histologic analysis of the core showed trabeculae of varying thicknesses and good connectivity. New bone that had formed around particles of CPS putty had formed bridges with other areas of new bone, resulting in a good cancellous bone pattern (Figure 13).

**Figures 6–13.** Figure 6. Preoperative view of the nonrestorable upper left second premolar. Figure 7. The involved tooth was extracted without flap reflection. Figure 8. Immediate postextraction radiographic view of the socket. Figure 9. The socket was filled with an alloplastic graft that displays putty consistency and is easily injected into the socket, thus saving important clinical time. Figure 10. A collagen plug is trimmed and adapted over the graft in order to occlude the socket. Figure 11. Clinical view of the healed site 18 months post extraction. The dimensional stability of the ridge will allow for the ideal restoratively driven positioning of an implant. Figure 12. Radiographic image of the socket at the 18-month recall appointment. The trabecularization of the regenerated bone is similar to the native bone. Note the pneumatization of the sinus. Figure 13. Calcium phosphosilicate putty core at 6 months. The red-stained tissue is mineralized, newly regenerated bone with visible cell nuclei. Some residual graft particles can be seen in all images. New bone formation is quite robust surrounding particles of bio-active glass. The yellowish-green staining shows osteoid and the newly entrapped osteocytes in the very immature bone. NB indicates new bone; CPS, calcium phosphosilicate putty; OS, osteoid; and OB, osteoblast.
**DISCUSSION**

It is frequently necessary for clinicians to extract teeth for a variety of reasons such as root fracture, periapical pathology, extensive decay, or periodontal disease. Even when removal of the tooth is exercised in the most atraumatic way, vertical and horizontal bone resorption is an inevitable natural consequence. Approximately 40% of bone height and 60% of bone width are lost in the first 6 to 12 months post extraction.7,17 Variations of the “socket-plug” technique have been used for more than a decade to help minimize the amount of bone loss and ensure the esthetics of the future restoration.24 The major limitation for the application of this technique is the status of the buccal plate. When the buccal plate is severely damaged, a barrier membrane should be employed in order to contain the graft and prevent the soft tissue from occupying the buccal space.53 Another contraindication for the “socket-plug” technique is acute infection of the tissues surrounding the hopeless tooth. Acute infection of the area may lead to rapid resolution of the collagen sponge and failure of the graft material.54

The flapless ridge preservation technique provides certain advantages including preservation of blood circulation, soft tissue architecture, hard tissue volume at the site, decreased surgical time, minimal patient discomfort, and accelerated recuperation. Patients are able to resume normal oral hygiene procedures immediately after the surgery. Drawbacks of raising a flap and placing a membrane for ridge preservation are prevented, such as reduction of keratinized gingiva, alteration of gingival contours, and migration of the mucogingival junction due to coronal displacement of the flap in an attempt to achieve primary closure.

As far as the dimensional stability of the ridge with this technique is concerned, an in vivo study reported that in sockets treated with the “socket-plug” technique using anorganic bovine bone mineral, the resorption after 3 months was limited to 14% of the initial bone width, whereas the control group had a resorption of 21%.55 Our results demonstrated a similar reduction of approximately 12% in the orofacial dimension. Histologic outcomes of the “socket-plug” technique comparing allogenic and xenogenic bone grafts showed that the allograft was completely integrated into the newly formed bone after 3 months of healing, whereas the anorganic bovine bone was only partially integrated with distinguishable graft particles remaining.56 In our case example, newly formed bone was well trabeculized, and the particles of CPS putty alloplastic bone substitute were bridging with the newly formed bone.

**CONCLUSION**

Previous publications indicate that the alveolar ridge resorption process can be limited. Ridge preservation requires careful tissue handling during and after the extraction of one or more teeth, as well as proper use of available bone substitutes. The “socket-plug” technique can help the clinician to provide the best possible outcome with the least patient discomfort. The results of this technique depend not only on the delicate handling of the area but also on the resorption rate of the graft material and its timely replacement by mature bone capable of withstanding functional loading.

**ABBREVIATIONS**

CEJ: cementoenamel junction
CPS: calcium phosphosilicate
FDBA: freeze-dried bone allograft

**REFERENCES**

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