Mineralized Bone Allograft-Plug Socket Augmentation: Rationale and Technique

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Background: *Socket augmentation allows clinicians to preserve alveolar bone height. This, in turn, could maintain adjacent soft tissue (papillae) height to promote optimal implant esthetics.*

Materials and Methods: *A new regimen for the socket augmentation technique (the mineralized bone allograft-plug technique) is introduced. It uses solvent-preserved mineralized cancellous allografts to fill the sockets up to 1–2 mm below the bone crest. This is covered with a bioabsorbable collagen wound dressing (CollaPlug®; Zimmer Dental, Carlsbad, CA). Illustrations to demonstrate the technique are introduced. A case treated with this approach is presented.*

Results: *This technique is easy to perform with minimal trauma. Both clinical observation and histological results showed excellent bone formation.*

Conclusion: *Our clinical experience, as well as histologic data, suggest that the mineralized bone allograft-plug is a suitable technique for socket augmentation. (Implant Dent 2007;16:33–41)*

Key Words: allograft, mineralized bone, extraction socket, bone regeneration

Loss of alveolar bone volume, both horizontally and vertically, after tooth extraction is an inevitable outcome.[1–4] An average of 40% to 60% of original height and width is expected to be lost after tooth extraction, with the greatest loss occurring within the first year.[5–8] This can negatively influence bone volume that is needed for future dental implant placement as well as proper ideal esthetic restoration. Various socket augmentation techniques with different bone graft techniques have been evaluated and have shown promising results.[9–11] The rationale for socket augmentation at the time of extraction is an attempt to reduce crestal bone loss, encourage socket fill, minimize horizontal ridge resorption, and ultimately reduce or eliminate the need for further ridge augmentation. The Bio-Col technique, proposed by Sclar,[12] uses bovine hydroxyapatite bone graft (Bio-Oss; Osteohealth, Shirley, NY), bottom two thirds and covered with an absorbable collagen dressing (CollaPlug®; Zimmer Dental, Carlsbad, CA), top one third, then seals with tissue glue (Isodent; Ellman International, Inc., Oceanside, NY). The author claims that this technique prevents the loss of both hard and soft tissues, reduces the number of surgical interventions, and provides optimum esthetics with greater predictability. However, a study has shown that there are bovine hydroxyapatite particles remaining even after 4 months of healing.[13] Therefore, there is a need to identify alternate bone grafts that could be quickly replaced by the host bone. A human mineralized cancellous bone graft (Puros; Zimmer Dental Inc.) has been introduced to fulfill this goal. It consists of a mineralized bone allograft material processed through unique solvent-preserved processes for tissue preservation and viral inactivation, which differ from the standard cryopreserved process. Solvent-preserved, mineralized cancellous allograft is the only allograft that claims to preserve the trabeculation of the bony structure with high porosity when compared to freeze-dried bone allografts.[14] Therefore, it has a better potential for osteoconductivity. Recently, it has been shown to promote bone formation in both periodontal and augmentation therapies.[15–17] Bone graft, by itself, should be able to promote some bone ingrowth. However, due to the nature of the extraction socket, the majority of bone grafts may wash out if no protection is provided. Therefore, the use of collagen wound dressing material was suggested not only to protect the graft materials but also induce blood clot formation and stabilize the wound.[12,18] Collagen dressing materials are preferable due to their inherent properties. The material is a hemostatic agent, and possesses the ability to stimulate platelet aggregation and enhance fibrin linkage, which may lead to initial clot formation, stability, and maturation.[19] Furthermore, collagen has demonstrated to be chemotactic for fibroblasts *in vitro*.[20] This property could enhance cell migration and promote primary wound coverage that are fundamental for bone growth. In another study, the histological examination of 7 samples from 5 subjects revealed new bone formation and minimal residual graft particles (H-L Wang, DDS, MSD and Y-P Tsao, DDS, MS, unpublished data, 2007). Most of the bone formation appeared

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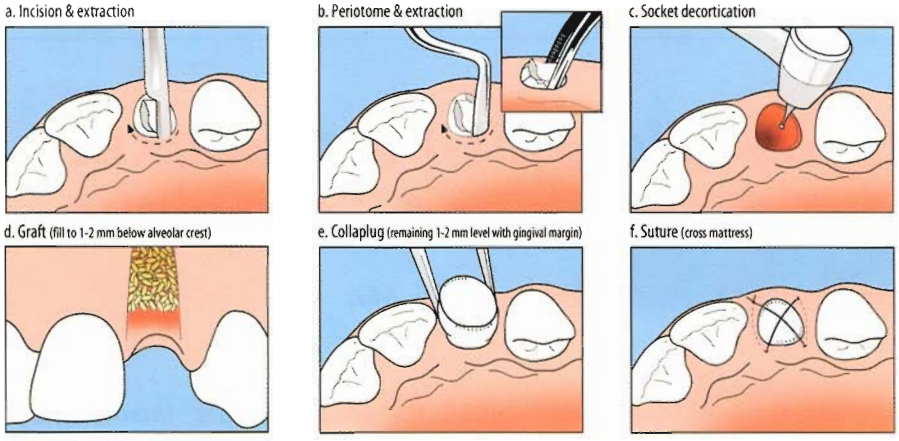

Fig. 1. The mineralized bone allograft-plug (MBP) socket augmentation technique. (A) A 15C scalpel was used to dissect supracrestal gingival fibers. (B) A periotome was used to widen the periodontal ligament space. (C) Bleeding is stimulated with curettes or (No. 1/2) round bur. (D) Human mineralized cancellous bone allograft (Puros) fills the extraction socket up to 1–2 mm below the alveolar bone crest. (E) Collagen wound dressing material fills (CollaPlug®) the remaining 1–2 mm of the socket. (F) A cross-mattress suture is applied to secure the wound dressing material.

lamellated with some woven type of bone. A minimal amount of residual graft particles were noted in all samples. The residual graft particles were found to be in close contact with bone structure or connective tissues. Histological results obtained from core biopsy indicated a mean volume of vital bone of 68.45%, residual particle of 4.83%, and connective tissue of 27.74%. This is similar to the composition of human bone. Therefore, it is the purpose of this study to introduce the mineralized bone allograft-plug (MBP) for predictable socket augmentation.

Mineralized Bone Allograft-Plug

Fig. 1 illustrates the technique step-by-step. A case example follows (Fig. 2). The tooth was extracted following the protocol described by Wang *et al.*[18] Briefly, a No. 15C blade was used for intrasulcular incisions to sever the supracrestal gingival fibers (Fig. 2B), followed by periotomes to widen the periodontal ligament space (Fig. 2C). If necessary, a fine long fissure bur can be used to create space for periotomes or remove a fractured root tip. After the tooth was luxated with periotomes and elevators with notable mobility, it was gently extracted using dental/root tip forceps. A close examination was performed to ensure complete removal of soft tissue fragments or infected granulation tissues in the socket. Scraping the walls of the socket with either curettes or a No. 1/2 round bur can easily achieve profuse bleeding (Fig. 2D). This procedure also triggers the regional acceleratory phenomena, which is known to stimulate new bone formation and graft incorporation.[21] Solvent-preserved mineralized cancellous allografts (Puros) were hydrated with normal saline (or sterile water). Bone grafts were then placed and densely packed into the extraction socket, either with Buser's elevator or amalgam carrier, then condensed with wet gauze. Unlike the previously described technique,[18] in which bone graft materials were filled up to two thirds of the socket, in this present technique, bone grafts were packed till 1–2 mm below the bone level to enhance preservation of the alveolar bone (Fig. 2E). Bioabsorbable collagen wound dressing material (CollaPlug®) was gently packed on top of the bone grafts (Fig. 2F), remaining 1–2 mm to compensate bone remodeling and soft tissue thickness. A cross-mattress suture with 4-0 Vicryl (Ethicon, Inc., Johnson & Johnson, Somerville, NJ) was applied on top of the bioabsorbable collagen to achieve site stability (Fig. 2G). The postoperative care includes rinsing twice daily with warm salt water for the first 2 weeks before switching to twice daily rinsing with 0.12% chlorhexidine gluconate mouth rinse for the next 2 weeks. Systemic antibiotic prophylaxis is not recommended unless signs of active infection are found. If indicated, antibiotics such as amoxicillin 500 mg t.i.d. for 10 days, or in cases of allergy to penicillin and derivatives, azithromycin 500 mg/day for 3 days should be prescribed. Pain medication such as ibuprofen is often prescribed to help relieve discomfort associated with the procedure.

Generally speaking, 2-week postsurgery sockets showed uneventful healing and almost complete soft tissue coverage over the extraction site. The healing process should be monitored radiographically, and implant placement or stage II surgery can usually be performed 4 months after treatment. Radiolucencies persisting for more than 4 months are indicative of inadequate graft incorporation, frequently requiring an additional procedure for debridement of the graft particles and possibly a new grafting procedure.

Case Presentation

Case (C.H.) illustrated socket management using mineralized bone allograft-plug socket augmentation technique (Fig. 2): A, preoperative radiographic view; B, a 15C scalpel was used to dissect the supragingival attachment; C, periotomes were used to widen the periodontal ligament space; D, the socket was free of infection and presents profuse bleeding; E, the bone graft material was inserted into the extraction socket up to 1–2 mm below the alveolar crest (Puros); F, a collagen wound dressing material (CollaPlug®) was applied to cover the augmented extraction socket; G, a cross-mattress suture is placed to stabilize the wound; H, postoperative view showed uneventful healing 4 weeks after socket augmentation; and I, 6-month postoperative radiography showed bone filled (increase bone density).

Another case treated with the MBP had a reentry 5 months later and showed complete bone fill. A bone core biopsy obtained from this case showed that lamellar bone, woven bone, and connective tissues surrounded residual allografts (Fig. 3).

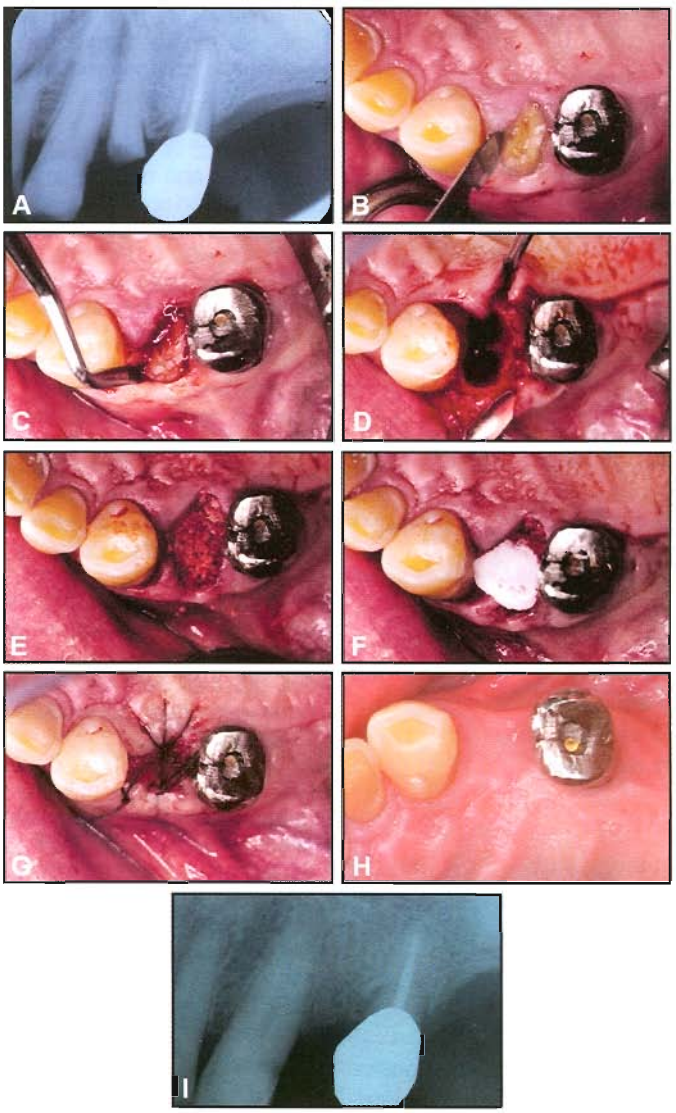

Fig. 2. Case (C.H.) illustrated socket management using the mineralized bone allograft-plug (MBP) socket augmentation technique. (A) Preoperative radiographic view. (B) A 15C scalpel was used to dissect the supragingival attachment. (C) Periotomes were used to widen the periodontal ligament space. (D) The socket was free of infection and presents profuse bleeding. (E) The bone graft material was inserted into the extraction socket up to 1–2 mm below the alveolar crest (Puros). (F) A collagen wound dressing material (CollaPlug®) was applied to cover the augmented extraction socket. (G) A cross-mattress suture is placed to stabilize the wound. (H) Postoperative view showed uneventful healing 4 weeks after socket augmentation. (I) Six-month postoperative radiography showed bone filled (increase bone density).

Discussion

Many osseous graft materials, including autogenous bone, demineralized freeze-dried bone allograft, mineralized freeze-dried bone allograft, solvent-preserved mineralized bone allograft, bovine hydroxyapatite, and alloplasts, had been evaluated in different studies for socket augmentation.[13,22–26] Promising results have been reported in many studies, but the search for the ideal technique and materials remain. Sclar[12] in 1999 proposed the "Bio-Col" socket augmentation technique. In his technique, bovine hydroxyapatite was used as graft material up to two thirds of the socket, and the remaining socket was filled with the bioabsorbable collagen dressing (CollaPlug®). The concern associated with this technique is the remaining higher percentage of bovine hydroxyapatite particles.[13,27] As a result, allogenic bone graft materials have been advocated because of their availability and biologic activity. Solvent-preserved, mineralized bone allograft is a graft that contains human mineralized component, organic matrix, and collagen. The Tutoplast process preserves it with solvent and low-dose gamma-irradiation. This allograft has been claimed to preserve the trabeculation structure of the bone with high porosity. Recently, studies have shown its effectiveness in various periodontal and implant-related defects.[3,16,17] From our clinical experience as well as our recent histologic evaluation (H-L Wang, DDS, MSD, Y-P Tsao, DDS, MS, unpublished data, 2007), we found that this solvent-preserved mineralized osseous graft material could be replaced by newly formed bone and showed a high degree of biocompatibility with the surrounding tissues.

Bone graft, by itself, should be able to promote bone ingrowth. However, because of the nature of the extraction socket, the majority of bone grafts may be lost if no protection is provided. Therefore, the use of collagen wound dressing material was suggested not only to protect the graft materials but also induce blood clot formation and stabilize the wound.[18] A collagen dressing material is preferable due to its high biocompatibility and hemostatic ability that can enhance platelet aggregation, and, thus, facilitate clot formation and would stabilization.[19] Collagen also has a high chemotactic function for fibroblasts. This might promote cell migration and primary wound coverage.[20] Based upon our clinical experience, the use of bioabsorbable collagen wound dressing such as CollaPlug® over the mineralized cancellous allografts has achieved quick healing and more primary wound coverage. Nonetheless, future controlled clinical trials to test the effect of this additional wound dressing material are needed.

Our recent histomorphometric evaluation of the mineralized bone allograft-plug technique showed a mean 68.5% (ranging from 58.7% to 76.5%) of bone formation and a mean 4.8% (ranging from 0.2% to 10.6%) of residual graft particles. This is a promising finding for implant site development, and it is similar to a previous histological study using the same graft material in sinus augmentation.[16]

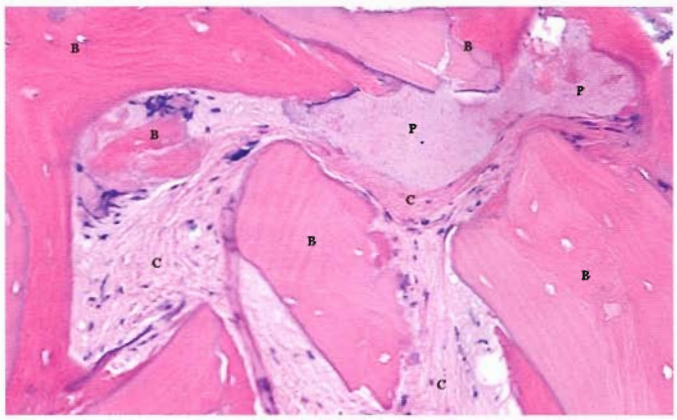

Fig. 3. Patient J.R. treated with the mineralized bone allograft-plug (MBP) socket augmentation technique. Bone core biopsy obtained from this case showed that lamellar bone, woven bone, and connective tissues surrounded the residual allografts (hematoxylin and eosin, original magnification ×20). B indicates bone suggesting new bone formation; c, connective tissue; P, Puros particle.

Gapski *et al*[16] demonstrated that using the same graft material in sinus augmentation achieved a mean bone density of 73.3% (ranging from 66.1% to 85.0%), which is comparable to the native bone density reported in their study (bone density from maxillary ridge: mean 73.2% [ranging from 61.6% to 84.4%]). These data illustrate the consistent properties of the solvent-preserved mineralized osseous graft material and its biocompatibility. Other histomorphometric analyses of socket augmentation with different graft materials indicated slightly lower bone density compared to ours. Artzi *et al*[13] showed a mean bone density of 46.3% with bovine osseous graft, and Froum *et al*[10] showed a mean bone density of 59.5% and 34.7% for bioactive glass and demineralized freeze-dried bone allograft, respectively. The examined graft particles noted in our technique are similar to those reported by Froum *et al*[10] with bioactive glass (5.5%) and were lower than that in others (*i.e.,* 13.5% of demineralized freeze-dried bone allograft for Froum *et al*,[10] and 30.8% of bovine osseous graft for Artzi *et al*[13]). This suggests that the MBP proposed here shows a promising ability in converting bone graft particles to the human bone in a timely manner.

Conclusions

The MBP is a suitable and predictable technique for socket augmentation to promote bone regeneration and preserve alveolar ridge. Nonetheless, future controlled clinical trials with substantial sample size are recommended to validate the findings of the current technique.

Disclosure

The authors do not have any financial interests, either directly or indirectly, in the products listed in the study.

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