IMPLANT DENTISTRY

Current State of Bone Replacement Grafting Materials for Dental Implants

Robert A. Horowitz, DDS

Contemporary dental implant therapy has flourished in recent years thanks in large part to advances made in bone augmentation capabilities. Bone grafts, which are often crucial to the success of implant restorations, are used mainly in three instances: at the time of extraction for delayed implant placement, when an immediate-socket implant is placed, and for ridge augmentation either laterally or vertically. Many bone grafting options are available to the surgeon depending on the site to be treated and the requirements in the area. Bone grafts and barriers come from different sources and are seen by the body's cell types in different manners. This yields a variety of biological outcomes, some of which have been published while others are in the process of being studied.

History and Concerns

Early periodontal studies followed oral surgery research and evaluated autogenous bone grafts used in patients with periodontal bone loss and defects in extraction sockets.[1,2] Because of risks of disease transmission when using fresh frozen marrow, harvesting issues, or due to other factors, periodontists and many dentists have mostly switched to alternative sources of bone replacement grafts. Handschel and coauthors in a systematic review stated that for early implant placement in a grafted site the use or addition of autogenous bone is advantageous; however, they showed a decrease in total bone volume in sites grafted with autogenous bone over time.[3] Other studies examining long-term bone volume in sinus grafting have shown significant decrease in volume with autogenous bone compared to other graft materials.[4]

Numerous publications have covered the use of anorganic bovine bone mineral (ABBM), such as Bio-Oss® (Geistlich Pharma North America, geistlich-na.com), for ridge augmentation. Compared to autogenous block grafts, there is no chance of morbidity in the donor site. Also, more bone formation was noted when ABBM was combined with a high percentage of autogenous bone from the anterior mandible and placed under a titanium mesh for an anterior maxillary ridge augmentation.[5] However, closely examined histologic specimens showed no osteoclastic activity and no resorption of the xenograft particles. Also, four of the seven meshes became exposed during healing.[5] Any graft that is not resorbed and not either replaced by bone or surrounded by vital bone may potentially interfere with osseointegration. An example of this is shown in Figure 1 and Figure 2 in a patient after immediate-socket implant placement with an unknown graft by another surgeon. The periapical x-ray (Figure 1) shows crestal bone loss on the distal aspect with questionable bone formation on the mesial of the implant adjacent to the graft. On CBCT evaluation (Figure 2), a trough around the shoulder of the implant is evident.

Histologically, results were not as promising in sinus grafts or extraction sockets when ABBM was compared to mineralized cancellous allograft. In a bilaterally controlled sinus graft study, almost two times as much vital bone was found when allograft was inserted.[6] In both conventional and simulated extraction sockets, similar histologic results were obtained with ABBM. In 9 months in humans, Tal's group found only 16% vital bone at the crest[7] and deemed the bone graft to be nonresorbable.[8] In the same relative timeframe in dogs (3 months), Artzi et al showed histologically that the graft particles almost completely encased in connective tissue in the central portion of the created defects.[9] In humans, when a radiograph is taken in a buccolingual direction, all that is visible is

ABOUT THE AUTHOR

Robert A. Horowitz, DDS

Adjunct Clinical Assistant Professor, Department of Periodontology and Implant Dentistry, New York University College of Dentistry, New York, New York

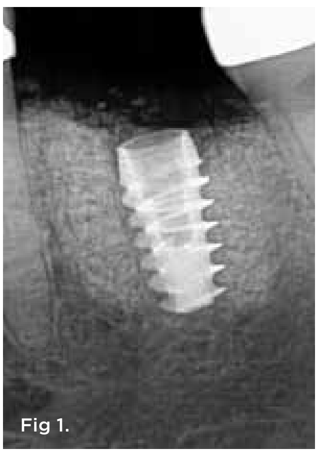

Fig 1. A 4.5-year buried implant showing bone loss. **Fig 2.** Sagittal view of CBCT of implant in Fig 1 showing trough bone loss.

the radio-opaque graft material. If any radio-opaque graft material is not resorbed, the clinician cannot determine when there is an increase in vital bone percentage in the site. This could be why some authors have advised that ABBM may not be an ideal graft material to place in extraction sockets.[2]

Alloplastic materials have been incorporated into sinus augmentation and extraction socket therapy, either alone or added to graft materials (Figure 3). Due to its physical and biologic activity, calcium sulfate can improve graft handling as well as angiogenesis[10] and osteogenesis.[11-13] Pure-phase beta-tricalcium phosphate (ß-TCP) has been studied in multiple indications from sockets to sinus grafting.[14-17] Through particle shape and slow release of calcium, a long-term stimulation of bone formation occurs in the grafted site leading to actual bone formation. Because the graft particles are salts, they dissolve and are not dependent on osteoclastic resorption to be replaced by vital bone.

Novel Biomaterials and Growth Factors

In patients or sites that are challenged, the use of bioactive materials may be beneficial to obtain improved physical and/or biologic results. In 2019, Dragonas and coworkers completed a literature search on various formulations and methods of fabrication of platelet-rich fibrin (PRF) and the effect on bone formation in different indications.[18] Based on the literature, they could not conclude that there was an improvement in ridge preservation, augmentation (based on histomorphometric evidence), or bone quality in sinus augmentation. Miron et al reached similar conclusions in 2017.[19] However, incorporation of PRF (Intra-Spin®, BioHorizons, biohorizons.com) does decrease washout of graft particles due to the ability to form "sticky bone" or "bone blocks" (Figure 4),[20,21] provide anti-infective capabilities,[22] and can enhance soft-tissue closure over the site.[23]

A recent retrospective case series of molar extraction sockets grafted with mineralized cancellous allograft demonstrated clinical and histologic success.[24] Horowitz and Kurtzman achieved preservation of alveolar ridge width and an enhanced amount of keratinized tissue after grafting and barrier placement. Using atraumatic extraction techniques,[25] the authors were able to preserve maximal blood supply and minimize damage to the facial plates of bone. Following available literature on techniques, grafts, and barriers[26] led to appropriate choices of materials and instrumentation in their cases. The crestal bone and soft tissue have held up well over time. The vital bone percentage where analyzed was 47% to 70%,[24] significantly higher than found with many other classes of bone replacement graft materials.

Clinicians and patients often prefer to avoid the use of autogenous bone harvesting for the treatment of deficient alveolar ridges. When ABBM is combined with recombinant human platelet-derived growth factor-BB (rhPDGF-BB), the literature has demonstrated turnover of ABBM, vital bone formation, and successful implant placement in dogs[27] and humans.[28,29] The technique in humans as described by Lee utilizes a tunnel approach with a remote vertical incision to deliver graft to the deficient site.[29] Incorporating this growth factor when hydrating the bone replacement graft mixture enables recruitment and differentiation of mesenchymal stem cells from the elevated but not incised periosteum.[30] Circumventing the use of an apical incision avoids damaging blood supply, eliminates chances of nerve injury,[31] and decreases swelling and discomfort.

Biphasic calcium sulfate maintains its shape and can set on insertion in a socket.[32] Its use can help preserve alveolar volume, enhance keratinized tissue, and enable vital bone formation in sockets. New research on a formulation with added hydroxyapatite has shown promise in alveolar ridge augmentation.[33] Silica-calcium phosphate nanocomposite is a bioactive TCP with sodium and silica ions. It is fully resorbable and has been shown clinically to preserve socket dimensions[34] and upregulate cellular markers of bone formation.[35] Unlike any other graft material studied so far, this material also has been shown to inhibit osteoclastic activity.[36]

> *Please visit compendiumlive.com/go/cced1979 to read the remainder of this article, view cases illustrating the application of bioactive bone grafting materials, and see the reference list.*


Fig 3.


Fig 4.

Fig 3. Bioactive silica-calcium phosphate composite being prepared into a leukocyte-PRF (L-PRF) block. **Fig 4.** "Sticky" bone of L-PRF block with mineralized cancellous allograft.