



Alveolar Ridge Augmentation Techniques for Implant Site Development

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Introduction

Placement of dental implants has become a common procedure among practitioners as patients seek a fixed, esthetic, long-term restorative solution at sites of missing teeth. Successful restoration of dental function and health utilizing dental implants requires several considerations. Of major importance is adequate width and height of alveolar bone for implant placement. A retrospective study of patients referred to a specialist for dental implant placement found 51.7% of the sites required additional bone augmentation.¹ Following tooth extraction the height and width of the alveolar bone is reduced. Approximately 50% of alveolar ridge width is lost one year after tooth extraction, with two-thirds of that loss occurring in the first three months.² Alveolar bone resorption following tooth loss or other pathologic or disease processes raises the question of how best to regenerate bone and augment edentulous alveolar ridges for future dental implant placement. The two most common methods currently used for alveolar ridge augmentation for implant site development are block grafting and guided bone regeneration using particulate bone graft.

Bone Graft Materials

Several types of bone grafting sources are available including autogenous, xenograft (different species), allograft (same species) and alloplast (synthetic) materials as discussed by McAllister.³ Xenograft, allograft and alloplast materials are available in plentiful quantities and, in contrast to autografts, do not require a harvest site which can reduce patient morbidity. Allograft materials can be divided into mineralized (freeze-dried bone allograft or FDBA) and demineralized (demineralized freeze-dried bone allograft or DFDBA) types. Xenografts and FDBA are mainly osteoconductive as they serve as a scaffold for vasculature infiltration and bone formation. A limiting factor to these materials is that they lack osteogenic (native cells that form bone) and osteoinductive (inducing mesenchymal stem cells to become bone forming osteoblasts) properties that autografts and demineralized allografts contain.³

Block Grafting

Block bone grafts are often used to augment moderately to severely deficient alveolar ridges. Block grafts may come from the same patient (autograft) or from another human donor source (allograft). Autogenous blocks can be retrieved intra-orally from the mandibular ramus, symphysis, or maxillary tuberosity or they may be harvested from extra-oral sites such as the iliac crest, tibia or calvarium. Mandibular block autografts were shown to provide 2.5 – 7 mm of ridge width increase at 6 month re-entry, with an average of 4.6 mm.⁴ Factors to consider when harvesting ramus block grafts are the potential for traumatization or de-vitalization of adjacent neurovascular bundles (e.g. inferior alveolar nerve), mandibular fracture and trismus. Possible complications associated with a symphyseal block graft are damages to the mental nerve, altered sensation of the mandibular anterior teeth and chin ptosis. Misch report-

ed graft resorption of up to 25% four to six months following placement of symphysis or ramus block autografts with 100% graft survival rate.⁵

Alternatively, allograft blocks eliminate the need for a second surgical site reducing patient morbidity and operative time. Keith⁶ studied mineralized block allografts in partially edentulous patients. No resorption was observed in 69% of subjects, however 0.5 - 2.0 mm of localized resorption around block fixation screws, or around the blocks themselves occurred in 31% of subjects. A case report by Lyford examined freeze-dried cancellous block allografts covered by a membrane and placed at five deficient sites. After 6 months healing time a gain of 2.0 - 4.0 mm in ridge width was achieved with these grafts. Despite the increase in ridge width, 1.0 - 2.0 mm of surface resorption was recorded at three out of five grafted areas⁷. These studies indicate that while autogenous and allograft blocks can successfully increase deficient ridge dimensions for future implant placement, a drawback is the associated potential for graft resorption.

Guided Bone Regeneration (GBR) Using Particulate Bone Graft

Guided bone regeneration is an alternative method to achieve hard tissue augmentation utilizing a barrier membrane. Successful GBR is based on the following criteria: 1) obtain primary closure of the tissue flap, 2) utilize a barrier membrane to prevent epithelial and gingival cell migration into the graft site, 3) stabilize the membrane, and 4) maintain the space under the membrane for bone regeneration.⁸ Barrier membranes serve to exclude epithelial cells from infiltrating the augmentation site, which can interfere with bone regeneration. If the intended graft space is maintained, the underlying blood clot remains undisturbed which allows initial immature woven bone to be replaced by mature lamellar bone during the bone healing and remodeling process. Buser⁸ described a staged approach to ridge augmentation in which autogenous bone was grafted under a non-resorbable membrane, tented with fixation screws and left to heal for approximately 9 months in two patients. After 9 months the membranes were removed, revealing adequate bone to allow for implants to be placed in the regenerated sites at this same appointment. This technique using particulate grafting with a membrane was shown in another study conducted by Buser to yield ridge width increases ranging from 1.5 – 5.5 mm.⁹

Barrier Membranes

Membranes used in guided bone regeneration are either resorbable or non-resorbable. Resorbable membranes are derived from sources such as bovine or porcine collagen, human amnion chorion, or synthetic polymers. These membranes are advantageous as they do not require removal, demonstrate good biocompatibility with the surrounding tissue and may reduce rates of incomplete wound healing. Disadvantages include rap-

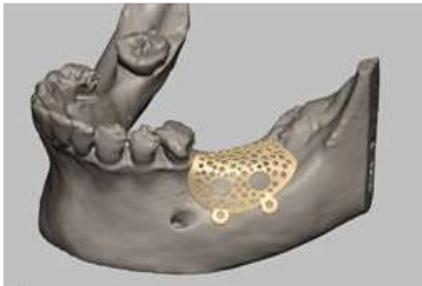
id degradation upon exposure to the oral cavity and potential of collapsing at the augmentation site due to a lack of rigidity. These membranes are often used in combination with a bone graft material to maintain the desired space. Non-resorbable membranes are traditionally made from expanded polytetrafluoroethylene (e-PTFE) material with or without titanium-reinforcement. Advantages of this type of membrane include graft outcome predictability¹⁰, a bio inert composition, rigidity for superior space maintenance, and the ability to remain in place for long periods of time which is often required when augmenting large sites. A higher potential for membrane exposure, along with required removal are disadvantages associated with this type of barrier.

Titanium mesh is another type of non-resorbable membrane originally used in neurosurgery for cranioplasty. Pieri¹¹ treated 19 alveolar ridge defects using commercially available titanium mesh. The titanium mesh was trimmed and fixated over a bone graft, resulting in mean vertical and horizontal bone gains of 3.71 mm and 4.16 mm respectively after 8-9 months of healing. Following 2 years of functional loading, all implants placed in regenerated bone were retained. As with other membrane types, titanium mesh exposure can be a common problem when employed with GBR. A study by Her¹² evaluated 26 patients for complications associated with titanium mesh used for ridge augmentation. A 26% mesh exposure rate (7 sites) was reported. The exposures however, did not prevent implant placement.

A Newly Developed Hard Tissue Ridge Augmentation Technique

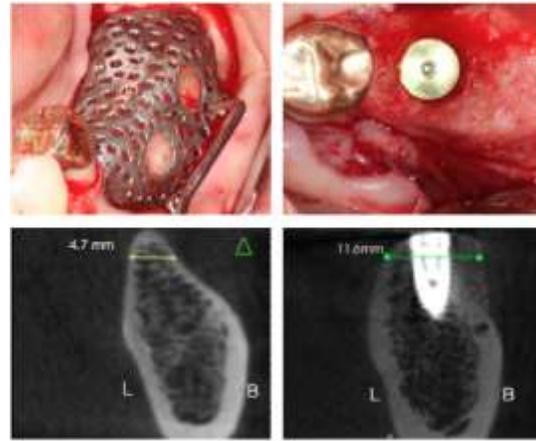
Advances in GBR using computer-aided design (CAD) and electron beam melting (EBM) have resulted in the creation of a novel bone augmentation technique using a custom titanium ridge augmentation matrix (CTRAM) in combination with a mineralized allograft (FDBA). Recently, in conjunction with the 3D Medical Applications Department, NPDS clinicians have utilized information digitally obtained from CBCT scans (stl files) to produce these customized matrices. Using the CBCT information with CAD and print capabilities allows practitioners to pre-surgically create a precise virtual model of the jaw upon which ideal bone dimension can be established.

The figure below shows the virtual jaw model created from the pre-surgical CBCT and the designed CTRAM for clinical use.



The combination of CT imaging and CAD technology to create CTRAM from virtual 3D models of the jaw allows for precise pre-surgical planning, resulting in an ideal augmentation

of the patient's defect. This technology enables 1) pre-surgical determination of required bone for ridge augmentation to facilitate future implant placement, 2) reduction of intraoperative time, and 3) application of the critical principle of rigid space maintenance.



The pictures above illustrate before and after bone augmentation with placement of implant

Summary

When bone reconstruction is needed due to alveolar ridge deficiency, the selection of the techniques and bone graft materials must be based on the recipient site, time available for graft maturity, size of defect, horizontal and vertical extent of the defect, surgical objectives, and the patient's desires.

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