Alveolar Ridge Augmentation

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ABSTRACT

Alveolar bone resorption is a common clinical problem that can occur physiologically and pathologically. Defects that occur due to loss of teeth due to extraction, advanced periodontal disease, trauma, long term use removable prosthesis, dehiscence and fenestration defects, developmental abnormalities of teeth, odontogenic cysts and tumors. Post extraction socket resorption can occur horizontally, vertically, buccal and lingual direction. Success of a dental implant can be affected by the width of the alveolar ridge, an indication of the amount of bone available to hold the implant. The objective of the study was to describe the hard tissue augmentation for treatment of alveolar ridge defect and the choice of material. Surgical reconstruction procedures for the preparation and placement of dental implants have been more numerous and complex. Various augmentation procedure can be used, the procedure has been categorized by defect dimensions: horizontally or vertically. Horizontal ridge augmentation can be performed using particulate or block grafts with or without barrier membranes. From the review evaluated the outcomes of horizontal and vertical augmentation procedures, that no specific technique was superior. The choice of materials should be based on the clinical indication.

Keyword: Alveolar ridge defect, augmentation, barrier membranes, bone graft, dental implant.

INTRODUCTION

Alveolar bone resorption is a common clinical problem that can occur physiologically and pathologically. Defects that occur due to loss of teeth due to extraction, advanced periodontal disease, trauma, long term use removable prosthesis, dehiscence and fenestration defects, developmental abnormalities of teeth, odontogenic cysts and tumors. Post extraction socket resorption can occur horizontally, vertically, buccal and lingual direction. A classification of alveolar ridge defects has been proposed (Seibert 1983, Allen et al. 1985, Wang & Al-Shammari 2002):
These resorption patterns form the alveolar ridge was not appropriate for optimal prosthodontic rehabilitation. Success of a dental implant can be affected by the width of the alveolar ridge, an indication of the amount of bone available to hold the implant. The objective of the study was to describe the hard tissue augmentation for treatment of alveolar ridge defect and the choice of material.

DISCUSSION

Surgical reconstruction procedures for the preparation and placement of dental implants have been more numerous and complex, on the size and morphology of alveolar bone defect. Various augmentation procedure can be used, the procedure has been categorized by defect dimensions: horizontally or vertically. The method used to increase bone width horizontal and vertical bone deficiencies including bone grafts and monocortical particulate block grafts. Barrier membrane can be used with bone graft to reconstruct all types of alveolar ridge defect. Repair alveolar ridge defect to the normal position, in terms of altitude and thickness, it is very important to achieve a harmonious balance between the biological condition of the tissue, function and aesthetic appearance.3,4

Barrier membranes.

Different types of barrier membranes have been tested for GBR. These membranes must fulfill specific criteria for promoting bone regeneration of the edentulous ridge, such as biocompatibility, cell occlusion properties, integration by the host tissue, and space making capacity. Their specific composition falls into two broad categories: non-resorbable and resorbable. ePTFE has been the most frequently used material for non-resorbable membranes in both periodontal and bone regeneration clinical applications. ePTFE membranes are flexible with an external porous structure allowing for tissue integration and an internal occlusive layer providing the barrier mechanism. They are composed of a chemically stable and biologically inert polymer that resists microbiologic and enzymatic degradation and does not elicit any immunologic reactions. To enhance the space making capacity of these devices, a titanium scaffold is applied between the two ePTFE layers, adding stiffness and reinforcing the membrane structure. These non-degradable barrier membranes require a second surgical intervention to remove them. This disadvantage, together with the high occurrence of postoperative complications, mainly from early membrane exposure, has limited their clinical use and has led to the development and broader use of resorbable membranes.5

Bioresorbable membranes must ensure that the tissue reactions during the process of membrane resorption or biodegradation are minimal and do not affect the outcome of bone regeneration (Hardwick et al. 1995). Several bioresorbable materials have been tested with varying success in bone regeneration applications. Bioresorbable membranes are either natural (xenogeneic collagen type I or III) or made of synthetic polymers, including polyurethane, polylactin 910, polylactic acid, polyglycolic acid, polyorthoester,
polyethylene glycol, and different combinations of polylactic and polyglycolic acid (Sandberg et al. 1993; Zellin et al. 1995; Brunel et al. 1998; Jung et al. 2006). When inserted into an aqueous environment, such as a biologic system, the biodegradable polymers undergo enzymatic degradation by hydrolysis. The natural collagen membranes undergo resorption by enzymatic degradation. 

Several experimental studies have compared the potential of these barrier membranes for promoting bone regeneration. When non-resorbable ePTFE membranes were compared with synthetic bioresorbable membranes made of poly d,l-lactide-co-trimethylen-carbonate, significantly more bone was formed around implants covered with ePTFE membranes, although both test and control implants exhibited new direct bone-to-implant contact (Hurzeler et al. 1997). These differences are mainly due to the lack of stiffness and space-making capacity of bioresorbable membranes, which when placed directly over the implant threads, tend to collapse and occlude the space available for bone regeneration. This problem is usually overcome by using a scaffold or graft material under the membrane that provides the space for tissue ingrowth and subsequent bone formation. Experimental studies comparing non-resorbable and collagen resorbable membranes, with and without the use of a scaffold, have shown similar bone regenerative outcomes for the non-resorbable membranes and the collagen resorbable membranes used with a scaffold (Hurzeler et al. 1998). 

The choice of membrane material usually depends on the amount of bone regeneration needed, mainly in the vertical dimension. ePTFE barrier membranes have demonstrated more favorable results when compared with resorbable devices, mainly due to their better space making capacity, longer barrier function, and lack of a resorption process that may negatively affect bone formation (Hämmerle & Jung 2003). Nevertheless, a high rate of soft tissue dehiscence was observed with the use of ePTFE membranes. When this complication occurs, early contamination of the exposed membrane usually jeopardizes the regenerative outcome. A metaanalysis evaluating the influence of membrane exposure on the outcomes of regenerative procedures reported that new bone formation was six-fold greater when no soft tissue dehiscence occurred (Machtei 2001).
As already mentioned, these frequent complications and the need for a second surgery to remove the membrane with non-resorbable membranes make resorbable membranes the current gold standard, provided they are used with an adequate space making graft material.\textsuperscript{5}

**Bone grafts.**

Autogenous bone grafts (autografts) have historically been the gold standard in bone regeneration therapies since they have well-documented osteoconductive, osteoinductive, and osteogenic properties (Yukna 1993). In alveolar bone augmentation surgeries, autogenous bone is used either as a particulate or a block graft. Particulate bone grafts are normally har- vested from intraoral sites and used in combination with barrier membranes following the principles of GBR. These bone chips have the disadvantages that their availability is limited within the oral cavity and, as they lack a rigid and supportive structure, they do not provide the space making capacity necessary for the treatment of class II and III defects. In these cases, rigid titanium-reinforced ePTFE barrier membranes or other space maintenance strategies, such as tenting screws or microimplants, have been used in conjunction with particulate bone autografts. Another drawback with the use of autografts is their fast resorption rate, which requires early implant placement to assure functional loading to the regenerated bone, thus preventing its resorption.\textsuperscript{5}

Monocortical block autografts may be harvested from intraoral or extraoral sites. Common intraoral donor sites are the mandibular chin or the ascending ramus area, whereas common extraoral donor sites are the iliac crest or the calcuta. They may be used

![Figure 2. (a, b) Use of an allograft block in the posterior maxilla. (c) Re-entry after 6 months. (d) Histologic evaluation of the regenerated bone shows significant osteoconductivity and incorporation of the allograft block particles with new/vital bone. Use of block grafts to overcome severe horizontal ridge deficiencies have proven very predictable.](image-url)

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in combination with barrier membranes or alone, and they require fixation to the recipient crestal site with mini screws to avoid micro movements during healing. These grafts, due to their excellent space maintenance capacity, are indicated in large crestal defects in which there is a need for vertical bone augmentation. Their main disadvantage is the morbidity associated with their harvesting, mainly from the chin area. As with particulate autografts, their resorption rate is high, although when combined with a barrier membrane or with bone particulate xenografts, resorption is slowed.5

**Bone substitutes.**

In order to avoid the morbidity associated with the harvesting of autogenous bone grafts, allografts, xenografts, and alloplasts have been indicated and tested.5

Allografts are bone grafts harvested from cadaver donors and processed by freezing or demineralization and freezing. These grafts are then sterilized and supplied by specially licensed tissue banks as bone particles or large blocks. Demineralized freeze-dried bone allografts (DFDBAs) have shown osteoconductive as well as osteoinductive properties due to the release of bone morphogenetic proteins (BMPs) during the demineralization process. There is some concern, however, regarding their absolute non infectivity, although there have been no reported cases of disease transmission from DFDBAs used for dental purposes among over 1 million cases over 25 years (Yukna 1993). These allografts are usually used in combination with barrier membranes following the principles of GBR.5

![Figure 3](image)

**Figure 3** (a, b) Class 2 defect (Selbert). (c–e) Implant placement and horizontal guided bone regeneration procedure with deproteinized bovine bone mineral + non-cross linked collagen membrane. (g) Implant supported prosthesis.5

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Xenografts are graft biomaterials of animal origin, mainly bovine and equine. These graft materials are deproteinized in order to completely remove the organic component and thus avoid any immunogenic reaction. This chemical or low heat process preserves the original bone architecture and the inorganic mineral composition, which assures the osteoconductive properties of the biomaterial. Inorganic bovine bone grafts are usually particulate and utilized according to the principles of GBR in combination with resorbable collagen membranes. Different preclinical and clinical studies have demonstrated their safety and efficacy as bone substitutes for both periodontal and peri-implant augmentation procedures (Baldini et al. 2011). Recently, highly purified porcine collagen type I has been added to xenografts to enhance their clinical handling by improving the cohesion between the mineral granules.\(^5\)

Alloplasts are synthetic bone substitutes that include different combinations of calcium phosphates fabricated under different sintering conditions, which yields different physical properties and resorption rates. The combination of hydroxyapatite and beta-tricalcium phosphate (\(\beta\_TCP\)) provides a scaffolding function (hydroxyapatite) as well as osteoconductive properties (\(\beta\_TCP\)). These biomaterials are usually resorbable and delivered as granules. They should be always used in combination with barrier membranes.\(^5\)

**Horizontal ridge augmentation,**

Horizontal ridge augmentation can be performed using particulate or block grafts with or without barrier membranes (Fig. 50-7). The use of particulate grafts together with barrier membranes (GBR) is especially indicated in conjunction with the placement of an implant in class I defects, when there is enough bone width to allow good implant primary stability. In severe class I defects, a delayed bone regeneration approach (staged) is indicated and a block graft is often advocated to assure enough space maintenance to allow significant horizontal augmentation. Both GBR and block grafts have been demonstrated to be a successful and predictable treatment modality to augment a horizontally deficient ridge (Florellini & Nevins 2003; Schwartz & Arad & Levin 2005; Schwartz & Arad et al. 2005). According to Donos et al. (2008), the implant survival rate for staged GBR was 99–100%, while that for one-stage ridge augmentation was 87–95%, but this systematic review was hindered by a lack of randomized clinical controlled trials and heterogeneity of the available studies, thus restricting the number of studies included in the systematic review.\(^5\)

The use of autografts is currently somewhat limited due to the morbidity associated with their harvesting and their high resorption rate (mainly when used as bone chips). The use of bone substitutes, mainly of xenogeneic origin, together with resorbable membranes (collagen), has demonstrated good results in one-stage or delayed horizontal bone augmentation techniques with minimal patient morbidity and few postoperative complications. Moreover, these xenogeneic grafts have a very slow resorption rate, which assures their long-term stability.\(^5\)
Vertical ridge augmentation.

Moreover, the available studies are very heterogeneous and with relatively small sample sizes, which limits the ability to draw valid conclusions. From the limited information available, it appears that vertical augmentation is a highly technique-sensitive procedure which may give successful treatment outcomes, like adequate gain in vertical bone height and successful implant placement (Fig. 4).⁵

A recent systematic review evaluated clinical outcomes of vertical bone augmentation to enable dental implant placement (Rocchietta et al. 2008). The review evaluated clinical, histologic, and long-term outcomes of implants placed in vertically regenerated bone and identified three main groups of vertical bone augmentation techniques: (1) GBR (seven studies), (2) onlay bone-block grafting (five studies), and (3) distraction osteogenesis (13 studies). The lack of clinical trials, the heterogeneity of the studies, and the small sample sizes limited the ability to perform any metaanalysis, although the authors reported that there was clinical and histologic evidence corroborating that vertical ridge augmentation may be achieved successfully. Nevertheless, a broad range of technique-related complications
were highlighted. For GBR, the reported complication rates were 0–45.5% and complications were mainly related to membrane exposure. For distraction osteogenesis, complication rates were higher (10–75.7%), and complications included fractures or infection of the distractor, neurologic alterations, fractures of the distracted or basal bone, and lingual or palatal inclination of the distracted bone. Minor complications were reported after onlay block bone grafting and these were related to the morbidity from harvesting the block and graft shrinkage. These results are consistent with data from an earlier systematic review that evaluated the outcomes of horizontal and vertical augmentation procedures (Esposito et al. 2009). From this review it was concluded that no specific technique was superior and the complexity of these techniques and the high frequency of complications was highlighted.5

There are several published case series demonstrating the possibility of attaining a significant vertical bone augmentation, but also highlighting the technical difficulties and the high number of postoperative complications of this technique. In a small clinical study, six partially edentulous patients were recruited and 14 implants were placed leaving the coronal third exposed circumferentially. Autogenous bone grafts covered with titanium-reinforced ePTFE membranes were used to cover the implants and the flaps were raised to allow for a submerged healing. An average of 4.95 mm of bone height was gained after 12 months in areas where the membranes were not exposed (Tinti et al. 1996). In a similar study, Simion et al. (1994) placed implants protruding 4–7 mm above the bone crest in five patients. ePTFE membranes were used to cover the exposed implant threads. At 9 months, the histologic assessment showed bone formation up to 3–4 mm above the previous bone crest and the implant fixture was osseointegrated with the new bone. In a multicenter long-term study, Simion et al. (2001) evaluated the survival rate of implants placed at the time of the vertical ridge augmentation. The 123 implants with 2–7 mm of exposed implant thread were assigned to three groups: titanium-reinforced ePTFE, allograft, and autograft. The overall implant success rate was 97.5% in the group with ePTFE membranes, and this was the group demonstrating the least amount of bone loss.5

Choice of material.

This choice should be based on the clinical indication. For small bone defects requiring mainly horizontal bone augmentation, the use of xenografts and allografts has demonstrated excellent results. The use of xenografts with a much slower resorption rate demonstrated significantly better preservation of the socket walls than the nongrafted sites. Histologically, these xenograft granules were integrated and fully surrounded by newly formed bone (Araújo & Lindhe 2009). In a similar experimental model, a βTCP alloplast demonstrated limited bone promotion properties, with the graft particles being encapsulated with connective tissue (Araújo et al. 2010).5

In crestal defects requiring horizontal augmentation, particulate bone grafts should be utilized in combination with barrier membranes. Experimental studies testing different graft materials [biphasic hydroxyapatite + βTCP (BCG)] or collagen-coated deproteinized bovine bone mineral (DBBM) (BOC) showed that both biomaterials increased bone fill and
the percentage of osseointegrated bone graft particles, and it was concluded that both BCG and BOC provide an osteoconductive scaffold to support GBR procedures at dehiscence type defects (Schwarz et al. 2007).6

In large crestal defects for which the aim is both horizontal and vertical bone augmentation, the use of monocortical autogenous corticocancellous block grafts is recommended.

CONCLUSION

From the review evaluated the outcomes of horizontal and vertical augmentation procedures, that no specific technique was superior. The approach is largely dependent on the extent of the defect and specific procedures to be performed for the implant reconstruction. The choice of materials should be based on the clinical indication.

REFERENCES