Thin alveolar ridges prevent dental implant placement. A variety of autogenous, allografts, xenografts, and alloplastic onlay grafts, alone or in different combinations, have been used to provide sufficient ridge width for proper positioning of endosseous implants.

Disadvantages with the iliac crest donor site include significant resorption, patient morbidity, and high costs due to hospitalization and general anesthesia. Early placement and loading under function of dental implants within iliac crest onlay bone grafts have shown to markedly decrease progressive resorption of the graft and maintain a significant quantity of bone and a high percentage of stable functional implants over the long term.

Symphyseal or ramus grafts from the mandible seem to undergo less resorption due to a thick cortical layer and rigid three-dimensional structure. Complications associated with harvesting symphyseal grafts include a limited amount of donor bone, damage to the anterior dentition, and sensory nerve disturbance in up to 10% of patients.

Barrier membranes placed over bony defects allow cells from the adjacent bone to populate the space under the membrane and generate bone under the membrane. Successful lateral ridge augmentation using a combination of block and particulate symphyseal or ramus bone in conjunction with barrier membranes has been reported. Complications with membranes include tissue dehiscence, membrane displacement, and membrane collapse reducing the volume of the graft. Long-term evaluation of osseointegrated implants in vertically regenerated bone using the principles of guided bone regeneration with autograft or allograft showed that the regenerate bone responds to implant placement similar to nonregenerated bone.

Particulate autogenous bone has been used to augment the mandible. Control of the surgically expanded soft tissue volume is believed to prevent resorption of graft material over the long term. With the procedure described by Marx, a full-thickness periosteal reflection of the bone is performed, and dental implants up to 15 mm in length are placed to create, control, and maintain the periosteum from the bone. Bovine bone mixed with autogenous particulate bone combined with tissue sealant (fibrin glue) has been reported as a successful method to augment the horizontal dimension of the ridge, using an open approach to place the material.

Hydroxylapatite augmented ridges are infiltrated with bone several years after ridge augmentation. This osteoconductive material, when placed under periosteum using a simple tunneling technique, is eventually infiltrated with bone. Implants have been placed successfully into hydroxylapatite augmented ridges 5 to 10 years after the ridges have been augmented.

Human mineralized cancellous bone can be used for preservation of ridge width after tooth extraction. By preserving the space that was previously maintained by the presence of the tooth, the particulate graft, after 4 months, has excellent ridge width and sufficient preservation to place wide-diameter implants. Severe labial bone loss was reconstructed at the time of tooth extraction with particulate material. The advantage of this material is that it is slowly resorbed.
and replaced with bone, maintaining space and the mineralized graft material’s osteoconductive properties.

Based on our review of the literature, common themes persist. If the periosteum is raised and the space is maintained with an osteoconductive material, bone ingrowth into the space can occur. For dental implants, it is desired to have a high density of bone formation within the augmentation without excessive loss of volume during the remodeling phase of the augmentation material. The ideal ridge augmentation material for implant reconstruction has the following characteristics:

- The graft material should be able to maintain space for the time necessary to achieve bone ingrowth and implant healing. Bone ingrowth should be rapid and of sufficient density for implant stabilization.
- The resultant ridge augmentation should be stable over the time for graft consolidation and implant integration, which may take 6 to 8 months.
- The resultant ridge augmentation should be stable after the implants have been restored, without evidence of bone loss.
- The graft material should be able to promote osteoconduction of the neighboring cells to form bone within the augmentation.
- The bone augmentation material should be able to be remodeled into long-lasting bone based on the functional matrix theory.
- The material should have ease of placement to avoid patient morbidity.
- The material should have predictability, with an incidence of success at least equal to onlay grafts.

The technique used for horizontal augmentation is similar to the ridge augmentation methods described for hydroxylapatite augmentation of the edentulous ridges. Because of the bone ingrowth found within hydroxylapatite-augmented ridges, without the use of membrane barriers and the evidence of the osteoconductive nature and slow resorption found with mineralized bone particles, a subperiosteal tunneling approach with placement of the particulate graft material directly on bone is performed in patients whose alveolar ridges have sufficient height but insufficient width for implants. This graft technique results in bone formation sufficient to allow placement of at least small-diameter implants, with maintenance of the newly formed bone after final restoration.

Patients are selected for this procedure if they have satisfactory vertical height of the posterior alveolus superior to the inferior alveolar canal but less than 4 mm of bone width. The patients are warned that particulate grafts may resorb and may not result in sufficient bone for augmentation. If this happens, onlay grafting with ramus or symphyseal bone is performed. In a consecutive series of 35 patients by this author, onlay grafts were not required because the resultant ridge width was sufficient for the placement of at least small-diameter implants. However, there was a 2% incidence of implant failure in the grafts and a 5% incidence of isolated graft resorption adjacent to a natural anterior tooth near the incision that resulted in a ridge that was too thin for implant placement.

The patient who is a candidate for the proposed particulate onlay procedure should have adequate vertical height but lack horizontal width. In addition, the shape of the thin crest should widen as the ridge approaches basal bone, with the resulting thin ridge forming a medial wall and the wider inferior aspect forming a “floor” for the graft. This two-wall type defect is ideal for this procedure.

**Surgical technique**

Topical anesthesia is placed over the edentulous ridge. Up to 3.6-ml of 2% Xylocaine with 1:100,000 epinephrine is infiltrated into the edentulous ridge as a hydropic dissection, limited laterally to the external oblique ridge and posteriorly up to the retromolar pad, without violation of the peripheral muscle attachments (Fig. 1A). Ten minutes are allowed before starting the surgery.

The general principle for choosing the incision location is to keep the incision away from the planned tunnel and to allow for tension-free closure. If the incision is too close to a natural
Fig. 1. (A) Patient presents with thin right mandibular posterior ridge with less than 3 mm width determined by probing. Treatment plan is for an implant-supported, three-unit prosthesis. The arrows point to the area of the planned augmentation. Local anesthesia is administered only in these areas to perform a hydropic dissection. (B) After administration of local infiltrative anesthesia, a small vertical incision is made, and a conservative subperiosteal tunnel is created. Care is taken to preserve lateral and posterior muscle attachments. (C) For this patient, 1-ml of human mineralized cancellous bone (350–500 μm diameter) was placed into a 1-ml syringe with the tip cut at a bevel. The graft was placed into the tunnel directly on the bone and compacted to form a firm augmentation. (D) The graft is compacted firmly into the tunnel. Note the graft augmenting the area adjacent to the premolar tooth. (E) Resorbable sutures were used to close the incision. Note the obvious augmentation. (F) After 16 weeks to allow for graft consolidation and bone formation, the patient returns for implant placement. The ridge palpates firm and resists penetration with a small needle. (G) The augmented ridge before placing the implants. Note the vascularity of the new bone. (H) The implants were placed requiring at least 35 N-Cm torque as per the drilling console. (I) A 2-year, post-restored radiograph showing excellent bone preservation at the implant sites. (J) The final prosthesis, fabricated after 4 months of healing of the implants in the graft.
tooth, closure is difficult after the augmentation due to the tenting of the tissue from the graft. An anterior location may be useful.

The incision to access the thin ridge is made starting on the superior aspect of the crest running inferiorly in a vertical fashion (Fig. 1). The incision can also be placed inferior to the superior crest region but should not cross the attached tissue on the crest into the lingual mucosa. If the incision enters the loose lingual mucosa, then closure is more difficult, and incision breakdown may occur.

Using a small, blunt-ended periosteal elevator, a subperiosteal tunnel is developed posteriorly to create a well-defined pocket. Care is taken to avoid excessive dissection, keeping the dissection limited to the external oblique ridge and anterior to the retromolar pad without violating the peripheral muscle attachments. At the crest of the ridge, the periosteum is elevated slightly over the ridge to release the periosteal attachment of the lingual mucosa at the crest. It is critical to avoid excessive lingual dissection to maintain a well-defined tunnel for graft placement and to prevent migration of the particles after placement. At the site of the incision, the tissue is gently reflected anteriorly to allow for tension-free closure.

After the subperiosteal tunnel is formed, the particulate material, ranging in volume from 0.5-ml for two tooth sites to 1.5-ml for missing premolars and molars, is placed. Most posterior edentulous ridges require 1-ml of graft material. The tip of a plastic 1-ml tb-type syringe is removed at an angle to form a bevel; this is similar to the syringes used in the past for hydroxylapatite augmentation.

The human mineralized bone graft material is hydrated and mechanically placed into the 1-ml syringe(s). The particle size used by this author ranges from 350 to 500 $\mu$m. Smaller particle sizes tend to flow with the blood, and larger sizes can pierce the overlying mucosa due to sharp edges.

For larger (1.5-ml) augmentations, two syringes are used to facilitate the surgery. With the aid of gentle retraction using a small periosteal elevator, the syringe is inserted, bevel down, into the subperiosteal tunnel; care is taken to place it directly onto bone. The syringe is advanced to the most posterior aspect of the planned augmentation. With gentle pressure, the graft material is extruded from the syringe and firmly compacted in position, forming a dense graft. Digital
pressure is used to mold the graft along the thin ridge to achieve the desired shape of the lateral ridge augmentation. The incisions are closed using interrupted resorbable sutures. Patients are placed on antibiotics and analgesics. No prostheses are allowed over the grafted sites for 4 months. The patients are instructed to ingest a soft diet without chewing on the grafted side and are followed weekly and then monthly.

Usually, the thin ridges have a 5- to 8-mm lateral ridge augmentation immediately after placement of the material, with subjective evaluation indicating maintenance of at least 50% of the augmentation 4 months later. A few patients may be prone to more resorption and a few to less resorption. The best results are in patients with obvious two-wall–type morphology (Figs. 2–7).

Fig. 2. (A) A 78-year-old woman with two premolars in need of extraction and a thin ridge posterior. The patient desires a fixed restoration in this quadrant. (B) A vertical incision was made anterior to the first premolar, combined with a sulcular incision around the necks of the two teeth planned for extraction. A subperiosteal tunnel was created for the posterior ridge augmentation. Care was taken to avoid excessive stripping laterally. (C) Approximately 1-ml of human mineralized bone was placed into a 1-ml syringe and compacted firmly into the posterior subperiosteal tunnel. (D) The graft has been placed into the extraction sites in preparation for placing implants after 4 months of healing. Note the posterior extent of the graft. (E) The periosteum has been scored to allow for a tension-free closure over the extraction sites. Note the clearly defined posterior extent of the graft. (F) After allowing 4 months for graft consolidation, a crestal incision was made to expose the graft site. Three implants have been placed. Note the clear demarcation of the graft, which is similar in position as seen in Fig. 2E.
Summary of clinical results

Incision healing

The incisions heal uneventfully in 75% of patients, with small incision breakdown and loss of a small amount of the graft adjacent to the incision. The open incisions heal within 7 days by secondary intention. Open incisions are treated with gentle irrigation and the use of a gentle mouth rinse until the sites heal.

Ridge “feel”

The ridges are firm to palpation within 2 weeks and are “bone hard” after 3 months. At 3 months, radiographs are taken, and the patients are scheduled for fabrication of the surgical guide stent and implant placement. After 4 months, graft resorption may occur, and the graft site can decrease in width, similar to autogenous grafts.

Implant placement observations

Four months after ridge augmentation, implants are placed into the grafted ridges. For implant placement, a crestal incision is made combined with anterior and posterior vertical release if necessary, followed by full-thickness periosteal reflection to expose the ridge. After confirmation of at least 5 mm of ridge width, implants are placed; the number and location are dependent on the prosthetic plan. In 10% of patients, the ridge was too narrow in the site immediately adjacent to the most anterior tooth (canine or premolar) secondary to loss of graft from incision dehiscence, but the ridge was sufficient two teeth distal from the adjacent tooth for implant placement. In these ridges, the anterior tooth in the posterior restoration is typically cantilevered forward based on two premolar- and molar-positioned implants.
Fig. 4. (A) This photograph was taken after administration of local anesthesia. This ridge palpated to no greater than 2 mm in width. The treatment plan called for a graft and an implant for a single tooth restoration. (B) For the placement of the particulate graft, an incision was made under the adjacent tooth in the loose mucosa, and a subperiosteal tunnel was created over the labial aspect of the thin ridge. The previous concave ridge profile was easily converted into a convex profile by the periosteal elevator. (C) Approximately 0.5-ml of human mineralized bone was placed and compacted firmly to over-augment the ridge. The resultant graft created a ridge width approximating 6 mm. (D) Four months after the graft was placed, local anesthesia was infiltrated into the edentulous site, and a crestal incision was made to expose the grafted ridge. The resultant ridge measured 4.5 mm in width. (E) A 3.25-m diameter implant was placed with no implant dehiscence. Bone covered all of the implant and was solid during the placement process.
Fig. 5. (A) An 80-year-old woman was referred for extraction of the second premolar and augmentation of a thin posterior ridge and placement of three implants for a fixed restoration. (B) An enlarged panoramic radiograph showing the premolar root approximately 3 mm from the mental foramen. The surgical plan was to graft the extraction site and perform an open ridge augmentation posteriorly. (C) A crestal incision was combined with a vertical incision to expose the ridge. The tooth was extracted. (D) Particulate bone was placed to augment the thin ridge and to graft the extraction site (arrows). (E) After 4 months, implants were placed and then exposed 4 months later. Shown are the bone around the extraction site and one implant within the augmented bone.
Fig. 6. (A) A 55-year-old woman was referred for extraction of the mandibular left two premolars and third molar, combined with extraction site grafts and horizontal ridge augmentation in the thin edentulous region. Note the extensive radiolucency in the site of the first premolar. (B) Clinical view showing the thin ridge in the edentulous region, to be later compared with the resultant ridge in Fig. 6H. (C) The teeth were extracted, and the sites and ridge were augmented. Shown is the augmented ridge 4 months after graft placement. (D) The panoramic radiograph was taken immediately before placing the implants. Note the lower radiodensity in the region of the first premolar. (E) The ridge was exposed and the augmentation seemed to be adequate for the placement of three implants. The bone at the anterior implant site was softer than the posterior two implant sites. (F) Three implants were placed. (G) At the time of implant exposure 4 months later, the anterior implant was found to have minimal integration and was removed. The final restoration was fabricated on the posterior two implants placed into grafted sites. (H) The final restoration with a pontic cantilevered anteriorly. Note the excellent ridge form and bulk in the area of the previously thin ridge.
Fig. 7. (A and B) Right and left thin posterior ridges in a patient who desires fixed restorations rather than her removable partial denture. Bilateral ridge augmentations were performed placing 1-ml of particulate human mineralized bone into subperiosteal tunnels. (C and D) Four months after grafting, crestal incisions were made and implants placed, with two implants on the right and three implants on the left. Note the excellent bone width present around the implants. (E) Periapical radiographs 2 years after placement of the final restoration, showing excellent bone levels in the sites of the augmentation. (F) Final restoration. Note the excellent gingival response and ridge bulk.
Augmentation of the bone within 5 mm of the adjacent tooth is difficult to achieve because of the usual gradual decrease in ridge width from the tooth to the thinner part of the ridge and the difficulty maintaining the graft adjacent to a tooth (eg, the first premolar location adjacent to a canine). Patients took narcotic pain medication for up to 4 days, with a majority only needing non-narcotic medication.

The resultant augmentation has been sufficient for at least the placement of small-diameter implants. Implants are exposed after 4 months for integration. Failures have occurred in sites requiring grafts in large lytic areas of bone loss involving the lateral portion of the alveolus.

Follow-up examinations 2 years after restoration placement indicate stable facial bone levels as indicated by the pockets no greater than 3 mm in depth and pain-free function.

Summary

The successful use of onlay grafts using ramus or symphyseal bone is well known. However, these procedures carry with them a level of morbidity, which can be a negative for the patient and the referring restorative dentist. Our choice of which procedure to use is on the basis of which procedure can provide the necessary goal with less morbidity. The procedure described in this article is performed efficiently in the office setting with local infiltrative anesthesia and with minimal patient morbidity. If this procedure fails, then a conventional onlay graft can be performed.

A similar procedure has been reported using bovine bone combined with autogenous chips. The authors report using a fibrin glue product to retain the graft’s form because they used an open approach to access the ridge. Our results are similar to those reported with bovine/autogenous bone product.

In our patient series, this procedure has been predictable and has allowed patients a less morbid alternative. It is anticipated that not all augmentations will be successful and that in the future other materials may prove to be excellent. Long-term follow-up is important to complete the evaluation of this method.

Further readings


