Interpositional Osteotomy for Posterior Mandible Ridge Augmentation

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This report reviewed the published data concerning different methods for vertical augmentation of the posterior mandible for implant placement. The main purpose was to compare and contrast the different treatment methods, with a more detailed review of the use of the interpositional osteotomy to vertically augment the posterior mandible. After the data review, we present a case illustrating this method. On the basis of the data review, the use of the interpositional osteotomy might be the method of choice for select patients.

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Patients often request fixed dental implant restoration of missing posterior teeth in the mandible, defined for the present report as the region posterior to the mental foramen. This region has obvious limitations for implant placement, including bone deficiency and the presence of the inferior alveolar nerve (IAN) within the body of the mandible.

After the teeth are removed, a continuous resorptive process of the alveolar ridge occurs that is accelerated by denture wear1 and is the most pronounced during the first 12 months after the extractions.2,3 The continuing resorption of alveolar bone will eventually result in less than ideal bone superior to the IAN, preventing dental implant placement without performing augmentation of alveolar bone height. Augmentation of the bone superior to the IAN should provide sufficient bone for implant placement and long-term successful restoration of missing teeth with fixed implant borne prostheses. All suggested methods should consider patient-related issues, including pain, swelling, sensory nerve disturbances, the incidence of graft failure and resorption, and the functional restoration long term.

Techniques Available, Historical Perspective, Advantages and Limitations

NERVE REPOSITIONING

Repositioning of the IAN consists of exposing the nerve from a lateral approach with its release from the canal, and moving it laterally from the cancellous space, allowing implants to be placed to the inferior border of the posterior mandible. Surgical exposure and moving the nerve laterally results in a high incidence of sensory nerve disturbance and an excessive crown-to-root ratio of the prosthesis.4-11

SHORT IMPLANTS

One question is whether short implants can be used when no more than 5 mm of bone is above the IAN. Mechanical studies using cylindrical implants of different width and lengths have indicated that mechanical pull-out resistance is inversely proportional to the length of an implant, but not its diameter.12,13 Previous reports have indicated that more failures occurred in the posterior mandible with short implants.14 Short implants lead to a poor crown-to-root ratio and compromised the results of the final prosthesis, depending on the type of prosthesis used and the interarch distance.15,16 On the basis of the evidence available regarding the success with short implants, the shortest implant length for the posterior mandible was traditionally recommended to be 10 mm.16 However, recent improvements in implant design, especially in thread specifications, and improvements in implant surface characteristics, have been shown to be effective for implants 8 mm or shorter in length for the posterior mandible, after completion of evidence-based clinical series with long-term follow-up.
ONLAY GRAFT PROCEDURES

Grafting bone on the superior surface of the residual alveolar cortical bone is accomplished by first gaining access to the cortical bone, placing and securing a bone graft to the region to be augmented, and closing the soft tissue. Various graft materials have been used, including iliac crest cortical and cancellous bone, calvarial bone, symphyseal and ramus bone, and banked bone, including both allograft and xenograft. The grafts have included blocks of material, particulate material with membrane coverage, or combinations of both. The advantage of using an onlay graft is avoidance of direct damage to the IAN, ease of placement of the graft, and immediate postoperative vertical augmentation. However, incision breakdown over the graft can result in a reduction of the long-term augmentation, especially when using grafts composed predominantly of cortical bone.1,17-20 Grafts composed of corticocancellous bone blocks from the iliac crest resorb rapidly during the remodeling process; hence, the implants must be placed in a timely manner, typically between 3 and 4 months after iliac crest block augmentation.

Bone resorption resulting in loss of bone augmentation height has been reported by Cordaro et al.18 Onlay block grafts from either the ramus or chin lost 41.5% of height during the first 6 months. Bell et al.14 accessed the severely atrophic edentulous mandible using an extraoral approach and placed corticocancellous block grafts from the posterior ilium. The vertical bone height increased in the posterior mandible from 5 to 8 mm; however, after 4 to 6 months, 3 mm of bone was lost in the posterior mandible (23% loss). Because of vertical bone resorption in these cases, implants were placed only in the anterior mandible.

Proussaef et al19 and Proussaef and Lozada20 performed intraorally harvested autogenous block grafts for vertical alveolar ridge augmentation. Their results showed a vertical augmentation at 1 month after surgery of 5.75 mm and a vertical augmentation at 4 to 6 months after surgery of 4.75 mm. The total bone loss during the first 6 months was 17.4%.

Pikos21 used block grafts harvested from intraoral sites to augment the posterior mandible 6 mm. Pikos22 allowed 5 months for graft healing before implant placement and reported 0% to 20% graft resorption provided no flap dehiscence occurred.

Chiapasco et al15 reported using either distraction osteogenesis (DO) methods or rigidly fixated autogenous block onlay grafts from the ramus. The DO group showed an average increase in the vertical height of the mandible of 5.3 mm versus 4.6 mm for the onlay group. The results of their study showed that DO had a clinically similar bone response to that with traditional onlay grafting. No differences were found in bone resorption after the implants were placed.17 Perry et al22 also compared DO and onlay grafting. The results in a canine model were similar to those from the study by Chiapasco15 and showed no significant difference between DO and onlay grafting.22

Particulate Bone Augmentation With Membranes

The use of particulate bone with membrane coverage allows for both horizontal and vertical augmentation of the mandible. The membrane is designed to prevent infiltration of the particulate graft with connective tissue and allow bone to infiltrate into the particulate graft mass rather than connective tissue, with the formation of bone sufficient to support implants and, through implant functional loading, retain the bone that has formed.25 A total of 3 to 6 mm of vertical bone augmentation has been reported.23-24 A modified technique using dental implants left supracrestal as “tent poles” with graft material packed around the implants resulted in stable bone formation, especially when a titanium-reinforced titanium membrane was used.25

One of the major concerns with particulate bone with membrane is that postoperative bone graft resorption is inhibited only as long as the membrane is in place but begins to resorb once the membrane is removed.25-27 Therefore, numerous investigators have advocated leaving the membranes in place for 9 months before exposure and implant placement.23-24,28 or leaving the membrane in place for up to 12 months.29

The main disadvantage of the use of membranes is the premature exposure of the membrane through the mucosa. The subsequent infection of the grafted site will inhibit bone formation.15,16,29 The percentage of premature membrane exposure has ranged from 0% to 37.5% (Rasmusson et al,25 0%; Tinti et al,29 13.6%; Artzi et al,24 20%; and Chiapasco et al,15 37.5%).

The use of metallic mesh has been advocated to form and retain a particulate graft for vertical ridge augmentation. Boyne et al50 used mesh to form a new maxillary ridge in patients with anterior combination syndrome and others with an atrophic maxillary ridge. When the mesh did not become exposed early after placement, the bone formation was predictable. When the mesh became exposed during the healing process, it required removal, which, depending on the interval from placement, resulted in good or poor bone ridge augmentation. The use of smaller mesh pores and more flexible mesh for posterior mandibular ridge augmentation has shown excellent results,
but the exposure of the mesh is still a factor to consider.51 The use of a mesh-type material with a combination of graft materials, such as allograft, xenograft, synthetic scaffolds, and growth factors (bone morphogenetic protein, platelet-derived growth factor) might have potential use for vertical ridge formation, as new evidence becomes available.

INLAY–INTERPOSITIONAL PROCEDURES

Creating a horizontal osteotomy of an edentulous section of the mandible or maxilla with creation of a gap between the segments has a long history in edentulous patients. When performed in the posterior mandible superior to the IAN, excellent stability of the vertical augmentation has been achieved, although the vertical augmentation is limited by the stretch of the soft tissue. DO has been used to increase the height of the ridge, because both soft and hard tissue genesis occurs, deceasing the limitations resulting from the soft tissue envelope. The lengthy time to achieve distraction of the superior segment and the occasional need for hard tissue grafting before implant placement makes this method less attractive for many patients. All the mentioned procedures have specific indications and contraindications that have been discussed.

The concept of interpositional or “sandwich” grafting is based on the theory that bone placed between 2 pieces of pedicled bone with internal cancellous bone will undergo rapid and complete healing and graft incorporation.32,33 In 1966, Barros Saint Pasteur34 described the interpositional bone grafting technique. Barros Saint Pasteur35 described a 2-stage technique that involved a mandibular horizontal osteotomy from the retromolar pad inferior to the IAN. Three weeks later, the cephalic portion was raised and either plaster of Paris or a bovine allograft was placed as an interpositional graft.34-36

Schettler37,38 proposed the “sandwich technique” for vertical augmentation of the mandible, involving a horizontal osteotomy of the mandible, leaving the lingual soft tissue attachments. The cephalic bone was raised, and autogenous grafting material was inserted in the defect, healing with minimal bone resorption, regardless of the interpositional graft material used. At 30 months of follow-up, Schettler37,38 reported no bone resorption with autogenous bone and a 1-mm decrease in vertical height with bone bank bone. Schettler and Hottermann39 then revisited the studies by Schettler using a rabbit model. The data showed well-vascularized grafts after 6 weeks. No significant differences were seen histologically between the autogenous and homologous bone grafts.39 Other studies also demonstrated rapid and complete incorporation when the grafted material was placed between 2 corticocancellous segments of the mandible.32,33,40

A classic osteotomy method to augment the vertical height of the anterior and posterior edentulous mandible was introduced by Harle,41,42 and further evaluated and modified by Stoelinga et al.43,44 The visor osteotomy involved a parasagittal osteotomy of the mandible from body to body,43 with the lingual plate of bone raised superiorly and pedicled to the lingual soft tissue. After 3 years, 36% vertical height relapse had occurred, and the average increase in height to the anterior mandible was 7.8 mm.42

The classic sagittal visor osteotomy was modified to include a horizontal osteotomy in the anterior mandible, with autogenous bone placed within the interpositional gap. After 1 year, 20% of the vertical augmentation of the mandible had resorbed.43,44

A series was reported in which the IAN was removed from the canal, with a horizontal osteotomy performed, including the ridge from the retromolar pad to the retromolar pad, with the alveolar bone raised superiorly and immediately grafted with autogenous corticocancellous bone and circum-mandibular wire fixation.45 A vestibuloplasty was performed after bone healing, typically 12 to 16 weeks after the osteotomy. After 8.8 months of follow-up, Frost et al45 reported graft resorption of 26.1% in the autogenous group. All patients were reported to have some degree of neurosensory disturbances.45

Interpositional osteotomies in the alveolar bone heal with rapid vascularization and bone remodeling in the bone gap.32 After 12 weeks, the interpositional grafts were almost indistinguishable from the surrounding native bone. After 4 weeks, the lacunae of the grafted bone were empty, as expected. The marrow spaces contained cellular fibrous tissue containing blood vessels. Signs of active osteogenesis with minimal bone resorption were found in all specimens. The cranial segment was vital in all animals, and most of the lacunae contained osteocytes. Attachment of the cranial segment to the graft was observed. At 12 weeks, the grafts were fully incorporated into the bone of the mandible. The lacunae of the graft were all empty, although new bone had been deposited on all surfaces of the graft. Little or no resorption had occurred during the first 12 weeks. It was concluded that with interpositional grafts, the osteocytes of the graft do not survive; however, the graft was well tolerated, and new bone quickly formed around the graft. The grafted bone was connected to the surrounding bone by new mineralized tissue. The superiorly repositioned bone segment maintained its vascular supply, demonstrating that the mobilized segment received adequate circulation from the lingual soft tissue pedicle to maintain its vitality.
The visor osteotomies have been abandoned owing to the risk nerve damage and lack of bone retention after grafting. The high resorption rate of these early bone grafting procedures resulted from numerous factors. Most early visor and sandwich osteotomies received vestibuloplasties. The disruption of the periosteum of the grafted sites resulted in continued resorption of the grafted area. Maloney et al found that by not performing a follow-up vestibuloplasty after performing the Stoelinga-styled “3-piece osteotomies,” less bone resorption occurred. A second reason for the bone loss could be attributed to the large area of periosteal separation from the bone and the very large movement of bone, ranging from 10 to 20 mm, which might have gone beyond the effective blood supply to the bone.

These early grafting techniques used wire or suture fixation of the segments and grafts. Micromotion of the grafted area disrupts the vascular ingrowth and slows the osteogenic capabilities of the grafted area. Bone grafts secured both rigidly and nonrigidly in areas of low motion and high motion showed that the rigidly fixed grafts maintained 56% of their volume after 14 weeks compared with 46% for nonrigidly fixed grafts. When grafts were placed into areas of low motion versus areas of high motion and compared, only the high-motion sites showed significantly improved survival for the rigidly fixed group. Rigid fixation exerts its most profound effects during this early phase of healing and should be used to eliminate movement of the graft during the early healing phase.

When performing an interpositional osteotomy and moving the mobilized alveolar bone segment vertically, the clinician must decide on the optimal material to graft the defect. Cancellous/particulate marrow grafts have shown more rapid vascularization and more osteogenic activity compared with autogenous block grafts. Burchardt demonstrated that cancellous grafts tend to repair completely with time, but cortical grafts remain as a mixture of both necrotic and viable bone. Canzona et al studied the resorption rates in inlay and onlay bone grafting in adult mongrel dogs and concluded that inlay grafts survive better than do onlay grafts. Schettler and Hottermann believed that less bone resorption would occur with interpositional grafts because the graft is surrounded by bone and periosteum on all sides, facilitating a rapid vascular connection with the surrounding tissues.

### INFLUENCE OF IMPLANTS ON BONE GRAFT RESORPTION

The rate of resorption of the grafted site decreases considerably after implant placement. Bell et al augmented both the anterior and the posterior mandible with iliac bone using an extraoral approach. After 6 months, implants were placed in the anterior mandible between the mental foramen but not in the posterior mandible. Vertical bone graft resorption was found in the posterior nonimplant-supported area but not in the anterior implant-supported bone. Breine and Branemark conducted a study on a canine model in which autogenous composite grafts were placed containing integrated titanium implants. The results indicated that implant placement into a grafted area results in graft persistence and implant stability. They concluded that implant placement can slow the resorption process. After the bone grafts had

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stabilized, the loss of the bone surrounding the implants was less than 0.1 mm/year.

In long bones, the removal of load-bearing results in significant bone remodeling, including endosteal, intracortical, and, to a lesser extent, periosteal remodeling. Without a load-bearing stimulus, the bone mass declines, resulting in disuse osteoporosis. A physiologic dynamic strain or load is required to prevent the decline in bone mass after tooth extraction.

In 2006, Jensen reported on interpositional or “sandwich” osteotomies in the posterior edentulous mandible before implant placement. Jensen was able to achieve up to 8 mm of vertical augmentation of the posterior mandible using the sandwich technique. The preoperative bone height was 3 to 7 mm of bone above the IAN canal. Horizontal osteotomies were created 2 mm above the IAN canal. The lingual-based flap was stretched superiority 4 to 8 mm. A miniplate was used for rigid fixation. A cortical wedge of bone from the external oblique ridge and particulate autograft were placed in the interpositional graft site. After 4 months of healing, the miniplates were removed, and short implants (8 to 11 mm) were placed. The implants were loaded 3 to 4 months after placement. The average vertical augmentation of the posterior mandible achieved with Jensen’s technique was 6 mm. Bone resorption was 0 to 1 mm at a follow-up of 1 to 4 years. Marchetti et al reported similar results, using autogenous cancellous particulate bone as the graft.

There are limitations to interpositional grafting for the mandible (Table 1). Interpositional grafting only corrects vertical defects, not horizontal defects. An anatomic limitation also exists to the amount of vertical gain that can be achieved with interpositional grafting. This anatomic limitation is the stretch of the soft tissue attachments to the pedicled mobilized alveolar segment of bone, which can typically only be raised 5 to 8 mm. Undue strain on the lingual soft tissue pedicle by vertically repositioning the mobilized bone can lead to a compromised blood flow,
incision breakdown, graft loss, and/or accelerated graft resorption. By diligently respecting the anatomic limitations of the soft tissues, avoiding excessive periosteal reflection, carefully maintaining attachments on superior aspect of crest. At proposed vertical osteotomy sites, periosteum was minimally reflected. Piezotome cutting device used to create osteotomy through labial and lingual bone and in 2 vertical sites. Cuts were completed, resulting in mobile superior segment. Careful raising of superior bone segment resulted in 5 to 7 mm of bone augmentation. Small plate used to stabilize segment. Screw size was 1.2 mm in diameter, keeping screw profile very small. Plate was secured to superior segment first, then raised to desired position and secured to inferior portion of mandible. Unicortical screws were used, not bicortical screws. Care was taken to align lingual portion of cortices to prevent sharp edges of bone. Interpositional gap was grafted with particles of allograft, specifically, 350 to 500-μm mineralized bone. After graft had been carefully placed, incision was closed with resorbable sutures using tapered needles.


Case Studies

The patient presented with an intact anterior mandible dentition in excellent health, with bilateral missing posterior teeth. She desired fixed restoration of the missing teeth and had had problems wearing a removable partial denture. Her posterior maxillary teeth were in the proper plane of occlusion without supraeruption. Her posterior interocclusal space was excessive. A cone-beam computed tomography scan
indicated 5 mm of bone superior to the IAN bilaterally. The treatment options presented to the patient included a new removable partial denture, extraction of her remaining anterior teeth, with placement of 5 implants for a fixed hybrid or fixed removable “spark erosion”-type prosthesis, or interpositional osteotomies to vertically augment the posterior mandible.

The cone-beam cross-section computed tomography images were used to plan the procedure. After the patient signed a consent form informing her of the risks of sensory nerve damage, failure to achieve vertical dimension, failure of the graft to consolidate, and failure of the implants, she was prepared for surgery. The patient was sedated for the procedure. Local anesthesia was administered into the vestibule of the left and right posterior mandible. After a satisfactory interval had elapsed for hemostasis, an incision was made in the unattached gingiva at least 10 mm lateral to the junction of the attached and unattached gingiva. Anteriorly, the vestibular incision was joined with a vertical incision made to the interdental areas of the teeth anterior to the edentulous site. A full-thickness flap was developed and combined with the dissection made from the lateral vestibular incision. Mucosa-only dissection was performed sharply and bluntly to isolate the nerve branches of the mental nerve. The periosteum was incised above the foramen to avoid damage to the nerve. The periosteum was reflected only inferiorly, maintaining the periosteum to the superior aspect of the ridge. No lingual mucosa was elevated.

A piezotome cutting tip was used to create the horizontal osteotomy above the IAN canal. The vertical cuts were made with minimal elevation of the periosteum. The ostectomy cuts were made through
the lingual cortical bone. Osteotomes were not used to prevent shearing of the lingual bone. A finger was placed over the lingual mucosa to feel the piezotome cutting blade exit the bone but not the lingual mucosa. The segment was mobilized passively and elevated to the extent of the soft tissue attachments. If the floor of mouth is high, the elevation can be greater than if the floor of mouth is low. The segment was elevated, and a small bone plate was attached first to the superior mobilized segment of the crest. The screw size was usually 1.2 or 1.5 mm. After the plate was secured to the mobilized segment, the segment was elevated and oriented to minimize bone irregularities on the lingual mucosa, and the final screws were placed in the inferior mandibular intact bone.

The space was grafted with a freeze-dried mineralized allograft. After the graft was placed, the incision was closed without tension.

The patient was instructed to consume a liquid diet and was given antibiotics. Antibacterial rinses were not started until 3 days after surgery. After 3 months, a new computed tomography scan was taken to confirm bone consolidation, and the implants were placed in a routine manner.

References

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