



The Lazarus Bone Graft: Revitalizing Allogenic Bone Blocks

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About the Author



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INTRODUCTION

The use of dental implants to replace missing and failing teeth has become routine clinical practice. Following tooth loss and alveolar bone resorption, the edentulous span may often present with inadequate available bone for ideal implant placement. There are several methods and materials available for bone augmentation of the maxilla and mandible for dental implant placement. The choice of a particular augmentation technique or graft material depends on several factors including the anatomic region, degree of atrophy, morphology of the osseous defect, type of prosthesis, and clinician or patient preferences. Although no studies document that one bone augmentation technique is necessarily superior, the implant surgeon should strive to select a method that offers predictable results for the presenting clinical situation.¹

Autogenous bone grafts have long been used to reconstruct osseous defects and jaw atrophy.^{2,3} Also, autogenous bone has long been considered the gold standard of graft materials.^{3,4} The superior biologic properties of autogenous bone, including osteogenesis and osteoinduction, offer significant advantages

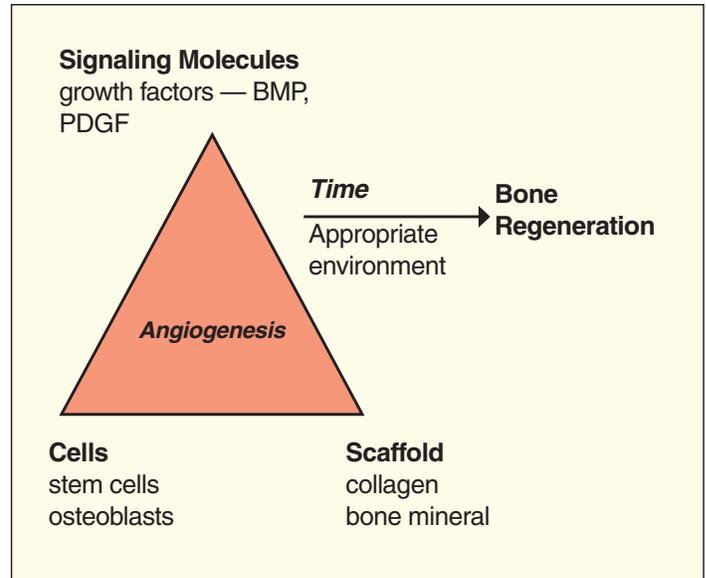


Figure 1. The *tissue engineering triad*.

over bone substitutes when reconstructing the atrophic ridge. Large autogenous bone grafts may be procured from the iliac crest in the form of corticocancellous blocks or cancellous marrow combined with titanium mesh. For limited defects, the use of intraorally harvested cortical blocks from the chin or ramus may be considered.⁵ Small defect repair can be performed with locally derived particulate autograft with titanium mesh or membranes. Autogenous grafts offer several advantages for bone augmentation including short healing time, favorable bone quality, limited cost, and predictable results. However, the inherent disadvantages are morbidity from bone harvest, added surgical time, and a limited supply of bone.

The developing field of tissue engineering offers a strategy to replace the need for harvesting autogenous bone from the patient. Tissue engineering may be used to regenerate bone by combining cells from the body with growth factors and scaffold biomaterials.⁶ This combination of cells, signaling molecules, and scaffold is often referred to as the *tissue engineering triad* (Figure 1). Growth factors are naturally occurring signaling proteins that can recruit cells and stimulate cell proliferation and differentiation. Bone morphogenetic protein (BMP) is chemotactic for mesenchymal stem cells and induces their differentiation into osteoblasts.⁷ Autogenous bone grafts fulfill all 3 aspects of the tissue engineering triad as they contain bone-forming cells, BMP, and bone mineral. Recombinant human bone morphogenetic protein (rhBMP) is a genetically engineered version produced in the laboratory that is identical in structure and action to the naturally occurring cytokine.⁸ Recombinant human bone morphogenetic protein-2 (rhBMP-2) has been under

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investigation as a replacement for autogenous bone grafts use in ridge augmentation.⁹⁻¹²

The cytokine rhBMP-2 induces bone formation at the site of application. The commercially available rhBMP-2 product (INFUSE Bone Graft [Medtronic]) has received US Food and Drug Administration approval for use in the repair of extraction socket defects and sinus bone grafting. However, the use of rhBMP-2 for ridge augmentation is considered an “off-label” application. The off-label designation does not prevent clinicians from considering rhBMP-2 for ridge augmentation, but patients must be properly informed of this status, any risks, and alternative treatment options. Adverse effects must also be well documented. The rhBMP-2 protein comes packaged as a lyophilized powder that is reconstituted with sterile water and absorbed into a collagen sponge. Despite the fact that the absorbable collagen sponge (ACS) has been proven to be an optimal carrier for the rhBMP-2 molecule, it has poor scaffolding properties to resist flap compression.⁸

When horizontal or vertical bone augmentation is needed, titanium mesh has been used as a method to provide space maintenance and protection of the rhBMP-2/ACS graft for bone ingrowth.⁹⁻¹² The use of titanium mesh with bone grafting is a well-documented method for 3-D reconstruction of ridge deficiencies. Exposure of the mesh is the most common complication with this technique.¹³ Another disadvantage of mesh is the need for removal after bone graft healing. A matrix that gradually resorbs in conjunction with bone formation would be the ideal scaffold. Combining a resorbable scaffold with a growth factor that is chemotactic and osteoinductive for mesenchymal stem cells would complete the tissue engineering triad and match the properties of autogenous bone.

Allogenic bone grafts have been utilized as an alternative to harvesting bone from the patient. This decreased morbidity is well appreciated and preferred by most patients. However, the incorporation of an allogenic bone block to the native bone is difficult due to the lack of cells within the graft.¹⁴

Although studies on dental implant survival rates in allogenic bone blocks are favorable, histologic studies show large



Figure 2. Immediate postoperative CT scan of a Lazarus block bone graft.



Figure 3. CT scan of the healed graft 6 months later. Note the improved bone density.



Figure 4. Exposure of the atrophic anterior maxilla.

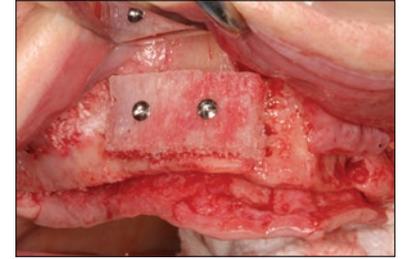


Figure 5. Fixation of the allogenic block bone graft with screws.



Figure 6. The rhBMP-2/absorbable collagen sponge mixed with particulate bone graft was packed around the block.

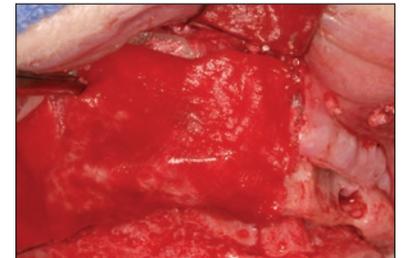


Figure 7. A collagen membrane soaked in platelet concentrate was placed over the grafted site.



Figure 8. The maxillary denture flange was removed over the graft site.



Figure 9. An implant was inserted into the healed bone graft.



Figure 10. Preoperative view of the failed maxillary fixed bridge.



Figure 11. Exposure of the extremely thin maxillary right residual ridge.

segments of necrotic bone with empty lacunae, little osteoclastic activity, and diminished direct contact between remodeled and grafted bone.¹⁵ One finding seen with rhBMP-2 is a higher turnover of bone substitutes.⁹ This accelerated remodeling of

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the bone mineral scaffold may have a positive effect on graft incorporation and subsequent implant placement. The Lazarus bone graft technique combines the use of an allogeneic block bone graft with the growth factor rhBMP-2/ACS. The growth factor brings the cadaveric piece of bone “back to life” as it is replaced with new vital bone. The block bone graft provides 3-D space maintenance. The cancellous portion of the allogeneic block is porous and allows revascularization and cellular ingrowth. The block is replaced by new bone as it is resorbed (Figures 2 and 3).

Lazarus Graft Technique

It is important to define the prosthetic goals prior to the implant reconstruction. The design of the final prosthesis determines the number of implants required and their ideal positions. If there is inadequate available bone for implant placement in the desired locations, then bone augmentation is considered. Computed tomography (CT) is extremely useful in assessing the anatomy, ridge deficiency, and volume of bone augmentation required. CBCT machines are now common in many dental offices (ie, Carestream 9000 3D System). CBCT exposes the patient to less radiation and provides an immediate assessment of the patient’s condition. The CBCT scan can also be used to produce a stereolithographic model of the maxilla or mandible (AnatoModel [Anatomage Dental]). The 3-D model is helpful for patient education and surgical planning for the reconstruction. The model can also be sterilized and used during surgery to aid in fitting of the bone blocks. Additionally, dental implant planning software can be used with the CT scan to precisely evaluate implant sizes and positions as well as the augmentation needs of the patient (SimPlant [Dentsply Sirona Implants]). However, the actual implant surgery is staged after healing of the bone graft.

The size of the defect and the volume of the planned augmentation will determine the appropriate dosage of rhBMP-2. The dosage of rhBMP-2 is approximately 1.05 mg (XXS kit, INFUSE) for a block bone graft measuring up to 20.0 mm long.⁹ The collagen sponge included in the INFUSE Bone Graft Kit is evenly saturated with the reconstituted rhBMP-2 (1.5 mg/mL) liquid. A minimum of 15 minutes is allowed to pass for binding of the growth factor to the collagen carrier. This should be performed prior to the start of surgery.

After the delivery of local anesthesia, a crestal incision is made along the ridge, extending well beyond the graft margins. Vertical releasing incisions are employed (as needed), and a broad-based mucoperiosteal flap is developed to completely expose the ridge



Figure 12. A layer of collagen soaked with rhBMP-2 was placed on the underside of the block.



Figure 13. A piezoelectric saw was used to harvest a block bone graft from the tuberosity.

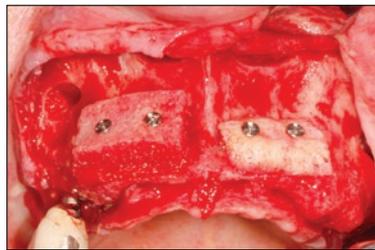


Figure 14. The allogeneic block (left) and autogenous block (right) were fixated to the anterior maxilla.



Figure 15. The grafted sites were covered with collagen membranes.

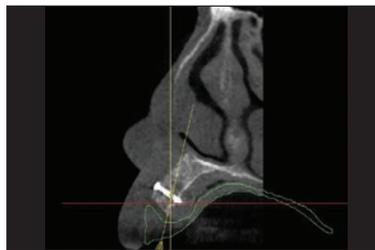


Figure 16. A CBCT scan was obtained to plan the implant surgery. Note the complete incorporation of the Lazarus graft with the native bone.

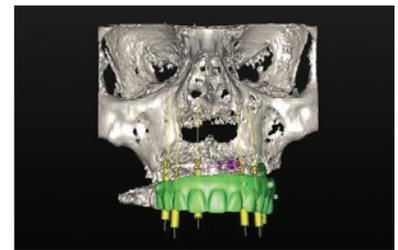


Figure 17. The dual scan was used to plan the implant sites.

deficiency and to identify local anatomy (Figure 4). Several perforations of the cortical bone surface are performed with a small round bur to expose the medullary mesenchymal stem cells and expedite revascularization of the graft. The allogeneic bone block must be hydrated after it is unpackaged. Some companies provide the bone block in solution (Rocky Mountain Tissue Bank). Any sharp edges around the block should be smoothed with a bur. Block grafts do not tolerate micromovement and will fail to incorporate unless they are stable and rigidly fixated. The block graft needs to be mortised into position onto the ridge. It is easier to modify the host bone to improve the fit instead of adjusting the graft. Holes are drilled into the block after assessing the best areas for fixation in the host bone. A lag screw technique is used for fixation of the bone graft. The screw should easily pass

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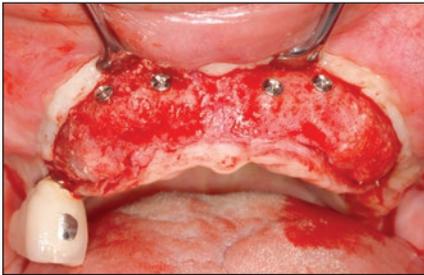


Figure 18. The block bone grafts were well incorporated. Note the favorable revascularization of the new bone.



Figure 19. A guided surgical template was used to place the implants.



Figure 20. The 6 implants were placed into the grafted maxilla.

through the oversized hole, and the threads should not engage the graft, only the host bone. A piece of the rhBMP-2 sponge is placed between the block and the host bone to promote incorporation of the graft. The block is positioned onto the ridge and the drill from the screw kit is used to prepare the sites for screw fixation. Fixation screws typically range from 1.0 to 2.0 mm in diameter (OsteoMed Mincro Screw Kit [OsteoMed]). A screw length that extends beyond the block and maximizes retention within the host bone should be selected. As the lag screw threads into the host bone, it compresses and rigidly fixates the block. Although one screw may be considered for small block grafts, 2 or more screws should be used for larger grafts to prevent rotation (Figure 5). Confirm the block is stable and free of any sharp corners or edges. The remaining rhBMP-2/ACS is cut into small pieces with scissors and mixed with a particulate mineralized bone allograft (MinerOss [BioHorizons]) in a ratio of 50% by volume. This mixture is packed around the periphery of the block graft and used to fill any small discrepancies between the graft and host bone (Figure 6). The inclusion of a platelet concentrate in the mixture can improve the containment of the particulate graft (IntraSpin [Intra-Lock]). A collagen membrane (OSSIX PLUS [OraPharma] or Bio-Gide [Geistlich Biomaterials]) is then used to completely cover the site (Figure 7). A scalpel blade was used to incise the periosteum along the base of the facial flap and obtain release for advancement over the graft site. The flap margins are then advanced over the graft and approximated without tension. The flaps are closed primarily with polytetrafluoroethylene, polyethylene, or polyglactin 910 mattress and interrupted sutures. It is imperative that the graft is not traumatized during healing. A fixed provisional prosthesis, such as a temporary bridge or bonded prosthesis, is preferred if possible. A removable vacuum-formed or Essix retainer are other excellent options for cosmetic tooth replacement, as the retainers are supported by the teeth and do not place any pressure on the graft site. The use of any soft-tissue-borne removable prosthesis is discouraged for the first few weeks until the incision has healed. A soft-tissue-borne

removable prosthesis should be generously adjusted to prevent any contact with the grafted site (Figure 8). The bone graft is allowed to heal for 6 months before dental implants are inserted (Figure 9). The fixation screws are removed prior to implant insertion (Dentsply Sirona Implants).

CASE REPORT

A patient was referred for an implant consultation. She had a failing maxillary bridge and atrophy of the anterior maxilla (Figure 10). A preoperative CBCT scan revealed the ridge was extremely thin. The plan was to augment the thinner right anterior maxilla with a Lazarus graft and the left anterior maxilla with an autogenous block graft. An incision was made along the ridge crest in the maxilla. A mucoperiosteal flap was reflected to expose the thin ridge (Figure 11). A layer of rhBMP-2/ACS was placed between the block and the ridge (Figure 12). The allogeneic block bone graft (Rocky Mountain Tissue Bank) was fixated to the right anterior maxilla with titanium alloy screws. A block bone graft was harvested from the left tuberosity with a piezoelectric saw (Figure 13). The allogeneic block and autogenous block graft were fixated with titanium alloy screws (Osteomed Mincro Screw Kit) (Figure 14). A composite mixture of rhBMP-2/ACS and particulate mineralized bone allograft was packed around the periphery of the block and the grafted site was covered with a collagen membrane (OSSIX PLUS or Bio-Gide) soaked in platelet rich plasma (IntraSpin) (Figure 15). The flap was released and advanced for primary closure with 4-0 polyglactin 910 horizontal mattress sutures. After 5 months of healing, a diagnostic tooth setup was performed for fabrication of a dual scan template. A CBCT revealed the bone graft was well incorporated (Figure 16). The virtual implant surgery was planned using the dual-scan protocol (SimPlant) (Figure 17). After 6 months of healing, surgical exposure of the maxilla found the block bone grafts were well healed (Figure 18). Both grafts had a similar clinical appearance. A guided surgery template was used to prepare the osteotomies

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and place the implants (Figure 19). Six implants were inserted into the reconstructed maxilla (MinerOss) (Figure 20). Upon integration of the implants in 4 months, they were uncovered for restoration with a fixed bridge.

CLOSING COMMENTS

The search continues for graft materials that can replace the need for bone harvest. There is a definite trend in implant dentistry toward minimally invasive procedures that decrease patient morbidity. The Lazarus bone graft technique has been effective in cases requiring significant horizontal ridge augmentation for implant placement. This technique has the potential to replace the need for autogenous bone harvest. The surgery may be performed in an office environment under sedation and local anesthesia instead of an operating room under general anesthesia. The elimination of a graft harvest greatly reduces surgical time. However, the ability to manage the surgical flaps to attain tension-free primary closure is still a requisite to graft success. The disadvantages of the Lazarus bone graft compared to an autogenous graft include greater postoperative edema, longer graft healing times, and higher material costs.

The use of rhBMP-2/ACS with an allogeneic bone block offers another alternative to managing bone deficiencies in the maxilla and mandible.

Clinicians will need to weigh the higher costs of this technique against the simplified technique, enhanced biologic response, and potential for reduced morbidity.♦

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POST EXAMINATION QUESTIONS

1. **Surgical shortcomings, such as missing papilla or residual vertical deficiencies, can create difficult prosthetic dilemmas and poor outcomes.**
a. True b. False
2. **Following anterior tooth loss, the reduction of bone in the vertical height dimension is the greatest.**
a. True b. False
3. **Longer prosthetic teeth, missing papilla and lack of facial contour are not uncommon flaws when reconstructing larger defects.**
a. True b. False
4. **With new technologies, it is not difficult at all to provide absolute guidelines for the number and distribution of implants to support the fixed prosthesis.**
a. True b. False
5. **If the plan is to surgically reconstruct the defect back to "normal" anatomy, then pontic sites can be planned between the implants in an attempt to provide more soft tissue height.**
a. True b. False
6. **Regeneration and repair of an osseous defect primarily originates from the surrounding bony walls, so the morphology of a bone defect should influence the choice of material or technique.**
a. True b. False
7. **Autogenous block bone grafts have not yet been proven to be a predictable method for reconstruction of vertical defects.**
a. True b. False
8. **A staged approach to implant placement allows for graft remodeling and assessment of graft incorporation.**
a. True b. False

