Predictable Maxillary Guided Bone Regeneration with a Bioabsorbable Membrane and Particulate Allograft: A Case Series Spanning Extraction to Final Prosthetics

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### Abstract



**Background:** Guided bone regeneration (GBR) is an increasingly reliable method of addressing particular types of ridge resorption prior to and after implant insertion. Use of more convenient and body-promotive materials including bioabsorbable barriers, particulate grafts and bioactive molecules (i.e., growth factors) curtail surgical pressure as well as patient comfort. Spacemaking and small to moderate nonspacemaking defects benefit from treatment with GBR, the sequence details and results of which are documented in this case series.

**Methods**: Three cases of pre and peri-implant GBR with a bioabsorbable cross-linked collagen membrane and particulate freeze-dried bone allograft at varying locations in the mouth (anterior, posterior, full-arch) are depicted. Each case followed the patient from tooth extraction to final implant-retained or implant-supported restoration. One case involved application of autologous plasma rich in growth factors.

**Results**: GBR performed using the protocol outlined resolved all ridge and peri-implant defects. 100% implant survival plus complete functional and esthetic success was attained.

**Conclusion:** Predictable GBR ensues using a cross-linked collagen membrane and particulate freeze-dried bone allograft. The use of autologous plasma rich in growth factors may have contributed to a smoother post-operative course but the degree of its influence on bone regeneration or implant survival remains unclear

### KEY WORDS: Guided bone regeneration, dental implants

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### INTRODUCTION

It is natural to demand expediency in the internet age, an era characterized by immediate dispersal of innumerable things. The growing impatience cultivated by customs of the digital world leaches into the material one, warping established mores and patterns of conduct. Inured to relentless but meaningful upgrades in technology, patients expect treatment to be newer, better and faster than before. Compounded by a recent heady (and promising) burst of discoveries in material science and bioengineering, this desire for a quick, easy fix becomes irresistible to doctors as well. But does such therapy exist in dentistry?

Brandishing the requisite "modern medicine" accoutrements - controlled cellular manipulation, bioactive substances, rejuvenation of lost tissue, and diminished morbidity - guided bone regeneration (GBR) is a very real and consistent answer to the problem of alveolar ridge resorption. That is, when it is appropriately applied, i.e., to spacemaking defects; small to moderate non-spacemaking defects; dehiscences/fenestrations. GBR depends ultimately on the inborn ability of the body to heal. Bone maturation typically occurs 18 to 54+ weeks post-surgery, and there is currently no reliable way to speed it up.<sup>1,2</sup> Although guided methods fail to noticeably hasten the regenerative process, they do trigger and sustain it well enough to attain consistently lateral and vertical ridge expansion of at least 3mm and over 90% coverage of fixture dehiscences/fenestrations. Implant survival in regenerated bone mirrors that in native arches, ranging from roughly 93% to 99% over 11 years, statistics that are of course contingent upon operator experience and the quality of the residual ridge.3-7

Early studies described that a non-resorb-

able, stiff material such as expanded polytetrafluoroethylene (ePTFE) inserted over an infrabony deformity appeared to hinder the ingress of epithelial cells into the wound site, allowing osteoblasts and other bone precursors to repopulate the space; this constituted GBR. Thus, clinicians began to use ePTFE and titanium mesh membranes to direct preferred cells into and repel unwanted cells from resorptive defects. These barriers, however, required retrieval and if exposed, tended to become infected, contaminating the surgical area. As a result, bioabsorbable membranes, both collagen-based and/ or synthetic, gained popularity. These membranes integrated with host tissues, sealing the regenerative site from epithelial and fibrous tissue invasion.8-10 They also adapted more intimately to the defect shape and handled well.

Bioabsorbable materials, however, possess less robust space-maintaining properties than their ePTFE prototypes. To fortify a potential regenerative space, a bioabsorbable membrane requires placement of an underlying adjunct graft such as anorganic bovine bone mineral (ABBM) or freeze-dried human allograft (FDBA).<sup>11</sup> A calcified xenograft, ABBM is primarily osteoconductive and slow-resorbing. FDBA too has a slower turnover and shows osteoconductivity at the outset, but mineral processing by the body eventually exposes the bone morphogenetic proteins (BMPs) embedded in the graft. BMPs are growth factors and therefore confer osteoinductivity. A graft then is not only a buttress for a membrane, but also a regenerative instigator in its own right.

With resorbable barriers there is a fear of premature degradation. The length of time preferred for a membrane to stay in function is directly proportional to the amount of regenerated tis-



Figure 1: Initial clinical presentation of failing tooth #7.

sue wanted, but most likely the barrier function does not need to last until the maturation phase or even lamellar development for that matter. On average, at least 2-4 months of membrane function is necessary for predictable results. One solution to this problem involves the cross-linking of collagen molecules in such membranes. Cross-linking slows the progression of membrane breakdown as well as minimizing adverse immunologic host reactions to the material.<sup>12,13</sup>

Ultimately, a prudent approach to case selection, a methodical grafting sequence, and adequate healing periods beat rushing through planning and surgery only to suffer the consequences of expedient but reckless care. Treatment may take time, but it should proceed in the most atraumatic, comfortable manner possible for not only the patient but also the doctor.

The GBR series presented in this paper is an example of how to streamline treatment as much as possible without sacrificing results. For suitable ridge situations, pre and peri-implant GBR obtained good augmentation results in anterior, posterior and full-arch areas. A cross-linked, porcine Type I collagen membrane with a functional



Figure 2: Initial periapical radiograph of failing tooth #7.

time of 4-6 months was employed (Ossix<sup>™</sup> Plus, OraPharma, Warminster, PA). All implant placements were performed under sterile conditions.

### CASE 1

### Patient History

A medically and periodontally stable 70-yearold man who smoked one cigar a day presented with tooth #7 failing due to recurrent end-



Figure 3: Buccal fenestration over site #7.



**Figure 4:** Ridge augmentation with bioabsorbable collagen membrane overlying bone graft material.



**Figure 5:** Periapical radiograph of site #7; 6 months postextraction and augmentation.



**Figure 6:** Clear visualization of regenerated area after residual barrier removal and degranulation.

odontic infection manifesting as chronic apical periodontitis and a draining buccal fistula; the tooth also exhibited Miller Class I recession covered by a Class V composite restoration (figure 1).<sup>14</sup> Tooth #7 had a history of root canal treatment and apicoectomy (figure 2).

### **Treatment Plan**

- 1. Extraction of tooth #7 and localized ridge augmentation
- 2. 6 month healing period



**Figure 7:** Periapical radiograph of implant #7 on day of insertion.

- 3. Placement of implant #7
- 4. 4 month healing period
- 5. Implant #7 exposure and placement of healing abutment
- 6. Final implant #7 crown restoration

### **Pre-Implant GBR**

After oral sedation with 0.25 mg triazolam one hour prior to surgery and local anesthetic induction using 2% lidocaine with 1:100,000 epinephrine and 0.5% bupivacaine with 1:200,000



**Figure 8:** Clinical healing of #7 site 4 months postimplantation. Area is temporized with a resin-bonded fixed partial denture.



Figure 9: Frontal view of #7 final restoration.

epinephrine, a palatally-oriented lateral incision was made from the mesial of tooth #6 to the distal of tooth #8, and a sulcular extension around the buccal aspect of tooth #8 to its mesial line angle was created. To visualize the #7 apical lesion, a vertical incision with a small right angle coronal modification was placed at the distobuccal line angle of #6; a straight vertical cut followed at the mesio-buccal line angle of #8. A full-thickness flap was elevated past the mucogingival junction, and periodontal scoring took



**Figure 10:** Final periapical radiograph of #7 implant and crown.



Figure 11: Initial frontal view of case 2. Note severe attachment loss.

place near the base of the flap to facilitate coronal advancement necessary for primary closure. Hopeless tooth #7 was extracted atraumatically. Thorough degranulation of the extraction site, periapical defect and exposed ridge with a pear-shaped carbide finishing bur, Neumeyer bur, and Prichard curette followed; this exposed a buccal fenestration measuring 6 mm in diameter roughly 3 mm apical from the alveolar crest (figure 3). Implant placement was attempted but aborted due to lack of primary stability.

FDBA was used to obliterate the extraction socket and bony fenestration as well as to augment the ridge labially to ideal proportions. A bioabsorbable collagen membrane (Ossix<sup>™</sup> Plus, OraPharma, Warminster, PA) was used to cover the grafted area on the buccal (figure 4). The area was secured using 4-0 expanded ePTFE sutures in interrupted and horizontal mattress configurations. The restorative dentist temporized space #7 with a resin-bonded fixed partial denture (RBB) and ensured that the pontic did not rest on the grafted ridge. After 6 months of uneventful healing, Stage 1 implant placement was initiated.

### **#7 Fixture Placement**

A pre-operative radiograph 6 months after extraction and localized ridge augmentation revealed adequate hard tissue fill (figure 5). After oral sedation with 0.25 mg triazolam and local anesthetic induction using 2% lidocaine with 1:100,000 epinephrine and 0.5% bupivacaine with 1:200,000 epinephrine, a flap was created using the same incision design and elevation/ dissection method previously described. Initial exposure of the ridge showed the continued presence of the collagen barrier, the bulk of which



**Figure 12a:** Occlusal view of maxillary arch extraction sockets.



**Figure 12b:** Buccal view of maxillary arch extraction sockets. Note severe dehiscence over the #6-8 sites.



**Figure 13:** Socket preservation and ridge augmentation using freeze-dried bone allografts.

was removed using forceps. Degranulation of the site with a pear-shaped carbide finishing bur and Neumeyer bur divulged the complete bone regeneration of the extraction socket and fenestration (figure 6). Following osteotomy creation, a rough-surfaced, external hex 4 x 15 mm implant was placed into the filled site (Osseotite<sup>®</sup> Parallel Walled Implant, Biomet 3i, Palm Beach Gardens, FL) (figure 7). Primary stability was achieved, and the flap was primarily closed with 4-0 ePTFE sutures in an interrupted fashion after placement of the cover screw. The area was retemporized with a resin bonded bridge (RBB).

### **Implant Exposure and Final Prosthetics**

Site #7 healed well and without incident after 4 months (figure 8). Using a tissue punch technique, a one-piece healing abutment was placed on the #7 implant, after which endstage restorative procedures began. 5 months after implant placement, or 11 months after treatment began, the patient received a final #7 fixed prosthesis (figure 9). A periapical radiograph showed suitable peri-implant bone height (figure 10). The patient was satisfied with the functional and esthetic result. **Post-Operative Instructions** 

After each surgical procedure, the patient was instructed to take ibuprofen 600 mg q4-6 hours, hydrocodone 7.5 mg/acetaminophen 750 mg q<sup>4-6</sup> hours PRN pain, and doxycycline 100 mg QD for 10 days. The patient was instructed not to brush at or near the surgical site but instead to rinse with 0.12% chlorhexidine or warm saline twice daily. The



**Figure 14:** Bioabsorbable collagen membrane in place over bone allograft.

patient was also directed not to chew in the affected area for at least 2 weeks. Suture removal occurred at 10-14 days post-surgery.

### CASE 2 Patient History

A non-smoking, medically stable 58-year-old male presented with periodontal abscesses, generalized severe bone loss, generalized tooth mobility, an altered occlusal scheme and esthetic concerns (figure 11). His periodontal history involved non-surgical therapy 20 years ago and maintenance therapy every 3 months interspersed with episodes of scaling and root planing thereafter.

### **Treatment Plan**

- 1. Maxillary full-arch extraction with ridge preservation
- 2. Simultaneous mandibular full-arch extraction, immediate implantation of 6 implants and immediate temporization
- 3. 6 month healing period
- 4. Placement of 7 maxillary implants



**Figure 15:** Mandibular arch immediately following extractions.

- 5. 5 month healing period
- 6. Maxillary healing abutment placement
- 7. Final maxillary restoration with implant-retained bar overdenture with Locator<sup>®</sup> attachments (Zest Anchors, Escondido, CA)
- 8. Delivery of mandibular final hybrid prosthesis

# Maxillary Full-Arch Extraction and Pre-Implant GBR

After intravenous sedation with 0.25 mg triazolam and local anesthetic induction using 2% lidocaine with 1:100,000 epinephrine and 0.5% bupivacaine with 1:200,000 epinephrine, a sulcular incision was made around all the upper teeth and extended to the left and right maxillary tuberosities. A midline vertical incision was created to facilitate tissue mobility and ridge visualization. Full-thickness elevation past the mucogingival junction occurred, with split-thickness dissection in the alveolar mucosa to allow for flap release. All maxillary teeth were extracted atraumatically. The sockets and remaining bone were degranulated using a pear-shaped carbide finishing bur, Neumeyer bur and Prichard curette as well as



**Figure 16a:** Alveoplasty of mandibular arch creates a wider, implant-supportive ridge.

irrigated with 0.12% chlorhexidine. Due to the patient's severe periodontal condition, large alveolar defects existed with a significant dehiscence approximating the #6-8 region (figures 12a, 12b).

FDBA was used to seal the extraction sockets and bony dehiscence (figure 13). A bioabsorbable collagen membrane (Ossix<sup>™</sup> Plus, OraPharma, Warminster, PA) was used to cover the graft buccally and crestally in the anterior sextant (figure 14). Coronal advancement of the flap permitted primary closure via 4-0 ePTFE sutures in interrupted and horizontal mattress configurations.

### Simultaneous Mandibular Full-Arch Extraction, Immediate Implantation and Immediate Temporization

Immediately after maxillary edentulation and regenerative procedures, similar treatment was initiated in the mandible. The flap design, extraction, degranulation and irrigation on the lower arch paralleled that executed in the maxilla. Tieback of the lingual flap further enhanced surgical accuracy (figure 15). Alveoplasty of



**Figure 16b:** 6 mandibular interforaminal implants inserted.

the cleansed ridge mostly eradicated the extraction sockets and generated a wide bone shelf amenable to the placement of 6 interforaminal implants (figures 16a, 16b). Rough-surfaced, internal hex fixtures of 4 x 15mm dimensions were inserted at positions #22, 23, 24 and 25 along with a 4 x 11.5mm fixture at site #27(Osseotite<sup>®</sup> Parallel Walled Certain<sup>®</sup>, Biomet 3i, Palm Beach Gardens, FL). Position #21 received one rough-surfaced, external hex, expanded platform 4/5 mm x 11.5 mm implant (Osseotite® XP, Biomet 3i, Palm Beach Gardens, FL). Immediate temporization with an acrylic fixed hybrid prosthesis followed using a proprietary restorative kit intended for such one-visit full-arch scenarios (DIEM<sup>®</sup>, Biomet 3i, Palm Beach Gardens, FL) (figures 17a, 17b).

The mandibular and maxillary interim prostheses were adjusted to occlude properly. Because of maxillary GBR, however, the patient was instructed not to insert or function with his upper complete denture for at least 2 weeks. 6 months of uneventful healing and maintained esthetics passed prior to the next surgery.



**Figure 17a:** Buccal view of temporary restorative abutments placed on 6 mandibular fixtures.



**Figure 17b:** Occlusal view of temporary restorative abutments placed on 6 mandibular fixtures.



**Figure 18a:** Residual bilateral concave buccal deficiencies in the maxillary anterior sextant six months after extractions.



**Figure 18b:** Sufficient occlusal bone fill of maxillary extraction sockets.



Figure 19: Surgical guide for placement of maxillary fixtures.

### Placement of 7 Maxillary Implants and Peri-Implant GBR

6 months after maxillary edentulation, implantation took place. The patient and flap were prepared as before. The matured ridge displayed residual bilateral concave buccal deficiencies in the anterior sextant but filled well occlusally (figures 18a, 18b). Using a surgical guide, 7 maxillary fixtures were inserted with primary stability (figure 19).

It was apparent, however, that only a thin



**Figure 20a:** Relatively thin labial bone over implants #7 and #8.



Figure 20b: Fenestration of 5 threads of implant #10.



**Figure 21:** Guided bone regeneration of buccal defects with freeze-dried bone allograft covered with bioabsorbable collagen membrane.

layer of labial bone existed over implants #7 and #8, and implant #10 showed an outright fenestration of 5 threads (figures 20a, 20b). Periimplant GBR thus commenced, using FBDA and an overlying bioabsorbable collagen barrier (Ossix<sup>™</sup> Plus, OraPharma, Warminster, PA) (figure 21). The site was closed primarily with 4-0 ePTFE sutures in interrupted and horizontal mattress patterns. The maxillary interim complete denture was relieved and adjusted to fit



**Figure 22:** Residual membrane over implant #10 seen 6 months after guided bone regeneration procedure.

the intact mandibular interim hybrid prosthesis.

Tissue perforations and membrane exposure developed over the 5-month healing period. Nevertheless, no infections developed, and the mucosal fenestrations closed spontaneously. The course of healing was otherwise uneventful.

### Maxillary Implant Exposure and Final Prosthetics

Stage 2 maxillary implant procedures occurred



**Figure 23:** Degranulation reveals obvious hard tissue regeneration.

5 months post-implantation. The patient and flap were prepared as before. Upon flap reflection, residual membrane material was noted over implant #10 (figure 22). Degranulation made clear the amount of bone regenerated from periimplant GBR, which was considerable (figure 23). One-piece healing abutments were then used to replace the cover screws and the flaps were sutured together with 4-0 ePTFE using interrupted, continuous and mattress techniques. The uncovered inter-implant areas were left to granulate in (figure 24).

The end-stage prosthetic process began after mucosal maturation following fixture exposure. 15 months after the start of the treatment plan, the maxillary arch received a maxillary CAD/CAM bar overdenture with Locator<sup>®</sup> attachments (Zest Anchors, Escondido, CA) while the mandibular arch was restored with a final fixed hybrid prosthesis (figures 25a, 25b). The patient was satisfied with the functional and esthetic result (figure 26). Periapical radiographs showed suitable periimplant bone height (figure 27). The marginal height of the #7 implant crown closely approxi-



**Figure 24:** Maxillary healing abutments placed with secondary closure.

mated that detected at original presentation.

### **Post-Operative Instructions**

After each surgical procedure, the patient was instructed to take ibuprofen 600 mg q4-6 hours, hydrocodone 7.5 mg/acetaminophen 750 mg q4-6 hours prn pain, and doxycycline 100 mg qd for 10 days. The patient was instructed not to brush at or near the surgical site but instead to rinse with 0.12% chlorhexidine or warm saline twice daily. The patient was also directed not to function with his maxillary interim complete denture for at least 2 weeks. Suture removal occurred at 10-14 days post-surgery.

### DISCUSSION

GBR using a long-functioning collagen membrane and particulate allograft with or without plasma rich in growth factors creates abundant ridge augmentation when surgical principles (primary stability, primary closure, space maintenance, blood supply continuation) and healing periods are adhered to, even in cases of more extensive resorption. A bioabsorbable bar-



**Figure 25a:** Maxillary CAD/CAM bar with Locator<sup>®</sup> attachments (Zest Anchors, Escondido, CA).



Figure 26: Smile and facial views of final results.

rier may resist the negative aftermath of exposure and continue to encourage the growth of high-quality, high-quantity, implant-supportive hard tissue. Regenerative methods to preserve existing or generate new bone may commence at the time of extraction or immediately following implant insertion if the defects addressed are fully or partially encased by bone and if a sufficient healing time remains uncompromised. Within this context, the GBR portrayed in this paper dependably reverses a myriad



**Figure 25b:** Internal view of maxillary implant-retained overdenture.



**Figure 27:** Final maxillary and mandibular periapical radiographs showing suitable crestal bone heights.

of defects at any stage prior to restoration.

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