# Maintenance of Regenerated Bone Beneath Pontics: Preliminary Clinical Report of 43 Sites

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Ridge augmentation was achieved through the use of guided bone regeneration procedures in pontic areas of 43 planned fixed prostheses. Measurements taken through templates, which fit over the final fixed prostheses, at the time of prosthetic placement and a mean of 123 weeks after prosthesis placement demonstrated a change of less than 0.1 mm in buccopalatal dimension of the regenerated hard tissues.
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The efficacy of guided bone regeneration (GBR) has been well documented in the dental literature. By excluding all nonosteogenic extraskeletal connective tissue cells from a healing bone defect, GBR has proven successful in a variety of clinical situations, including the regeneration of bone at the time of tooth extraction, buccolingual and apico-occlusal ridge augmentation, and the rebuilding of bone over dehisced and/or fenestrated implant surfaces.[1–10] The technical prerequisites for maximizing the results of GBR procedures have also been well elucidated.[11–13] The importance of appropriate patient and defect selection, anticipatory flap designs, decortication of existing bone, space maintenance and clot stabilization beneath the placed membrane, adequate fixation of the membrane, and the attainment of passive primary soft tissue closure throughout the course of regeneration have all been detailed. In addition, implants placed in regenerated hard tissues demonstrate success rates comparable to implants placed in nonregenerated bone.[14,15]

As the applicability and utilization of GBR therapy have expanded, therapeutic goals have evolved. No longer only a functional therapy, GBR is utilized to improve the esthetic profile in edentulous areas beneath fixed prostheses. However, while GBR has proven highly successful in augmenting edentulous ridges in pontic regions,[16] no studies have explored the stability of regenerated bone beneath final fixed prostheses in the absence of implant placement. While no functional forces are placed upon the newly regenerated hard tissue beneath pontics, the stability of the regenerated bone in such situations has not been documented. Preliminary documentation of such stability is explored in this article.

## Materials and Methods

**Patient Selection.** Following a thorough review of medical histories, patients were deemed unsuitable to receive augmentation therapy based upon the following criteria:

1. The presence of uncontrolled diabetes, immune diseases, or other contraindicating systemic conditions.
2. Radiation therapy in the head and neck region in the 12 months prior to proposed therapy.
3. Chemotherapy in the 12-month period prior to proposed therapy.
4. Uncontrolled periodontal disease, or an unwillingness to undergo needed periodontal therapy, around remaining teeth.
5. A smoking habit of 1 package or more of cigarettes per day.

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6. A psychologic problem, including depressive states and extreme nervousness or agitation, which in the opinion of the authors would have rendered the delivery of comprehensive therapy untenable and would have precluded the patient undergoing numerous, lengthy treatment visits.
7. An unwillingness to commit to a long-term, posttherapy maintenance program.

Forty-three patients were treated; of these patients, 25 (59%) were female and 18 (41%) were male. Patient age ranged from 27 to 57 years of age.

A complete examination of oral hard and soft tissues was carried out for each patient, and an overall dental treatment plan was formulated in conjunction with the treating restorative dentists. Panoramic radiographs were taken of all patients by one certified dental assistant. Diagnostic casts, face-bow articulator mountings, wax-ups, and surgical templates were also utilized as needed. Surgical templates were potentially useful at the time of augmentation as a guide to the desired final ridge dimension buccolingually and apico-occlusally. All surgical therapy and pre- and postoperative measurements were recorded by the authors.

**Surgical Technique.** Following a split-thickness palatal approach, a supracrestal incision was made, as described by Langer and Langer,[17] with mesial and distal releasing incisions extending well into the buccal fold, and a full-thickness mucoperiosteal buccal flap was reflected. Mesial and distal palatal releasing incisions were placed, and a palatal full-thickness mucoperiosteal flap was reflected, taking care to include the tissue that remained over the crest of the ridge as a result of the prior split-thickness approach. This tissue now became part of the "extended" palatal flap. Following thorough soft tissue debridement of the residual alveolar ridge, an appropriate titanium-reinforced Gore-Tex membrane (W.L. Gore, Flagstaff, AZ) was chosen and trimmed to size. The buccal and crestal aspects of the residual alveolar bone were decorticated using a #2 round carbide bur, as deemed necessary. The decision to decorticate the ridge was based upon the presence or absence of bleeding marrow cavities. When such cavities were not noted and the residual ridge appeared somewhat cortical in nature, decortication was undertaken. The membrane was secured at its most apical extent with Freos fixation tacks (Steri-Oss, Yorba Linda, CA). Particulate material was placed beneath the membrane in one of the following mixtures:

- Equal parts of demineralized freeze-dried bone allograft (DFDBA) 500 to 800 μm in diameter (Musculoskeletal Foundation, Holmoel, NJ) and resorbable tricalcium phosphate (TCP) (Augmen, Miter and Co, Warsau, IN) (16 patients)
- Bovine bone matrix (Bio-Oss, Osteohealth, Shirley, NY) (27 patients)

The titanium-reinforced Gore-Tex membrane was bent over the particulate material so as to overlap the crest of the residual alveolar bone. One or two Freos fixation tacks were placed on the palatal aspect of the residual ridge to help secure the membrane.

The ability to attain passive soft tissue primary closure of the buccal and palatal mucoperiosteal flaps was then examined. If necessary, the releasing incisions were extended and/or a rotated palatal pedicle flap approach was employed.[18] The flaps were sutured with interrupted Gore-Tex sutures, and the temporary fixed prosthesis was recemented utilizing temporary cement, after appropriate modification of the pontic or pontics to a non-contact state. While some incidental apico-occlusal grafting occurred in a number of the patients, the primary reason for grafting was to increase buccolingual dimension.

**Postoperative Management.** Medications prescribed included Peridex rinse (Procter & Gamble, Cincinnati, OH) twice a day for 14 days; amoxicillin 500 × 40 four times a day (enteric coated erythromycin 400 × 30 three times a day was utilized for penicillin-sensitive patients); ibuprofen 600 × 20 as an antiflammatory four times a day, unless medically contraindicated; and pain medication (Tylenol with Codeine #3 [McNeal Pharmaceutical, Fort Washington, PA] or Percocet [Dupont Pharma, Wilmington, DE]) as necessary. Sutures were removed 10 to 12 days postoperatively. Although no membrane exposure was noted throughout the postoperative healing phase, such exposure would have necessitated reinstitution of Peridex rinses twice a day and antibiotic administration until the time of membrane removal.

**Healing Time.** Buccal and palatal full-thickness flaps were reflected 5 to 7 months postoperatively to remove the titanium-reinforced Gore-Tex membrane and fixation tacks. The mucoperiosteal flaps were replaced and sutured with interrupted Gore-Tex sutures, and the temporary fixed prosthesis was again recemented utilizing temporary cement.

**Prosthetic Therapy.** Approximately 5 to 6 weeks after membrane removal, the restorative dentist began his or her final prosthodontic treat-

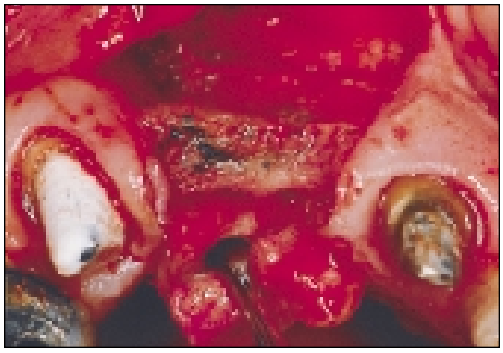

**Fig 1** Flap reflection reveals a severely atrophic ridge in the pontic area of the anticipated fixed prosthesis.

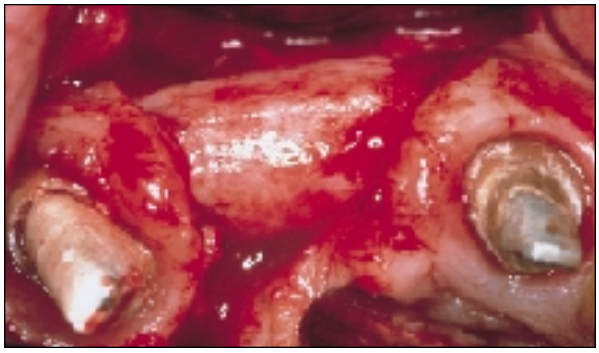

**Fig 2** Six months after performance of a GBR procedure utilizing Bio-Oss and a titanium-reinforced Gore-Tex membrane that was fixed in place, extensive regeneration of the previously atrophic edentulous ridge is noted.

ment procedures in the area. All patients were restored with permanently cemented ceramometal fixed prostheses.

**Data Collection Intervals.** Following completion of the final fixed prostheses, acrylic resin shells were made that fit securely but passively over the fixed prostheses. Holes were made in these shells, utilizing a #2 round diamond bur, both buccally and palatally at the midpoint of the sight of regeneration. If the edentulous ridge that was treated via regenerative therapy encompassed more than 1 tooth mesiodistally, buccal and palatal holes were made in the acrylic resin template to correspond to the center of each pontic apical to the pontic at the sight of regeneration. Local anesthesia was given, and the sharpened calipers were utilized to sound the bone buccally and lingually, providing a baseline buccolingual dimension of the regenerated ridge at the points of template perforation.

These measurements were repeated under anesthesia utilizing the same calipers at a mean time of 123 weeks after the initial measurements had been taken. The range of time between the initial and final measurements was 118 to 127 weeks.

**Assessment of Success.** Patient definition of success depended upon the esthetic outcome of surgical and reconstructive therapy. The patient goal was a natural-looking fixed prosthesis, with no evidence of ridge depression in the pontic area.

Operator success, in addition to meeting patient needs and desires, was defined as stability of regenerated hard tissues over the course of the study. Such success was reported to both in absolute numbers of change and in a percentage change when compared to the extent of augmentation that had initially been recorded. Success was defined on an absolute scale as a buccopalatal dimensional change of less than 0.5 mm throughout the course of the study and on a relative scale as a buccopalatal dimensional change of less than 5% of the extent of ridge augmentation that had been originally obtained.

## Results

The patient-based esthetic criteria for success were met to the satisfaction of all 43 patients (Figs 1 and 2).

The average buccopalatal dimensional change over the course of the study (a mean time of 123 weeks) was less than 0.1 mm, and the greatest dimensional change noted was less than 0.2 mm (Table 1). Reported on a scale relative to the extent of regeneration originally obtained, the average dimensional change was less than 2%, and no sites demonstrated a relative dimensional change greater than 3%.

No apparent differences were noted between the 2 different particulate materials that were utilized beneath the titanium reinforced Gore-Tex membranes. In addition, the stability of the regenerated ridge did not vary with the mesiodistal dimension of the edentulous space. Regenerated edentulous ridges 1 or 2 teeth wide yielded the same stability over the course of the study (Table 2).

**Table 1** Buccopalatal Dimension of Hard Tissue Before and After Guided Bone Regeneration

| Patient | Site | BP at baseline (mm) | BP at data collection (mm) | BP change (mm) | Elapsed time (wk) |
|---|---|---|---|---|---|
| 1 | MRCI | 6.0 | 6.0 | 0 | 122 |
| 2 | MRL | 5.9 | 5.9 | 0 | 127 |
| 3 | MRL | 6.2 | 6.2 | 0 | 126 |
| 4 | MLL | 6.2 | 6.1 | 0.1 | 124 |
| 5 | MLL | 5.7 | 5.7 | 0 | 124 |
| 6 | MRL | 6.1 | 6.1 | 0 | 125 |
| 7 | MRL/MRCI | 6.2/6.1 | 6.1/6.1 | 0.1/0 | 126 |
| 8 | MRL | 6.3 | 6.3 | 0 | 124 |
| 9 | MRL | 6.3 | 6.3 | 0 | 118 |
| 10 | MLCI | 6.6 | 6.4 | 0.2 | 123 |
| 11 | MRL | 6.2 | 6.1 | 0.1 | 126 |
| 12 | MLL | 6.1 | 6.1 | 0 | 124 |
| 13 | MRCI/MLCI | 7.1/7.1 | 7.1/7.1 | 0/0 | 121 |
| 14 | MRCI/MLCI | 6.8/6.7 | 6.8/6.7 | 0/0 | 122 |
| 15 | MLL | 6.3 | 6.2 | 0.1 | 120 |
| 16 | MLL | 6.3 | 6.3 | 0 | 125 |
| 17 | MRL | 6.3 | 6.3 | 0 | 125 |
| 18 | MRCI | 6.6 | 6.6 | 0 | 124 |
| 19 | MLCI | 6.1 | 6.1 | 0 | 122 |
| 20 | MLCI | 6.6 | 6.6 | 0 | 122 |
| 21 | MLCI | 6.4 | 6.4 | 0 | 122 |
| 22 | MRL/MRCI | 6.6/6.6 | 6.5/6.5 | 0.1/0.1 | 123 |
| 23 | MRCI | 6.6 | 6.6 | 0 | 122 |
| 24 | MLL | 6.1 | 6.0 | 0.1 | 122 |
| 25 | MLCI | 6.5 | 6.5 | 0 | 124 |
| 26 | MLCI | 5.9 | 5.9 | 0 | 124 |
| 27 | MRCI/MLCI | 6.5/6.6 | 6.5/6.6 | 0/0 | 120 |
| 28 | MRL | 6.0 | 5.9 | 0.1 | 125 |
| 29 | MRCI | 6.1 | 6.1 | 0 | 122 |
| 30 | MLL | 5.8 | 5.8 | 0 | 125 |
| 31 | MLL/MLCI | 6.5/6.5 | 6.5/6.5 | 0/0 | 118 |
| 32 | MLCI | 6.5 | 6.5 | 0 | 124 |
| 33 | MRL | 6.0 | 5.9 | 0.1 | 124 |
| 34 | MRC | 7.1 | 6.9 | 0.2 | 118 |
| 35 | MLC | 6.8 | 6.8 | 0 | 123 |
| 36 | MLC | 6.8 | 6.8 | 0 | 123 |
| 37 | MRL | 5.9 | 5.9 | 0 | 122 |
| 38 | MLL/MLCI | 6.4/6.4 | 6.4/6.4 | 0/0 | 124 |
| 39 | MRCI/MLCI | 6.5/6.6 | 6.5/6.6 | 0/0 | 120 |
| 40 | MRL | 6.1 | 6.1 | 0 | 124 |
| 41 | MRL | 6.1 | 6.1 | 0 | 121 |
| 42 | MRCI | 6.0 | 6.0 | 0 | 122 |
| 43 | MLL | 6.1 | 6.1 | 0 | 122 |

BP = buccopalatal dimension of hard tissue; MRC = maxillary right canine; MRL = maxillary right lateral incisor; MRCI = maxillary right central incisor; MLCI = maxillary left central incisor; MLL = maxillary left lateral incisor; MLC = maxillary left canine.
BP change was recorded as 0 if less than 0.1 mm.

**Table 2** Buccopalatal Dimensional Changes with Respect to Size of Treated Site

| | No. of sites | Average elapsed time B-P° to B-P∝ (wk) | Average BP change (mm) | Average percentage BP change |
|---|---|---|---|---|
| 1-tooth sites | 35 | 124 | 0.03 | 0.4% |
| 2-teeth sites | 8 | 121 | 0.02 | 0.3% |

## Discussion

While GBR therapy has been shown to be highly predictable, to result in formation of viable new bone, and to withstand functional forces around implants,[1–16] no studies have demonstrated the stability of such bone over time in the absence of implant placement. Although only a preliminary exploration of the question, this paper demonstrates predictable stability of regenerated atrophic ridges beneath the pontics of fixed prostheses for a mean time of 123 weeks. Since no functional forces were being placed on this regenerated bone, there is no reason to expect the resorptive process to initiate itself as time progresses.

No autogenous bone was placed beneath any of the titanium-reinforced Gore-Tex membranes. Autogenous bone is widely recognized as the "gold standard"[19] when performing regenerative therapy because of its significant osteoinductive effect and its ability to thus shorten the length of therapy. However, successful and predictable GBR results have been demonstrated in the absence of autogenous bone, both around implants and when treating atrophic ridges. The advantage to utilizing nonautogenous material is the elimination of the need for a second surgical site, which decreases patient morbidity. The disadvantage is that the length of time necessary to effect regeneration is increased.

More seminal to the attainment of maximum regenerative results, regardless of the time frame considered, is proper patient selection and technical execution, as discussed in detail in previous publications.[7,13,18] Once an appropriate site has been selected, delicate and innovative flap management are prerequisites to obtaining passive primary closure and thus maximizing regenerative results. No materials other than autogenous bone have conclusively demonstrated clinically significant osteoinductive capabilities or the advantage of a shorter duration therapy. As a result, the crucial characteristics necessary with nonautogenous materials are that they be osteoconductive, possibly wholly resorbable if implant placement is to be anticipated, and that the material help with clot stabilization, both to assist in keeping the clot intact and to help prevent clot shrinkage beneath the membrane, which would compromise the regenerative result.

More crucial than the material selection is the selection and handling of the appropriate membrane. In a non–space maintaining defect, titanium-reinforced Gore-Tex membranes have the advantage of forming and maintaining a well-circumscribed space, thus aiding significantly in clot protection and governing the exact contours of the final regenerated hard tissues. Membrane fixation is also crucial, as it limits or prevents micromovement, further protecting the clot and lessening the possibilities of obtaining a thick fibrous layer of soft tissue between the membrane and the regenerated bone at the time of membrane removal. Finally, the already discussed need for passive primary soft tissue closure is of paramount importance, as it ensures a maximization of the regenerative result. Such passive primary closure should be easily attainable if proper tissue manipulation and flap design considerations are actuated.

## Conclusions

Atrophic ridges rebuilt through GBR procedures have been shown to remain stable over the course of this clinical trial (a mean time of 123 weeks). Since no functional forces were placed upon these regenerated tissues, there is no reason to expect a resorptive process to initiate itself in the future.

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