The Multilayer GBR Technique: An Alternative Approach for One-Stage Transmucosal Implant Placement in the Presence of Horizontal Defects. A Case Series

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This study presents a one-stage technique for horizontal guided bone regeneration and transmucosal implant placement in the presence of hard and soft tissue defects. The proposed technique uses autologous bone particles, deproteinized bovine bone matrix, collagen membranes, and concentrated growth factor membranes to create a multilayer barrier and enhance tissue regeneration. Four patients were treated with a total of seven implants. Digital analyses of intraoral scan data taken at baseline and at 6 months postsurgery showed a mean increase in tissue volume of 157.4 mm³. The patient satisfaction was high, and no complications were observed. Int J Periodontics Restorative Dent 2022;42:e113–e120. doi: 10.11607/prd.6084

Alveolar bone resorption and soft tissue collapse are typical changes in the periodontium that take place after tooth loss.¹ On average, 29% to 63% of bone volume is lost in the first 6 months after tooth extraction;² and the facial soft tissue thickness in the anterior maxilla is reduced by 1.6 mm.³ Hard and soft tissue defects may jeopardize the function and esthetics of the final rehabilitation.⁴ Thus, surgical reconstruction of hard and soft tissues⁵ may be helpful in improving results, especially in the anterior areas, where preserving or restoring symmetrical tissue volume is a key factor for predictable and successful results at both the implant sites and neighboring teeth.⁶

Guided bone regeneration (GBR)⁷ is pivotal for the treatment of horizontal bone defects and can obtain up to 7.0 mm of gain in the horizontal dimension.⁸ GBR can be carried out prior to (two-stage procedure) or simultaneously with (one-stage procedure) implant placement. In one-stage horizontal bone augmentation, satisfactory results with low complication rates can be obtained with resorbable collagen membranes, which can be used in combination with a variety of grafting materials.⁸ Combinations of grafting materials have also been reported; for instance, the addition of autogenous bone chips to

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deproteinized bovine bone mineral (DBBM) may enhance bone formation.\textsuperscript{10,11}

Growth factors have recently been introduced in periodontal and dental implant bone augmentation procedures.\textsuperscript{12,13} In particular, application of concentrated growth factors (CGFs) following posterior tooth extraction may reduce vertical and horizontal bone resorption and promote new bone formation.\textsuperscript{14} Using a CGF membrane in GBR may accelerate the healing process,\textsuperscript{12} increase the thickness of soft tissues,\textsuperscript{15} and improve implant osseointegration.\textsuperscript{16,17}

Multiple surgical procedures are often required to obtain adequate results. This can be disadvantageous because of the risk for tissue damage, scarring, and loss of keratinized tissue, as well as increased time, cost, and patient discomfort.\textsuperscript{18}

The aim of this report was to present a one-stage technique for horizontal GBR and transmucosal implant placement in the presence of hard and soft tissue defects. The proposed technique uses autologous bone particles, DBBM, collagen membranes, and CGF membranes to create a multilayer barrier and enhance tissue regeneration.

**Materials and Methods**

Eligible participants for this study were adults 18 years of age or older requiring implant placement in an esthetic area with horizontal tissue deficiency. Patients with systemic or local diseases contraindicating the surgical therapy, smokers, and pregnant and lactating women were excluded from the study. This study was conducted according to the guidelines of the Declaration of Helsinki, and each participant received detailed information and gave written informed consent.

**Surgical Procedure: Multilayer GBR**

A preoperative CBCT scan was performed to evaluate the 3D defect morphology and to plan for a prosthetically guided implant placement. The implant placement was performed either as an early procedure (between 6 weeks and 6 months after extraction) or as a delayed procedure (more than 6 months after extraction), although this technique can also be used in cases of immediate postextraction implantation. Before surgery, CGF membranes were prepared as described by Bozkurt Doğan et al.\textsuperscript{19} An expert surgeon (Mauro Merli) completed all of the surgical procedures. All patients underwent conscious sedation with continuous monitoring of vital signs throughout the entire surgical procedure. During the surgical procedures, the patients received the same pharmacologic protocol: fractioned administration of midazolam (0.5 to 1 mg) and atropine (0.5 mg), ceftriaxone (1 g), tramadol (100 mg), ketorolac (30 mg), and betamethasone sodium phosphate (4 mg).

Under local anesthesia (articaine with adrenaline 1:100,000), a mucoperiosteal flap was raised. Implant placement followed the transmucosal approach. The surgeon chose the diameter and length of the implant (SPI Element RC, Thommen Medical) and the dimensions of the healing abutment based on the virtual plan. After implant placement, a collagen porcine membrane (Bio-Gide, Geistlich) was positioned as a “poncho” and stabilized with titanium tacks (Smartact evo, Meta Technologies) on the palatal aspect. The cortical bone in the area of regeneration was perforated using a low-speed bur, without irrigation, to open access to bone marrow spaces.\textsuperscript{20} During implant site preparation, particulate autologous bone derived from the use of drills was collected through a sterile disposable filter connected to the surgical aspirator. If needed, an additional portion of autologous bone was harvested using a safe scraper from areas adjacent to the implant site. The defect was filled with both autologous bone and DBBM (Bio-Oss, Geistlich): A first layer of autologous bone was positioned on the exposed surface of the implant,\textsuperscript{21} and a second layer of DBBM, wetted with the patient’s blood, was applied to complete filling the defect. Xenograft associated with bone-conditioned medium (blood and products derived from bone cutting) has been reported to increase the migration, adhesion, and mineralization capacity of the preosteoblast.\textsuperscript{22} The collagen membrane was folded and fixed with mini tacks on the vestibular aspect, taking care to avoid empty space under the membrane. A first layer of CGF was applied at the crestal...
level, and a second layer on the vestibular aspect. A horizontal periosteal incision and, if necessary, a muscle dissection were performed to allow for a passive coronal placement of the flap and to achieve a proper seal around the positioned healing abutment. Horizontal mattress and single sutures 6/0 were used to close the flap.

Amoxicillin (875 mg) and clavulanic acid (125 mg) twice a day for 6 days, ibuprofen (600 mg) twice a day for 2 days and then as needed, and betamethasone for 5 days (doses decreasing daily from 4 mg to 0.5 mg) were administered to the patients. Ice packs were applied intermittently for the first 2 to 3 hours after surgical treatment. Patients were instructed to avoid mechanical plaque removal in the treated area for 1 week, to use chlorhexidine mouthrinse (0.12%) twice a day from the third postoperative day, and to apply chlorhexidine gel twice a day for 15 days. The presence of any complications was assessed up to 12 months postsurgery. A thermo-molded template or Maryland bridge was used as a provisional prosthesis. The implants were loaded after 8 weeks to begin the peri-implant conditioning phase, and the definitive prostheses were delivered 6 months after loading.

Bone level stability was measured with periapical radiographs taken immediately after the surgical procedure and 6 months postsurgery. At 12 months postsurgery, patients were asked to express their degree of satisfaction with the esthetic results using a visual analog scale (VAS) with the endpoints 0 (greatly dissatisfied) and 10 (very satisfied). In addition, an examiner (Marco Merli) registered the Pink Esthetic Score (PES).

**Volume Analysis**

Volume modifications of surgical sites were analyzed according to the following methodology. An intraoral scan of the surgical site was taken by one investigator (Mauro Merli) with the same intraoral scanner (Trios 3, 3Shape) before surgery (T0) and 6 months after surgery (T1). T0 and T1 scans were exported as standard tessellation language (STL) files and used for 3D analysis and comparisons in a surface matching software program (Geomagic Wrap 2021, 3D Systems). T0 and T1 scans were preliminarily aligned with each other using a two-phase best-fit superimposition, and then an additional local best-fit procedure that considered only the surface of teeth was performed to optimize the alignment on such surfaces. The area of interest (T0i) was defined on T0 by tracing a curve including the buccal aspect of the tooth/teeth involved in the surgical procedure. This curve was automatically projected onto a T1 scan to obtain the corresponding area of interest (T1i). A color difference map of each comparison was obtained for visualization and analysis of the deviation pattern.

T0i and T1i surface extensions were measured; then, an arbitrary reference plane was defined, and the volume obtained by projecting T0i and T1i onto such a plane was calculated (V0 and V1, respectively). The difference between V0 and V1 expressed the volume variation of the areas of interest and was considered the primary outcome. Cross-sections were also constructed onto T0i and T1i scans, and the corresponding linear distances were measured.

**Statistical Analysis**

Descriptive statistical analysis was performed at the patient level for age, sex, smoking habit, VAS, marginal bone level on periapical radiographs, and volume modifications. Mean and SD values were calculated for quantitative variables.

**Results**

Four clinical cases were treated. All patients recovered well, and no complications were observed. Patient 1 was a 53-year-old nonsmoking woman presenting with two maxillary central incisors showing root resorption and periodontal disease (Figs 1a and 1b). The incisors were extracted, and after 2 months, a hard and soft tissue buccal defect was evident (Fig 1c).

A mucoperiosteal flap was raised, and two transmucosal implants were inserted (Fig 1d). The first layer of autologous bone harvested during the implant placement procedure and the second layer of DBBM were covered by the collagen membrane, positioned as a poncho, and stabilized with titanium tacks (Figs 1e and 1f). A first layer of CGF membrane was
Fig 1 (a) Preoperative view prior to extraction. (b) Periapical radiography of the maxillary central incisors prior to extraction. (c) Facial view 2 months after extraction. (d) The mucoperiosteal flap was raised, the bone was exposed, and two transmucosal implants were inserted. (e) A collagen membrane was stabilized with titanium tacks on the palatal side, and a first layer of autogenous bone was applied on the exposed surfaces of the implants. (f) A second layer of DBBM was applied, and the collagen membrane was folded and fixed with mini tacks on the vestibular aspect, avoiding empty space under the membrane to facilitate blood clot stability. (g) A first layer of CGF was applied as a “poncho” at the crestal level. (h) A second layer of CGF was applied on the vestibular aspect. (i) The flaps were sutured in a coronal position. (j) Facial and (k) occlusal views 8 weeks after surgery. (l) Periapical radiograph taken at 6 months postsurgery. (m) CBCT scans taken at 6 months postsurgery. (n) Facial view of the definitive prostheses at 6 months postsurgery.
applied as a poncho at the crestal level, and a second layer on the vestibular aspect (Figs 1g and 1h). The flaps were then sutured (Fig 1i). The patient recovered without complications; the tissue appearance 2 months after surgery is shown in Figs 1j and 1k. The radiographs taken 6 months after surgery are shown in Figs 1l and 1m, and the definitive prosthesis in Fig 1n. The color map of the difference in volume between baseline and the 6-month follow-up is presented in Fig 2a. Two other images show the different tissue profiles in occlusal and lateral views before and 6 months after surgery, as well as the linear distance between the two surfaces (Figs 2b and 2c).

The images of another clinical case are shown in Fig 3. Two other patients besides those shown in Figs 1 and 3 were treated; individual patient data, mean and SD volume difference, PES, and VAS are reported in Table 1. The mean volume growth was 157.4 mm³, and all patients perceived the procedure favorably (all rating their satisfaction as 10 on the VAS).

Discussion

This pilot study assessed the clinical outcome of a one-stage procedure for horizontal GBR and transmucosal implant placement in the presence of hard and soft tissue defects. The four cases reported here showed positive outcomes resulting in substantial volume augmentation, good esthetics, no complications, and high patient satisfaction.

The rationale for layering the various materials presented in this technique relies on available evidence: The use of bone grafts and membranes promotes hard tissue regeneration in one-stage horizontal augmentation, and their use is advocated in systematic reviews.8,10

Fig 2 (a) Color map showing surface differences between baseline and the 6-month follow-up. (b) Tissue profiles before surgery (light pink color) and 6 months after surgery (transparent surface). The (D) values indicate the linear distance between the two surfaces. (c) Lateral view of Fig 2b.
DBBM was added because a recent randomized controlled trial comparing sites grafted in one-stage implant procedures with DBBM and a porcine collagen membrane for untreated osseous defects showed less vertical bone loss at the buccal aspect 6 months after implant placement, as well as less marginal bone loss between crown placement and 18 months posts-loading.

A peculiarity of this novel technique is the addition of a double layer of CGF membrane over the collagen membrane. The use of blood growth factors within bone augmentation procedures has been

**Fig 3** (a) Preoperative clinical and (b) radiographic views of a maxillary central incisor with root resorption. (c) Postextraction implantation was performed. (d) Clinical view of the definitive prostheses and (e) periapical radiographic view at 6 months postsurgery.

**Table 1 Patient Characteristics Before and After Treatment**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Sex</th>
<th>Smoker</th>
<th>Reason for tooth extraction</th>
<th>Implants, n</th>
<th>Buccal area of interest, mm²</th>
<th>Difference in volume between T0 and T1, mm³</th>
<th>PES</th>
<th>VAS</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>53</td>
<td>F</td>
<td>No</td>
<td>Endodontic</td>
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<td>110.4</td>
<td>153.0</td>
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</tr>
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<td>2</td>
<td>55</td>
<td>F</td>
<td>No</td>
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<td>2</td>
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<td>54.9</td>
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<td>10</td>
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<tr>
<td>3</td>
<td>46</td>
<td>M</td>
<td>No</td>
<td>Fracture</td>
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<td>103.0</td>
<td>212.0</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>M</td>
<td>No</td>
<td>Root resorption</td>
<td>2</td>
<td>103.9</td>
<td>209.5</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Mean</td>
<td>44.0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1.7</td>
<td>106.5</td>
<td>157.4</td>
<td>10.7</td>
<td>10</td>
</tr>
<tr>
<td>SD</td>
<td>15.2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.5</td>
<td>3.6</td>
<td>73.5</td>
<td>1.3</td>
<td>0</td>
</tr>
</tbody>
</table>

PES = Pink Esthetic Score; VAS = visual analog scale.

PES and VAS scores were evaluated at 12 months postsurgery.

*FDI tooth-numbering system.

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well described in the literature, showing promising results regarding acceleration of the osseointegration process, soft tissue healing, new bone formation, and postoperative discomfort. In particular, previous studies have indicated that CGF accelerates new bone formation related to GBR by delivering a number of growth factors to the application site, including transforming growth factor-beta 1 (TGF-β1), vascular endothelial growth factor (VEGF), platelet-derived growth factor (PDGF), insulin-like growth factor (IGF), epidermal growth factor (EGF), fibroblast growth factor (FGF), and bone morphogenetic protein (BMP). In addition, it has been reported that CGF application also had positive effects on surgical wound healing after implant placement.

The present results seem to confirm a positive cumulative effect of layered materials as used in the presented technique; moreover, as this layering can be performed in one surgical session, it is advantageous for minimizing patient discomfort. Furthermore, a connective tissue graft may not be required in this procedure.

An additional benefit of this technique is the coronal repositioning of the flap obtained by the horizontal periosteal and muscle incisions. In this way, the peri-implant soft tissue margin will adapt around the healing abutments, ensuring an adequate seal in a more coronal position and resembling adjacent teeth. The transmucosal implant placement makes it possible to start implant loading by means of a provisional prosthesis and tissue conditioning after 8 weeks, which is beneficial in improving the final aesthetic result. A potential limitation of this technique could be related to the surgical expertise required to perform tissue management and the layering of multiple materials. Furthermore, being a multilayer technique, it is also difficult to establish whether the same result can be obtained without using one or more layers. Comparative studies are needed to answer this question. It would also be interesting to compare the proposed technique to other multistage techniques proposed in the literature.

Conclusions

The present results seem to be promising, although the reduced number of cases included in this pilot study and the short follow-up period highlight the need for future research for validation of this technique.

Acknowledgments

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References


