This article describes a novel approach for horizontal guided bone regeneration (GBR) using a dehydrated amnion/chorion membrane (dHACM) in conjunction with a composite mixture of cortical autogenous particulate bone scrapings and mineralized bovine bone particulate in the anterior maxilla, allowing for placement of dental implants in a previously deficient alveolar ridge. The grafted region was reentered 8 months after GBR surgery, and a substantial increase in horizontal bone width was observed. Endosseous dental implants were placed with excellent primary stability in a prosthetically driven manner (which could not have been done prior to GBR) and successfully restored with a screw-retained bridge prosthesis. To the authors’ knowledge, this is the first reported documentation of successful horizontal GBR using dHACM with subsequent implant placement and restoration, and the first to demonstrate the excellent clinical potential of this biomaterial.


Following tooth loss, the alveolar ridge undergoes progressive resorption, resulting in loss of bone width and height.¹ This loss of dimension and structure can present challenges for optimal functional and esthetic reconstruction of the residual ridge.² Consequently, there has been much interest in the development of surgical techniques to augment deficient bone, restoring alveolar ridge height and width dimensions and permitting the prosthetically driven placement of endosseous dental implants.³ Guided bone regeneration (GBR) is a validated treatment modality that was developed for the purpose of increasing bone volume in deficient residual ridges to facilitate implant placement, as noted above.⁴,⁵ GBR involves the placement of various particulate bone graft materials, used individually or in combination with complementary materials, underneath a resorbable or non-resorbable barrier membrane.⁶ For horizontal GBR, resorbable membranes are preferred, given that a secondary surgery for membrane removal is not required and thus there is decreased morbidity.⁷

Over the past decade, there have been several studies focused on the use of dehydrated amnion/chorion membranes (dHACMs) derived from human placental tissue for procedures such as extraction...
The first description of dHACM use for horizontal alveolar ridge augmentation by way of GBR.

Clinical Case

A 49-year-old healthy man presented with missing maxillary central incisors and a missing left lateral incisor (Figs 1a and 1b). These teeth were lost due to sports-related trauma when the patient was in his early 20s, and he had been wearing a removable partial denture since. The patient was interested in rehabilitating his edentulous span with an implant-supported prosthesis. CBCT scans (Figs 1c and 1d) taken preoperatively showed significant alveolar ridge atrophy that would preclude prosthetically driven implant placement into an ideal bone envelope.

Thus, horizontal GBR for ridge augmentation was indicated. The prosthetic treatment plan involved the provision of a screw-retained bridge prosthesis supported by two dental implant fixtures in the central incisor sites, which would serve as abutments.

Materials and Methods

GBR Procedure

After administration of local anesthetic (2% lidocaine with 1:100,000 epinephrine; Xylocaine, Dentsply Sirona), a paracrestal incision was made and extended within the gingival sulci to the distobuccal line angles of the teeth immediately adjacent to the region that was to undergo GBR. Oblique vertical

Fig 1 Preoperative maxillary situation. (a) Buccal view of the maxillary anterior edentulous region to undergo horizontal GBR. Note the healthy appearance of tissues and sufficient zone of keratinized gingiva. The alveolar ridge was evident apically. (b) Occlusal view of maxillary anterior edentulous region. The tissue’s thick clinical appearance is not necessarily suggestive of sufficient underlying bone. (c) A representative CBCT slice of the right central incisor site showing mild alveolar ridge concavity and a decreased alveolar ridge width. (d) A representative CBCT slice of the left lateral incisor showing substantial ridge concavity and a decreased alveolar ridge width.
incisions were made just beyond the mucogingival junction. Upon flap elevation, the alveolar bone was debrided gently in order to remove adherent but unneeded soft tissue fibers in the treatment area. The deficient residual ridge was observed clinically after flap elevation (Fig 2a). Intramarrow perforations were made in the cortical bone with a quarter-round diamond bur (Brasseler) using high-speed rotary instrumentation with copious irrigation to promote the flow of marrow-derived cells and blood, which also contains osteoprogenitor cells, into the surgical wound. The residual ridge was grafted with a 1:1 composite mixture of cortical autogenous bone scrapings harvested from the native site (using a bone scraper) and mineralized bovine bone particulate (OCS-B, Keystone Dental) to construct dimensions sufficient for the later placement of endosseous dental implants in a functionally and prosthetically favorable position. The grafted ridge was then draped over completely with dHACM (BioXclude, Sanoasis Medical; Figs 2b and 2c). Using the rounded edge of a periosteal elevator (P24G, HuFriedy) wetted with saline, the membrane was intimately adapted and extended at least 2 mm beyond the margins of the newly grafted alveolar ridge to effectively “seal” the graft from surrounding tissues. Finally, a periosteal releasing incision connecting the vertical incisions was made, permitting coronal advancement of the buccal flap that would be used to completely cover the graft and membrane after surgery. Tension-free primary closure was achieved with 4-0 polytetrafluorethylene sutures (Cytoplast, Osteogenics Biomedical) using the bilayered closure technique described elsewhere14 (Fig 2d). The vertical releasing incisions were closed using interrupted 5-0 chromic gut sutures (Ethicon, Johnson & Johnson).

Postoperatively, the patient was prescribed amoxicillin (500 mg) three times daily for 1 week and ketorolac hydrochloride (10 mg) three times daily as needed for pain for 5 days. The patient was also instructed to rinse with warm salt water four times daily and to avoid brushing teeth adjacent to the grafted area for 2 weeks. Supragingival prophylaxis was done at 1 and 2 weeks postoperatively before the patient was allowed to resume gentle oral hygiene in the area. Sutures were removed after 4 weeks of graft healing. The patient was seen 1 week, 2 weeks, 6 weeks, 3 months, and 6 months postoperatively to ensure that healing was progressing well. CBCT scans of the grafted site were taken after 6 months of graft healing to assess and quantify changes in

Fig 2 (a) Occlusal view demonstrating horizontal alveolar ridge deficiency in the anterior maxilla, corroborating findings from preoperative CBCT scans. Note that the ridge concavity is more pronounced in the edentulous left central and lateral incisor sites. (b) dHACM prior to placement over bone graft. (c) A 1:1 composite mixture of cortical autogenous bone scrapings and mineralized bovine bone particulate was grafted on the ridge and covered with dHACM at the left central and lateral incisors site. Grafting at the edentulous right central incisor site not shown. (d) Tension-free primary closure achieved.
alveolar ridge dimensions (Fig 3). The scans were also used to fabricate a surgical stent for optimal guided placement of dental implants according to the prosthetic prescription.

**Results**

Healing following the GBR procedure occurred uneventfully (Figs 4a and 4b). CBCT scans showed a substantial gain in bone width from preoperative levels. Reentry surgery and implant placement in the central incisor sites were performed 8 months postoperatively. Upon flap elevation, the substantial gain in horizontal bone dimension was evident and of sufficient quantity for placement of the selected implants (Tapered Internal and Tapered Internal Plus Implant System, BioHorizons; Fig 4) in a prosthetically driven fashion using a CT-fabricated surgical guide (Figs 4c to 4f). The regenerated bone quality was deemed to be a combination of Types 2 and 3.15 Each implant was placed with a minimum buccal bone thickness of 2 mm, which has been identified as a critical factor for long-term hard and soft tissue stability.16 Both implants were placed with excellent primary stability and a 35-Ncm insertion torque value. The implants were deemed to be successfully osseointegrated after 4 months and subsequently restored with a screw-retained bridge prosthesis by the patient’s referring dentist; the patient was seen by the primary author (V.M.B.) for a follow-up visit 2 months after prosthesis delivery (Fig 5).

**Discussion**

Currently, resorbable membranes are used most commonly in GBR procedures where horizontal augmentation is required. These membranes have been studied extensively, and the outcomes associated with their use have generally been favorable.17,18 These membranes have numerous advantages, such as rapid vascularization, good tissue integration, and the capability of spontaneous healing in the presence of mucosal dehiscence.19 However, they also carry significant disadvantages and limitations, including premature surgical exposure,20 unpredictable maintenance of barrier function over the requisite postoperative recovery period,21 and an inflammatory response seen during membrane resorption,19 all of which can interfere with wound healing and compromise bone formation, resulting in less-than-ideal reconstruction of the deficient residual ridge.

With any GBR procedure, the development of postsurgical soft tissue dehiscence and membrane exposure are of paramount concern, as they can be associated with extensive resorption of the grafted materials, which can lead to a lack of continuity between the graft and the recipient bed.22 In most cases, this loss of contiguity would constitute a failure of the graft; at best, it may lead to gains in hard tissue, but these would not be sufficient to support clinical use and good clinical outcomes. Indeed, when soft tissue dehiscence and membrane exposure occur, up to 6 × less bone formation can be expected compared to nonexposed sites.20 Furthermore, a meta-analysis by Garcia et al23 showed that for edentulous ridges,
74% more horizontal bone gain was achieved at sites without membrane exposure than at sites with exposure. In another recent systematic review and meta-analysis, it was shown that the weighted complication rate including membrane exposure and soft tissue dehiscence for conventional resorbable membranes was 18.3%. Of course, there are other factors that affect the outcome of GBR procedures, including the location of the surgical site. A retrospective analysis of risk factors for dehiscence following GBR described a nearly 30% risk of membrane exposure in the anterior mandible and anterior maxilla, whereas in other sites, the risk ranges between 16% and 21%, which is a clinically significant difference.

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Fig 4 (a) Buccal and (b) occlusal views of the grafted ridge 8 months after GBR, before reentry for implant placement, demonstrating excellent tissue healing and maturation. (c) Reentry of the grafted site at 8 months. There is noticeable increase in ridge width compared to the preoperative condition. (d) A tooth-supported CT-fabricated surgical guide was used to allow for placement of dental implants in a prosthetically driven manner. (e) Implants placed in intact bone with an adequate buccal bone shelf (> 2 mm) at prosthetically favorable locations in the right central incisor and left lateral incisor sites. (f) Periapical radiograph of the final implant placement. Implants (4.6 × 12 mm in the central incisor site; 3.8 × 12 mm in the lateral incisor site) were placed with a 35-Ncm insertion torque.

Fig 5 (a) The patient has a low lip line upon smiling, revealing favorable esthetics of the implant-supported restoration. (b) Retracted buccal view of the implant-supported restoration. Note the prosthesis emergence with sufficient zone of keratinized gingiva. (c) A periapical radiograph taken 2 months after placement of the implant-supported prosthesis shows stable bone levels.
dHACM

Based on the above-mentioned information and given that the risk of mucosal dehiscence and membrane exposure is obviously high in the surgical sites to be treated, it was decided that using dHACM may be preferred. This notion was based on data reported in other studies that examined soft and hard tissue healing when using dHACM for open-socket preservation grafting procedures.8,9,26 In these studies, the material was left completely exposed, and no attempt was made to reposition the buccal or lingual tissues to submerge it. Uneventful, spontaneous healing of soft tissues occurred, resulting in keratinized tissue gain over the grafted socket without compromising the quantity and quality of bone for implant placement.8,9,26 Notably, the dHACM did not elicit a foreign-body reaction, which can be attributed to its immune-privilege status.12 While the patient described in the present case report did not experience any postsurgical membrane exposure, the present authors have experienced this with other patients. However, the exposures were small, and no further treatment was required beyond careful monitoring of the area of exposure. Healing occurred uneventfully, as expected from the studies described.

Placental tissues possess both a collagen-based extracellular matrix (ECM) along with soluble signaling molecules, which presents antimicrobial and anti-inflammatory properties that can, in turn, accelerate healing.27 The patented Pu-
ing case series and controlled clinical trials using dHACM in horizontal GBR procedures will be required to better validate the predictability of the technique as well as evaluate long-term stability of the regenerated bone around implants in response to functional loading.

Acknowledgments

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References