Vertical ridge augmentation in the atrophic posterior region of the mandible

A 3D guided bone regeneration approach

Guided bone regeneration (GBR) has a strong scientific evidence base. It is a predictable, effective and widely documented technique for vertical and horizontal bone augmentation in implantology,[1–6] and compared with other techniques, it is the most reliable and stable in the long term, demonstrating less resorption, a low complication rate and low morbidity.[7] The biological principles that determine the predictability of bone formation using GBR techniques have been established by various authors.[1, 2, 8]

Dr Javier Mayor Arenal, Spain

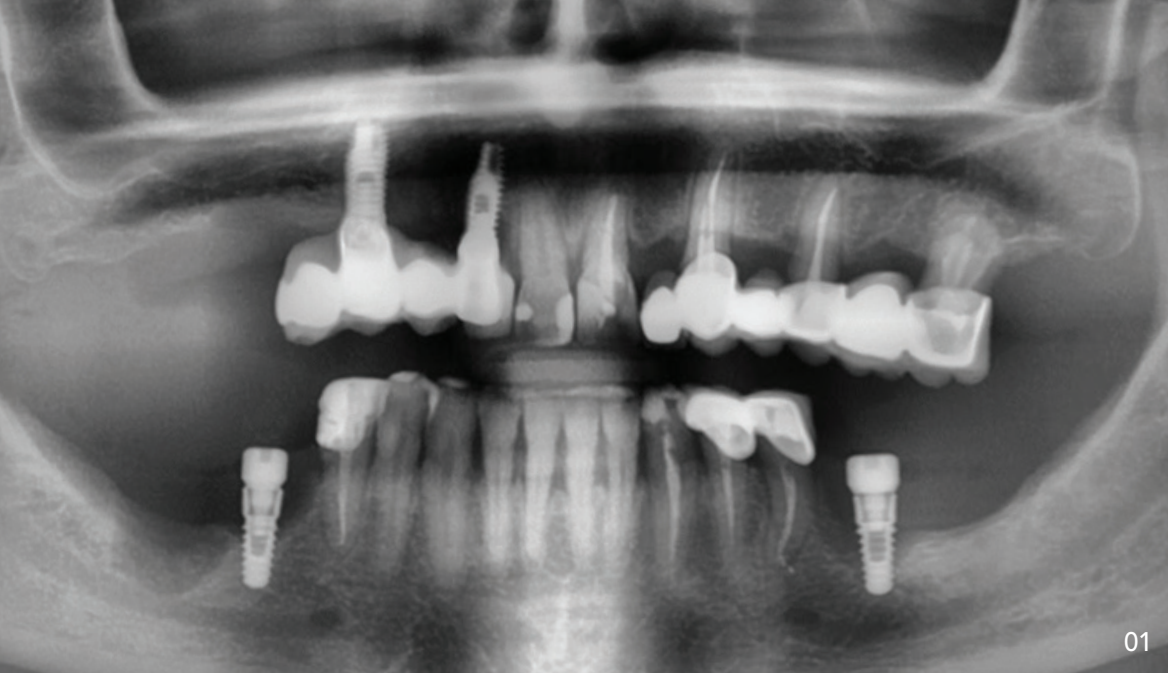
These principles are based on the placement of a membrane that acts as a barrier, selectively excluding unwanted tissue (epithelial cells and fibroblasts) and creating a closed space that can be populated by osteogenic cells, allowing bone formation within the defect. For this process to be successful, primary wound closure must be achieved after regenerative surgery, ensuring adequate vascularisation and maintenance of the regenerative space, as well as optimal mechanical stability of the bone graft and the wound during healing.[9] Horizontal GBR with resorbable membranes and vertical GBR with titanium-reinforced non-resorbable PTFE membranes allow substantial bone gain, achieving an average gain of 5.68 ± 1.42 mm for horizontal augmentation[10] and 5.02 ± 2.03 mm for vertical augmentation using e-PTFE[11] and 5.45 ± 1.93 mm using d-PTFE.[12]

Vertical ridge augmentation is supported by a substantial body of clinical and scientific evidence spanning more than 30 years.[5, 6, 11, 13–16] It is particularly demanding from a biological and technical point of view because vertical defects have a more limited supply of osteogenic cells and less vascularisation than other defects.[17, 18] In this type of procedure, the use of membranes capable of maintaining the space throughout the healing time (nine to 12 months) is essential so that the space can be occupied by newly formed bone.[18, 19] Autogenous bone is considered essential as a grafting material, either alone or mixed with allograft or anorganic xenogeneic bone mineral. When a mixture is used, it should contain at least 50% autogenous bone to obtain reliable bone gain and an adequate amount of vital bone at re-entry, which is considered indicative of treatment success. The therapeutic objective of these techniques is to regenerate hard and soft tissue at the defect site, enabling implant placement and subsequent provision of a fixed implant-supported prosthesis so that the patient can regain function and aesthetics.

The case reported in this article involved vertical ridge augmentation in the atrophic left posterior region of the mandible. In addition to the challenges posed by the complexity of soft-tissue management in this area, there is limited surgical access and reduced blood supply.[14] In this area, it is very important to have a clear understanding of the position of the relevant anatomical structures, such as the mental nerve, inferior alveolar nerve, sublingual space, sublingual artery, lingual nerve and Wharton's ducts.[24] Inadequate surgical management of these structures can result in adverse events or intra-operative complications. In presenting this case, I will discuss the critical factors of this technique in the atrophic posterior region of the mandible and how to perform adequate soft-tissue management while protecting the adjacent anatomical structures, using appropriate techniques to manage the lingual and buccal flaps and ensure passive, tension-free closure for a successful regenerative procedure.

Case presentation

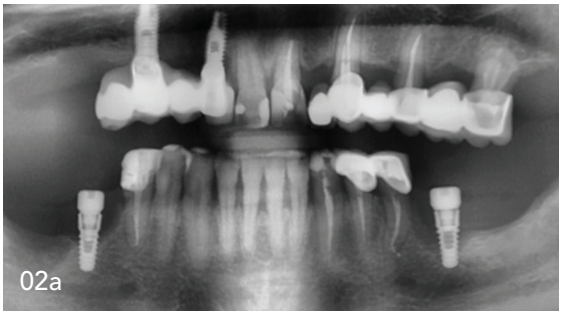
The 55-year-old patient, with no relevant medical history, presented with peri-implantitis affecting implants #36 and #46—only implant #36 is addressed in this report—as well as pain and suppuration in the area (Fig. 1). The patient requested a definitive solution and was advised to undergo explantation, followed by regeneration of the resulting defect in order to place a new implant, surrounded by bone, and finally restore function and aesthetics with a fixed implant-supported prosthesis.

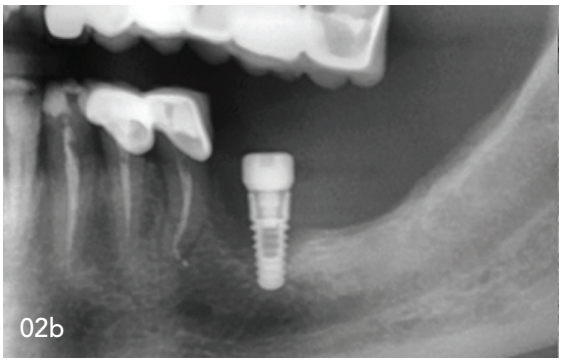


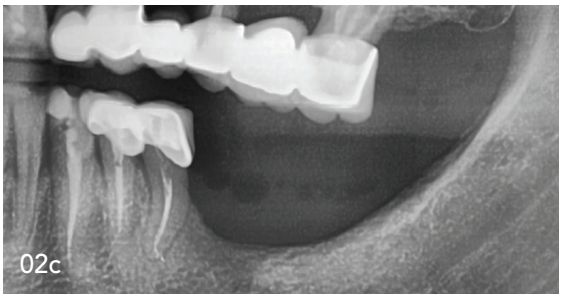
01
Initial panoramic radiograph of implant #36.

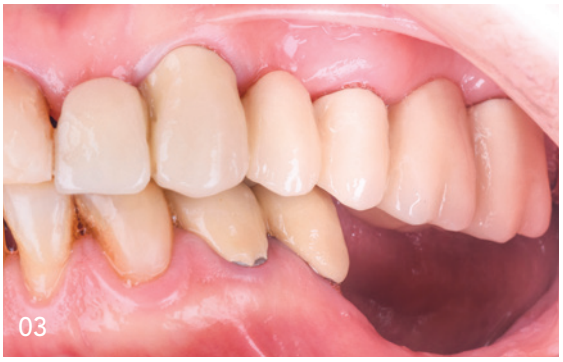
02a–c
Initial panoramic radiograph (a). Close-up of the affected implant and surrounding bone (b). Bone healing after explantation (c).

03
Clinical situation after explantation.







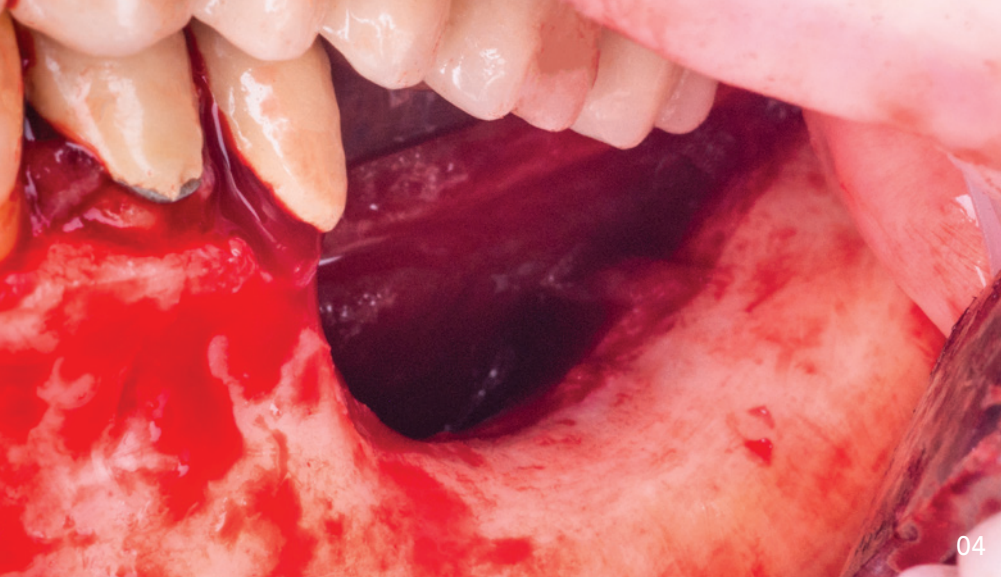


Treatment would involve vertical and horizontal GBR in the defect area, using a dual-texture e-PTFE membrane and a combination of 80–90% particulate autogenous bone and 10–20% anorganic porcine bone mineral. After the maturation of the bone graft, we would place a replacement implant at site #36, surrounded by bone. Once the patient had accepted the proposed treatment, implant #36 was explanted, and we waited for three months before performing surgery because the site presented with inflammation, erythema and bacterial contamination associated with the peri-implantitis (Figs. 2a–c). In such a case, it is more prudent to wait a few months (at least three) before surgery to allow the soft tissue to heal sufficiently for proper management during the regenerative procedure.

Surgical management

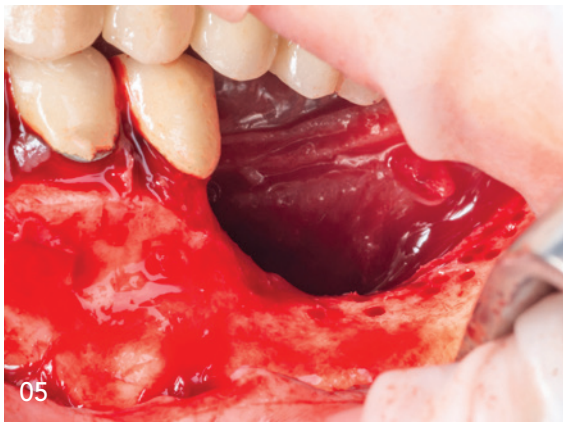
We began the procedure (Fig. 3) by making a full-thickness incision along the centre of the ridge, within the keratinised mucosa, using a No. 15 scalpel blade. The crestal incision ended distally 2 mm from the retromolar pad, and from there, we made a distal oblique vertical incision, keeping the scalpel blade in firm contact with the bone, towards the ramus of the mandible. Anteriorly, we made a vertical incision at the mesiobuccal line angle. This is ideally done two teeth beyond the surgical site,[14, 20, 24, 25] but in this case, we extended this to three teeth (avoiding vertical releasing incisions adjacent to crowned teeth). The extension also allowed local autogenous bone harvesting and tunnelled access towards the chin using special disposable scrapers. On the lingual side, we made a scalloped incision from tooth #35 to tooth #41, without vertical releasing incisions. Next, we refined the incision line with a 4R/4L curette to ensure ideal full-thickness flap elevation down to the bone, allowing us to properly and completely detach the periosteum from the incision line. For this elevation, we used a Molt-type periosteal elevator for both the buccal and lingual flaps.

We raised the lingual flap to the mylohyoid line, where the mylohyoid muscle attaches to the mandible. Anteriorly, generally from the canine, the mylohyoid attachment is located more apically, so in this area, we raised a full-thickness flap, since the anterior position of the mylohyoid does not interfere with flap management. Posteriorly, as the mylohyoid attachment is more coronal, we raised a full-thickness flap in the retromolar area. Lingually, we advanced approximately 3–4 mm by tunnelling, taking care to protect the lingual nerve because of its close proximity to the ridge crest in this region (Fig. 4).



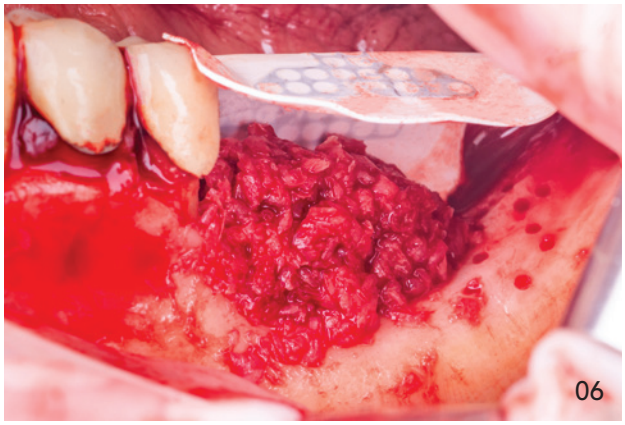
04
Bone defect after raising the full-thickness flap.

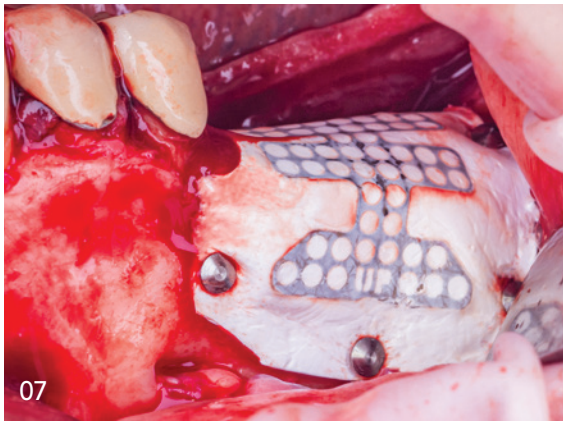
05
Cortical perforations performed to promote vascularisation and osteogenesis in the bone graft.



06
Stabilisation of the NeoGen membrane, beginning with lingual fixation and incorporation of autogenous bone graft into the defect.

07
Lingual and buccal fixation of the membrane, achieving adequate stability over the bone defect.





Buccally, we raised a full-thickness flap while protecting the mental nerve at its point of emergence and removed any remaining attached soft tissue with a back-action instrument. Regarding the management of the lingual flap, to achieve tension-free primary wound closure, different techniques can be used.[23, 26] In this case, we applied Urban's coronal advancement technique for the lingual flap, which involves the intentional preservation of the mylohyoid muscle attachment to the mandible.[24] This release was performed in three zones: Zone I (posterior), where we tunnelled and detached the retromolar pad, adequate release of which facilitates advancement of Zone II (middle), where we gently performed a blunt dissection of the superficial fibres of the mylohyoid muscle; and finally Zone III, the area with the highest complication rate,[14, 25, 27]where we took particular care to perform a shallow periosteal releasing incision using a slightly angled No. 15 scalpel blade, extending from approximately the level of the canine (where the presence of the periosteum is evident) to the position of the most anterior tooth involved in the flap, allowing sufficient and uniform release along the entire length of the flap and achieving passive primary closure. Regarding the advancement of the buccal flap, there are also different techniques,[14, 15, 28, 29] but in this case, we predominantly used the technique described by Ronda in 2015,[30] in which a periosteal releasing incision is made from anterior to posterior, along the buccal flap, combined with a brushing technique using a No. 15 scalpel blade in an angled position on the periosteal fibres, trying to dissect and separate the superficial part from the deeper part of the flap, thereby achieving effective and predictable coronal advancement.

Subsequently, we collected autogenous bone from the external oblique line and mandibular ramus using a curved disposable bone scraper (SAFESCRAPER TWIST, META Technologies). Using a trephine, we also harvested bone cylinders, which we ground together with the scraped bone to improve compaction of the grafting material, combining autogenous bone flakes with medium to large particles. [17, 18, 31] We used a mixture of 80–90% autogenous bone and 10–20% anorganic porcine bone mineral (THE Graft, Purgo Biologics).[12, 14, 21, 32]

Recipient site preparation

We prepared the recipient bone bed by decortication with a disposable bone scraper and by creating multiple cortical perforations with a 1.4 mm diameter round tungsten carbide bur in a handpiece, particularly in the crestal area, to

a depth of approximately 3–4 mm (Fig. 5), sufficient to reach the medullary bone and thus promote bleeding and increase angiogenic and osteogenic potential at the grafted site.[23, 33, 34]

Membrane adaptation and regeneration execution

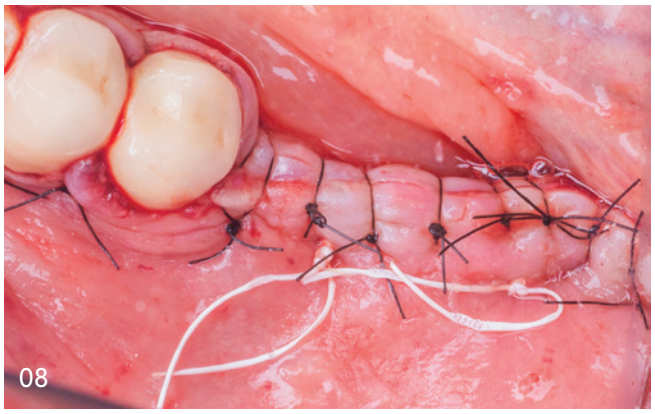
A titanium-reinforced, dual-texture e-PTFE membrane (NeoGen, Neoss) of the appropriate size was selected to overlap the adjacent bone by at least 2 mm and was trimmed to completely cover the graft volume while maintaining at least 1.5 mm of separation from the adjacent tooth.[14, 20] Prior to membrane fixation, we contoured the membrane to the desired ridge shape using the handle of a clamp, approximately 10 mm wide, folding the membrane over it to create a box-shaped regenerative compartment and a crestal plateau defining the desired ridge width and vertical gain. We then filled the compartment with sufficient bone graft.

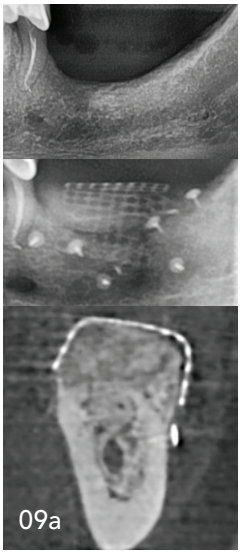
Membrane fixation is a critical aspect of this procedure. It must provide stability and maintain the regenerative space, immobilising the graft to allow for integration. The membrane is first stabilised lingually using tacks and/or 3 mm fixation screws, employing at least one mesiolingual and one distolingual fixation. If the first lingual fixation is difficult to place, a temporary tack or screw can be placed at the most distal aspect of the ridge or at a mesiobuccal site to stabilise the membrane temporarily and facilitate lingual fixation.[14, 35] Once membrane stability has been achieved, the temporary fixation is removed.

Using a Prichard periosteal elevator, we elevated the buccal portion of the membrane and then placed the bone graft, which had been prepared as a homogeneous mixture in a sterile metal dappen dish, over the ridge (Fig. 6). We then placed fixations on the buccal side from distal to mesial as we added and compacted more bone graft, finally securing the membrane mesially to achieve mechanical stability and maintain adequate space (Figs. 7+8). We thoroughly irrigated the membrane with sterile saline to remove any adherent dried blood clots and placed a collagen membrane over it in case of a wide gap or inadequate membrane adaptation over the defect.[12]

Wound closure

We immediately proceeded to wound closure, first reviewing the condition of the lingual flap and ensuring that the coronal advancement achieved using Urban's technique was sufficient.[27] We also confirmed that the buccal flap had achieved adequate coronal advancement, allowing tension-free closure of the wound. Next, we sutured the flaps in two layers, first with a horizontal mattress suture 5 mm from the flap edge using a #4/0 PTFE suture (W.L. Gore & Associates) and then by closing the mucosal incision with a #5/0 non-resorbable Polinyl suture (Sweden & Martina; Fig. 9). This close contact between the connective tissue of both flaps creates a barrier that prevents exposure of the membrane.[14] As postoperative medication, an anti-inflammatory and antibiotic regimen was prescribed for seven days, and the patient was instructed to rinse with 0.2% chlorhexidine twice a day until the sutures were removed, between two and three weeks after the operation.

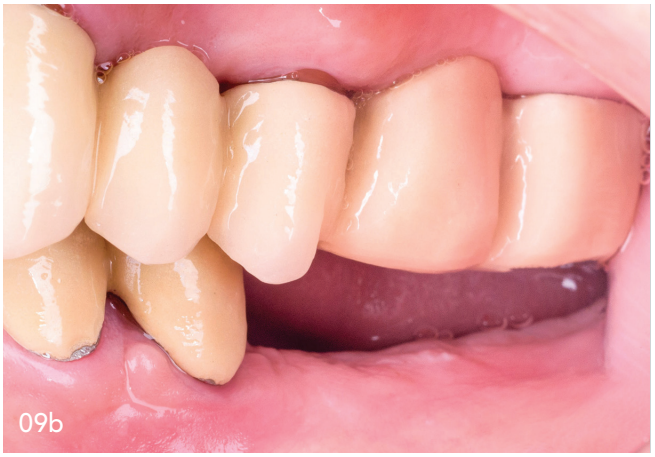


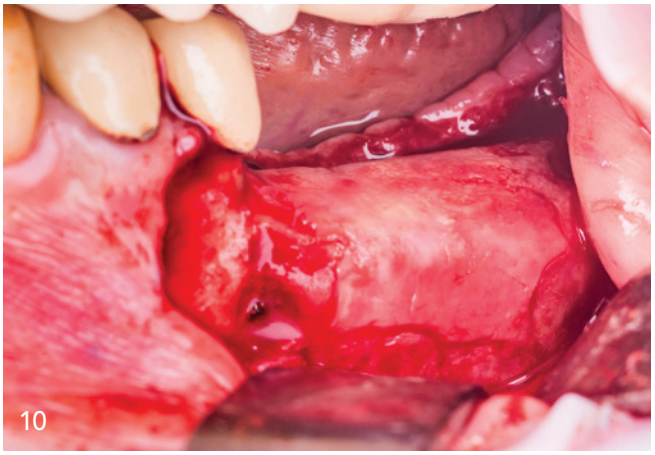


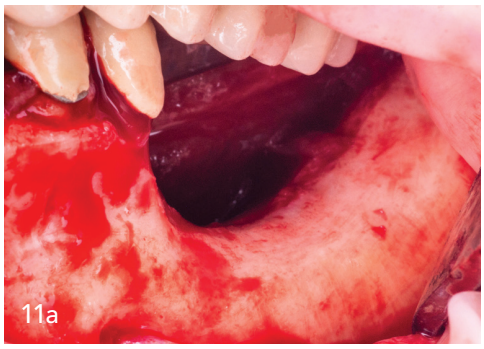
08
Primary tension-free closure through proper handling of the lingual and buccal flaps and adequate periosteal incisions, along with the application of horizontal mattress and simple sutures.

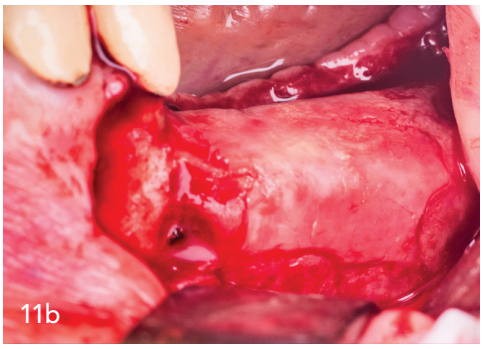
09a+b
Radiographic (a) and clinical status (b) of the regenerated area after ten months of healing.

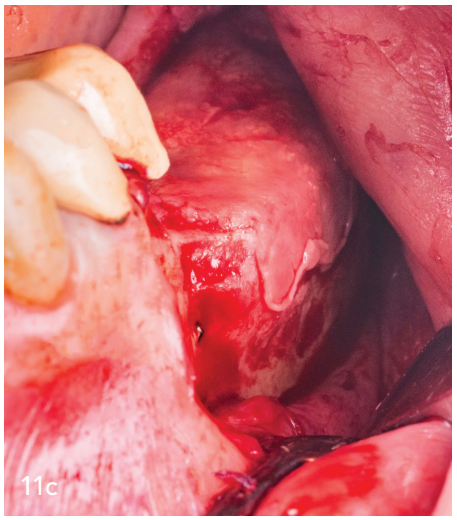
10
Re-entry at ten months, after removal of the membrane, revealing solid and vascularised newly formed bone.





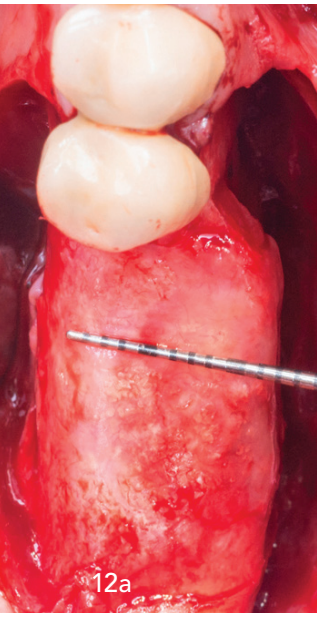


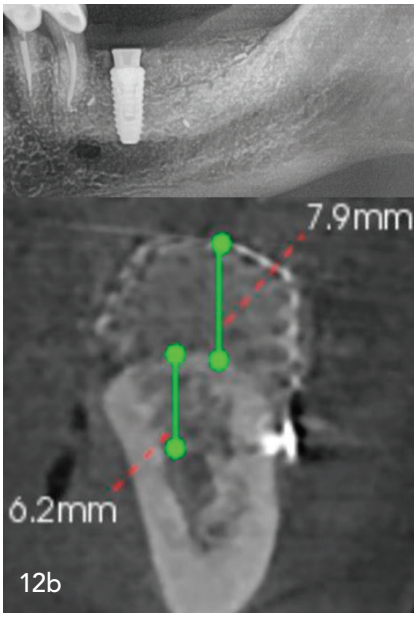


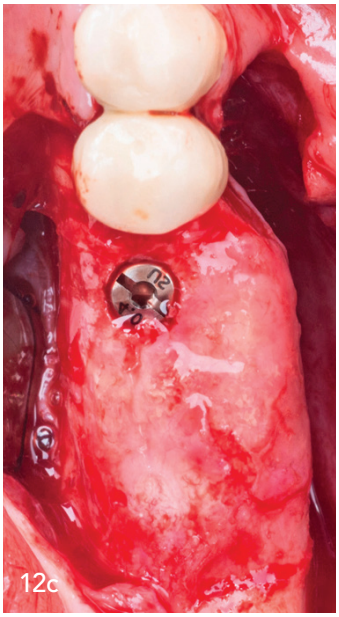


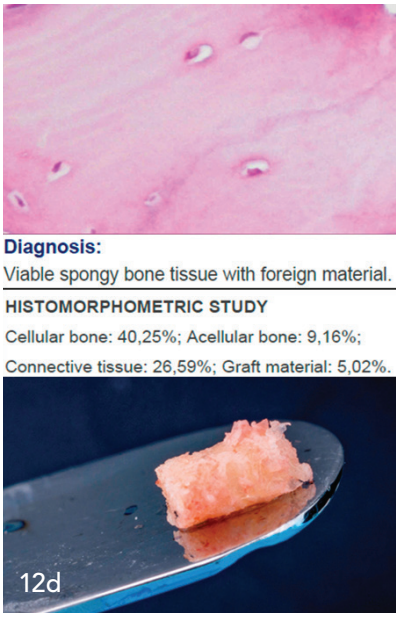
11a–c
Comparison of the situation before guided bone regeneration (a) and at re-entry ten months later (b+c).

12a–d
Width and height of the bone gain obtained (a+b), placement of implant #36 (c) and histomorphometric analysis of the bone tissue, obtaining 40 per cent vital bone (d).









Results
After a healing period of ten months (Fig. 10), we proceeded with the re-entry surgery in the regenerated area. We used a flap design on the buccal side similar to that employed on the day of the bone augmentation surgery, and on the lingual side, we used the same design in the area of the defect, but with a small vertical releasing incision one or two teeth mesial to the defect, to facilitate the removal of the mesiolingual fixation devices.

After healing without incident or complication, we removed the e-PTFE membrane and re-entered the regenerated area, finding vital, solid bone that bled during drilling (Figs. 11+12) and an average vertical bone gain of 7.5–8.0 mm (Figs. 13a–d). As is common after this type of regeneration, a thin layer of soft tissue partially covering the newly formed bone, without signs of inflammation, was identified.[3] This was classified as Type 1 (no pseudo-periosteum or a soft-tissue layer of < 1 mm) according to Cucchi et al.[36]

Subsequently, during preparation of the osteotomy for placement of implant #36, an en bloc bone biopsy of 3 mm in diameter was taken from the augmented area and immediately fixed in 10 per cent neutral buffered formalin. Histological analysis revealed the presence of cancellous bone tissue with trabeculae of varying sizes. At one end, these trabeculae were vital and attached to irregularly shaped fragments of an eosinophilic foreign material (anorganic porcine bone mineral graft). Histo-morphometric analysis revealed an average of 40 per cent vital bone.

Three months after this last intervention, we performed soft-tissue surgery to increase the width of keratinised mucosa and vestibular depth. The best-documented and most commonly indicated technique for this purpose is the free gingival graft,[37] associated with an apically repositioned flap. Grafts in this area are more susceptible to contraction and to a reduction in the final gain in keratinised mucosa during healing because the buccinator muscle originates from the alveolar process of the mandible at the level of the molars. We therefore performed a free gingival graft using two strips (Figs. 14a–e), one placed crestally and the other apically, and then applied tissue adhesive (PeriAcryl 90HV, GluStitch) to improve graft stability and reduce contraction (Fig. 15).[38]

Bone Growth Concept

copa SKY IMPLANT SYSTEM

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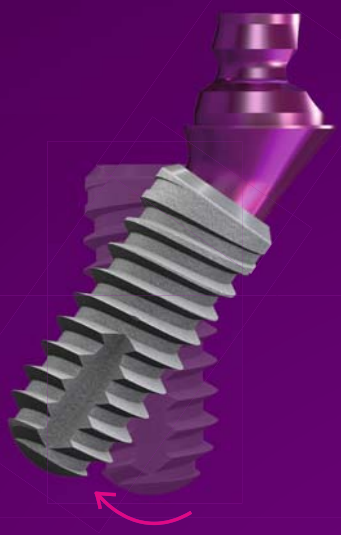
copaSKY

with one connection and microstructured backtaper.

Slim.

3.0 mm

Angled.



Up to 35°

Ultra short.

5.2 mm

PERFECT

for any bone situation.
for all indications.
for immediate restoration.
for digital workflows.

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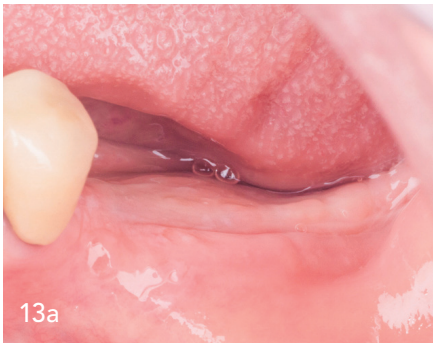
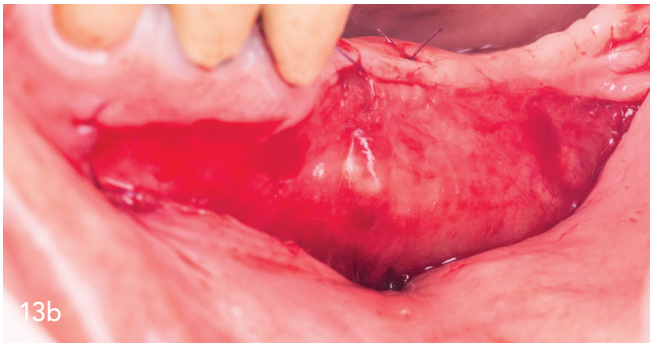
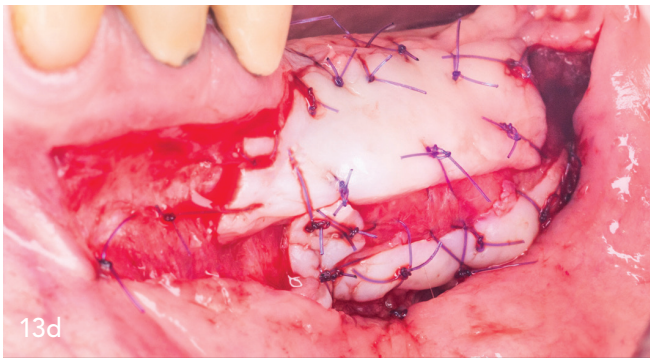
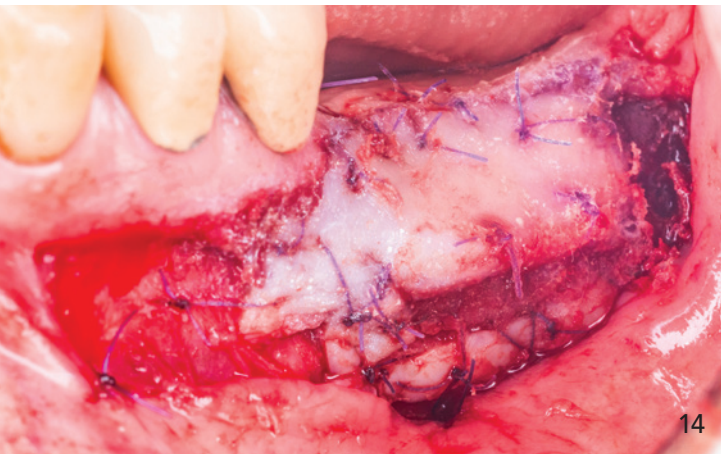




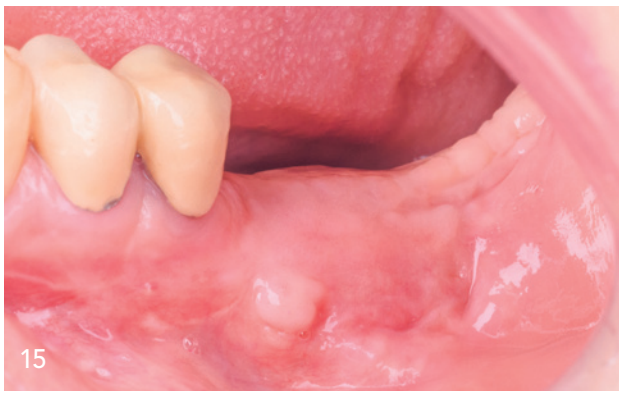


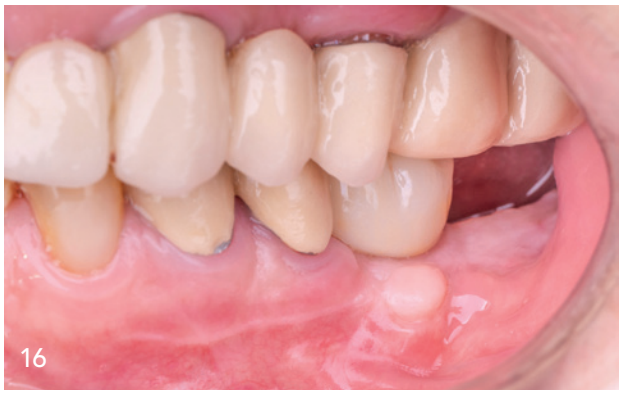
13a–d
Soft-tissue surgery to increase the width of keratinised mucosa using a free gingival graft in the regenerated area, one strip placed crestally and the second apically.



14
Application of tissue adhesive over the free gingival graft to improve its stabilisation.

15
Free gingival graft during maturation before placement of a healing abutment and subsequent implant restoration.

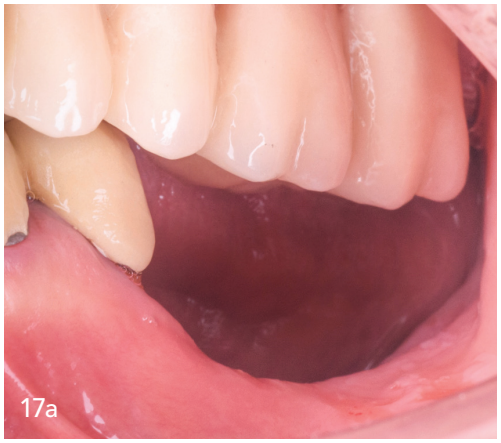


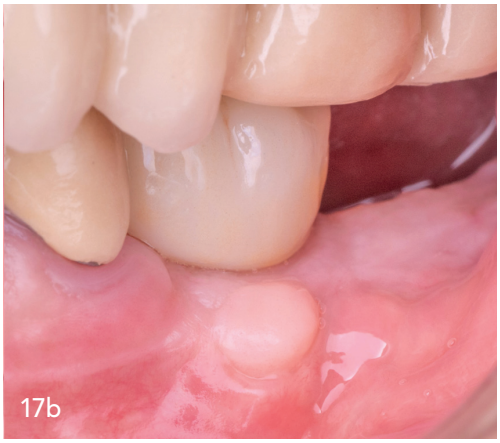


16
Restoration on implant #36 at the three-year follow-up, showing stable tissue around it and a satisfactory aesthetic and functional result.

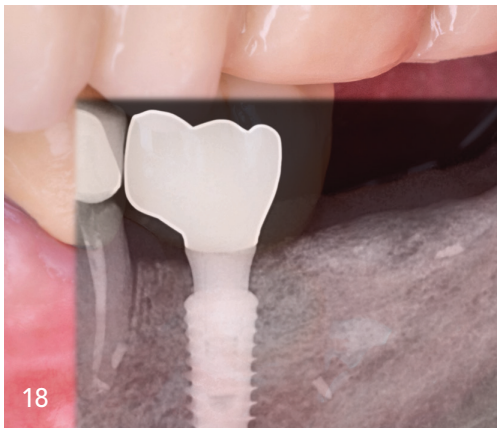
The purpose of this mucogingival surgery around the implant, using the free gingival graft technique, is to promote adequate long-term peri-implant health, since it seems clear that the presence of at least 2 mm of keratinised mucosa is associated with a healthier peri-implant state (less mucosal recession and loss of attachment), especially in susceptible patients with poor oral hygiene or plaque accumulation[39–41] and in patients with poor adherence to peri-implant maintenance therapy.[42] After three months of healing (Fig. 16), we placed a healing abutment on implant #36, and subsequently, we took the appropriate records for the fabrication of the prosthesis.

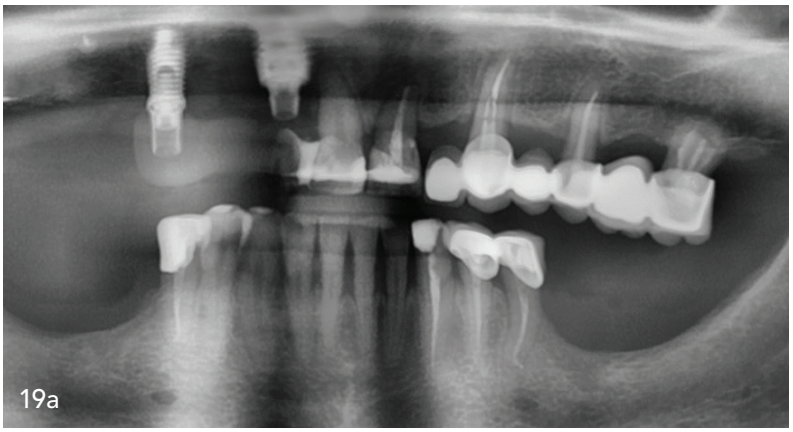
At the three-year follow-up, clinical evaluation confirmed that the peri-implant soft tissue was stable and showed no signs of inflammation or recession (Figs. 17–19). These results underscore the long-term success and predictability of regenerative procedures using a non-resorbable dual-texture e-PTFE membrane and a combination of particulate autogenous bone (> 50 per cent and anorganic porcine bone mineral.





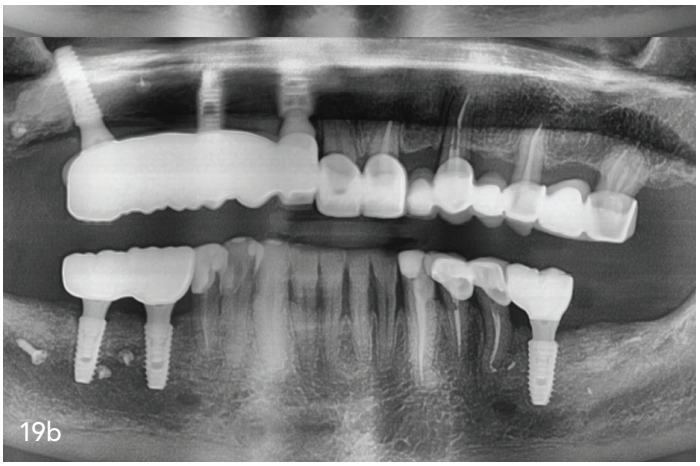
17a+b
Comparison between the initial state of the defect (a) and the gain in hard and soft tissue at the three-year follow-up after implant restoration (b).





18
Periapical radiograph showing the bone gain in relation to the initial state showed in Figure 17a and the placement of the new implant surrounded by bone with the restoration in place.

19a+b
Panoramic radiographs showing the initial situation (a) and the three-year follow-up after the implant was restored (b), demonstrating the bone gain.



Conclusion

Vertical and horizontal GBR is a predictable and effective technique when an appropriate clinical protocol is followed and quality biomaterials are used to maintain the regenerative space for sufficient time to allow new bone formation. This enables regeneration of the defect and formation of vascularised, solid and vital bone suitable for implant placement and restoration. We achieved all of this through the combined use of a non-resorbable, dual-texture e-PTFE membrane and autogenous bone graft with a small proportion of anorganic porcine bone mineral, along with an adequate healing period (greater than nine months) before implant placement. The implant showed stable marginal bone levels after loading, confirming that predictable clinical results can be achieved through appropriate biomaterial selection, a suitable surgical protocol and sufficient healing time for GBR.

Dr Javier Mayor Arenal
Madrid, Spain
info@jmaregeneracion.com
www.javiermayoregeneracion.com

Literature