original research article

THE "UMBRELLA TECHNIQUE": A NEW PROCEDURE FOR HARD AND SOFT TISSUE AUGMENTATION IN THE VERTICAL DEFECTS OF THE JAWS

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SUMMARY

Objective. To propose a new procedure to restore both hard and soft tissues in the vertical defects of the jaws.

Methods. A tenting screw was inserted in a mandibular vertical bone defect in the molar region. A titanium mesh was trimmed and stabilized to a tenting screw with its cover screw. The mesh was shaped not to cover the whole defect but just the area above the tenting screw, like an umbrella, with the aim to help a resorbable membrane not to collapse over the defect. A collagen membrane, stabilized with tacks both on the lingual and buccal side, covered the defect, filled with particulate autogenous graft mixed with a xenograft in a 1:1 ratio. After 3,5 months, a split thickness flap was raised, the mesh and the tenting screw were removed, a palatal graft was harvested from the palate and stabilized with sutures on the recipient site to augment the band of keratinized tissue. Nine months after bone augmentation the site was re-opened for implants and healing abutments application.

Results. At implant insertion stage, both hard and soft tissue grafts were completely healed and matured.

Conclusion. This procedure shortens the overall treatment time, inserting the implant in matured and stable augmented hard and soft tissues.

Key words: vertical bone augmentation, soft tissue augmentation, gingival graft, resorbable membrane, tenting screw.

Introduction

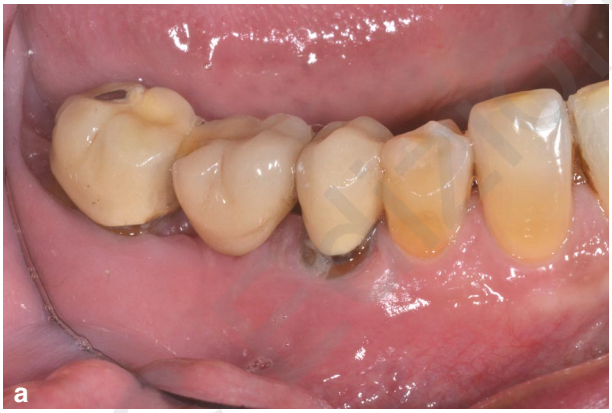
Mandibular and maxillary vertical bone defects may be treated with different surgical techniques (1). Among these, guided bone regeneration (GBR) is one of the most widely utilized, since the use of titanium-reinforced polytetrafluoroethylene (TR-PTFE) membranes allows space maintenance, that has been postulated to be one of the prerequisites for a successful GBR, and act as a physical barrier when applied over bone defects, preventing the ingrowth of competing, non-osteogenic cells into the membrane protected space (2). Infection of the regenerated site, with or without membrane exposure, and the need of a second invasive surgery for membrane removal, are considered the most important drawbacks of this technique.

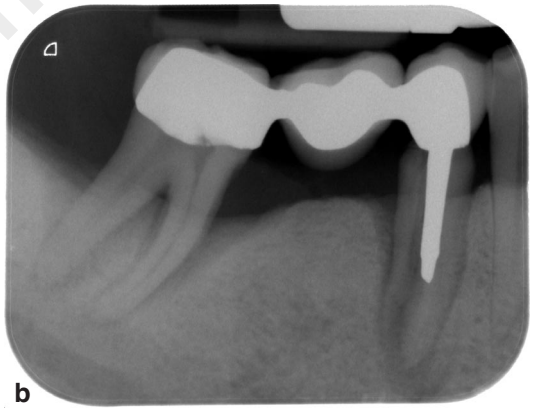
Another disadvantage of these membranes lays in the fact that they exclude the periosteum, which potential in the formation and regeneration of bone tissue has been widely demonstrated (3, 4), from the regenerated area for all the time they are maintained. This often results in immature regenerated bone, especially in areas further from the residual bone walls, from which neovascularization and new bone formation start. Immature bone

could easily lead to bone resorption and marginal bone loss around implant neck, favoring the establishment of mucositis and peri-implantitis.
A drawback, common to all regenerative techniques, is the reduction of the band of keratinized tissue (KT) due to the coronalization of the flaps, in order to cover the increased bone volume. To restore a proper amount of keratinized mucosa (KM), a free gingival graft (FGG) is widely considered the most reliable treatment option (5).
The authors introduce a new procedure to restore both hard and soft tissues in the vertical defects of the jaws, and simultaneously reduce the overall treatment time.

Methods

A case report describes all the steps of the "Umbrella Technique". An healthy 60 years old male patient came to the attention of the authors for the failing of a prosthetic bridge, due to the vertical fracture of the root of the lower right second premolar and the periodontal disease of the distal molar (Figures 1 a, b). After bridge removal and teeth extraction (Figure 1 c), a cone beam computed tomography (CBCT), performed 3 months later, showed an horizontal and vertical bone defect, present at the premolar and molar site respectively (Figures 2 a, b, c).
Eight months after extractions, soft tissues were completely healed (Figure 3 a). A mucoperiosteal flap was raised, a crestal incision connected the two vertical releasing incisions of the buccal flap, one on the mesial line angle of the first premolar, the other made at the level of the retromolar trigone. No vertical releasing incision was made on the lingual flap, that was extended mesially involving 3 teeth, whose papilla were





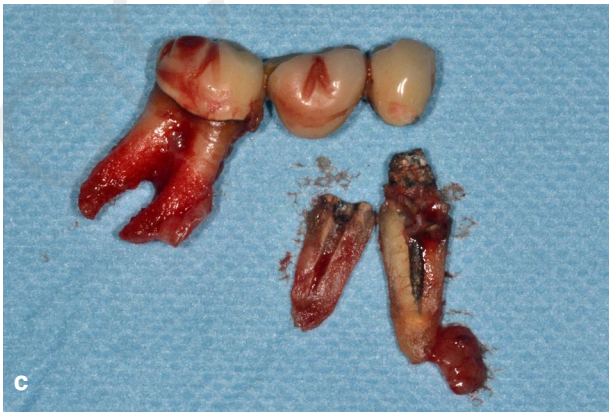


Figure 1
a, b) clinical and radiographic view showing the vertical fracture of the second premolar and the periodontal disease of the second molar; c) teeth extracted.

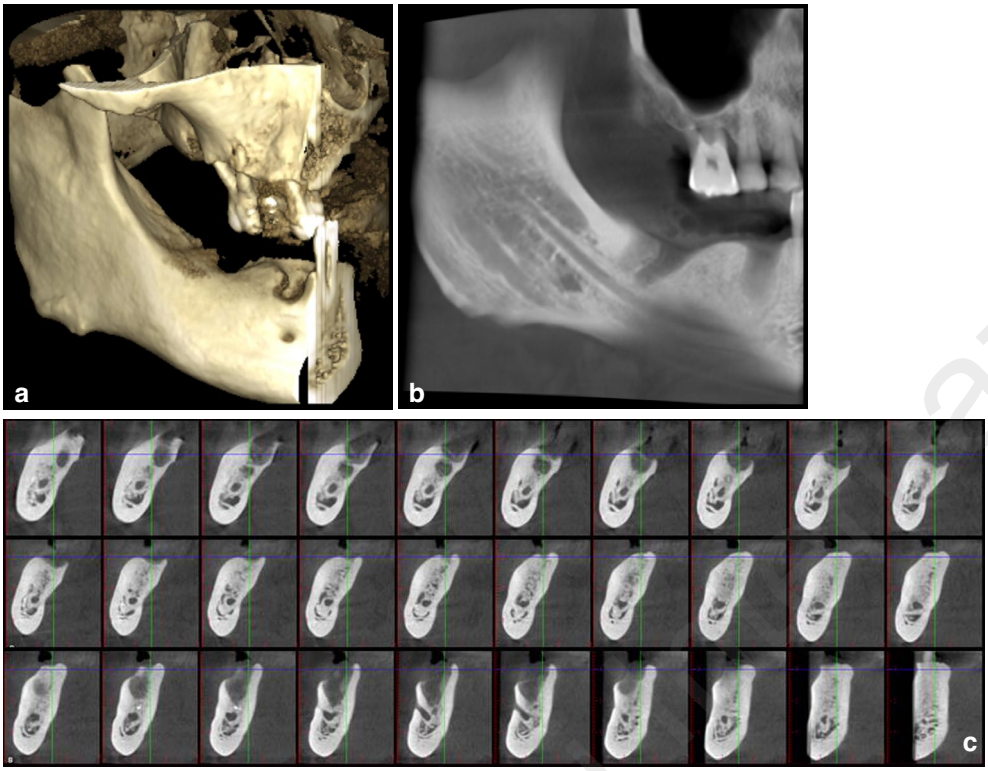


Figure 2
a, b, c) CBCT scans showing the horizontal and the vertical defect.

not reflected but cut at their base. After flap reflection, the horizontal and the vertical bone defects were clearly evident (Figures 3 b, c). Buccall flap was mobilized performing a continuous periosteal incision through the entire length of the flap between the 2 vertical releasing incisions. The cut through the periosteum gives access to the more flexible elastic fibers that can be expanded by the use of a blunt dissector or a blade that works in a brushing way. Lingual flap was coronalized separating the superior fibers of the mylohyoid muscle, that in the molar region is close to the crest, from the connective tissue of the lingual flap, applying a gentle pressure on the flap with a periosteal elevator.

Cortical perforations were done with a small round bur in order to open the marrow cavities and promote bleeding, giving vascular support to a bone graft consisting of particulate autogenous graft, harvested locally with a disposable scraper (Safescraper Twist, Meta, Reggio Emilia, Italy), mixed with a porcine xenograft (Zcore, Osteogenics Biomedical, Lubbock, TX, USA) in a 1:1 ratio. A self-drilling tenting screw (B Screw, Way4Dental, Italy) was inserted in the vertical bone defect of the molar region (Figures 4 a, b). A collagen membrane (Cytoplat RTM, Osteogenics Biomedical, Lubbock, TX, USA) was stabilized with tacks on the lingual side (Figures 4 c, d, e). A titanium mesh (T-Mesh, Way4Dental, Italy) was trimmed and stabilized only to the tenting screw with its cover screw and not to the bone (Figures 5 a, b, c). The mesh was shaped not to cover the whole defect but just the area above the tenting screw, like an umbrella, with the aim to create space and help the resorbable membrane not to collapse over the defect. Then the defect was filled with the composite graft (Figure 5 d), packing the particulate bone under the mesh and laterally to it (Figures

Figure 3
a) clinical view, 8 months after teeth extractions; b) horizontal defect in the premolar site; c) vertical defect in the molar site.

5 e, f). Then the membrane was moved buccally to cover the graft and stabilized with tacks (Figures 6 a, b, c, d). Flaps were closed (Figure 6 e) with horizontal mattress and single 4-0 PTFE sutures (Cytoplast, Osteogenics Biomedical, Lubbock, TX, USA). Healing was uneventful and 2 weeks later sutures were removed. The yet thin band of KM was reduced, due to the coronal movement of the flaps (Figure 7 a). After 3,5 months, a split thickness buccal flap was raised, the mesh and the tenting screw were removed (Figures 7 b, c), a FGG was harvested from the palate (Figure 7 d) and stabilized with sutures on the recipient site (Figures 7 e, f) to augment the band of KM. Seven months after bone augmentation a CBCT was repeated to evaluate the amount of the regeneration (Figures 8 a, b). The bone defects appeared completely filled by the regenerated tissues. Nine months after GBR (Figures 9 a, b, c) the site was re-opened for implants and healing abutments application. A mucoperiosteal flap was raised with a design similar to the one of the first stage but with a minor extension, especially on the lingual side (Figure 10 a). No graft particle was noted to be entrapped within the width of the flap and the bone appeared to be mature and well mineralized. After implant bed preparation (Figure 10 b), two implants (Inno Sub, Cowellmedi, Seoul, South Korea) were inserted in the premolar/molar region (Figures 10 c, d), and healing abultments were applied simultaneously (Figures 10 e, f).

Results

This bone augmentation procedure was effective for the reconstruction of the alveolar ridge defects and the re-establishment of a proper band of

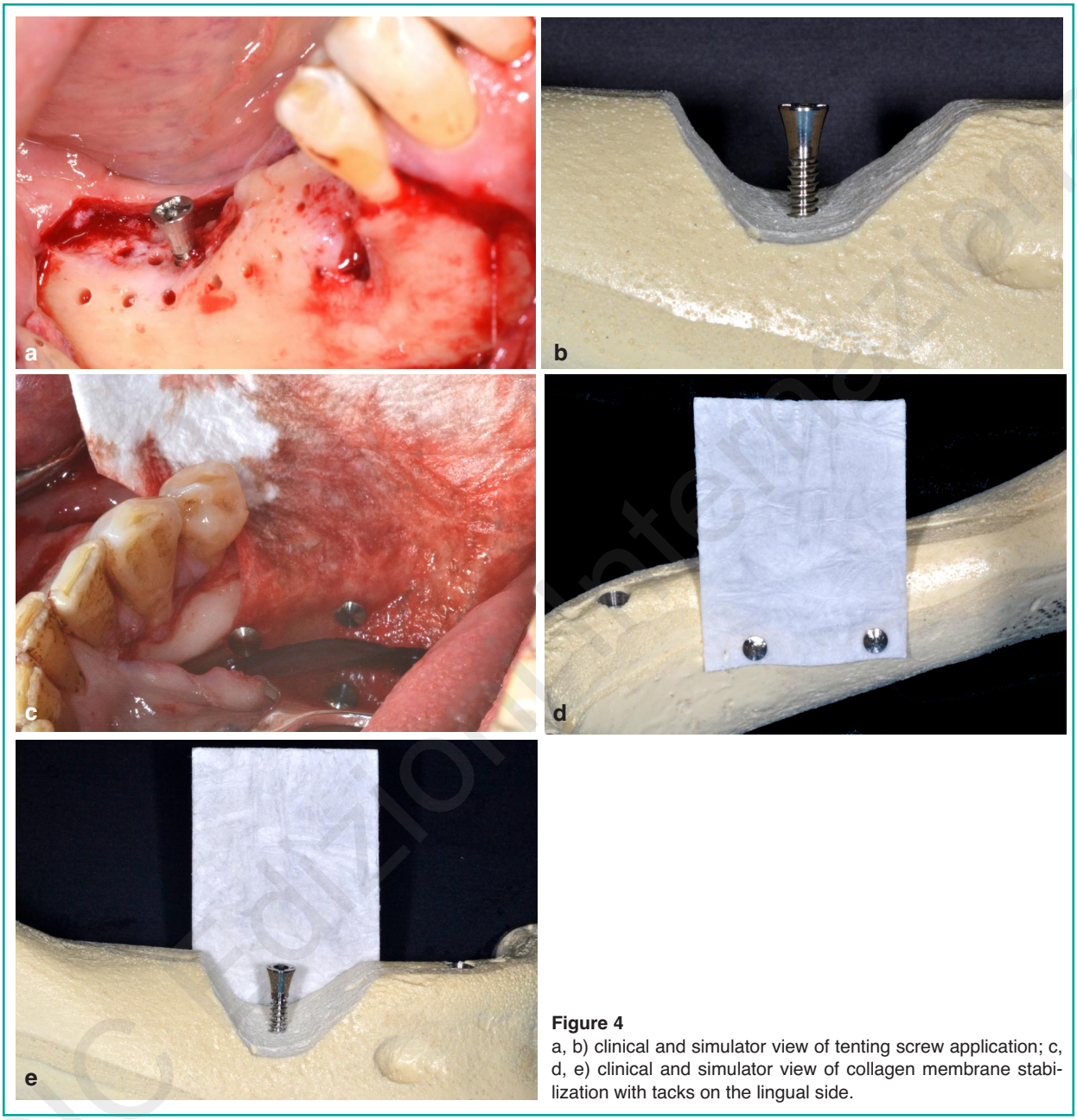


Figure 4
a, b) clinical and simulator view of tenting screw application; c, d, e) clinical and simulator view of collagen membrane stabilization with tacks on the lingual side.

KM. No additional ridge augmentation was required for prosthetically driven implant placement. Although a 30% contraction of the gingival graft happened, the increased KM was equally divided by the lingual and buccal flap in adequate quantities. Regenerated bone had a "stone-like" quality and implants reached primary stability very easily.

Discussion

Some procedures are demanding and bear a higher risk for post operative complications. GBR with non resorbable membranes, aimed to to achieve vertical ridge augmentation, is a highly technique sensitive surgical intervention, and the

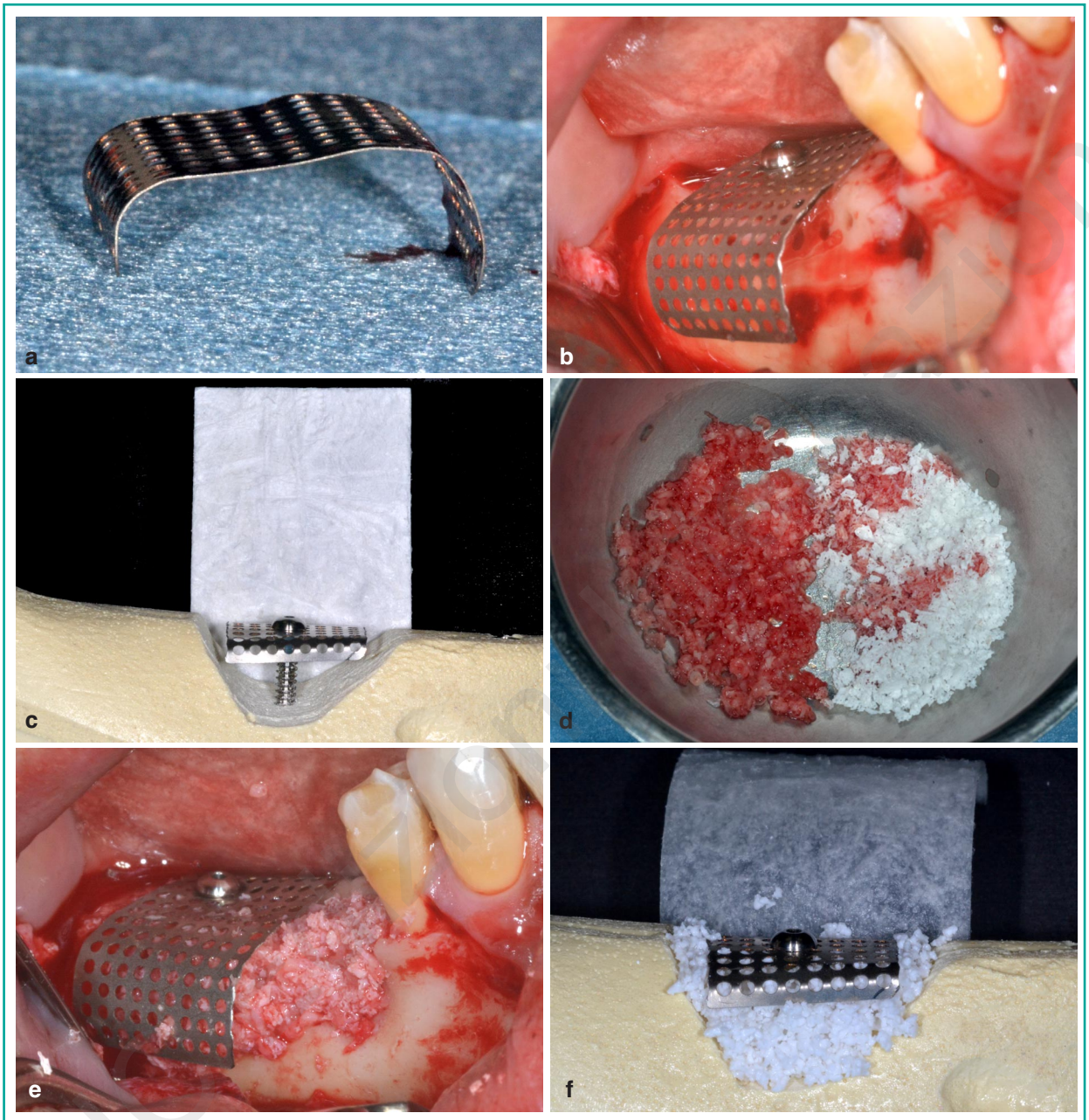


Figure 5
a) titanium mesh shaped; b, c) clinical and simulator view of the mesh stabilized on top of the tenting screw; d) particulate autogenous bone mixed in a 1:1 ratio with porcine xenograft; e, f) clinical and simulator view of bone graft application.

most frequently reported related complications are wound dehiscences, membrane exposure, graft exposure, loss of graft material, and infection (1).

Bone augmentation can be performed simultaneously with or prior to dental implant placement. The staged approach offers several advantages compared with the simultaneous application of implants and barrier membrane (6):

- it provides a larger bone surface to contribute to new bone formation, since no implant is inserted in the defect area. With a simultane-

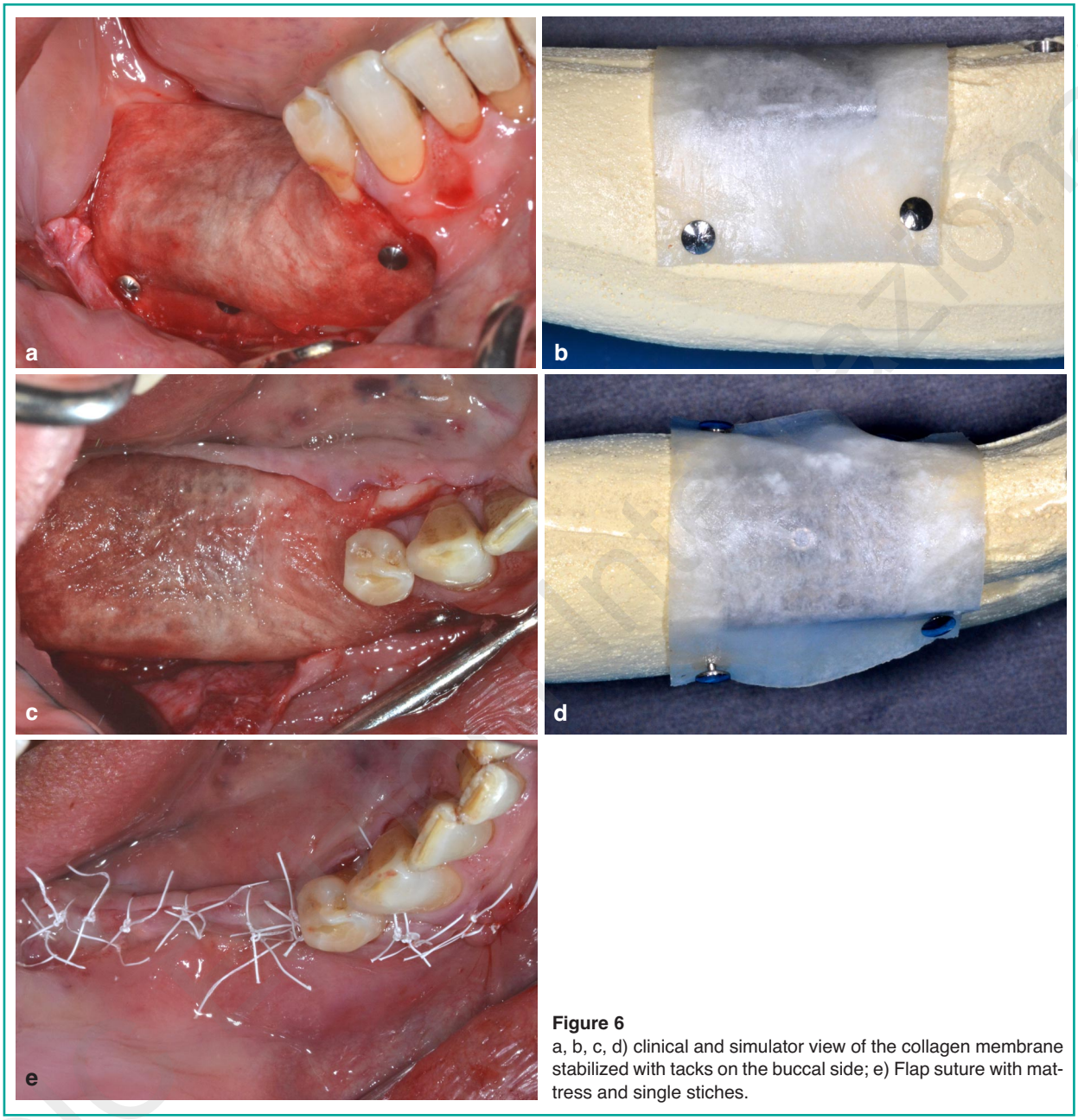


Figure 6
a, b, c, d) clinical and simulator view of the collagen membrane stabilized with tacks on the buccal side; e) Flap suture with mattress and single stiches.

ous implant placement, the implant reduces the exposed bone surface and its marrow space as a source of angiogenic and osteogenic cells, and an incomplete bone regeneration could be experienced in the most coronal part of the implant;

- easier preparation of the recipient site and a better primary stability for the implant;
- implant positioning can be optimized (especially important for the esthetic indications);
- offers the possibility to harvest a bone specimen for histologic evaluation;
- better success rate in case of complications;
- advantages with respect to bone maturation, since new bone formation is activated twice by the local release of growth factors. The

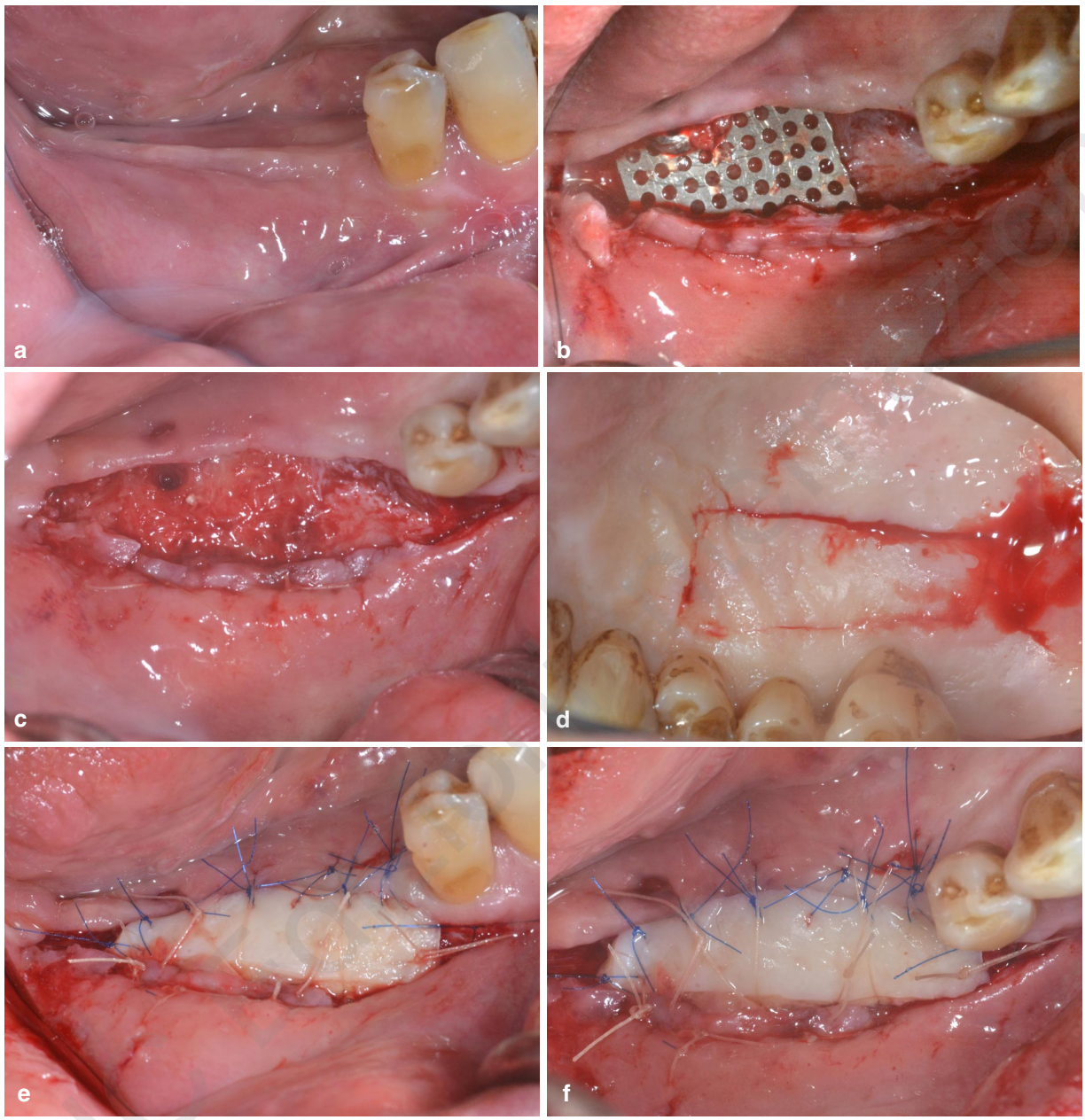


Figure 7
a) healing 15 weeks after GBR; b) flap reflection to uncover the titanium mesh; c) after tenting screw and titanium mesh removal, a vascular bed was prepared with a split thickness flap; d) gingival graft harvested from the palate; e, f) gingival graft sutured on the recipient site.

first activation occurs during membrane surgery, when the cortical layer is perforated prior to graft placement to open the marrow cavity. The second activation occurs during implant placement, when the implant recipient site is prepared into the newly regenerated alveolar crest;

- better bone apposition to the titanium surface can be achieved, since the "travel distance" for osteogenic elements from the exposed

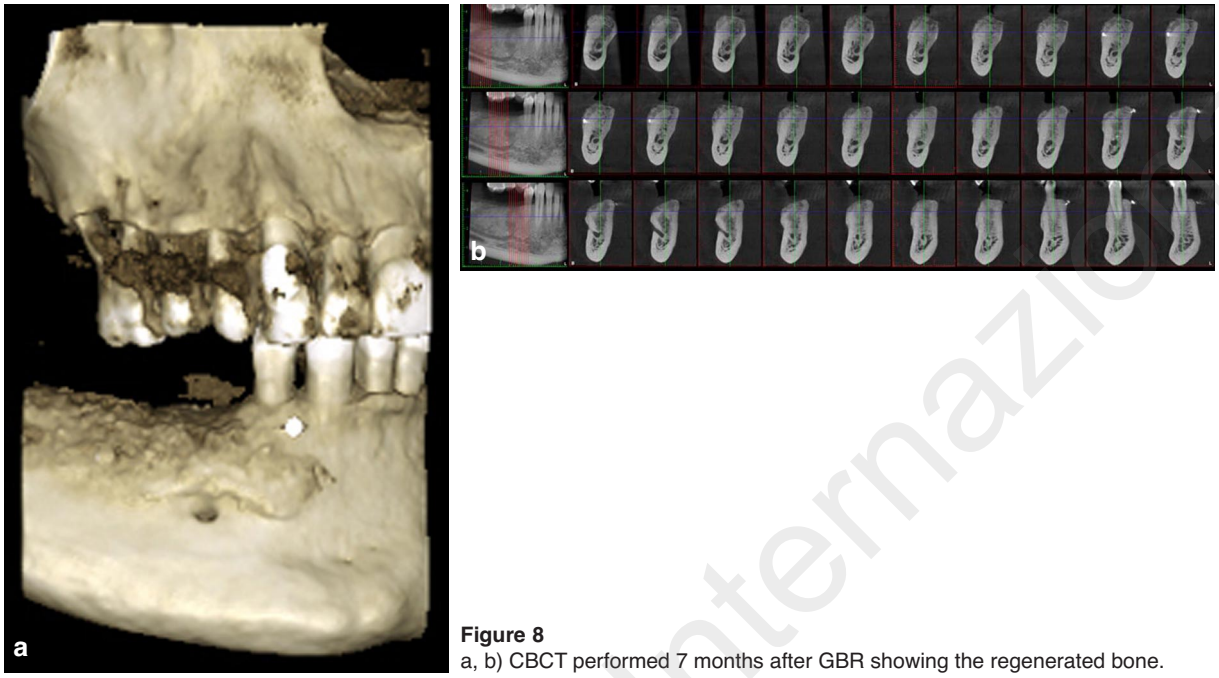


Figure 8
a, b) CBCT performed 7 months after GBR showing the regenerated bone.

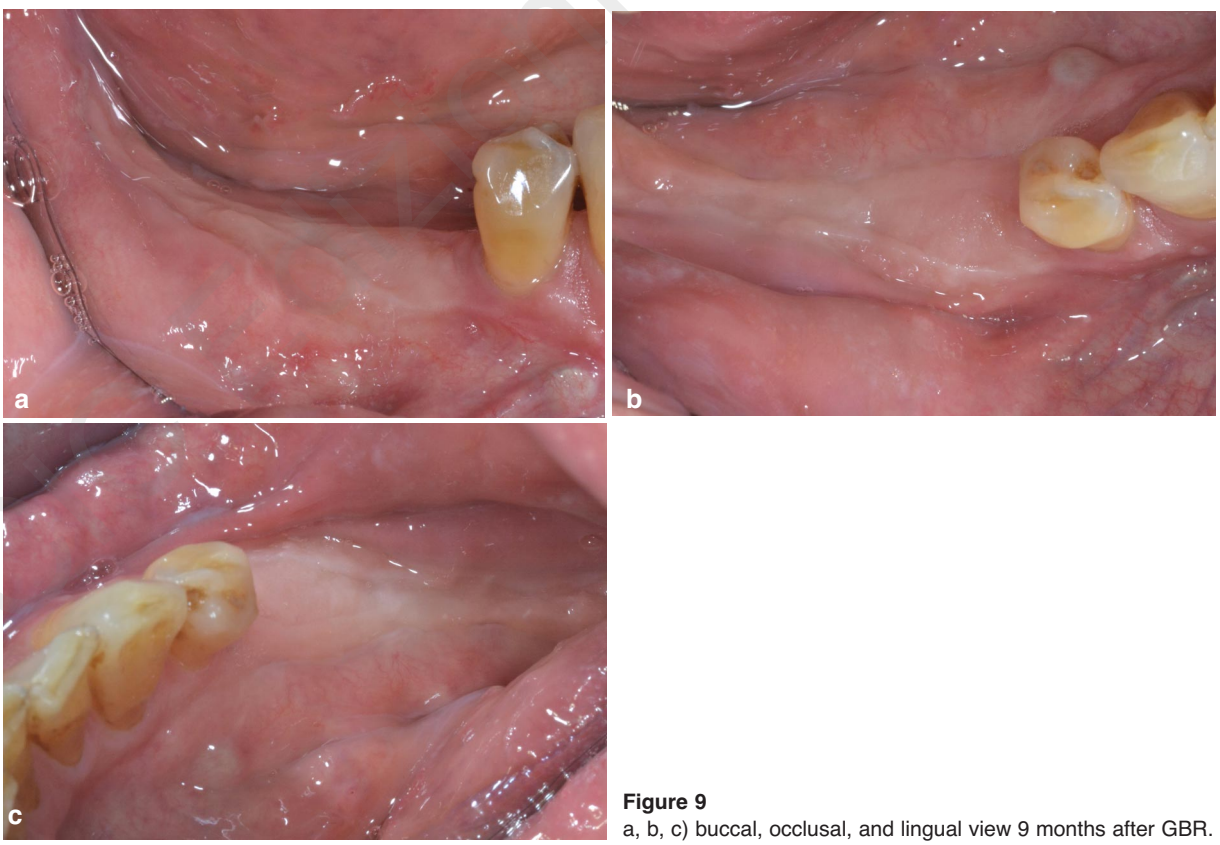


Figure 9
a, b, c) buccal, occlusal, and lingual view 9 months after GBR.

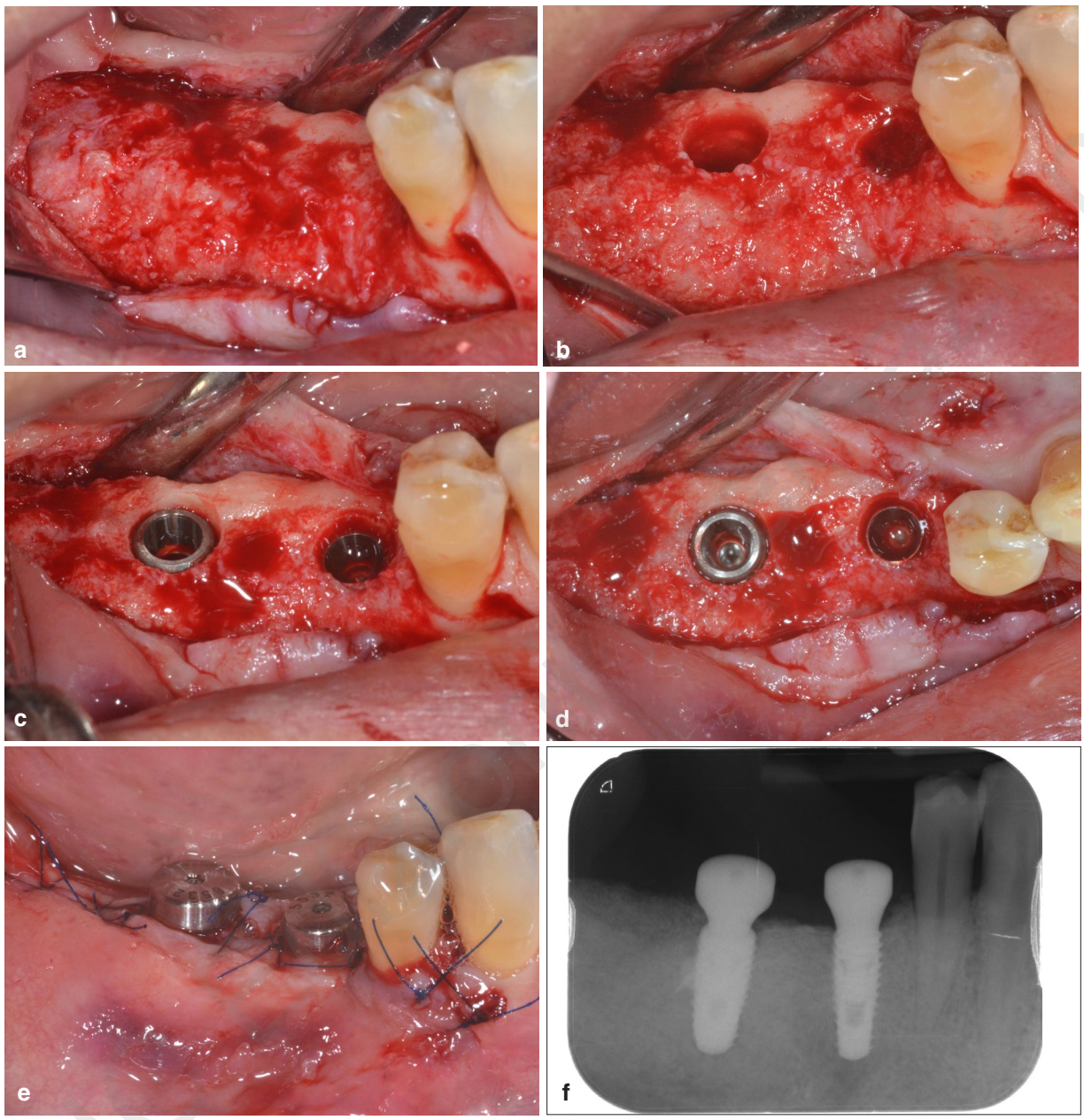


Figure 10
a) regenerated bone 9 months after GBR; b) implant sites preparation; c, d) implants inserted in the premolar and molar sites; e) healing abutments application; f) post-operative radiograph.

marrow cavity to the implant surface is much shorter.

In the technique proposed, as well as in the case reported, a staged approach was chosen. In the first stage, a resorbable collagen membrane was used to augment bone both vertically and horizontally. The membrane was sustained by a little piece of titanium mesh, stabilized only with a tenting screw in the most coronal part of the vertical defect. These two supporting devices helped the membrane not to collapse over the defect and were removed after a primary bone graft remod-

eling happened. At this second stage, 3,5 months after GBR, the bone graft was still immature to receive implants, so it was taken the opportunity to correct the soft tissues at this stage, augmenting the band of KM, previously reduced by flap coronal advancement, and deepening the vestibule. Implants were placed during the third and last stage, nine months after GBR, during which both bone and gingival graft had the time to get matured. At this final stage healing abutments were applied too, since a thick and wide band of KM had been previously restored, avoiding a subsequent uncovering surgery.

Although the need of having a proper band of KM around the implants is still a controversial issue, the majority of the studies are in favor of having a band of KT to not only improve esthetic appearance but also to facilitate oral hygiene performance for better implant long-term stability (1, 7-9), and it was shown to be related to better peri-implant-tissue health (10). The presence of KT results in a more stable seal around the implant neck that facilitates the ability of the patients to clean the reconstructions and to limit bacterial infiltration (11). Implant sites with less than 2 mm of KT were more prone to brushing discomfort, plaque accumulation, and peri-implant soft tissue inflammation compared to implant sites with ≥2 mm of KT (12). A lack of adequate KM around endosseous dental implants is associated with more plaque accumulation, tissue inflammation, mucosal recession, and attachment loss (9, 13).

FGG has been shown to be the most reliable way to increase the amount of KM and vestibular deepening. This was further confirmed by a systematic review, which reported that FGG remains the best documented and the most successful approach to increase KM width (5). KM band augmentation surgeries can also be performed at different time points during implant treatment, prior to implant placement, during the phase of tissue integration, or after final restoration. However, 4–6 weeks before healing abutment connection was regarded as an optimal time point for this procedure. On the contrary, soft tissue augmentation after final restoration could be less predictable because of highly required skills (5, 14). A recent review revealed that the stability of soft tissue, in terms of KT width, can be obtained 3 months after surgery (15).

New bone formation into the grafted area may come either from the residual bone and from the periosteum. Periosteum is accepted to be the essential source for the repair of the bone tissue (3, 4). The osteogenic activity of the periosteal tissues has a great importance regarding the purposes of reconstruction. Ortak et al. (16) found that periosteal flaps had a very fast and stable reconstructive capacity of osteogenesis.

Bone resorption after vertical ridge augmentation with TR-PTFE membranes was attributed to the poor quality of the regenerated bone (17). The difficulty to preserve the regenerated crestal bone and the rational to perform a secondary particulate graft, composed by 30% autogenous bone and 70% xenograft, covered by a collagen membrane, in order to prevent any bone resorption after implant placement, were described by these Authors. Bone fragility and fracture of the newly formed ridge during implant placement were even reported.

Some studies found that barrier membranes limited the amount of new bone formation in the portion of the graft closer to the periosteum. Simion et al. (18) evaluated the outcome of vertical ridge augmentation in a standardized dog model by combining purified recombinant platelet-derived growth factor and a block of deproteinized cancellous bovine bone, with or without the coverage by a resorbable barrier membrane. They found a larger amount of newly formed bone, and a larger amount of bone-to-implant contact in the group treated without placement of a barrier membrane, than the group where the collagen membrane was used. They concluded that the results seemed to point to the importance of the periosteum as a source of os-

teoprogenitor cells in growth factor-mediated regenerative procedures.
This is consistent with the study of another group of researchers, who found a significantly more bone formation closer to the residual bone (29%) compared with the portion of the graft closer to the periosteum (16%) in laterally augmented defects treated with the use of a resorbable membrane (19). The authors explained that these results were influenced by the fact that the use of a membrane obstructed the mesenchymal cells of the cambium layer of the periosteum.
The use of a novel perforated resorbable barrier membrane (PRBM) was firstly described to enhance guided tissue regeneration (GTR) of periodontal defects (20), and then for a lateral bone augmentation of a horizontal maxillary defect for implant site development (21). The concept of PRBM consists of mechanically perforating a barrier membrane to allow the contribution of progenitor cells and growth factors from the periosteum and gingival connective tissues (CTs) into both intrabony osseous and periodontal defects.
GBR protocol consist of using barrier membranes to create a secluded space to allow the ingrowth of angiogenic and osteogenic cells to populate and regenerate these defects with bone, and simultaneously prevent the ingrowth of more rapidly proliferating soft tissues, such as periosteum and CTs, in which mesenchymal stem cells have been identified (22, 23).
Those studies demonstrated enhanced clinical outcomes when using novel PRBMs compared to occlusive membranes in GTR procedures (20), and 38,1% new vital bone regeneration in the horizontal GBR procedure (21). These results may be affected by the penetration of gingival CT contained stem cells and periosteal cells and their differentiation into components of the attachment apparatus and the regenerated bone.
Another clinical investigation, comparing vertical ridge augmentation with the use of either TR-PTFE membranes or a resorbable membrane sustained by a titanium mesh with the same bone graft, found that titanium-mesh group exhibited a slightly larger bony tissue area and lower soft tissue area than those of the TR-PTFE group (24). The authors explained these results with the fact that the use of a resorbable membrane offers a better revascularization and mineralization of the bone graft compared to a PTFE membrane whose cellular occlusive effect was more lasting.
The technique described in this report lets the periosteum being in contact with the bone graft for a long period before implant placement. The use of a collagen membrane ensures that when this is reabsorbed, the periosteum can vascularize and supply osteoprogenitor cells to the graft. Even in the most coronal part, once the tenting screw and the titanium mesh have been removed, the periosteum will improve the quality of the regenerated tissue that, after a period of 9 months of maturation, that is considered to be a mean healing time for vertical GBR (24), was found to be of the highest quality, well remodeled and mineralized, allowing the implant to achieve a high primary stability, and the possibility of carrying out immediate loading.
Handling of titanium mesh was very easy, since it was not extended to cover the entire area of the defect, but was just limited in dimensions to the most coronal part of the defect, defining the roof of the area to be regenerated. Normally, titanium mesh has the tendency to return to its original shape after being molded, increasing the risk of wound healing, and is more difficult to place, stabilize and remove than TR-PTFE membrane (25). In this case, the procedure was easier because of the reduced dimension of the mesh and the stabilization to the tenting screw with just one screw and not with tacks to the lingual and buccal plates.
Finally, the use of a resorbable membrane, in case of wound dehiscence and membrane exposure, reduces the risk of complications compared to TR-PTFE membranes (1).

Conclusion

The "Umbrella Technique" is a procedure that allows the increase of hard and soft tissues, a reduction of the overall treatment time and complication rate, and an improved bone graft quality and maturation with respect to non-resorbable membranes. Clinical outcome from this case report is encouraging: further clinical and histologic human studies are needed to validate the advantages that this technique offer for vertical augmentation of the alveolar crest.

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