Novel technique using periosteum as a regenerative tool in alveolar bone augmentation

Periosteal membrane technique

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Severe alveolar bone resorption is a challenge for oral surgeons and implantologists aiming to reconstruct future implant sites. Various alveolar bone augmentation techniques are described for reconstructive surgical treatment of horizontal, vertical and combined alveolar bone defects. Despite the significant improvements in xenografts, allografts and alloplastic grafts that can be used alone or in association with autogenous bone, complications can occur. Most of these techniques require barrier membranes (non-resorbable or resorbable) and occlusive membranes (non-resorbable). Membrane exposure is a complication associated with the decrease of the rehabilitated new bone volume, delay of bone healing or even failure of implant-supported prosthetic restoration when associated with immediate implant placement. The objective of this paper is to present a novel surgical technique that uses adult human periosteum as a barrier membrane in guided bone regeneration of resorbed alveolar areas. The case reported here was a clinical success at the 36-month follow-up (alveolar bone gain of 4.7 mm in width). The benefits of using periosteum are graft stability, better vascularisation, absence of membrane exposure and necrosis risk, faster healing, and no pain or discomfort.

Introduction

Various surgical regenerative procedures have been developed to reconstruct alveolar defects. Most of these techniques are based on the guided bone regeneration (GBR) principle and mainly involve the use of autogenous bone grafts alone or combined with bone substitutes (al-

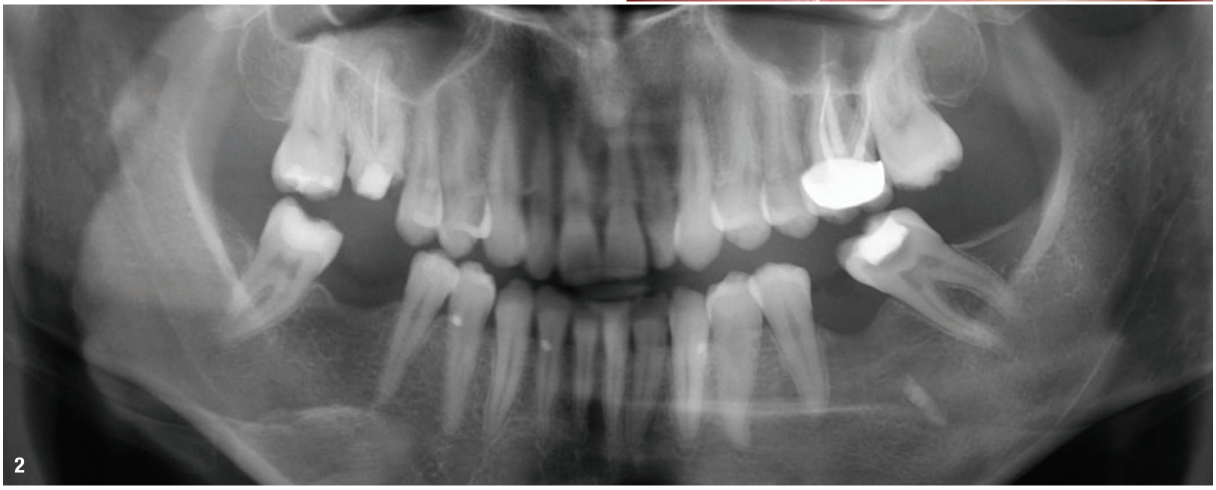


Fig. 1: Pre-op view of the horizontal bone defect. – **Fig. 2:** Pre-op panoramic radiograph.

Fig. 3: Crestal incision without sectioning the periosteum. – **Fig. 4:** Measuring of the gingival height. – **Fig. 5:** Elevation of the split-thickness flap starting from the line of incision.

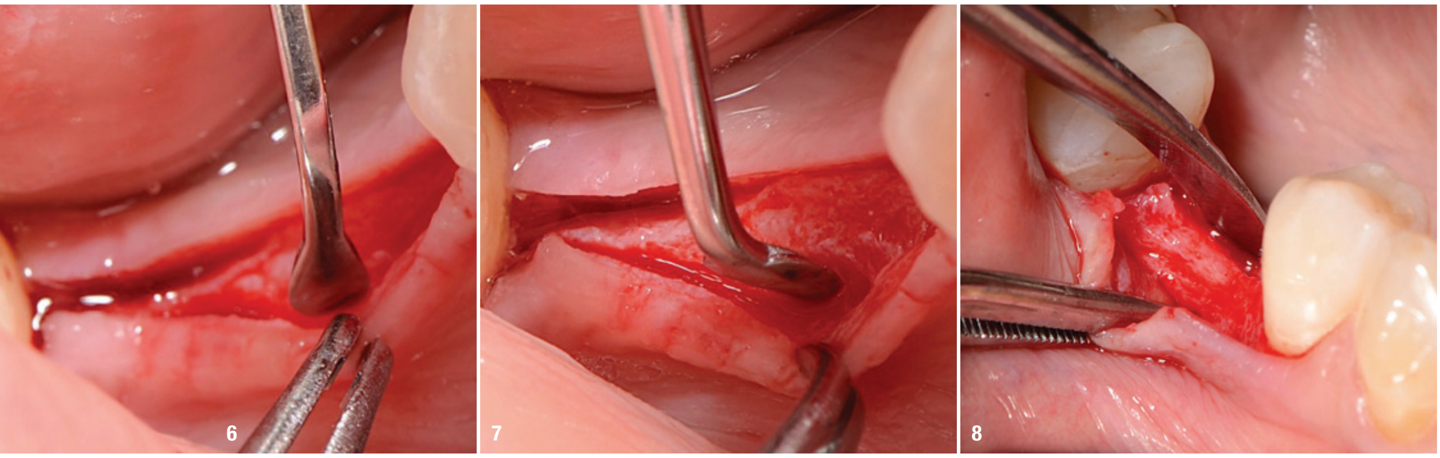


Fig. 6: Detaching the mucogingival junction with a blunt instrument. – **Fig. 7:** Buccal mucosal detachment with a splitting instrument. – **Fig. 8:** Lingual mucosal detachment.

logeneic, xenogeneic or alloplastic grafting biomaterials) in combination with barrier membranes.[1] Autogenous bone grafting is considered the gold standard owing to its osteoconductivity, osteoinductivity and osteogenic potential. The limits of autogenous bone are insufficient local availability and the need to harvest from a second oral surgical site (mandibular ramus and chin) or an extraoral donor site (iliac crest). This involves general anaesthesia, hospitalisation, longer recovery, higher costs, morbidity risk and postoperative pain.[2] The use of allogeneic, xenogeneic or alloplastic substitutes brings numerous benefits, such as less operative trauma and blood loss, availability, absence of donor site morbidity and low antigenic potential.[3] GBR is the best-documented technique for the treatment of the localised moderate or severe alveolar bone defects.[4] GBR utilises a barrier membrane to allow osteogenic cells to populate the space of bone defects by excluding epithelial and connective tissue cells.[5] GBR membranes may be resorbable, for example natural collagen or synthetic polymers with a similar composition to periodontal connective tissue, human, porcine and bovine pericardium membranes, and human acellular freeze-dried dermal matrix, or non-resorbable, such as dense polytetrafluoroethylene (d-PTFE), expanded PTFE, titanium mesh and titanium-reinforced PTFE.[5]
Although non-resorbable membranes are the most frequently used in vertical bone augmentation techniques, their exposure is the most common complication, having a detrimental effect on therapeutic success. For horizontal and vertical defects, both non-resorbable and resorbable membranes are used with similar success rates.[5] In immediate implant placement, a review found evidence of an increased defect height reduction for the membrane-covered groups, despite a 2.52 rate higher rate of complications.[6] A systematic review found that the mean vertical bone gain when GBR was followed by membrane exposure without suppuration was only 65% that of sites without membrane exposure.[7] The overall incidence of healing complications at the augmented site at the site level was 11.0%, and the site-level incidence of membrane exposure without suppuration was 8.7%.[7] Also, membrane exposure after GBR procedures results in 74% less horizontal bone gain compared with sites without membrane exposure. In peri-implant dehiscence de-

fects, sites with membrane exposure had 27% less defect regeneration compared with sites without exposure.[8]

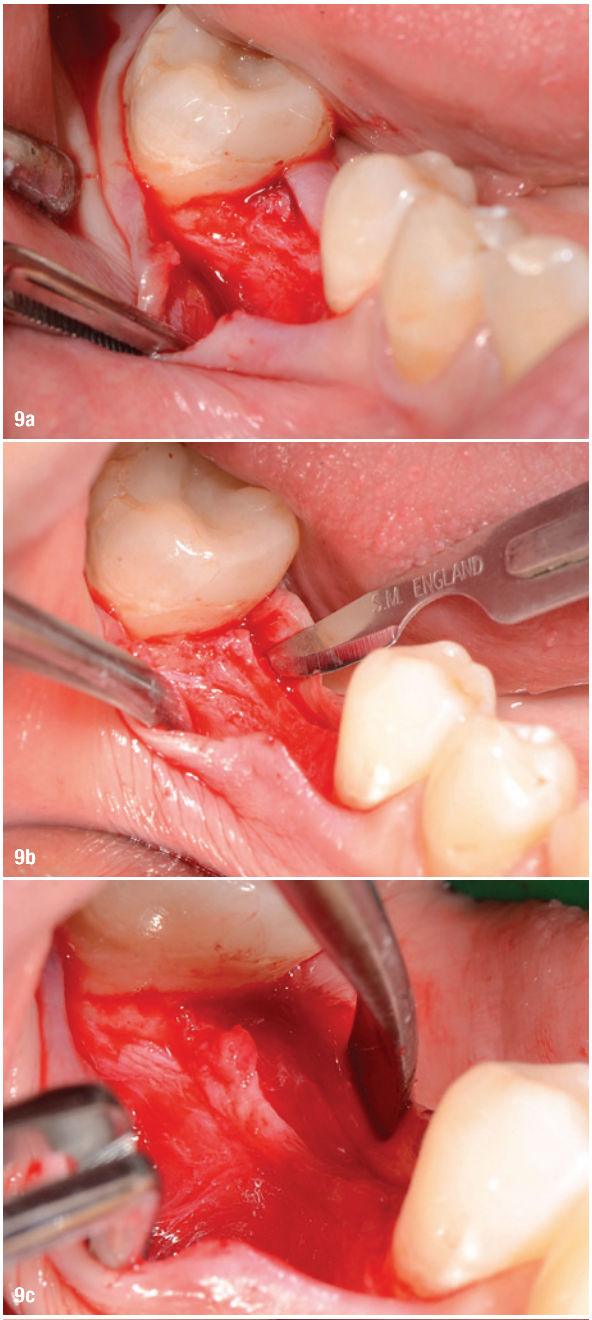
All these membranes possess certain shortcomings and limitations in the restoration of alveolar bone defects, stopping the progression of bone resorption but failing in the complete regeneration of bone defects.[9] Moreover, the greatest limitation of commercial GBR membranes is their occlusive feature that excludes soft-tissue ingrowth and blocks the inflow of the endogenous resources.[10]

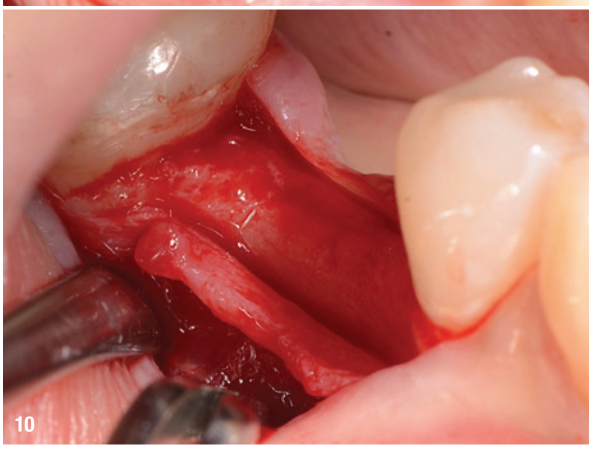
Bone healing is a complex process involving inflammation, repair and remodelling associated with intracellular signalling pathways regulating the regeneration of new bone tissue. Bone tissue engineering tools can be used to stimulate and accelerate the healing processes in the augmentation techniques of alveolar bone defects.[11] Mahajan considers that the potential of periosteum as a bone tissue engineering tool is highly underrated in the field of bone tissue regeneration in the oral and maxillofacial area, despite its use as a regenerative tool in the general medical field.[12–14] Moreover, periosteum-mimicking membranes[15,16] and hydrogel biomimetic periosteum[17,18] were proposed recently to accelerate bone fracture regeneration. The role of periosteum as a potential source of osteogenic cells, growth factors and blood is highlighted by a study that concluded that bone areas without periosteum are strongly compromised in contrast to areas with an intact periosteum.[19,20] The possibility of using periosteum in the regeneration of resorbed alveolar bone is based on the osteogenic potential of its cells to regulate the outer shape of alveolar bone and to regulate cortical bone thickness as well as the size and position of the bone in space.[21] Two studies have already established the potential of periosteum to stimulate periodontal regeneration and to rehabilitate lost periodontal tissue when used in the treatment of gingival recession defects.[22,23] The formation of a pseudo-periosteum layer, as a mechanical barrier and a potential source of osteogenic agents, was highlighted in a study that investigated the use of titanium mesh to create the space necessary for the GBR technique.[24]

The objective of this study is to present a novel surgical technique using adult human periosteum as a barrier membrane in a GBR technique used prior to implant placement in implant-supported prosthetic restoration of the mandibular posterior area. The periosteal membrane technique is described through a case report of a 35-year-old patient requiring implant-supported prosthetic therapy of the edentulous mandibular alveolar ridge with moderate horizontal resorption (Figs. 1+2).

Surgical technique

Anaesthesia was performed in the surgical area with articaine and 1:100,000 adrenaline (Ultracain, Normon Lab-





Figs. 9a–c: Sectioning the periosteum as lingually as possible. – **Fig. 10:** Sectioned periosteum.

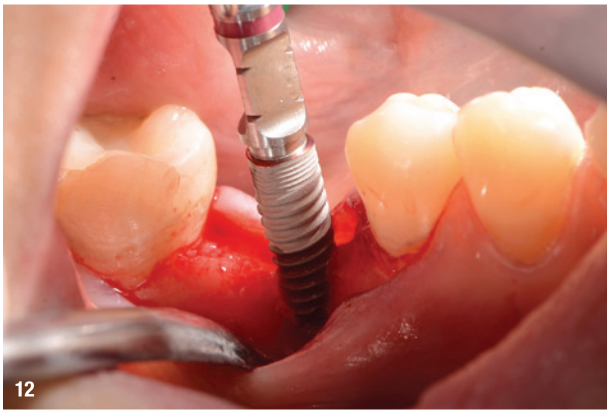
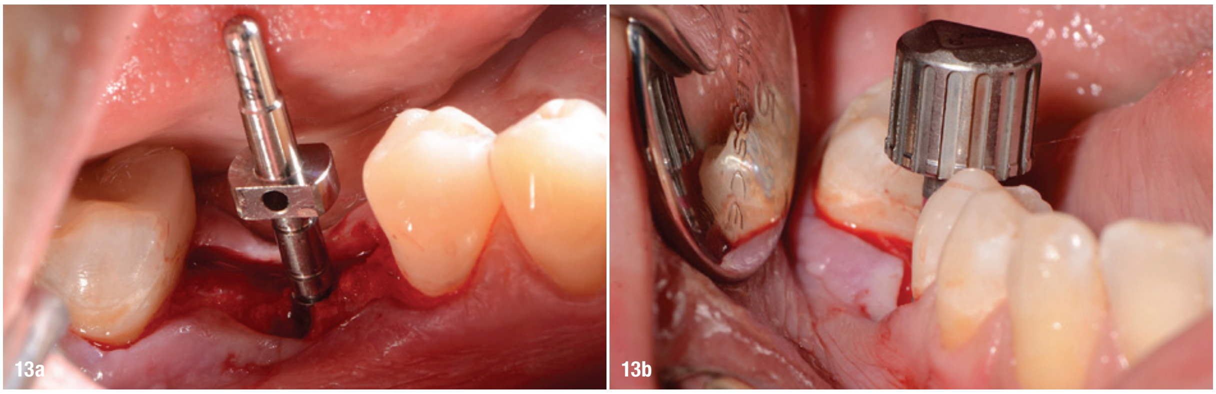


Fig. 11: Armamentarium for periosteum harvesting. – **Fig. 12:** Implant and abutment placement.



Figs. 13a+b: Checking the parallelism from different angles.

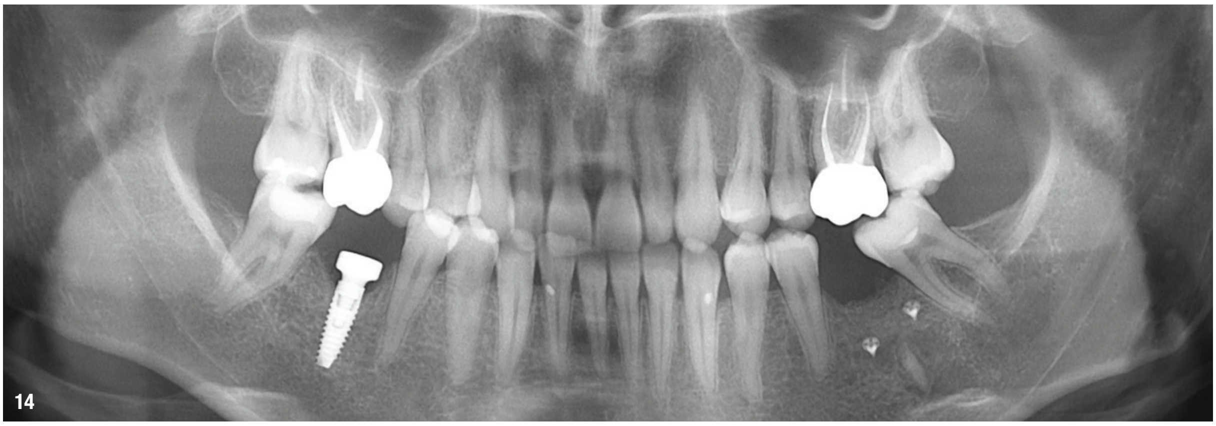


Fig. 14: Panoramic radiograph to confirm the implant position.

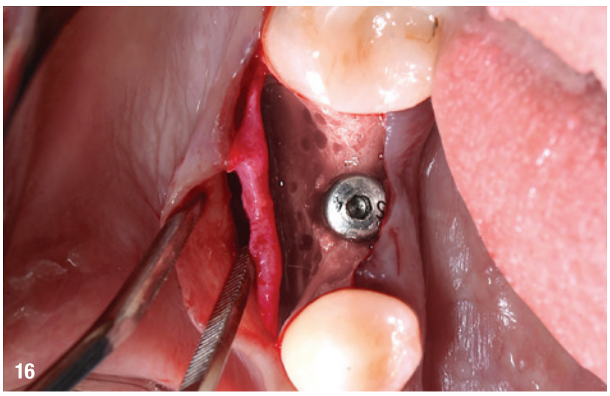


Fig. 15: Checking of the implant placement according to biologic width. – **Fig. 16:** After implant placement.

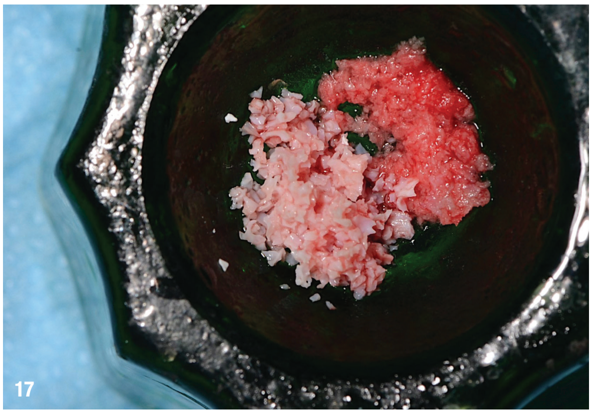


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Fig. 17: Augmentation material, autologous bone and xenograft granules.

oratories). A crestal incision was made without sectioning the periosteum (Fig. 3), the gingival height was measured (Fig. 4) and a split-thickness flap was elevated, starting from line of the incision (Fig. 5). The mucogingival junction was detached with a blunt instrument (Fig. 6), the buccal and lingual mucosa were detached with a splitting instrument (Figs. 7+8) and the periosteum was sectioned as lingually as possible (Figs. 9–11). The implant was placed (Fig. 12), its parallelism was checked (Fig. 13), its location was confirmed radiographically (Fig. 14) and its placement according to biologic width was checked (Fig. 15). The site (Fig. 16) was augmented with autologous bone and xenograft granules (Geistlich Bio-Oss, Geistlich Pharma; Figs. 17+18). The periosteum was sutured without tension (Figs. 19+20).

The patient was instructed to rinse twice daily with a 0.12% chlorhexidine mouthrinse for two weeks and to avoid mechanical hygiene on the operated area. Antibiotic therapy (amoxicillin and clavulanic acid) and anti-inflammatory therapy (400 mg ibuprofen every eight hours) were prescribed for seven days. The patient reported no discomfort or postoperative pain. The sutures were removed two weeks later. At the visit, an incision was made for an individualised healing abutment, and it was inserted (Fig. 21).

Clinical and CBCT measurements

Control visits took place at two days (Fig. 22), 30 days, four months (Fig. 23), 12 months (Fig. 24) and 36 months postoperatively (Figs. 25–27). Every control session con-

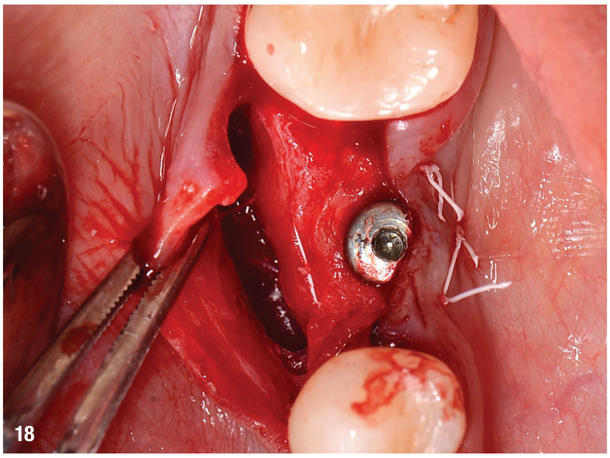

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Fig. 18: Alveolar bone augmentation. – **Fig. 19:** Suture of the periosteum on the lingual aspect.

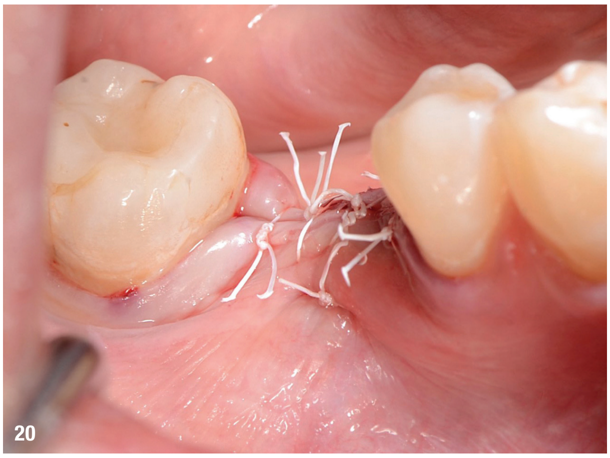

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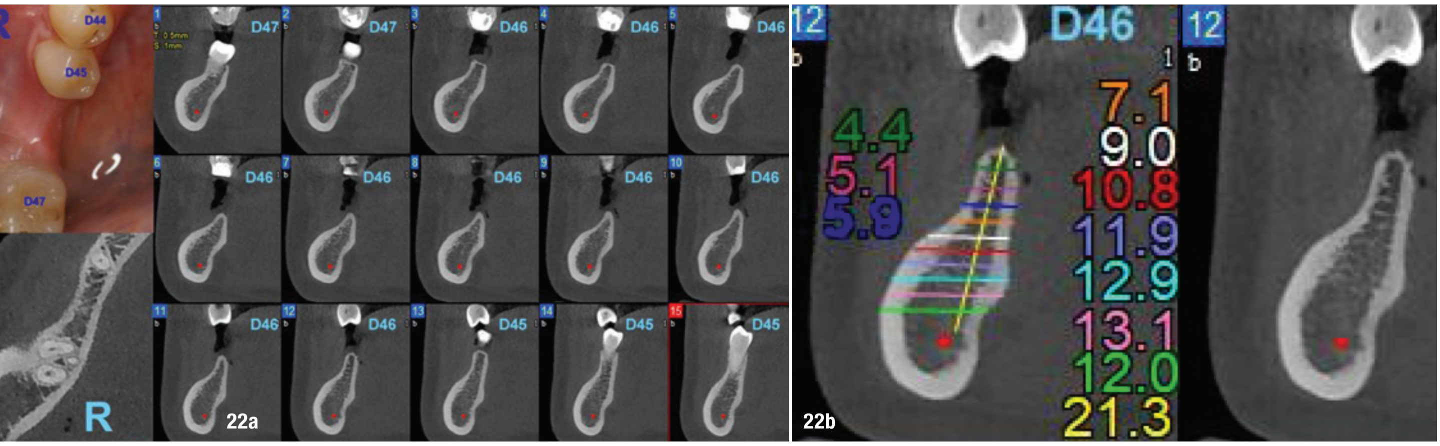
Fig. 20: Final suture without tension. – **Fig. 21:** Insertion of the individualised healing abutment.



Figs. 22a+b: Comparison between the radiographs taken pre-op **(a)** and two days post-op **(b)**.

sisted of a clinical examination during which the Modified Plaque Index, Modified Gingival Index, peri-implant probing depth and keratinised mucosa were measured. Each clinical examination found a healthy peri-implant status: a Modified Plaque Index of 0, a Turesky Modification of the Quigley-Hein Plaque Index of 0, a peri-implant probing depth of ≤ 3 mm and keratinised mucosa of ≥ 2 mm.

The alveolar bone width was measured preoperatively, at two days postoperatively and at 36 months postoperatively on CBCT images with OnDemand 3D (CyberMed Inc.). The alveolar bone width values were 4.4 mm preoperatively, 10.4 mm at two days postoperatively and 9.1 mm at 36 months postoperatively, representing an alveolar bone width gain of 4.7 mm (Fig. 28).

Discussion

Despite the use of periosteum in the regeneration of bone in general medicine and the suggestion by several research groups to use periosteum as a barrier membrane in periodontal and alveolar bone regeneration,[19, 22, 23, 25] there is a scarcity of studies focusing on long-term results to establish an effective standard protocol for using periosteal grafts as barrier membranes. Periosteal cells can be harvested from adjacent bone surfaces and can be stimulated to increase the progenitor cells of fibroblasts and osteoblasts at higher rates compared with bone marrow-, cortical bone- or trabecular bone-derived progenitor cells.[26] These periosteum-derived progenitor cells will differentiate into alveolar bone and thus will act synergically with both other periosteum-derived osteogenic agents and local natural processes involved in the regeneration of the alveolar bone. Thus, periosteum can be considered a barrier membrane for both periodontal surgery procedures and the pre-implantation surgical stage.[27]

This case report has presented the treatment of an edentulous patient with moderate mandibular alveolar bone resorption requiring a GBR procedure for restoration of the bone. Immediate implant placement was performed in the same session as the surgical pre-implantation procedure. The success of the augmentation technique, con-

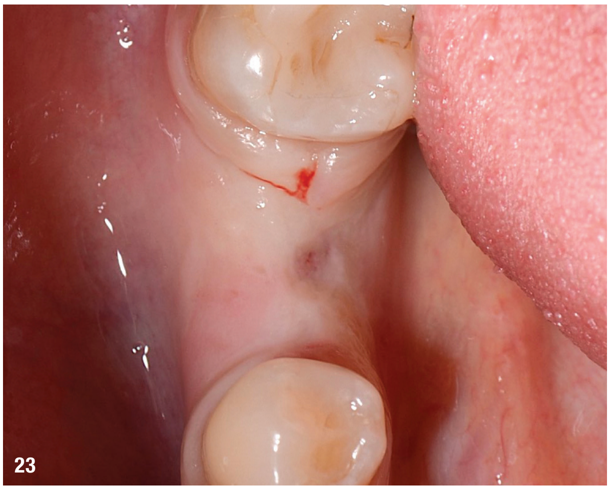


Fig. 23: Clinical aspect at four months postoperatively. – **Fig. 24:** Clinical aspect at 12 months post-op.

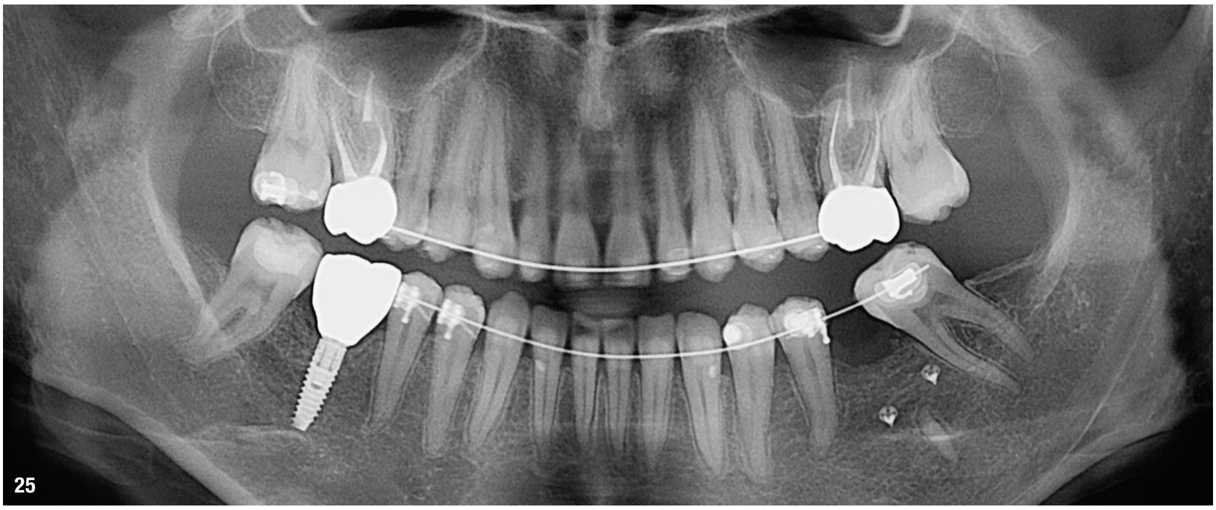


Fig. 25: Panoramic radiograph at 36 months post-op.

sisting of combination of autogenous bone and xenograft biomaterials and periosteum as a barrier membrane, was proved by bone width gains (4.7 mm) at 36 months postoperatively as well as by the absence of biological complications in the peri-implant area. The result is similar to findings reported by studies focused on horizontal bone augmentation employing the GBR technique using autogenous bone in combination with xenografts and bioresorbable membranes. Collagen membranes achieved width gains of 5.60 ± 1.35 mm,[28] 4.44 mm[29] and 3.23–4.93 mm,[30] and polymeric membranes had width gains of 3.95 mm.[31]

Autogenous bone is considered the gold standard of grafting materials owing to its osteogenic activity, supplying bone-enhancing substrates and vital bone cells to the recipient site.[19] The addition of xenograft material is due to an insufficient amount of autogenous bone and the properties of xenogeneic materials (i.e. inert osteoconductive filler materials serving as a scaffold for the formation of new bone).[19] Bioresorbable membranes (mostly collagen) are placed in direct contact with the surrounding bone surface, creating a space where only cells from the neighbouring bone or bone marrow will migrate into bone defects and avoiding the proliferation of the competing soft-tissue cells from the overlying mucosa, mechanical disruption and salivary contamination. The benefits of bioresorbable membranes are biocompatibility, tissue adhesion without mobility and blocking of soft-tissue ingrowth.[19] The disadvantages of collagen bioresorbable membranes are related to their lack of space-making ability (compensated for by their use with bone grafts or tenting techniques to prevent space collapse) and their fast degradation that reduces their effectiveness when used as physical barriers beyond one month.[32]

The technique presented in this case report supports the need of implantologists and oral surgeons for a membrane with the potential to stimulate the healing and regenerative processes (owing to blood supply and osteo-

Fig. 26: Final result. – **Fig. 27:** Clinical aspect at 36 months post-op.

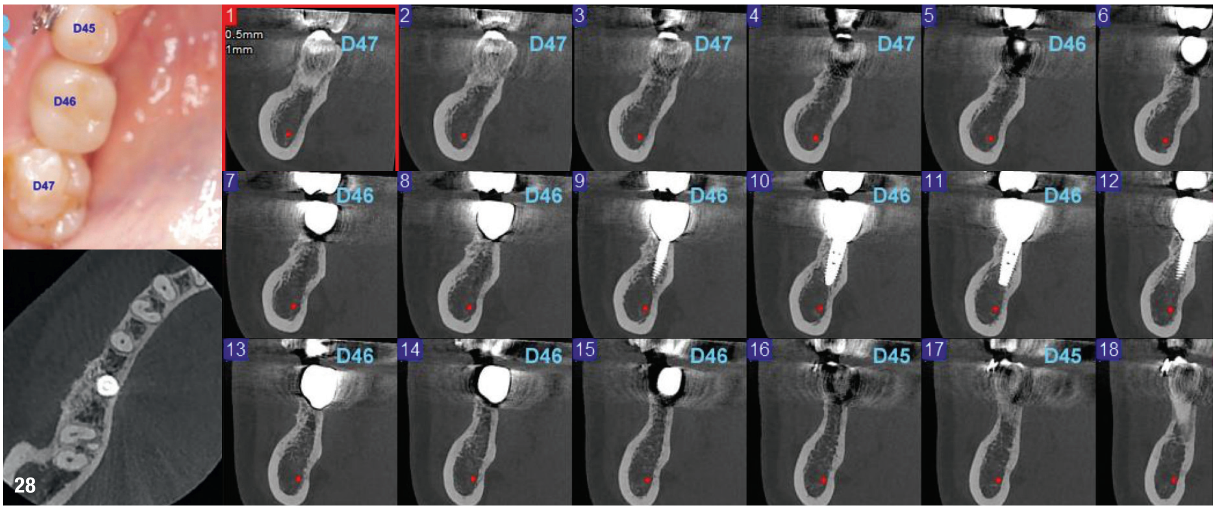


Fig. 28: Clinical aspect and CBCT measurements at 36 months post-op.

genic agents) and that can be harvested during the same routine oral surgery session, near to the alveolar bone defect and in the desired amount.[27,33] The human periosteum is such a membrane owing to its content of fibroblasts, osteoblasts and stem cells as well as high vascularity.[27] The clinical success reported in this case report can also be attributed to the progenitor cells of fibroblasts and osteoblasts in periosteum that have the ability to grow and differentiate into multiple mesenchymal lineages that sustain the regeneration of new bone tissue.[27] Well-designed research comparing GBR techniques using either resorbable membranes or periosteal membranes in association with the same grafting biomaterials is recommended in sufficiently large sample sizes to validate and support the routine use of periosteum as a barrier membrane in implant therapy.

Conclusion

The use of periosteum can increase the success rate of GBR procedures in the restoration of severely resorbed alveolar bone for the receipt of dental implants. Despite the lack of data that supports the use of periosteal grafts as a standard tool in the pre-implantation stage, this case report has demonstrated the regenerative potential of periosteum when used in the reconstruction of future implant sites.

Literature

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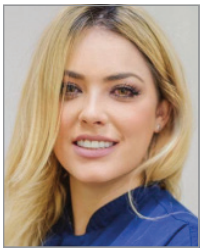
Dr Cosmin Dima graduated in dentistry from the Carol Davila University of Medicine and Pharmacy in Bucharest in Romania in 2001, was certified in implantology in 2004 and completed his PhD in surgery on the topic of bone regeneration around implants in 2019. He is the managing director of the Dental Progress clinic in Bucharest. He developed the Snake technique and the periosteal membrane technique for bone augmentation. Dr Dima is co-founder and educational director of the Digital Dentistry Society in Romania and a member of the Society of Esthetic Dentistry in Romania, European Society of Cosmetic Dentistry and International Congress of Oral Implantologists. In 2020, he received the World's Top 100 Doctors in Dentistry lifetime achievement award from the Global Summits Institute.



Dr Iulia Florea is a passionate and dynamic dental professional with a commitment to serving others through best practices and superior care and has over ten years of experience in general practice since graduating in dentistry from the Carol Davila University of Medicine and Pharmacy in Bucharest in Romania in 2012. Dr Florea is adept in planning and implementing appropriate and powerful patient care plans, leading to optimal results, and has a great passion for dental photography. She is in private practice at the Dental Progress clinic in Bucharest.

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