Vascular Delay Soft Tissue Technique in Oral/Maxillary Bone Reconstructive Surgery: A Technical Note

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Purpose: The present study describes a new presurgical soft tissue technique in oral/maxillary bone reconstructive surgery for reducing the risk of soft tissue dehiscence and its related complications. ***Materials and Methods:*** Ten consecutive patients with Cawood and Howell type V atrophy were scheduled for CAD/CAM titanium mesh bone reconstructive surgery after applying the vascular delay technique 21 days before regenerative surgery. The surgical and healing complications were clinically assessed at nine time points, ranging from the time of bone regenerative surgery to 9 months after surgery. Surgical complications included flap damage and neurologic and vascular complications. Healing complications were subdivided into four classes. These classes comprised Class I: small membrane exposure (≤ 3 mm) without purulent exudate; Class II: large membrane exposure (> 3 mm) without purulent exudate; Class III: membrane exposure with purulent exudate; and Class IV: abscess formation without membrane. ***Results:*** The study sample included seven men and three women (mean age: 48.2 ± 3.5 years) with seven mandibular cases and three maxillary cases. The defect length ranged from three to six teeth, with a mean mesiodistal distance of 29.9 ± 8.5 mm and a mean volume augmentation of 2.03 ± 0.9 cm^3. There were no surgical complications. One patient presented a Class I healing complication that did not affect the regeneration outcome. ***Conclusions:*** The vascular delay technique appears to reduce the risk of soft tissue dehiscence and exposure in bone regenerative surgery, though randomized studies involving larger samples and longer follow-up periods are needed in order to draw firm conclusions. *Int J Oral Maxillofac Implants 2024;39:135–141. doi: 10.11607/jomi.10477*

Keywords: delay phenomena, guided bone regeneration, ischemic preconditioning

Dental implants are an effective treatment option for the replacement of lost teeth, with high survival rates reported over long-term follow-ups.[1–2] However, the long-term success and stability of implants in function are directly correlated to the quality and quantity of available bone at the implant site. Sufficient alveolar bone volume is required to ensure correct placement of the implants and to achieve an esthetically pleasing outcome.[2]

A number of surgical techniques—such as guided bone regeneration, distraction osteogenesis, the alveolar bone ridge splitting technique/ridge expansion, and autologous inlay-onlay bone block grafts—have been used to overcome alveolar ridge atrophy.[3–7] There is strong clinical and histologic evidence of the effectiveness and predictability of guided bone regeneration techniques, though they are not free of complications. The most prevalent problems are soft tissue dehiscences, with consequent membrane or graft exposure, contamination, and eventual partial or total graft loss.[8]

Vertical bone regeneration is the most challenging situation in this scenario, with a complication rate of 16.9%; the most frequent problem is soft tissue wound dehiscence, which can lead to bone graft loss.[9] As reported by Hao Tay et al in 2020,[10] in cases with membrane exposure, a layer of fibrous connective tissue is often seen histologically at the interface between native bone and regenerated bone.[10] With adequate soft tissue management, establishing correct primary wound closure, and adequate membrane stabilization, the risk of wound dehiscence can be reduced.[11]

In the field of reconstructive surgery, the vascular delay technique is used to facilitate flap survival. This procedure was first described by Tagliacozzi in 1597 and is also called *ischemic preconditioning*, and it enhances vascularity through neovascularization under ischemic conditions achieved by a surgically or chemically induced decrease in blood flow to the flap.[12] Moreover, this procedure is able to adequately adapt the blood supply to the flap design. Thus, the delay technique is characterized by neovascularization and increased flap vascularization, and it has been shown to promote flap survival.[13–15] Vascular delay influences tissue blood flow in two phases: an initial phase in which sectioning of

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Submitted February 1, 2023; accepted May 3, 2023.

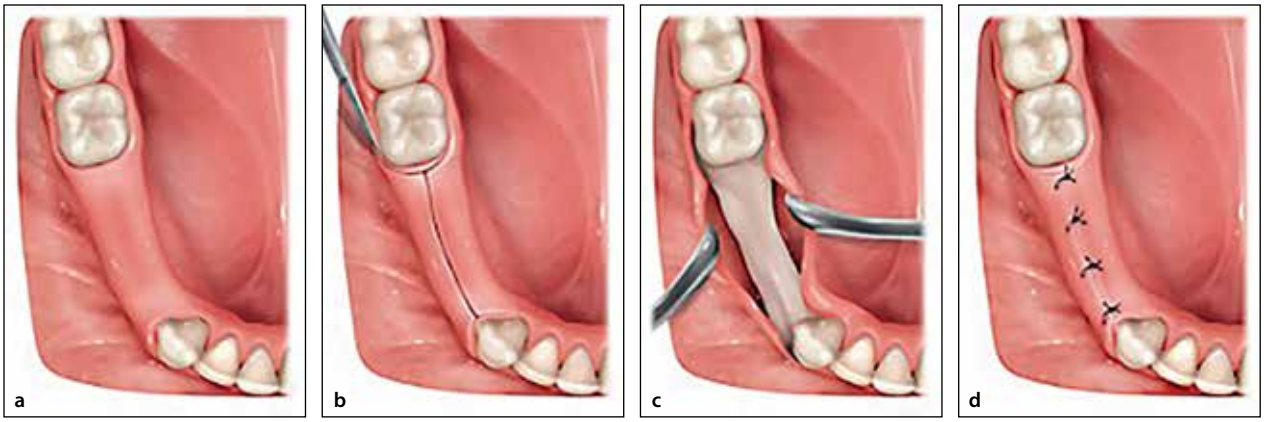

Fig 1 Schematic drawings of the vascular delay technique. *(a)* Initial situation. *(b)* Crestal and intrasulcular incisions. *(c)* Full-thickness flap exposing the bone defect. *(d)* Simple suture to close the flaps.

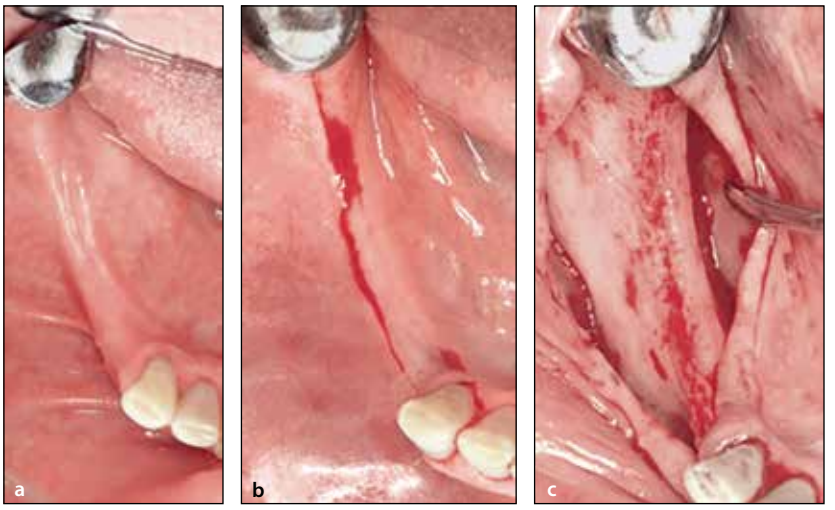

Fig 2 Intraoperative view of the vascular delay technique. *(a)* Initial situation. *(b)* Crestal and intrasulcular incisions. *(c)* Full-thickness flap exposing the bone defect.

the sympathetic fibers leads to dilation and reorientation of the choke vessels, and a late phase in which increased flap vascularization is generated due to the growth of new vessels.[16,17] The mechanisms underlying the creation of new blood vessels comprise angiogenesis and vasculogenesis. In this regard, angiogenesis refers to the generation of new vessels from a preexisting vascular network, while vasculogenesis refers to in situ vessel formation from bone marrow–derived endothelial progenitor cells. Likewise, vascular delay has been found to exert anti-inflammatory effects by altering neutrophil function.[18]

The present study describes a new presurgical soft tissue technique in oral/maxillary bone reconstructive surgery for reducing the risk of soft tissue dehiscence and its related complications.

MATERIALS AND METHODS

Study Design

Ten consecutive patients with Cawood and Howell type V atrophy treated between January 2018 and January 2020 were included in the study. All patients were scheduled for CAD/CAM titanium mesh bone reconstructive surgery, which was performed 3 weeks after applying the vascular delay technique. Surgery was performed by experienced surgeons of the Department of Oral and Maxillofacial Surgery at Universitat Internacional de Catalunya in Barcelona, Spain, and of the Institute of Maxillofacial Surgery at Teknon Medical Center in Barcelona, Spain (F.H.A. and G.M.R).

Patient Selection

The inclusion criteria were: Cawood and Howell type V atrophy in the maxilla or mandible; good systemic health (American Society of Anesthesiologists score I/II); and patient commitment to attending all study visits.

Fig 3 An individualized CAD/CAM titanium mesh was created.

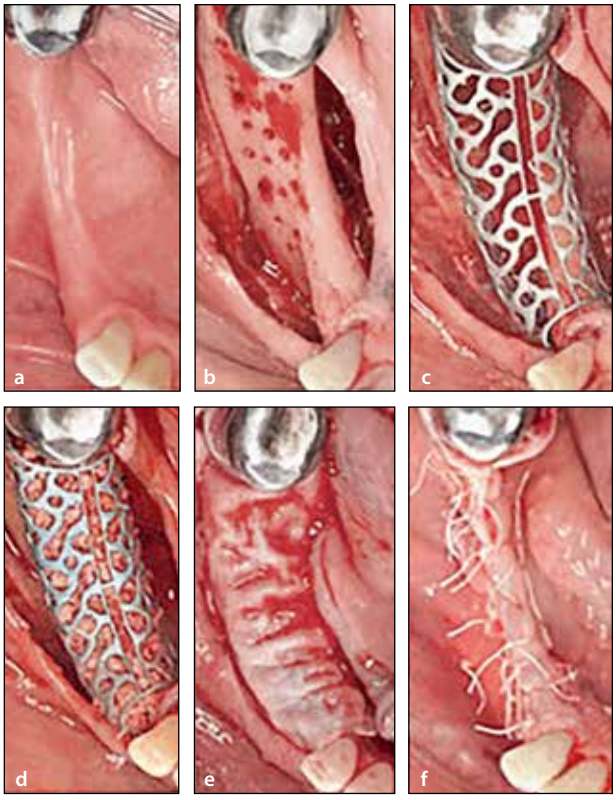

Fig 4 Step-by-step process of the bone regeneration performed utilizing the CAD/CAM titanium mesh. *(a)* Initial situation. *(b)* Bone decortication. *(c)* CAD/CAM titanium mesh try-in. *(d)* Fixed CAD/CAM titanium mesh. *(e)* Collagen barrier membrane. *(f)* Horizontal mattress and simple suture.

Patients were excluded if they presented a medical history contraindicating surgery; any disease, condition, or medication that might compromise soft and hard tissue healing (uncontrolled diabetes, liver functional disorders, immune system disease, immunosuppressant drugs, etc); or the presence of sufficient bone to allow rehabilitation with narrow or short implants. Patients with toxic habits capable of compromising recovery and bone healing, patients smoking > 10 cigarettes per day, and patients who had undergone chemotherapy or head and neck radiotherapy in the previous 5 years were also excluded.

Surgical Procedure

Before regenerative surgery, the diagnostic protocol included a clinical and radiographic examination with CBCT (i-CAT, Imaging Science International).

Twenty-one days before bone reconstructive surgery, the vascular delay soft tissue technique was performed under local anesthesia (articaine 4% plus epinephrine 1:100,000, Normon Laboratories). A mucoperiosteal full-thickness flap was reflected through crestal and intrasulcular incisions one tooth mesial and distal, if present, in order to completely expose the bone defect both buccally and lingually/palatally, without vertical releasing incisions. The flaps were then sutured using simple stitches (Vicryl 4.0, Ethicon; Figs 1 and 2). After 3 weeks, bone reconstructive surgery was performed using customized bone regeneration technology (Yxoss CBR, ReOss). From the DICOM files of the CBCT scan, an individualized titanium mesh was produced using CAD/CAM technology by ReOss (Fig 3). Bone reconstructive surgeries were performed under local anesthesia (articaine 4% plus epinephrine 1:100,000). A mucoperiosteal full-thickness flap, using the same design as performed in the vascular-delay soft tissue technique, was reflected through crestal and intrasulcular incisions (without vertical releasing incisions) until the bone defect was completely exposed. Then, soft tissue management was performed via a single periosteal incision in the buccal flap, and surgical scissors were used to open the periosteal incision until correct flap passivity was achieved. The lingual flap was managed according to Ronda and Stacchi,[19] detaching the superior fibers of the mylohyoid muscle until flap passivation was achieved.

Passive fit of the CAD/CAM titanium mesh was then checked. Autologous bone was harvested with a bone scraper (Micross, Meta) from intraoral regions such as the symphysis or the mandibular ramus. The titanium mesh was loaded with 60% autologous bone and 40% deproteinized bovine bone mineral (Bio-Oss, Geistlich). Then, the mesh was fixed in place using two osteosynthesis bone screws, only on the buccal side. The mesh was then covered with a resorbable collagen membrane (Bio-Gide, Geistlich). Double-line suturing was carried out with horizontal mattress sutures at the base and simple sutures on top (Cytoplast Non-Absorbable PTFE 4.0, Osteogenics Biomedical; Fig 4).

The patients received antibiotic treatment (875 mg amoxicillin and 125 mg clavulanic acid every 8 hours for 7 days, or 300 mg clindamycin every 6 hours for 7 days in the case of penicillin allergy), as well as anti-inflammatory medication and analgesic treatment (40 mg

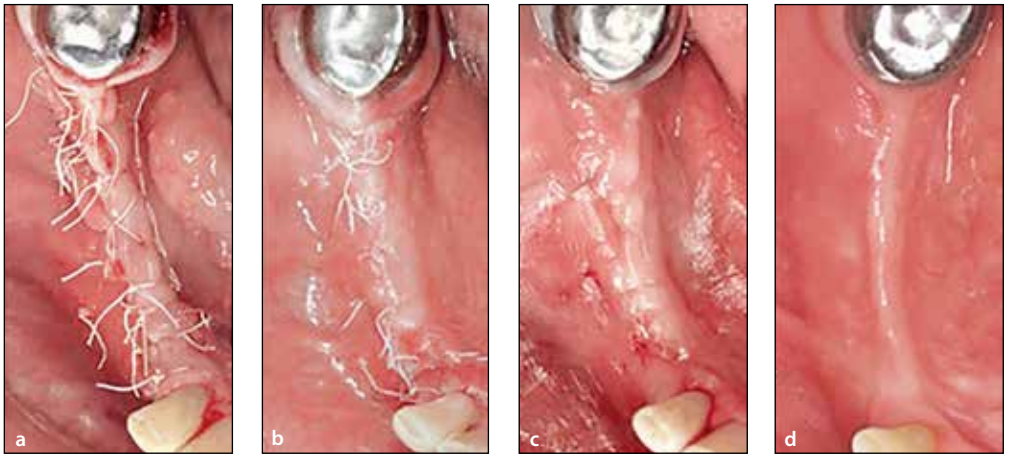

Fig 5 Bone regeneration healing process: *(a)* immediately postoperative, *(b)* 2 weeks postoperative, *(c)* after suture removal, and *(d)* 6 months postoperative.

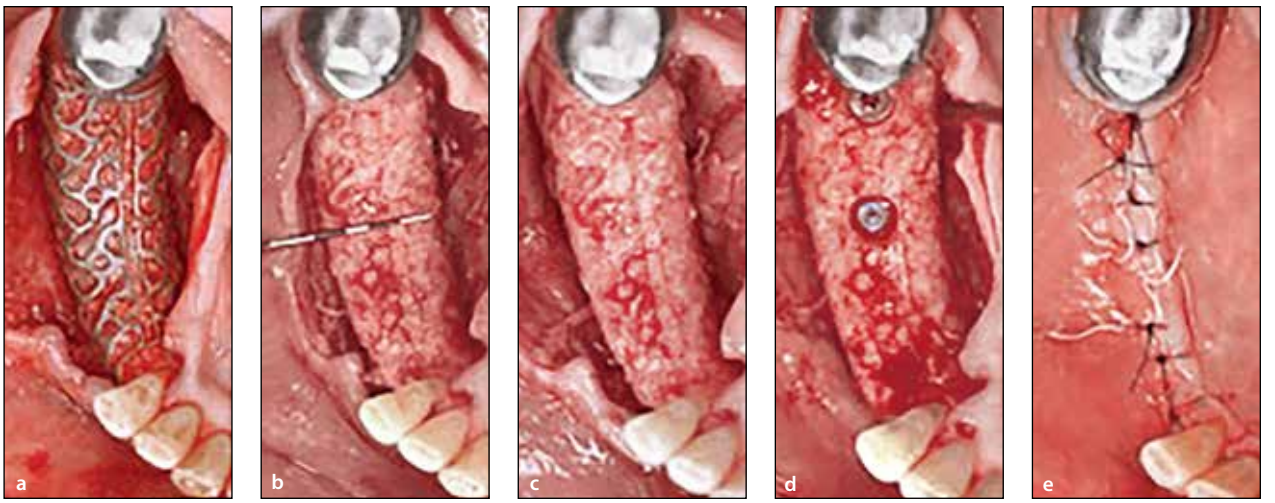

Fig 6 Step-by-step process of the bone regeneration progress at 9 months, reentry, and implant placement. *(a)* CAD/CAM titanium mesh after 9 months. *(b and c)* Newly regenerated bone. *(d)* Placed implants. *(e)* Simple suture.

prednisone once daily for 4 days; 25 mg dexketoprofen every 8 hours for 7 days; 575 mg metamizol every 8 hours for 7 days) and chlorhexidine rinses (Perio-Aid 0.20%, Dentaid, twice a day for 1 week). Patients were recalled after 7 days for virtual control and after 21 days for suture removal. Then, patients were recalled at 2, 3, 4, 6, and 8 months for virtual control (Fig 5).

After 9 months, a new CBCT scan was taken for implant planning using the Simplant Pro 18.0 application (Dentsply Sirona). At implant placement, the CAD/CAM titanium mesh was removed, and the implants were placed according to ideal 3D positioning, based on the final prosthesis position (Fig 6).

Study Variables and Measurements

The patients were clinically assessed at nine different time points: bone regeneration surgery (T1), after 7 days for virtual control (T2), suture removal after 3 weeks (T3), and 2 months (T4), 3 months (T5), 4 months (T6), 6 months (T7), 8 months (T8), and 9 months (T9) after regenerative surgery.

Complications were classified according to Fontana et al[20] and were divided into surgical and healing complications. Surgical complications included: flap damage (flap perforation or excessive flap thinning); neurologic complications (nerve damage, such as anesthesia, paresthesia, or dysesthesia); and vascular complications (edema and hemorrhage). Healing complications included: small membrane exposure (≤ 3 mm) without purulent exudate (Class I); large membrane exposure (> 3 mm) without purulent exudate (Class II); membrane exposure with purulent exudate (Class III); and abscess formation without membrane exposure (Class IV).

RESULTS

Patient demographic data and baseline situations of the 10 clinical cases are summarized in Table 1. The study sample comprised 7 men and 3 women with a mean age of 47.7 ± 6.01 years. Three patients had a history of periodontitis, no patients had smoking habits, and no

Table 1 Demographic Data, Study Variables, and Measurements

Patient no.	Sex	Age, y	Arch	Mesiodistal distance	Volume
1	M	52	Mandible	21 mm	1.51 cm^3
2	M	58	Mandible	29 mm	1.37 cm^3
3	F	43	Maxilla	21 mm	1.59 cm^3
4	M	47	Mandible	36 mm	3.47 cm^3
5	M	51	Maxilla	32 mm	2.54 cm^3
6	F	39	Mandible	45 mm	3.75 cm^3
7	M	47	Mandible	28 mm	1.09 cm^3
8	M	54	Mandible	18 mm	1.18 cm^3
9	M	38	Maxilla	27 mm	1.07 cm^3
10	F	49	Mandible	42 mm	2.78 cm^3

None of the patients experienced any surgical complications during treatment.

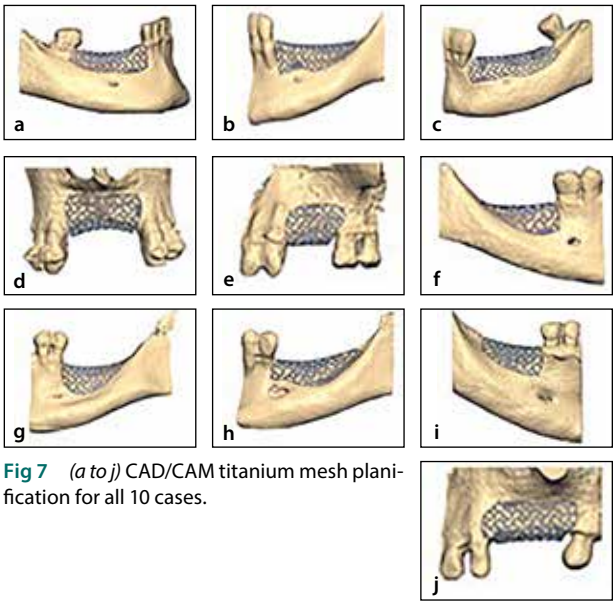

Fig 7 *(a to j)* CAD/CAM titanium mesh planification for all 10 cases.

patients had severe systemic or metabolic diseases. No dropouts occurred during follow-up period.

All patients underwent the vascular delay soft tissue technique 21 days before bone regeneration surgery with CAD/CAM titanium meshes (Fig 7). Seven cases were in the mandible and three in the maxilla; the length of the defect ranged from 3 to 6 teeth, and a mean mesiodistal distance of 29.9 ± 8.5 mm was seen, as well as a volume augmentation of 2.03 ± 0.9 cm^3.

Outcome Measurements

No surgical complications (flap damage or neurologic or vascular complications) were recorded. However, one patient had a Class I healing complication with a small membrane exposure (≤ 3 mm) but no purulent exudate in the mandible, which did not affect the result of regeneration and was treated with topical chlorhexidine gel 0.20% and mouthwash (PerioAid 0.12% Intensive Care Gel). A soft tissue dehiscence appeared 6 months after regenerative surgery (T7) without affecting bone regeneration. In all cases, standard implants could be placed without needing extra bone regeneration after 9 months.

DISCUSSION

The results of the vascular delay soft tissue technique showed no surgical or healing complications in 90% of the cases, with one patient (10%) presenting a small membrane exposure without purulent exudate.

Guided bone regeneration techniques using a nonresorbable membrane are considered to be a predictable surgical option for bone reconstruction in the atrophic maxilla and mandible.[21,22] However, the latest systematic review on vertical bone regeneration reported a weighted mean complications rate of 16.9%.[23] Upon further analysis, the incidence of complications ranges from 0% to 77.8% for the staged approach vs 0% to 45.4% for the simultaneous approach.[9,23] Interestingly, resorbable membranes were more prone to complications than nonresorbable membranes (22.7% vs 6.9%).[23] This wide range in complication rates implies that the procedure still appears to be very technique-sensitive and operator-dependent. Various recommendations have been proposed to avoid complications, such as accurate evaluation of the clinical history and personal characteristics of each patient, analyzing all risk factors that may interfere with wound healing, and the immune response, angiogenesis, and bone metabolism.[24] Additionally, flap passivation is essential for tension-free closure of the surgical wound and for avoiding early membrane exposure. The management of surgical flaps has been addressed by a number of authors, with descriptions of the coronally advanced lingual and buccal flaps used for the mandible.[25–28] In the maxilla, several flap designs have been described, with a special focus on the vestibular flap due to the difficulty of mobilizing the palatal flap.[29] The use of two-line suture techniques to protect the regeneration has also been described, as well as internal force-breaking sutures to reduce the risk of soft tissue dehiscences.[30]

To the present authors' knowledge, this is the first description of the use of an already published vascular delay technique in the field of extraoral reconstructive surgery intended to improve soft tissue quality and reduce dehiscence-related complications in intraoral bone reconstructive surgery.

Surgical vascular delay is a perfusion preconditioning technique in soft tissue flap reconstructive surgery,

based on the ability of the tissue to undergo neovascularization under ischemic conditions, with the vascular supply altered to fit the flap design.[13] In reconstructive surgery, it is used to create a strong axial blood supply where no such supply previously exists. It was decided to apply the technique to bone reconstructive surgery in order to increase blood flow in surgical flaps, which would ideally reduce the risk of complications, as an adequate blood supply is mandatory for bone formation and maturation.[14,15,31,32]

The present results show that this technique could be beneficial in reducing the risk of early complications in the form of soft tissue dehiscences, which are a main problem affecting bone regeneration outcomes. Only one patient presented a small membrane exposure 6 months after reconstructive surgery, which was treated with topical chlorhexidine gel 0.12% and mouthwash. Exposure did not extend more than 3 mm, and the complication did not affect bone regeneration.

The proposed technique was performed using a CAD/CAM titanium mesh, which is associated with a greater risk of exposure due to soft tissue dehiscence, and these meshes sometimes present difficulties during removal because the bone grows in the titanium perforations. However, the present technique can also be performed with other surgical barriers, such as block grafts, PTFE membranes, or resorbable membranes, and it can be performed after radiotherapy (especially in patients with vascular alterations).[32]

A possible drawback of the technique is the need for an additional surgical procedure. Although the second procedure is not particularly invasive and is well tolerated by the patients, it can increase the risk of surgical wound dehiscence and subsequent complications. More studies are needed to analyze the ideal time to perform surgery after the vascular delay technique, as well as the changes in blood flow after performing the technique. Multicenter and randomized studies comparing application vs nonapplication of the technique are also indicated.

The reported results suggest that the vascular delay technique should be included within the management armamentarium to improve oral soft tissue conditioning in the context of bone reconstructive surgery.

CONCLUSIONS

This is the first description of the ischemic precondition, intended to improve soft tissue quality and reduce dehiscence-related complications in intraoral bone reconstructive surgery. The vascular delay technique could have a positive impact in reducing the risk of dehiscence and soft tissue exposure in bone regeneration. Randomized studies with larger sample sizes and longer follow-up periods are needed to draw firm conclusions.

ACKNOWLEDGMENTS

The authors have no financial interests—either directly or indirectly—in the products or information listed in this article.

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