A novel two-stage surgical technique for severe three-dimensional bone atrophy associated with periodontal attachment loss: a case report

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Abstract

This report describes a minimally invasive two-stage method for managing partialedentulism associated with severe three-dimensional tissue deficit and periodontal attachment loss.A 51-year-old male presented with a missing maxillary left second molar, accompanied by a 7-mmvertical bone defect and loss of clinical attachment (9 mm) in the distal root of the first molar.The first treatment stage involved vertical regeneration using the guided bone regeneration (GBR) technique with a titanium-reinforced nonresorbable membrane, alongside periodontal defectregeneration of the adjacent tooth, without elevating the palatine flap. The membrane was pocketedand fixed using the transmucosal technique. After eight months, the second stage commenced withmembrane removal, implant insertion, and supracrestal soft tissue augmentation using a connectivetissue graft with a bilaminar technique. The implant was exposed five months later, and a lithiumdisilicate screw-retained crown was placed. Significant vertical bone increase, enhanced keratinizedsoft tissue, and a 6-mm clinical attachment gain at the adjacent tooth were observed one year aftersurgery. Radiographs confirmed stable new hard tissue around the implant and improvedperiodontal attachment. This case demonstrates the potential of combining GBR and periodontalregeneration techniques to reduce discomfort and surgical interventions while preserving adjacentnatural teeth.

Keywords: bone regeneration, dental implants, connective tissue, periodontal attachment loss, casereports

Introduction

Losing one or more dental elements leads to remodeling of the alveolar bone at thepostextraction site.[1] The bone volume loss continues during the years following tooth loss,occurring in both the coronal-apical and vestibulo-lingual directions.[2] In cases with lesions in theperiodontal tissue at the time of extraction—such as during infectious processes, mechanicaltrauma, or local inflammation—the resulting bone deficit is proportionally extensive, potentiallytriggering severe alterations to the integrity of the periodontal tissues.[3,4]Severe maxillary bone deficiency with vertical and horizontal loss of the alveolar process requiresthree-dimensional (3D) regenerative procedures in the context of a correct prosthetically guidedimplant approach.[5] Various techniques for the 3D regeneration of periimplant hard and soft tissueshave been proposed in scientific literature, and guided bone regeneration (GBR) is currently one ofthe most used and practical solutions.[6] Urban et al. proposed numerous stepswith long waiting times to manage major atrophies.[7,8] After extraction, the authors suggested aninterval of 3 to 6 months before proceeding with vertical bone regeneration, followed by

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surgicalreentry strictly related to the extension of the defect to be regenerated. Ren et al. highlighted theremodeling of the regenerated bone portion due to removing the nonresorbable membranes,suggesting a deferred implant reentry, usually after a few months.[9] Furthermore, the importance ofmanaging the supracrestal soft tissues following bone regeneration maneuvers to obtain an adequatethickness, a sufficient band of keratinized tissue, and the restoration of the correct depth of thevestibular fornix is often reduced due to the coronal displacement of the flaps in the GBR phase.Finally, the presence of bone peaks is still recognized as a limit to vertical regeneration, sometimesforcing the clinician to evaluate the extraction of the natural element adjacent to the vertical defectto obtain complete regeneration.[10]This case report describes a minimally invasive technique for 3D hard and soft tissue regenerationvia two interventions, with the absence of one bone peak and the periodontal regeneration of theadjacent tooth.

Case presentation

The present case report as redacted following the CARE guidelines (https://www.care-statement.org/).In January 2022, a 51-year-old male patient presented to our clinic seeking prosthetic implantrehabilitation for tooth 27, which was lost 9 years ago. The patient was classified as AmericanSociety of Anesthesiologists (ASA)-1, under the ASA Physical Status Classification System, hasno significant health concerns. He was a nonsmoker and maintained a good level of oral hygiene.His medical history revealed no systemic contraindications to oral surgery. Objective andradiographic examinations showed a probing pocket depth (PPD) value of 4 mm and a clinicalattachment level (CAL) of 9 mm on tooth 26. The vertical deficit of the alveolar process at site 27,measured using cone beam computer tomography (CBCT) with Romexis software (Planmeca,Helsinki, Finland), was 7 mm (Fig. 1a–b).The objective of the surgical treatment was to achieve 3D bone regeneration of the supracrestaleffect at site 27 while simultaneously promoting periodontal regeneration in the distal portion oftooth 26. Additionally, qualitative and quantitative restorations of the thickness of the atrophicsupracrestal soft tissue were planned to achieve the optimal biological width around the implant. Atwo-stage surgical and regenerative treatment was proposed; the first stage aimed to regenerate thesupracrestal hard tissue while addressing the periodontal defect affecting the adjacent natural tooth, while the second surgery involved the removal of

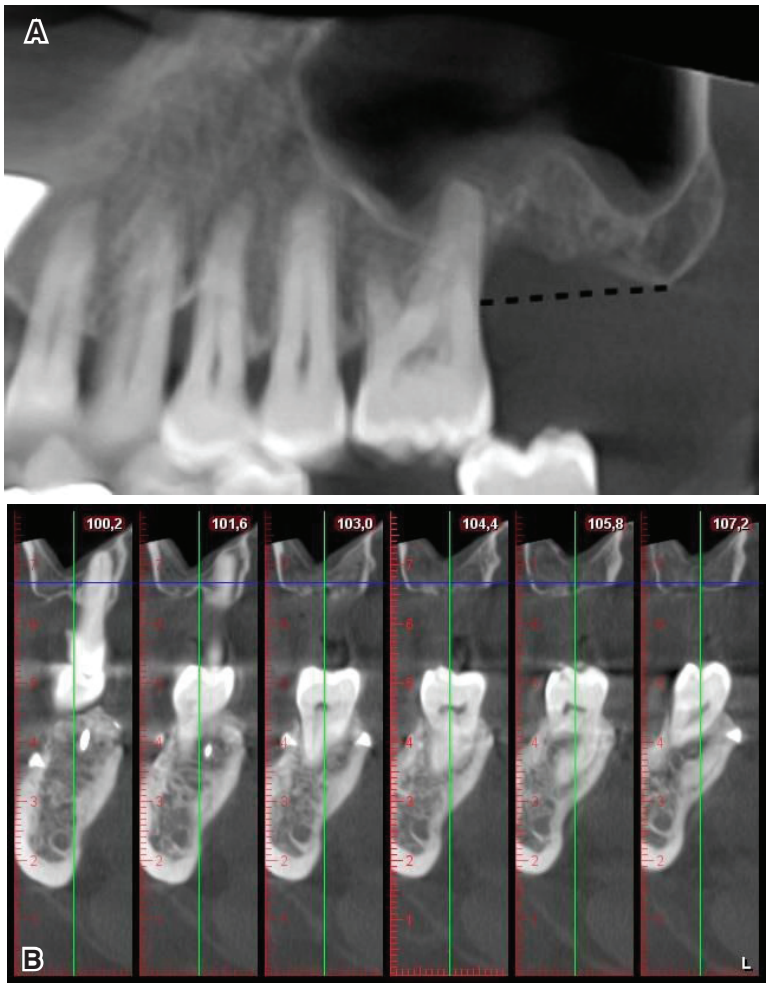

Figure 1. Preoperative evaluation via CBCT showing the extent of supracrestal bone defect and periodontal defect in tooth 26 (a–b).

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the nonresorbable devices, implant insertion, and enhancement of the supracrestal soft tissue using the connective tissue graft (CTG) technique.A virtual case resolution project was developed using 3D processing software according to theregeneration and guided prosthetic implantology guidelines.[5] The patient was informed about thestudy and the collection of data and images related to his case. A signed informed consent form wasobtained from the patient according to ethical standards.

First surgery

The patient underwent a complete oral hygiene session one week before surgery. On the day ofsurgery, he was instructed to rinse his mouth with chlorhexidine digluconate (0.20%) for 1 minute after verifying a full mouth plaque score of <20%. Local anesthesia was performed with 4%articaine (1:100,000 epinephrine).A crestal incision was made in the area of tooth 27, slightly toward the vestibular side, andcontinued in the sulcus of the two neighboring teeth; the incision ended with a vertical hockey-stick Releasing the cut for better access.[11] A full-thickness flap was raised on the buccal side. No releasingincisions were made on the palatal side, and the supracrestal soft tissue was tunnel-cut in the areacorresponding to the defect (Fig. 2a). The buccal flap was subsequently released in a disto-mesial direction.Direction exposing the underlying connective tissue with a single, continuous incision of the periosteum using a scalpel with a 15c blade. The tissue was stretched using a brushing technique,allowing significant coronal advancement of the flap.[12]A millimeter probe was used to measure the periodontal defect at the root portion of tooth 26,calculated from the residual bone plane to the cemento-enamel junction (CEJ) of the tooth, yieldinga measurement of 9 mm (Fig. 2b–2c). The vertical GBR technique was performed during the firstoperation using a titanium-reinforced dense-polytetrafluoroethylene (d-PTFE) membrane (Cytoplast.TI250XL, Osteogenics Biomedical Inc., Lubbock, TX, USA) and a graft made from a high-porositybiomaterial mixture of porcine-derived carbonate apatite (Zcore®, Osteogenics Biomedical Inc.,Lubbock, TX, USA) and autologous bone harvested from the left external oblique line of themandible (mixed in a 1:1 ratio). Bone sampling was performed through a single bucco-lingualincision (approximately 2 cm), creating a subperiosteal mucosal tunnel with a distal extension from the access incision. The bone particulate was collected and stored using a bone scraper (Micross,Meta Technologies, Reggio Emilia, IT) designed for tunnel techniques (Fig. 2d–2e).[13,14] Before proceeding with the GBR of the edentulous site, a periodontal regenerative procedure wasperformed on the distal root of tooth 26. The procedure involved curettage of the extraosseous rootportion, application of ethylenediaminetetraacetic acid (EDTA; Prefgel, Straumann, Basel,Switzerland) for 2 min, and placement of a layer of enamel matrix derivative (EMD; Emdogain,Straumann (Basel, Switzerland), according to the guidelines for regenerating periodontal intrabonydefects established by the American Association of Periodontology[15] and the European Federationof Periodontology of 2020.[16.] After treatment with EMD, a second thin layer of pure autologousThe bone was placed on the root portion. Following multiple perforations of the cortical bone, two 9-mm tenting screws were inserted at theedentulous site (Fig. 2f). The allograft was positioned, and the membrane was adapted and securedwith 3-mm self-drilling screws on the buccal and palatal sides (Profix™, Osteogenics BiomedicalInc., Lubbock, TX, USA). The membrane screws on the palatine side were inserted using atransmucosal technique to minimize excessive detachment of the palatine mucosal tissue (Fig. 2g).The margin of the membrane was modeled to remain 1–2 mm away from the natural tooth; the gapwas covered with collagen membrane (Bio Gide, Geistlich Pharma AG, Wolhusen, Switzerland).The coronally displaced flap was tested for passivity and sutured with a triple-layer suture usingforce-breaking stitches and employing a monofilament polyglycolic acid (PGA) suture thread (Serafast, Serag-Wiessner, Naila, Germany).[17]The patient was prescribed amoxicillin/clavulanate potassium (875 + 125 mg) tablets (Augmentin,GlaxoSmithKline, Brentford, UK) for a week, one tablet to be taken every 8 hours, and Toradol (20mg/ml; Recordati, Milan, Italy), 10 drops sublingually twice a day for 1 week. The patient was also instructed to spray a 0.5% chlorhexidine solution three times a day and to avoid mechanical plaque removal in the surgical area until the sutures were removed. The sutures were removed 2 weeks after surgery, and postsurgical visits were scheduled weekly for the first 3 weeks to monitor healingand verify wound closure during the postoperative period.

Second surgery

The patient was recalled 6 months after the first operation, and a new CBCT scan was performed toevaluate the maturation of the bone graft and plan the implant insertion. The scan showed a 3Dincrease in the residual alveolar process and a reduction in the periodontal defect (Figs. 3a–3b). Thedigitally calculated distance between the bone crest and the maxillary sinus floor was 8 mm.Therefore, a 3-mm crestal elevation was planned at the same time as the insertion of a 10-mm-longimplant with a transmucosal portion of 1.8 mm (3c). Loss of the vestibular fornix following the firstoperation appeared to be insignificant and did not require corrective surgery. The patient underwenta new oral hygiene session one week before the operation. After loco-regional anesthesia (40 mg/mlof articaine + 0.01 mg/ml of adrenaline), a sagittal incision was made in the crest without verticalreleases, extended mesially to the two elements adjacent to the defect, and followed by afull-thickness dissection of an envelope flap. The d-PTFE membrane was exposed, and the fixingscrews were removed. The membrane, which appeared particularly adherent to the underlying hard tissue, was removed using Lucas elevators and curettes (Fig. 4a), following which, the two support screws were finally removed. A distance of 4 mm between the new osseocrestal plane and the CEJof the distal portion of tooth 26 was measured with a millimeter probe (Fig. 4b). A crestal accesswas

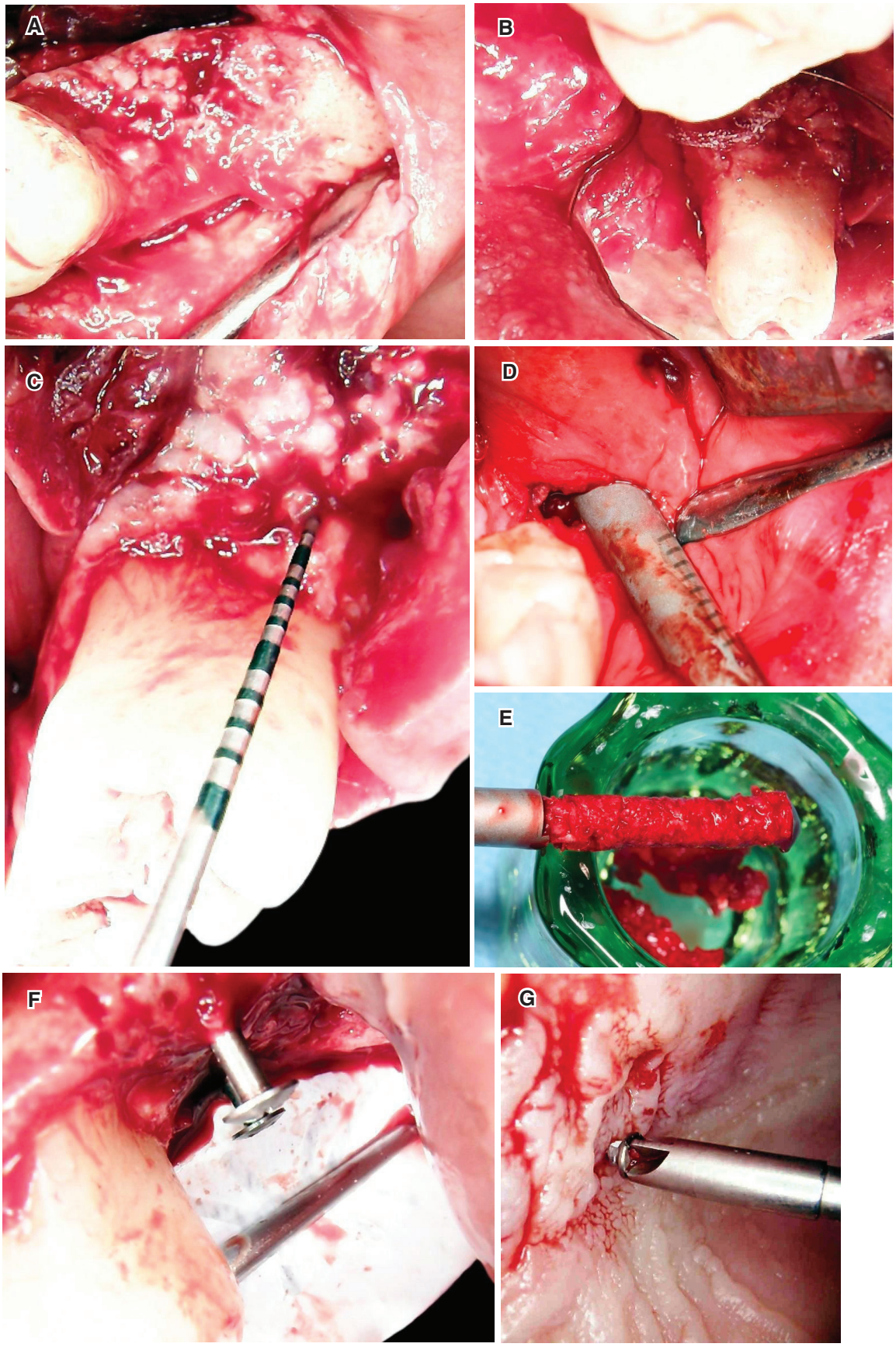

Figure 2. First surgery. (a) A full-thickness access flap was performed, and the bone defect was exposed. (b) The distal root portion of tooth 26 was smoothened and treated for 2 min with EDTA. (c) Distance between the residual bone crest and the distal CEJ. (d) A portion of the autologous bone was taken with a tunnel scraper and (e) mixed in proportions equivalent to the graft biomaterial. (f) A 9-mm tenting was positioned, and (g) the membrane was modeled and fixed transmucosally on the palatal site.

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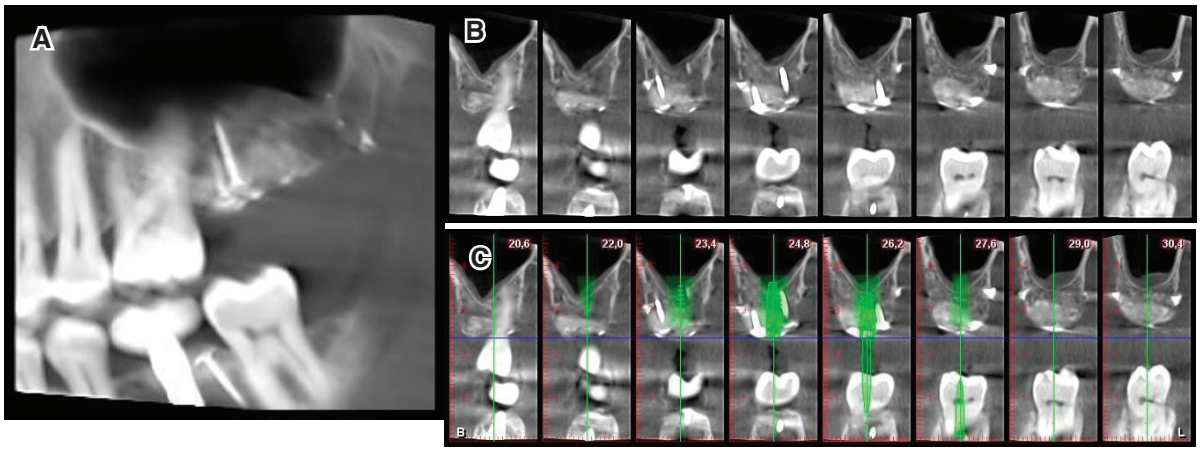

Figure 3. Check-up at six months. (a) Two-dimensional and (b) three-dimensional evaluation of the regenerated bone volume. (c) Implant planning in the regenerated bone.

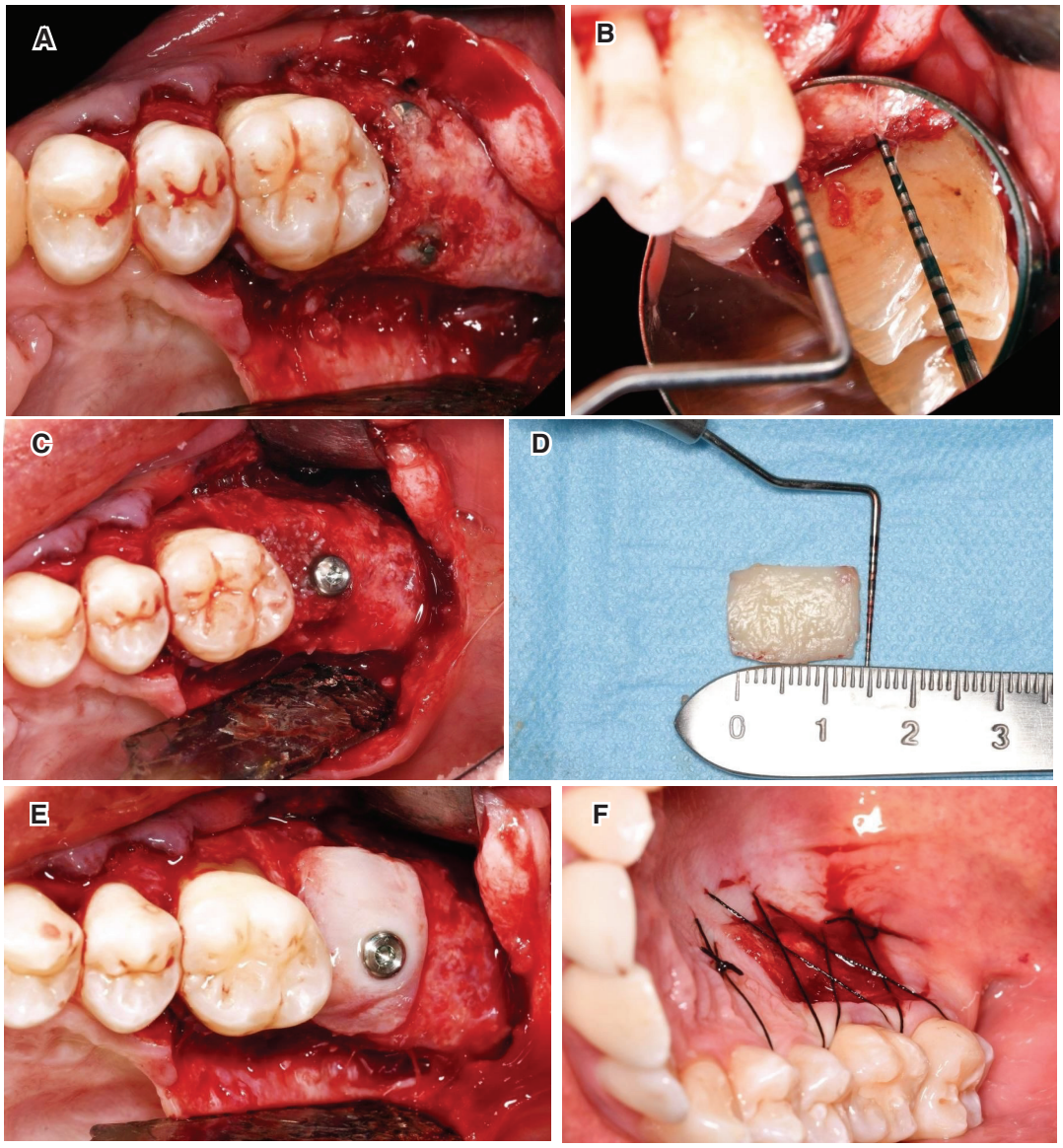

Figure 4. Second surgery. (a) An access flap was raised with a single incision and no vertical releasing incisions. (b) Distance between the new bone crest and the CEJ of the natural tooth. (c) After the removal of the nonresorbable devices, the implant was placed in a prosthetically guided position, and a second layer of biomaterial was applied. (d) A soft tissue graft was harvested from the palate, (e) deepithelialized, drilled, and fixed around the implant neck. (f) The donor site was covered with collagen and a compression suture.

created in a prosthetically guided position, and an implant site was prepared up to the floor ofthe maxillary sinus. Subsequently, access to the sinus was achieved using atraumatic rotating drills. (PRO SCV Sinus Lift, Resista, Verbania, Italy), A biomaterial, carbonate apatite andcross-linked hyaluronic acid mixture, was grafted (Hyadent BG, Regedent AG, Zurich, Switzerland). An implant with a 1.8-mm intramucosal neck was inserted (Prama, Sweden & Martina, Due Carrare,Italy). The neck was placed in a supracrestal position, and a minor correction of the bony contour ofthe alveolar process was performed with high-porosity porcine-derived carbonate apatite (Fig. 4c).Subsequently, a soft tissue augmentation technique was performed with a CTG derived from thedeepithelialization of a free gingival graft taken from the palate in the area adjacent to teeth 16 and17. The mesiodistal and apico-coronal dimensions of the CTG were approximately 14 and 11 mm,respectively, while the thickness was 2 mm (Fig. 4d). The graft was drilled in the center, in theposition of the neck of the implant, using a rounded punch (diameter, 2.5 mm), and stabilizedaround it (Fig. 4e). The flap was sutured over the graft using 5-0 monofilament PGA sutures; amedical collagen fleece was adapted and sutured at the sampling site on the palate (MediCipio C,Medichema GmbH, Chemnitz, Germany) (Fig. 4f).

Final prosthetic delivery and follow-up

After an additional 5 months of healing, an X-ray control was performed, followed by a flaplessuncovering of the implant using a rotating punch. A transmucosal healing abutment was placed.Two weeks later, the supracrestal soft tissue appeared free of inflammation, and a pink mucous conewas observed over the prosthetic Ultrathin Threaded Microsurface (UTM) neck connection of theimplant (Fig. 5a). CTG integration and enhanced supracrestal soft tissue were noted. Radiologically,the graft was distinguishable due to increased supracrestal hard tissue and an elevated maxillary sinus.Additionally, there were no local periimplant infections, and the periodontal bone defect affectingthe distal portion of tooth 26 was resolved (Fig. 5b). A PPD of 3 mm without recession(resulting in a CAL of 3 mm) was measured at the disto-buccal and disto-palatal aspects of the firstmolar. A CAL gain of 6 mm was obtained when compared to the measured variable at the time of the first operation. Two weeks after reopening, a digital impression of the implant position and soft tissuetissues were taken, and a screw-retained lithium disilicate crown was fabricated (Fig. 5c). Thepatient was then recalled 18 months after the prosthesis placement and examined with intraoralX-rays. The physical examination revealed good oral hygiene and the absence of gingivalinflammation, with the soft tissue appearing stable around the prosthetic restoration (Fig. 6a). Radiologically, the hard tissue was maintained in the periimplant region and the distal portion oftooth 26 (Fig. 6b).The timeline of the clinical case is shown in Figure 7.

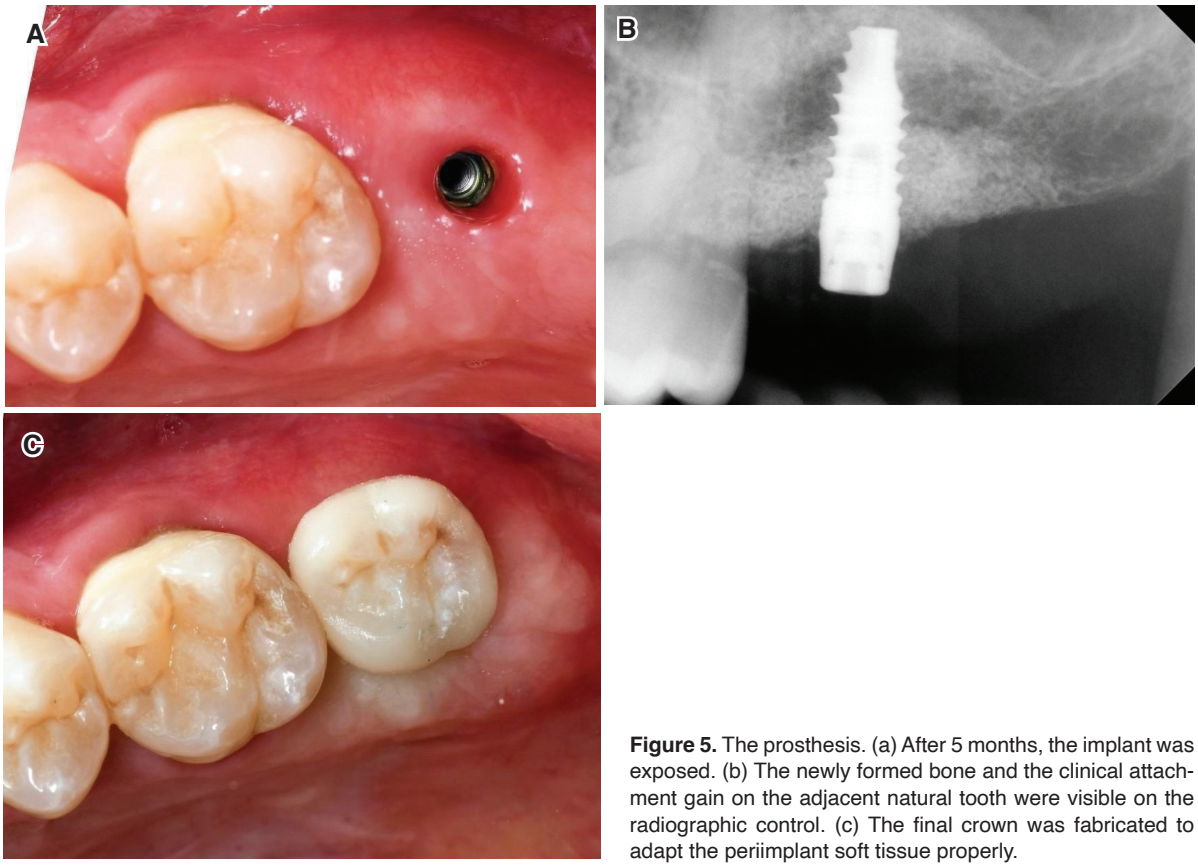

Figure 5. The prosthesis. (a) After 5 months, the implant was exposed. (b) The newly formed bone and the clinical attachment gain on the adjacent natural tooth were visible on the radiographic control. (c) The final crown was fabricated to adapt the periimplant soft tissue properly.

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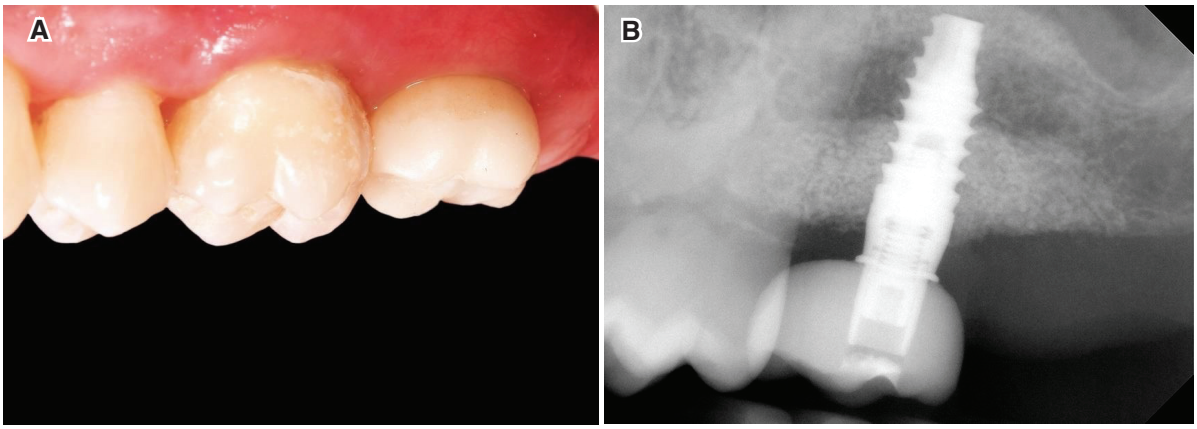

Figure 6. The 18-month follow-up. (a) The clinical situation appeared stable, with no recession or local inflammation. (b) The periapical X-ray showed no pathologic alterations with periimplant tissue stability.

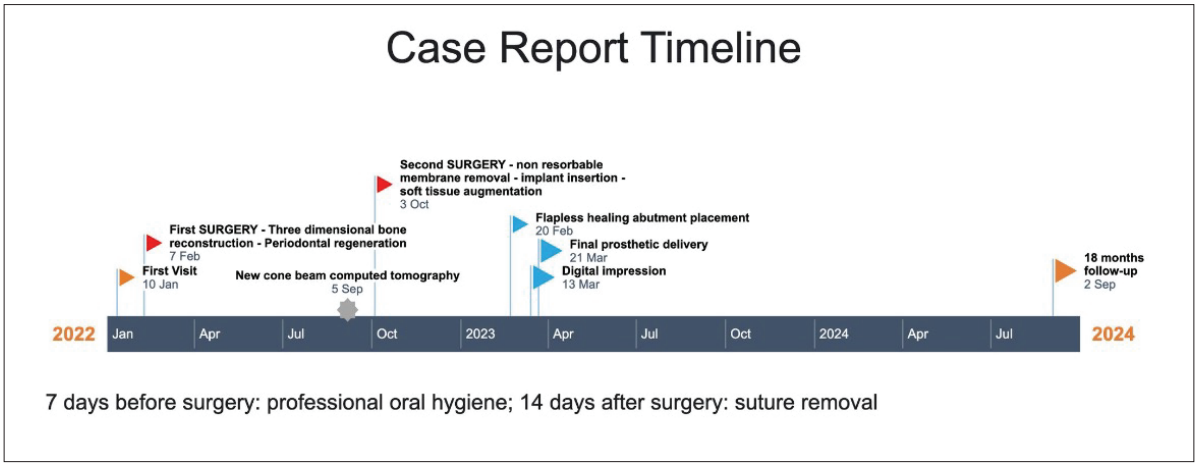

Figure 7 . Timeline of the study.

Discussion

Vertical bone ridge augmentation is a well-documented procedure, with implant success andsurvival rates comparable to those found in native bone.[19-20] Ridge augmentation techniques havesignificantly evolved over the last 20 years, facilitating the restoration of the physiological andanatomical morphology of the periimplant alveolar process, in terms of the complex and soft tissues.[21-22]The focus on reducing the invasiveness of oral surgery aims to preserve better the shape andphysiological function of the anatomical structures of the oral cavity, seeking procedures thatminimize interventions while optimizing treatment outcomes with less trauma, pain, and discomfortfor the patient.[23-24] Vertical ridge augmentation procedures are effective when using nonresorbablebarrier devices because they exhibit superior space-maintaining characteristics compared toresorbable membranes.[25-26] However, nonresorbable devices necessitate a removal procedure, which,along with the restoration of blood circulation between bone and periosteum, appears to induceremodeling and a reduction in the volume of the newly formed hard tissue.[27-28] Therefore, approaches that involve delayed timing between the removal of nonresorbable devices and theprosthetically guided implant insertion procedure have been proposed, sometimes associated with asecond grafting technique using layers of xenograft covered with resorbable membranes [29-30]In the present case report, a second layer of biomaterial covered by connective tissue was usedduring surgical reentry and removal of the d-PTFE titanium-reinforced membrane. The objective ofthis procedure was to counteract the potential contraction of the regenerated bone volume followingthe removal of the barrier device.[18-29] Soft tissue management is considered essential for thecompletion of oral regenerative techniques, and the key factors include the thickness of theperiimplant supracrestal soft tissue, the amount of keratinized gingiva, and the maintenance orrestoration of a proper mucogingival line.[31-32] Autologous connective tissue grafting, traditionallyperformed as a free gingival graft alongside major bone regeneration procedures, remains thetechnique of choice for restoring the quality of the supracrestal soft tissue. However, alternativesolutions favoring connective tissue grafts combined with bilaminar techniques as augmentationprocedures have recently gained traction.[33]The primary role of the CTG is to increase and improve the thickness and quality of the supracrestalsoft

tissue.[34-35] The use of CTG immediately after removing the nonresorbable barrier aimed toreduce the number of surgical interventions and, consequently, the treatment invasiveness and toleverage the temporary barrier effect of the connective tissue, thereby mitigating the remodelingprocess of the regenerated hard tissue. The implant design and surface characteristics may alsoinfluence the remodeling of the vertically regenerated hard tissue.[36-37] Therefore, using one-pieceimplants (such as tissue level) with hybrid implant surfaces and the subcrestal positioning of theimplants might counteract the regenerated bone volume shrinkage.The philosophy behind the intramucosal implant involves positioning the rough, sandblasted, andetched portion solely within the bone (intraosseous) while allowing for different placementoptions for the UTM neck between the hard and soft tissue, depending on the clinical situation. Theintramucosal neck of the implant serves as a useful anchoring element for the connective tissuepositioned around it, which is subsequently covered by the surgical flap.[38]In the current study, the absence of the bone peak adjacent to the natural element at the edentuloussite resulted in continuous periodontal and bony defects, resulting in the formation of a singleinfrabony defect bordered distally by the residual bone peak and mesially by the root wall ofelement 26. Such a configuration favors a regenerative approach, where GBR intersects withperiodontal-guided tissue regeneration (GTR). In GTR, the vertical regenerative potential of theperiodontal defect depends not only on the presence of the distal bone peak but also on the intactresidual walls around the natural element. The cells of the periodontal ligament and bundle bone areattracted to the residual bone tissue and the surrounding alveolar walls.[39-40] Thus, the number of intact walls around the natural tooth likely influences the regenerative potential of the periodontalintrabony defect.[41] Consequently, more intact walls may lead to higher clinical attachment gains inmillimeters.Finally, a common side effect in flap management during the initial surgical stage, observed in allcoronal flap advancement procedures, is the reduction in the vestibular depth. This issue was notsignificant enough in the current case study to necessitate surgical correction [41-42]. If needed, it can beaddressed during the second surgical stage with a vestibuloplasty associated with a free gingivalgraft or xenogeneic/ allogeneic materials.[43-44] Eighteen months after the final crown delivery, theregenerated tissue appeared stable, and no signs of CAL associated with the treated natural elementwere observed. Histological evaluations of the quality of the newly formed periodontal structureswere not performed.

Conclusions

The hard and soft tissue augmentation procedure performed in two surgical stages in this studyreduces the number of operations compared to other regenerative techniques. It facilitates 3D GBR, which includes the removal of fixation, tenting screws, and barrier devices, the insertion ofimplants, and the management of supracrestal soft tissues. Fewer surgical stages lead to shortertreatment times, reduced pharmacological therapies, and less overall inconvenience for the patient.Preliminary data on vertical bone loss after removal of the d-PTFE barrier suggest a reduction inbone loss with this technique, at least during the first year after surgery. Thus, using a graft with alayer of granular biomaterial covered by subperiosteal connective tissue at the time of membraneremoval may positively influence the remodeling process and superficial revascularization of thegraft, thereby minimizing short-term contraction. Within the limits of this case report, it can beconcluded that, in cases of periodontal defects affecting adjacent natural elements, an in-depthanalysis of the residual bone walls combined with a simultaneous bone and periodontal regenerativeapproach suggests regenerative potential, even in the absence of a perfectly maintained bone peak.Nonetheless, additional controlled randomized clinical trials with longer follow-ups are needed to confirm the efficacy of this technique.

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Conflict of interest

The authors report no conflicts of interest related to the study:

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