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Usage of xenogeneic bone intentionally left exposed to the oral environment after immediate implant placement: a case report with six-year follow-up

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Abstract

Objective: This clinical case report aims to demonstrate a successful treatment using an alternative technique for flapless immediate implant placement by letting the xenogeneic bone graft exposed to the oral environment.

Case report: A flapless immediate implant placement into the fresh mandibular first molar socket was done. The alveolar gap was filled by deproteinized bovine bone mineral (DBBM) up to the level of the gingival margin, and the biomaterial was intentionally left exposed and maintained only by the cover screw. A definitive restoration was placed six months after the implant insertion. This patient exhibited no clinical or radiologic complications throughout the six-year follow-up period.

Conclusion: The DBBM exposed to the oral environment showed stability and caused no sign of infection and clinical complications. Throughout the follow-up time, the patient presented a favorable peri-implant phenotype, with a wide keratinized mucosa width, stable peri-implant buccal bone, as well as the maintenance of crestal bone. Although the exposed biomaterial may be more susceptible to displacement, this approach showed satisfactory performance regarding uneventful healing, esthetics, and function, in a six-year follow-up. However, randomized clinical trials to evaluate the clinical predictability and soft and hard tissues healing profile are needed.

Keywords: Dental implant. Gingiva. Biomaterial. Bone grafting. Alveolar bone.

Introduction

Just being successful in implant installation does not mean that function and aesthetics demands have been achieved (Chappuis *et al*., 2017). The integrity of hard and soft tissue structures, compromised by the inevitable alveolar post-extraction remodeling process, is still a challenge in Implantology. This healing process alteration represents hard and soft tissue deficiencies (Berglundh *et al*., 2018). When compared to the periodontium, the peri-implant tissues exhibit certain differences, such as the absence of cementum and periodontal ligament, and moreover, the peri-implant epithelium is longer and lacks attachment of connective tissue into the implant surface (Berglundh *et al*., 2018). Immediate implant placement, despite not preventing alveolar ridge reduction (Araujo *et al*., 2005), is an interesting technique for minimizing the number of surgical procedures and optimizing treatment time (Blanco *et al*., 2019), and as efficient as compared to late implant placement (Morton *et al*., 2018).

Grafting of the gap using deproteinized bovine bone mineral (DBBM) significantly reduces the bone dimensional changes that occur following immediate implant placement (Araujo *et al*., 2011; Yuenyongorarn *et al*., 2020; Sanz-Sanchez *et al*., 2022). The presence of this biomaterial preserves the horizontal contour, with an approximate loss of 0.80 mm when socket grafting is performed and of 1.00 mm after immediate implant alone (Yuenyongorarn *et al*., 2020; Seyssens *et al*., 2022). Bone graft material placed into the implant gap tends to be advantageous for tissue preservation (Araujo *et al*., 2011; Chappuis *et al*., 2017; Yuenyongorarn *et al*., 2020; Seyssens *et al*., 2022), and has promoted a positive impact in terms of hard and soft tissue healing (Seyssens *et al*., 2022). A meta-analysis revealed that grafting the gap has 54% less horizontal buccal bone resorption and significantly less apical midfacial

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soft tissue migration (Seyssens *et al.*, 2022). Different materials and combinations are available to reduce volumetric change after tooth extraction (Thalmair *et al.*, 2013; Thoma *et al.*, 2020). The DBBM is used as a natural scaffold for new bone formation (Thalmair *et al.*, 2013), and demonstrates a tendency to improve volume of soft tissue and decrease invaginations during alveolar ridge preservation procedures, when compared to spontaneous healing (Thoma *et al.*, 2020). Usage of xenogeneic bone intentionally left exposed to the oral environment during alveolar preservation simplifies the clinical procedure and reduces surgical morbidity for the patient. However, there is limited information in the literature regarding this practice (Thalmair *et al.*, 2013; Thoma *et al.*, 2020; Levine *et al.*, 2022), and these cases (Thalmair *et al.*, 2013; Thoma *et al.*, 2020) were restricted to the socket, without immediate implant installation, which is the purpose of the present clinical case. Frequently, the DBBM is used alongside with an autogenous soft tissue graft, or with a barrier membrane, or with a collagen matrix, to seal off the opening socket (Blanco *et al.*, 2019). Preservation of the alveolar ridge with primary flap closure tends to have the level of the mucogingival junction located more apically (Seo *et al.*, 2023), compromising the keratinized mucosa band.

The peri-implant soft tissue phenotype is the combination of the height of the supracrestal tissue, the thickness of the mucosa and the keratinised mucosa. Keratinised mucosa seems to have advantages in terms of ease of plaque removal and patient comfort (Roccuzzo *et al.*, 2016; Berglundh *et al.*, 2018; Perussolo *et al.*, 2018), and suggests that deficient zones of keratinized mucosa (<2 mm) have greater tendency to develop bleeding on gentle probing, plaque accumulation, evidence of inflammation around the implant, discomfort during brushing, and marginal bone loss (Perussolo *et al.*, 2018).

The flapless technique for dental implant placement is a promising alternative to conventional flap, due to significantly less crestal bone loss (Lahoti *et al.*, 2021), a small reduction in buccal bone plate resorption (Blanco *et al.*, 2008; Blanco *et al.*, 2019), and maintenance of the buccal height almost stable (Lahoti *et al.*, 2021). These results can be explained by the flapless intact periosteum and blood supply (Blanco *et al.*, 2019; Lahoti *et al.*, 2021). After three months, the immediate implant placement procedure performed with a flap exhibited a buccal bone loss of 1.33 mm, whereas the flapless group showed a smaller loss of 0.82 mm (Blanco *et al.*, 2019). The flapless technique is more indicated to improve soft tissue implanting sites to preserve gingival papillae (Gao *et al.*, 2021). Furthermore, the keratinized mucosa thickness shows more increase in flapless approaches, compared to conventional flapped surgery (de Souza *et al.*, 2022).

Several techniques to increase the peri-implant soft tissue phenotype are proposed in the literature (Thalmair *et al.*, 2013; Chappuis *et al.*, 2017; Thoma *et al.*, 2020); however, patient morbidity and effective but simplified approaches have been motivating the development of alternative techniques. Thus, the present case report demonstrates a successful immediate implant installation combined with grafting of the gap using deproteinized bovine bone mineral left exposed to the oral environment, and its clinical follow-up.

Case report

A 34-year-old male patient presented to a private dental clinic complaining of tooth mobility, odor, and bleeding gums in the mandibular molar. He reported that a few years ago he had bitten something hard while eating, and that another professional had indicated tooth extraction. During the initial examination, the patient presented with good systemic health status and no medication use. Intraorally, all teeth were periodontally healthy, except for the left mandibular first molar (tooth #19) that had a 7-mm probing deep on the buccal side, and occlusal trauma. The clinical and radiographic examination revealed tooth #19 endodontically treated, and presence of a periapical lesion and bone loss in the furcation region, classified as endo-periodontal lesion in non-periodontitis patients, grade 3 (Papapanou *et al.*, 2018), indicating a bad prognosis (Figures 1 and 2).

Figure 1. Pre-operative view of the compromised mandibular left first molar, showing severe gingival retraction.

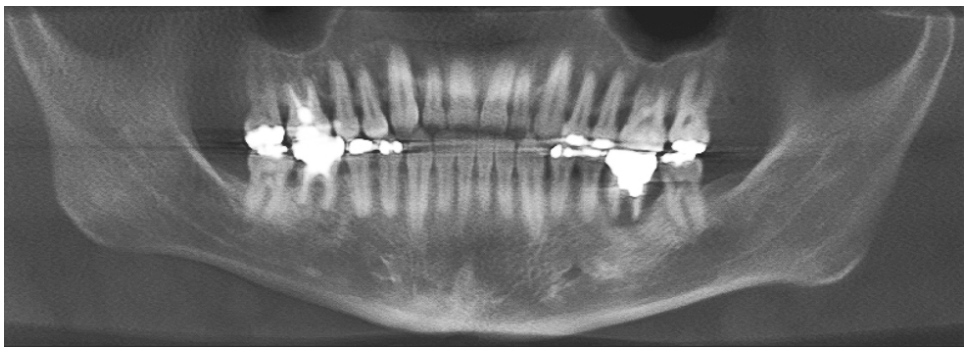

Figure 2. Initial panoramic radiographic aspect, showing a localized severe bone loss around the mandibular left first molar, with no signs of significant complications in the other areas.

The patient declined treatment with a fixed dental prosthesis, therefore, the chosen option was the immediately dental implant placement. The advantages and disadvantages of the process were clarified to the patient, and his consent was obtained after being fully informed.

Case management

The tooth was extracted atraumatically without raising mucoperiosteal flap or compromising the marginal gingiva, under local infiltration anesthesia using 0,5% bupivacaine with epinephrine 1:200,000 (Dentsply, IL, EUA). A fissure bur designed for surgery was utilized to cut the tooth in a buccolingual direction, guaranteeing that the mesial and distal aspects of the molar were entirely divided. Afterwards, the granulation tissue was removed with a Lucas surgical curette (Hu-Friedy®, Chicago, IL, USA), and the area was cleaned by rinsing it with a sterile saline solution. The implant drilling was performed following the standard surgical procedure, as suggested by the implant manufacturer. After cone beam computed tomography (CBCT) scan, pre-surgical diagnostics and treatment planning (Figure 3), an immediate implant (Tissue Level SP, SLActive®, TiZr, Straumann®, Basel, Switzerland), 3.3 Regular Neck (RN) × 14 mm, was placed in the interradicular septum region, at the basal bone, in the prosthetically correct position, with the implant smooth surface at subcrestal bone level (Figure 4).

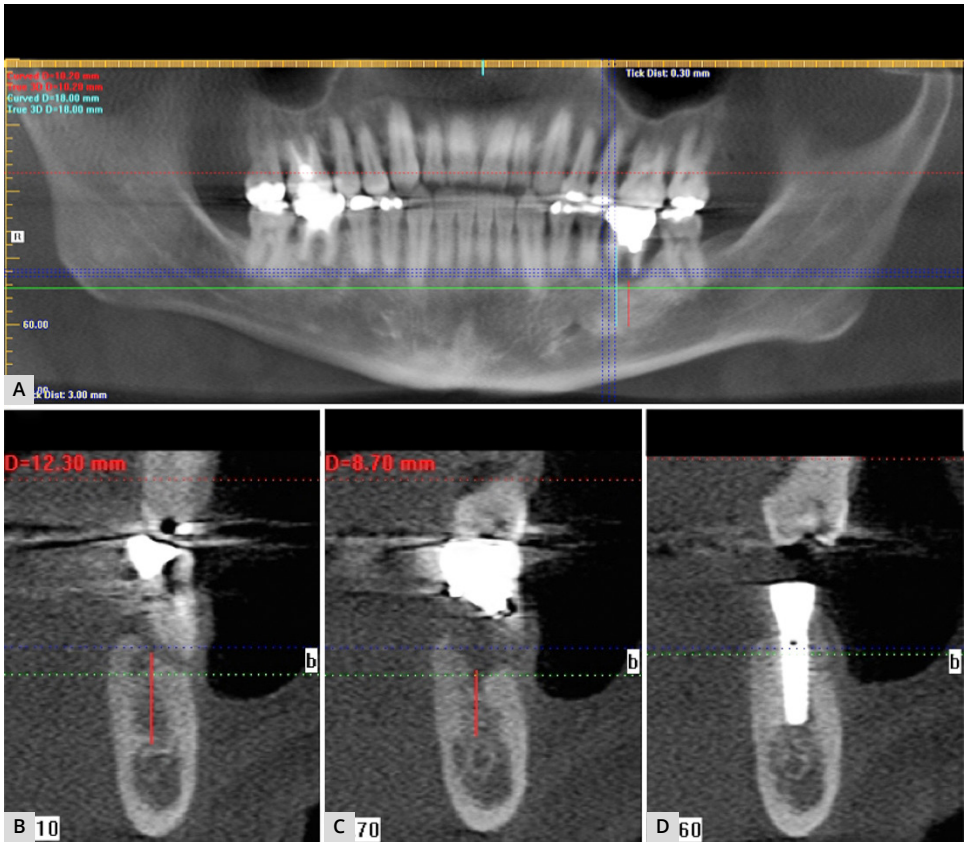

Figure 3. Preoperative and immediate postoperative cone beam computed tomography (CBCT) scans. A) Panoramic reconstruction, showing vertical measurements of the mesial and interradicular septum region of the left mandibular first molar. B) Close-up view of the CBCT image, showing the vertical measurements at the sagittal mesial section. C) CBCT image showing the vertical measurements at the sagittal middle section. D) Sagittal view of the postoperative CBCT image, to assess the implant placement.

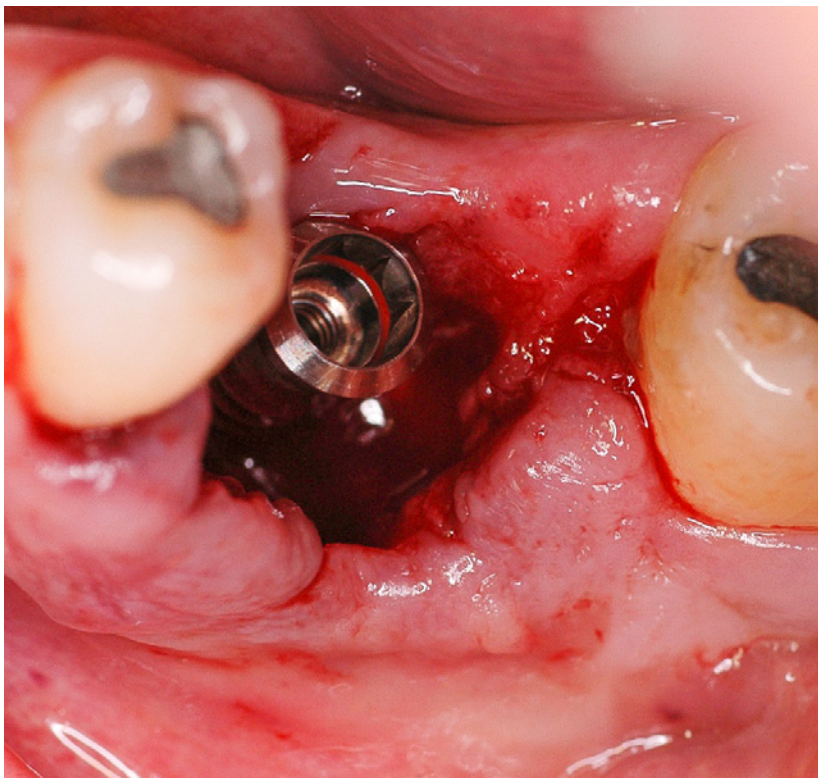

Figure 4. An immediate implant (Tissue Level SP, SLActive®, TiZr, Straumann®, Basel, Switzerland), 3.3 Regular Neck (RN) × 14 mm, was installed at the center of the fresh alveolar socket, with apical bone anchorage after a flapless atraumatic approach for the removal of the mandibular molar.

The healing abutment was positioned on the implants and a DBBM (Geistlich Bio-Oss 0.25–1 mm, 0.25 g; Geistlich Pharma AG, Switzerland) was placed to fill the gap up to the level of the marginal soft tissue. The biomaterial was left exposed to the oral environment and stabilized by an interrupted cross suture with a non-resorbable material (5-0 Vicryl, Ethicon/Johnson & Johnson, São José dos Campos/SP, Brazil) (Figure 5). The wound was monitored until an early clot formation was observed, to ensure stability of the grafted material.

The day before surgery, the patient received amoxicillin clavulanate (875 mg/ 125 mg, Novamox®, Ache Pharmaceutical Laboratories, SP, Brazil), orally, twice daily, for five days; Tylex 7.5 mg (paracetamol and codeine, Janssen Cilag Farmacêutica Ltda., São José dos Campos, SP, Brazil) four times daily, for five days; and 0.12% chlorhexidine digluconate mouthwash twice a day, for at least two weeks. The patient was asked not to chew on the surgery side, spit, perform suction or brush the surgical area for the first two weeks postoperatively.

Ten days following implant surgery, the mucosa was firm, pale pink and fitted tightly around the implant, showing no sign of acute infection (Figure 6). It was also possible to observe the presence of keratinized mucosa in the area in which the DBBM was exposed. The final impression was taken after six months of healing, and the ceramic restoration was completed afterwards. The evaluation was done at six months and four years postoperatively, and there was a visible gain in the keratinized mucosa and no signs of inflammation (Figure 7). The radiographic evaluation also evidenced stabilization of the bone around the implant (Figure 8).

Six years post-implant surgery, the patient was recalled for a follow-up (Figure 9). On intraoral examination, the soft tissue around the implant was stable and with the presence of a wider mucosal band, with 6 mm of keratinized mucosa. Periodontal pockets were maintained at 3 mm or less, with no plaque or bleeding on probing, and no attachment loss. A CBCT scan was made to evaluate bone and soft tissue, and did not show any marginal bone loss after six years (Figure 10 and Table 1).

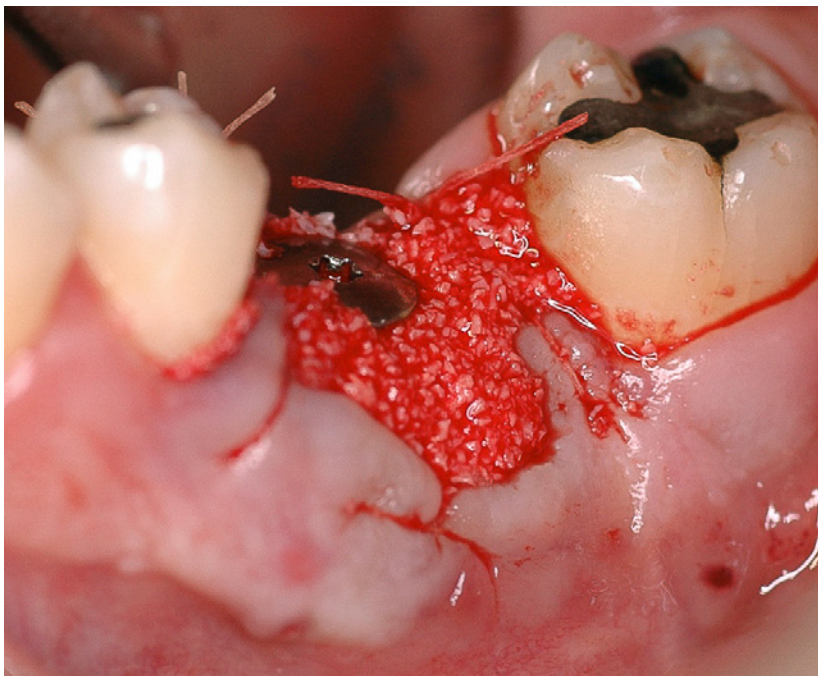

Figure 5. The gap was filled with deproteinized bovine bone mineral (DBBM) up to the level of the marginal soft tissue. After gentle placement of the graft, the particles were left exposed to the oral environment with interrupted cross sutures, only for blood clot stabilization.

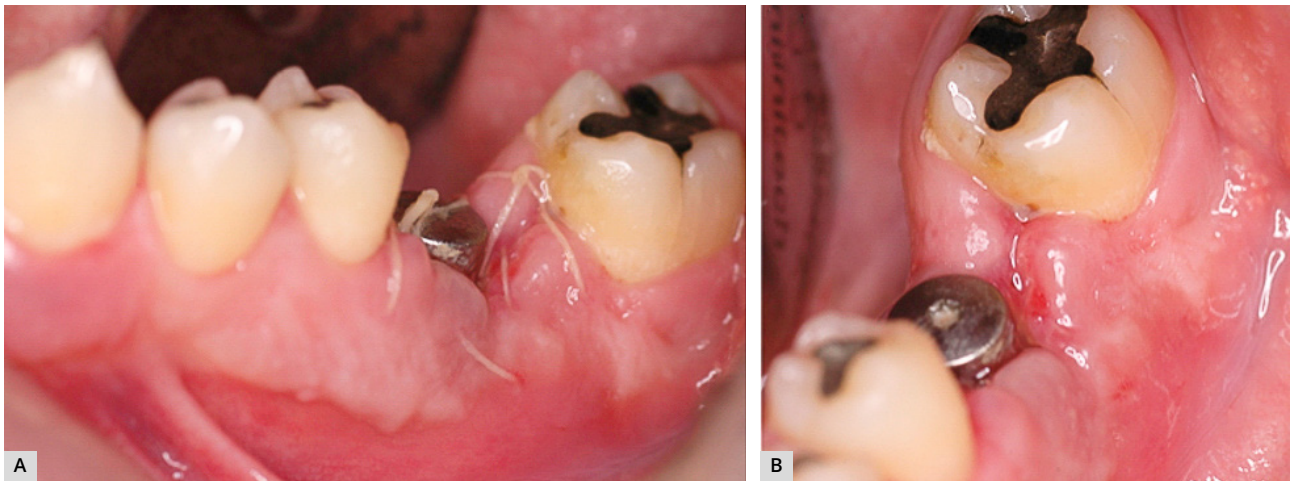

Figure 6. A) Ten days post-operative view before suture removal. B) Suture removed and uneventful healing socket.

Figure 7. Six months post-operative. A) Post-operative view presenting peri-implant health. B) The yellow-dotted line represents the amount of keratinized mucosa band obtained after the surgical procedure.

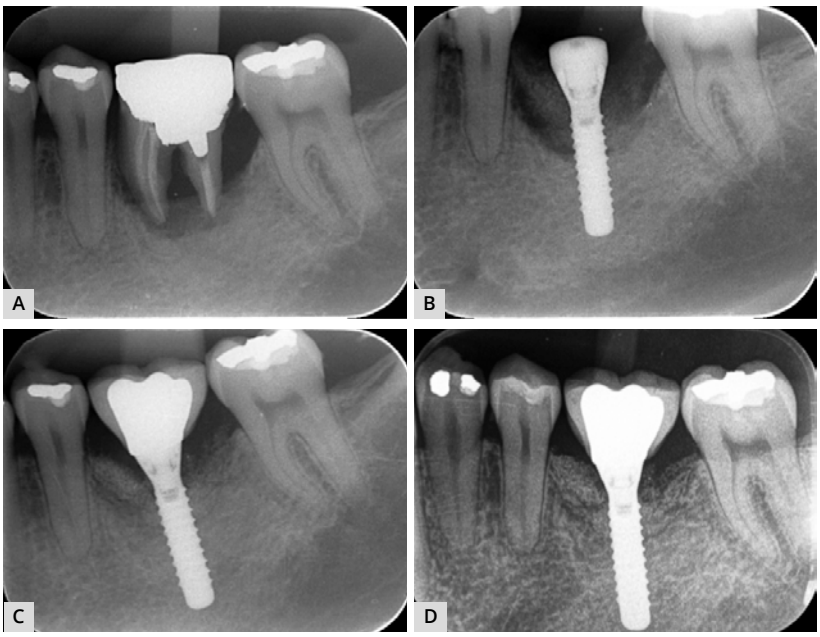

Figure 8. Radiographic views of the treatment phases: A) pre-operative aspect, B) immediately after implant installation, C) four years post-operative, and D) six years after the surgical procedure. These non-standardized images demonstrate the stability of the interproximal bony crest around the grafted area, with no signs of bone remodeling or progressive loss.

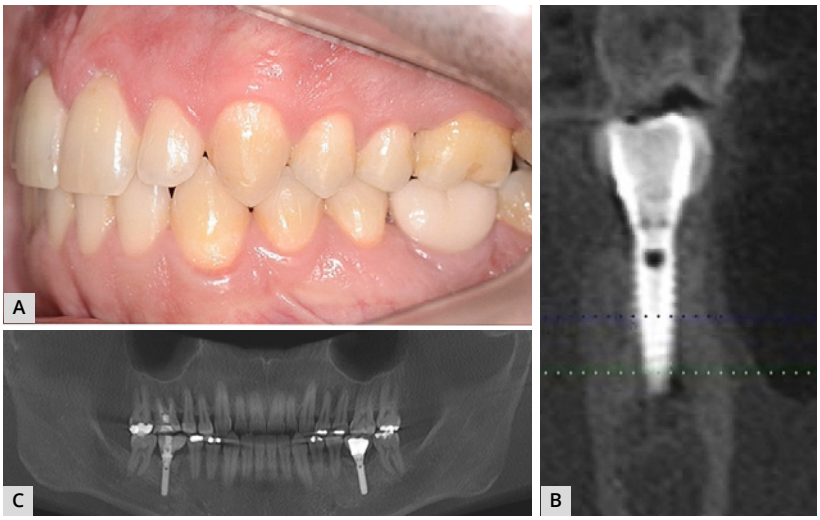

Figure 9. Clinical follow-up at 6 years: A) intraoral left side lateral view of the rehabilitated area, showing soft tissue stability, B) CBCT image showing the integrity of the buccal bone and soft tissue with favorable thicknesses, and C) radiographic follow-up showing crestal bone stability without interproximal radiolucent areas and bone level compatible with health.

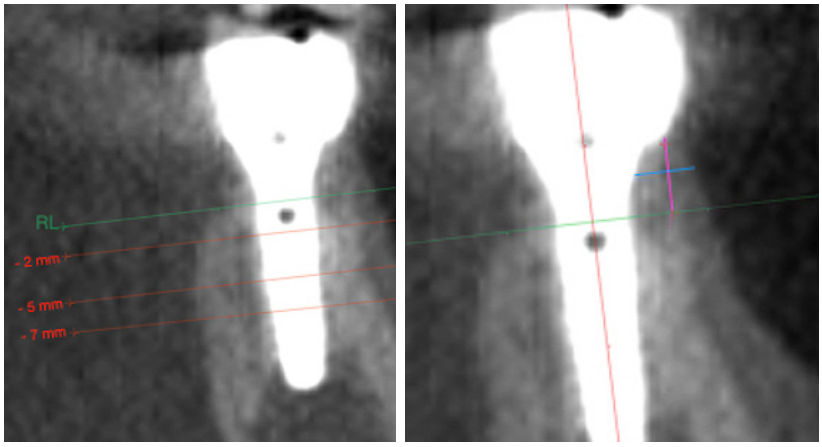

Figure 10. A horizontal reference line (RL) was defined below the machined collar for tissue level implant. The parallel horizontal width measurements were performed to evaluate hard and soft tissue at six-year follow-up. The horizontal width was measured at the RL and at 2 mm, 5 mm and 7 mm below the reference line. Above the RL, additional measurements were performed using the vertical (pink) and horizontal (blue) lines, to calculate soft tissue height and soft tissue thickness after the incorporation of Bio-Oss, respectively.

Table 1. Cortical bone and soft tissue measures above and below the horizontal RL at bone crest level around the implant neck.

Above RL	Buccal soft tissue width	Buccal soft tissue height	
	3.5 mm	3.4 mm	
Bone level below RL	**Buccal cortical width**	**Lingual cortical width**	**Buccal soft tissue width**
RL	0.6 mm	3.0 mm	3.4 mm
-2 mm	3.0 mm	4.1 mm	1.7 mm
-5 mm	3.5 mm	6.3 mm	2.1 mm
-7 mm	4.2 mm	6.3 mm	2.9 mm

RL = reference line. Horizontal bone level measurements considering only the cortical bone, without taking into account the volume of biomaterial (Bio-Oss). Height and width of soft tissue after the incorporation of biomaterial (Bio-Oss).

Discussion

The successful immediate implant installation, combined with a bone graft on the gap, obtained uneventful healing. This six-year follow-up of a successful case treated using an alternative approach allows to conclude that following basic surgical principles during the implant installation, in addition to patient compliance with post-operative recommendations for the early healing phase were determinant factors to the satisfactory outcome obtained. Larger diameter implants that come into contact with the buccal bone wall can lead to greater vertical bone loss. Therefore, to avoid this, the implant bodies should not touch the buccal bone and narrower diameter implants should be used instead (Blanco *et al*., 2019). For this reason, in the present clinical case, a 3.3 mm diameter implant was installed, which presented clinical success throughout the follow-up.

The placement of DBBM in the gap between an implant and the buccal bone walls on fresh socket extraction can change the tissue healing, resulting in formation of more hard tissue at the opening of the previous socket, preventing soft tissue recession and improving the contact level between the implant and marginal bone (Araujo *et al*., 2011). Immediate implant placement with simultaneous grafting does not entirely avoid bone resorption (Mazzocco *et al*., 2017; Seyssens *et al*., 2022); however, the biomaterial reduces peri-implant tissue loss (Yuenyongorarn *et al*., 2020; Seyssens *et al*., 2022). A meta-analysis (Seyssens *et al*., 2022) reported that by filling the gap with biomaterial in immediate implants presents advantages in hard tissue (0.59 mm less horizontal buccal bone resorption), as in soft tissue (0.58 mm less apical migration of the midfacial soft tissue level). In addition, in the present clinical case, it was also possible to appreciate an increase of the keratinized mucosa in the soft tissue that was formed at the recession area, compared to the baseline. The novelty and the significance we attribute to this technique is that DBBM acts as a support for the migration of epithelial cells, in which, where there was exposure of xenogeneic bone, keratinised tissue was formed, even in an area of gingival recession. A detail of this technique is that the DBBM was placed in the implant gap up to the level of the marginal soft tissue, while in other studies the bone substitute materials were placed within or slightly higher than the palatal bone plate (Thalmair *et al*., 2013; Mazzocco *et al*., 2017; Jacobs *et al*., 2020; Thoma *et al*., 2020), and maybe this can justify less invagination of the soft tissues.

Ways to reduce the impacts of physiological resorption involved using bone substitute materials, either with or without protective membranes or coverage from soft tissue (Blanco *et al*., 2019). The evaluated socket seal surgery techniques were free gingival graft, collagen sponge, acellular dermal matrix, collagen matrix, and polytetrafluoroethylene membrane (Lopez-Pacheco *et al*., 2021). The comparison between free gingival graft and collagen matrix with bone filling did not reveal any clinical variations in terms of changes in bone dimensions (Lopez-Pacheco *et al*., 2021). A collagen matrix has the potential to accelerate the initial healing process of soft tissue and may also lead to an increased thickness of the soft tissue (Blanco *et al*., 2019). Similarly, there were no differences in the width or gingival thickness when comparing collagen matrix and collagen sponge; however additional clinical studies are needed to prove the superiority of one technique over the other (Lopez-Pacheco *et al*., 2021). The use of a collagen matrix is a favorable option to avoid the need for a second surgical site, with less patient morbidity, reduced risk of necrosis, and fewer post-surgery complications (Blanco *et al*., 2019; Lopez-Pacheco *et al*., 2021); however, the technique described in this clinical case presents low cost, is familiar to clinicians and produces satisfactory results.

The risk of complications and infection arises more frequently in advanced defects (Zaki *et al*., 2021), and its main cause is wound dehiscence, with early exposure

of membranes often used in combination with bone substitutes. The management of this complication comprehends a variety of procedures depending on the extension and severity of the case. Topical application of antiseptics, removal of the barrier membrane and curettage of the graft are eventually required procedures. To avoid or at least to reduce the occurrence of these complications, careful patient selection, e.g., compliant non-smokers patients, and less invasive surgical approaches are recommended (Sanz-Sanchez *et al*., 2022). In this clinical case, the surgical procedure had met all the standards of good clinical practice and patient selection.

There are reports in the literature about performing ridge preservation techniques with xenogeneic bone exposed (Thalmair *et al*., 2013; Thoma *et al*., 2020), but in our clinical experience, we observed that the bone is expelled during healing, which may justify the lower volume of tissue when compared to the use of collagen matrix. Nevertheless, the presented technique is exclusively for immediate implant placement, in which the gap is smaller and more retentive to maintain the stability of the biomaterial during epithelialization phase. Then, this approach may work in a similar way to the use of collagen matrix coverage. Therefore, it is an easy technique, reproducible, fast, and with lower financial cost to the patient. Wound healing stability is crucial for proper healing (Sanz-Sanchez *et al*., 2022). The combination of the bone substitute with the implant body in the alveolar socket significantly reduced the gap volume (Araujo *et al*., 2011; Yuenyongorarn *et al*., 2020; Seyssens *et al*., 2022). This new more favorable clinical scenario, together with the stabilization sutures and the confirmation of the initial blood clot formation may be the reason of the positive outcome of this alternative approach. In addition, early clot formation in a moderately rough implant surface also prevents untoward events, since the clot is not dislodged (Milillo *et al*., 2021). There is a resistance to keeping the DBBM exposed in the oral environment because the biomaterial can become contaminated with bacteria and compromise the surgery. However, in our clinical experience and in other studies (Thalmair *et al*., 2013; Thoma *et al*., 2020), no post-operative complications occurred. Biologically, what makes this material escape infection may be the patient's meticulous oral hygiene measures associated with adjunctive chlorhexidine, followed by rapid epithelial coverage of the graft before it becomes contaminated. After the implant placement, a blood clot seal the interface between the implant and mucosa immediately, and an initial mucosal seal occurs after 4 days (Berglundh *et al*., 2007).

In clinical scenarios in which DBBM was placed and a criss-cross suture technique was used to stabilize the bone substitute material, without the aim of achieving primary wound closure, the soft tissue conditions demonstrated less invaginations and increased volume, when compared to spontaneous healing. In that scenario, the median thickness of the mucosa was 2.1 mm (Thoma *et al*., 2020). The use of DBBM may have a positive impact on the appearance of soft tissues over time, possibly due to the particles becoming integrated into the soft tissue and reducing the amount of bone loss, and resulting in improved long-term esthetics (Zaki *et al*., 2021). Based on that, another advantage of the technique used in this clinical case was to be able to keep the thickness of peri-implant tissues close to 2 mm, since some clinical studies have shown that when the ridge mucosa was thin (<2 mm), more bone resorption and angular bony defect were expected, due to less vascularization and increased risk of soft tissue recession around dental implants (Ioannidis *et al*., 2017; Berglundh *et al*., 2018; Mailoa *et al*., 2018; Thoma *et al*., 2018; Zaki *et al*., 2021).

Additionally, in the region between the bone crest and the junctional epithelium, the peri-implant tissues display lower vascularity, compared to the connective tissue zone of the periodontium (Berglundh *et al*., 2018). The presence of keratinized tissue around the implant neck creates a firmer seal that makes it easier for patients to clean their implants (Perussolo *et al*., 2018; Thoma *et al*., 2018) and restricts bacterial infiltration (Thoma *et al*., 2018). Also, it plays a crucial role in providing a flexible, highly insoluble, and mechanically resilient structure that shields the epithelial cells (Thalmair *et al*., 2013; Groeger and Meyle, 2015). Gingival keratinocytes are connected to each other by a variety of specialized transmembrane proteins, and cornification of the keratinocytes creates a tight barrier of dead cells that shields the organism from the external environment, being the first line of defense against bacterial challenges (Groeger and Meyle, 2015). Beneath the keratin layer, the extensive stratified epithelium not only protects the connective tissue mechanically but also serves as the primary point of contact with the immune system (Groeger and Meyle, 2015; Perussolo *et al*., 2018).

It is well documented that the presence of keratinized mucosa correlates to peri-implant health (Roccuzzo *et al*., 2016; Berglundh *et al*., 2018; Perussolo *et al*., 2018; Thoma *et al*., 2018; Blanco *et al*., 2019; Grischke *et al*., 2019) and this clinical approach may have created conditions for soft tissue gain and consequently improved gingival health. When DBBM was left exposed to the oral environment, it provided a wound surface that was transformed into a tissue very similar to the keratinized mucosa, which may suggest that there is an increase in this mucosa. As shown in this case report, after six years of follow-up, there was 6 mm of keratinized mucosa. Therefore, it can be considered an effective treatment solution, considering that this initial case also had soft tissue deficiency due to gingival recession.

The limitation of this case is that the presence of radiopaque peri-implant tissue does not necessarily indicate that the native bone has been regenerated, as the biomaterials used in the procedure are also radio-opaque. Without performing histological analyses, it is impossible to determine the exact nature of the soft tissue that was formed on the surface of the xenogeneic bone that has been exposed to the oral environment. Considering the advantages of a keratinized mucosa width, an easy reproducible technique, the lower cost for the patient, bone stability and peri-implant health, this report shows that the use of xenogenic bone intentionally left exposed to the oral environment after immediate implant placement can be beneficial in selected cases under strict clinical monitoring. This technique is open to speculation, as we only have the description of a clinical case report. So we suggest randomized clinical trials to evaluate the healing profile, in hard and soft tissue, that will guarantee greater security to indicate this approach.

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