CLINICAL ARTICLE

Applications of maxillary tuberosity block autograft

Juan Zufía DDS[1] | Francesc Abella Sans DDS, PhD[2]

[1]Private Practice, Madrid, Spain

[2]Department of Restorative Dentistry and Endodontics, Universitat Internacional de Cataluña, Barcelona, Spain

Correspondence
Francesc Abella Sans, Department of Restorative Dentistry and Endodontics, Universitat Internacional de Cataluña, C/Josep Trueta s/n, Sant Cugat del Vallès, Barcelona 08195, Spain.
Email: franabella@uic.es

Abstract

Objective: Autogenous bone grafts are considered the gold standard due to their compatibility and osteogenic potential to induce new bone formation through osteogenesis, osteoinduction, and osteoconduction. The aim of this paper was to describe clinical applications of the maxillary tuberosity block autograft in small and moderate localized defects of the alveolar process around implants and teeth.

Clinical Considerations: Maxillary tuberosity is often used as a particulate graft for augmentation of deficient alveolar ridge or maxillary sinus prior to or simultaneously with implant insertion, but not as a bone block graft. The maxillary tuberosity block autograft may also provide a valuable bone source for challenging situations such as immediate implant placement into types II and III extraction sockets, treatment of horizontal and vertical bone defects with simultaneous implantation, reconstruction of circumferential defects around implants, and preservation of alveolar ridge.

Conclusions: The advantages of the maxillary tuberosity include intraoral cortico-cancellous autogenous graft with fewer intraoperative difficulties, no need for donor site restoration, less morbidity, and an excellent correction of localized alveolar ridge defects.

Clinical Significance: Within the limitations of the presented case reports, the use of maxillary tuberosity block autograft has shown to be successful in alveolar ridges augmentation that lack both width and height.

KEYWORDS
autogenous bone, bone block graft, clinical applications, guided bone regeneration, maxillary tuberosity

1 | INTRODUCTION

Alveolar ridge defects stemming from periodontal disease, atrophy, and trauma may produce deficient bone volume or adverse vertical, transversal, and/or sagittal interarch relationship(s), demanding implant placement.[1] Many surgical procedures have been described to augment deficient bone volume.[2,3] The most widely used materials in block grafting procedures include xenografts, allografts, alloplastic, and autogenous bone. Of these materials, autogenous bone harvested

from intraoral or extraoral sites is the gold standard for bone reconstruction due to its osteogenic (containing bone-forming cells), osteoinductive (containing bone-inducing substances), and osteoconductive properties (serving as a scaffold for bone formation).[4,5] Autogenous bone also has the exclusive advantage of retaining cell viability and containing osteoblasts and osteoprogenitor stem cells, which trigger true osteogenesis.[5]

Extraoral bone block grafts, such as the iliac crest, offer a sufficient amount of bone, although there are several drawbacks,

including higher treatment costs, morbidity at the donor site, and the need for a second surgical site.[6] Quality and quantity of bone and high predictability outcomes are key factors for selecting optimum donor sites.[7] Despite the limited amount of available bone that can be harvested from intraoral sites, the primary benefit is its harvesting potential with minimal morbidity. Moreover, harvesting from the same surgical site may shorten the surgical intervention and minimize the surgical field.[8,9] The main intraoral donor sites are primarily the mandibular ramus and the symphysis (chin).[10] However, these sites have limited accessibility and are associated with considerable complications and postoperative morbidity such as neurovascular injury and neural dysfunction.[11,12] Both autogenous block grafts (chin and ramus) pose the inherent procedural challenges of using a saw or bur to remove a block graft from what is frequently dense cortical bone and to undertake a partial postoperative regeneration of the donor site.[13]

For several years, bone from the maxillary tuberosity has been harvested in particulate form for augmentation procedures and has the benefits over other intraoral donor sites in that the harvesting is trouble-free and involves minimum complications.[14–16] To our knowledge, Tolstunov was the first to introduce the potential of the maxillary tuberosity block graft in treating localized maxilla bone defects for implant placement.[15] In 2013, da Rosa et al. presented the immediate dentoalveolar restoration (IDR) technique, consisting of an immediate implant placement combined with a corticocancellous block graft harvested from the tuberosity and positioned in the gap between the implant and the buccal mucosa.[17] One year later, the same team described an adaption of the IDR technique entailing immediate implantation, reconstruction of the buccal bone wall, and restoration of the gingival recession in a single way with a triple graft (cancellous and cortical bone and soft tissue graft) from the maxillary tuberosity.[18]

In planning bone augmentation, the surgeon should use an accurate cone beam computed tomography (CBCT) to calculate the dimensions and volumes of intraoral donor sites and their surrounding anatomical structures.[7] The use of the maxillary tuberosity, if large enough and appropriate for a block graft, seems to be a relatively uncomplicated and useful alternative. This corticocancellous autogenous graft involves fewer intraoperative and postoperative complications, with no need to repair the donor site, and has excellent capacity to correct localized alveolar ridge defects.[15] However, few case reports have described the use of this procedure for bone regeneration in localized bone defects.[15,17,18,19–22] The aim of this paper was to describe the clinical applications of the maxillary tuberosity block autograft in small and moderate localized defects of the alveolar process around implants and teeth.

2 | CASE REPORTS

One clinician (Juan Zufía) performed all the surgical and prosthetic procedures in the cases presented below.

2.1 | Immediate implant placement into type II extraction sockets

Maintenance of the supporting tissues during dental extraction is indispensable for immediate implantation and provisionalization.[23] Nevertheless, implant placement in a fresh extraction socket is often related with the occurrence of peri-implant defects at the time of surgery. When the facial soft tissue is present preoperatively, but there is a partial or completely absent buccal plate of bone over the affected tooth, the tooth extraction socket is referred to as a type II socket.[24] The aim of this clinical case was to illustrate a technique to restore a type II socket defect using corticocancellous bone and a soft tissue graft harvested from the maxillary tuberosity.

2.1.1 | Case report 1

A 38-year-old systemically healthy woman was referred by an endodontist to our surgical practice for an implant consultation. Her medical history was non-contributory. Clinical examination revealed a 12 mm probing depth and a sinus tract in the mucogingival junction of the maxillary right central incisor (Figure 1A). Radiographically, a radiolucent image was observed in the cervical and middle third of the tooth, leading to a diagnosis of external resorption (Figure 1B). After the necessity of tooth extraction was confirmed, it was decided to perform a small volume cone beam computed tomography (CBCT) to evaluate the bone conditions around the hopeless tooth and to plan the anchoring of the implant. The CBCT cross-sectional images confirmed a total loss of buccal bone wall associated with the buccal and mesial position of the external resorption (Figures 1C–E). Likewise, the bone availability of the maxillary tuberosity was determined by visual inspection, digital palpation, and CBCT. The proposed treatment was an immediate bone defect restoration using corticocancellous bone and a soft tissue graft harvested from the maxillary tuberosity.

The affected tooth was removed atraumatically using a flapless extraction with care not to disturb the interproximal papillae and buccal soft tissue (Figure 1F). The socket was then debrided with surgical curettes, and the infected tissue was removed (Figure 1G–H). A supraperiosteal tunnel was made on the buccal and palatal aspect of the socket using a microsurgical blade (1.25 mm Crescent Sharpoint; Surgical Specialties Corporation, Wyomissing, PA). Subsequently, the buccal defect was measured to harvest an adequate graft with the same anatomical shape. Once the recipient socket was prepared, an immediate implant was placed (3.8 mm in diameter and 13 mm in length Camlog Screw Line; Camlog Biotechnologies, Wimsheim, Germany) by a palatal approach with ideal three-dimensional (3D) positioning and the final insertion torque was 40 Ncm (Figure 1I). The final implant position was 3 mm apical to the gingival margin.

To avoid contaminating the graft while handling the materials used to manufacture the crown, each step of the provisionalization
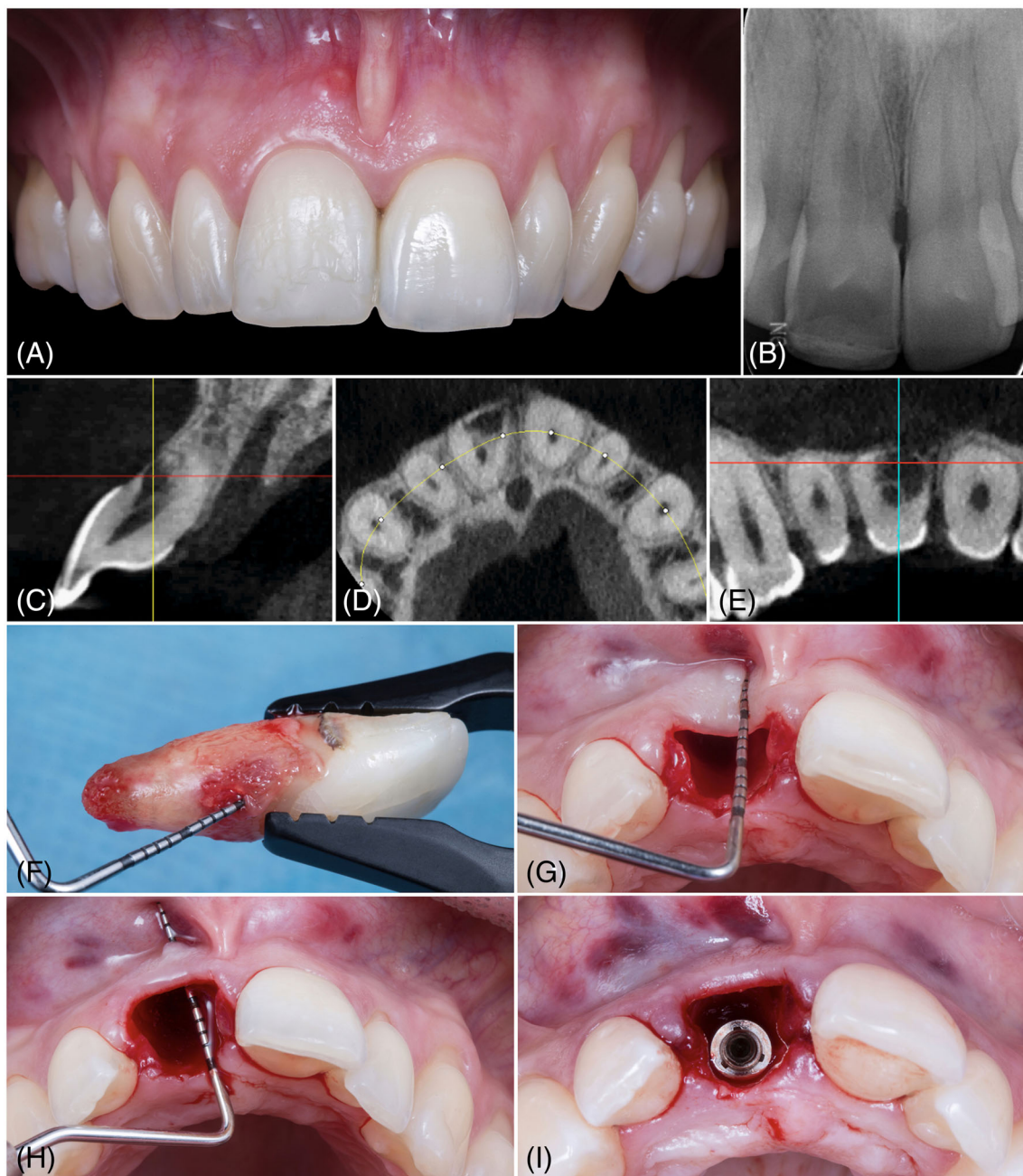
FIGURE 1 Immediate implant placement into type II extraction socket. (A) Clinical examination showed a 12-mm probing depth and a sinus tract in the mucogingival junction of the maxillary right central incisor (tooth 11). (B) Radiolucent image in the cervical and middle third of tooth 11 compatible with an external resorption. (C–E) Small volume cone beam computed tomography (CBCT) images confirmed a total loss of buccal bone wall associated with the buccal and mesial position of the external resorption. (F) Extraction of the affected tooth where the extension of the external resorption can be observed. (G) Absence of buccal bone wall confirmed after extraction. (H) Periodontal probe through the sinus tract after removal of infected tissue. (I) Immediate implant placement (13 mm × 3.8 mm, Camlog Screw Line; Camlog Biotechnologies, Wimsheim, Germany): the implant was anchored in palatal bone and 3 mm apical to the gingival margin

was performed before the bone graft procedures. After applying anesthesia to the maxillary tuberosity, a full thickness crestal incision was made following the distal contour of the maxillary right second molar. This incision was followed by a palatal release incision to access the donor area, thus replicating the profile of the defect in the recipient area.

The flap was raised in the tuberosity area and its connective tissue extracted using a 15c blade. A small portion of this connective tissue was preserved with the intact epithelium to ensure the primary closure of the wound in the donor area. Then, the bone graft was harvested from the underlying bone by using a 1 cm wide flat chisel (Bontempi; Quirurgical Bontempi; Barcelona, Spain) and a surgical
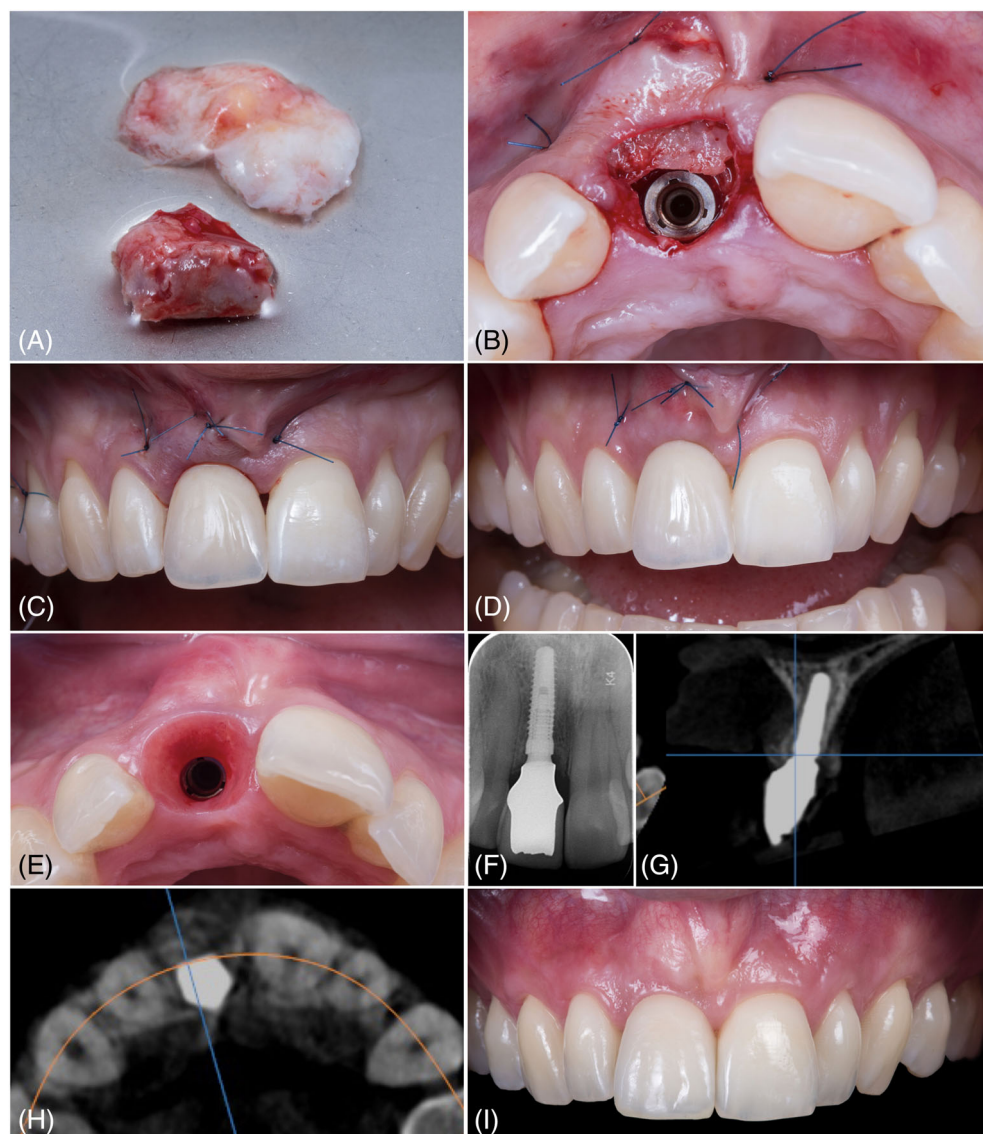
FIGURE 2   (A) Connective tissue graft and bone block harvested from the right maxillary tuberosity. (B) After placing the triple graft to the level of the implant platform. Note the connective tissue graft was in contact with the internal part of the gingival flap. (C) A screw-retained resin provisional crown, relined over a polyetheretherketone (PEEK) anti-rotation abutment, was placed out of occlusion. (D) Correct accommodation and maintenance of the soft tissues14 days post-surgery. (E) Occlusal view tooth extraction and implant placement at 4 months. (F) Three-year follow-up: facial view. (G,H) CBCT examination showing stable buccal bone plate at 3 years. (I) Three-year clinical control showing healthy and stabilized peri-implant soft tissues

hammer (Figure 2A). The corticocancellous graft was manipulated using a rongeur to reproduce the shape of the peri-implant bone defect. Next, the triple graft was carefully inserted to the level of the implant platform, leaving the connective tissue graft in contact with the internal part of the gingival flap (Figure 2B). The connective tissue graft was stabilized by suturing it to the gingival flap. Finally, a screw-retained resin provisional crown, relined over a polyetheretherketone (PEEK) anti-rotation abutment, was placed out of occlusion, establishing the ideal emergence profile to accommodate the soft tissues and to promote a thicker and more stable gingival tissue margin (Figure 2C,D).

At 4 months, the implant was finally restored with a titanium abutment base (Camlog®; Camlog Biotechnologies GmbH, Basel, Switzerland) and a zirconia crown with a buccal cut-back design for feldsphatic veneering (Figure 2E). At 3 years post-surgery, the aesthetic result was stable, and no increase in gingival recession was observed at the buccal surface of the implant. Radiographic examination showed a stable buccal bone plate with 2 mm of thickness in the

coronal aspect (Figure 2F–H). The peri-implant soft tissues appeared healthy, and the probing depths ranged from 3 to 4 mm with no bleeding on probing (Figure 2I).

2.2 | Immediate implant placement into type III extraction sockets

Reasons for tooth extraction and immediate implant placement include, among others, prosthetic failures, periodontal reasons, endodontic causes, and vertical root fractures.[25–27] A type III extraction socket is associated with soft tissue recession and buccal plate loss before extraction. Typically, treatment of sockets in this classification are very challenging and require soft tissue augmentation with additional grafts of connective tissue, or connective tissue and bone, in a pre-planned approach to rebuild lost tissue. This clinical case describes a procedure that uses maxillary tuberosity block autograft for restoring the buccal bone wall and soft tissue
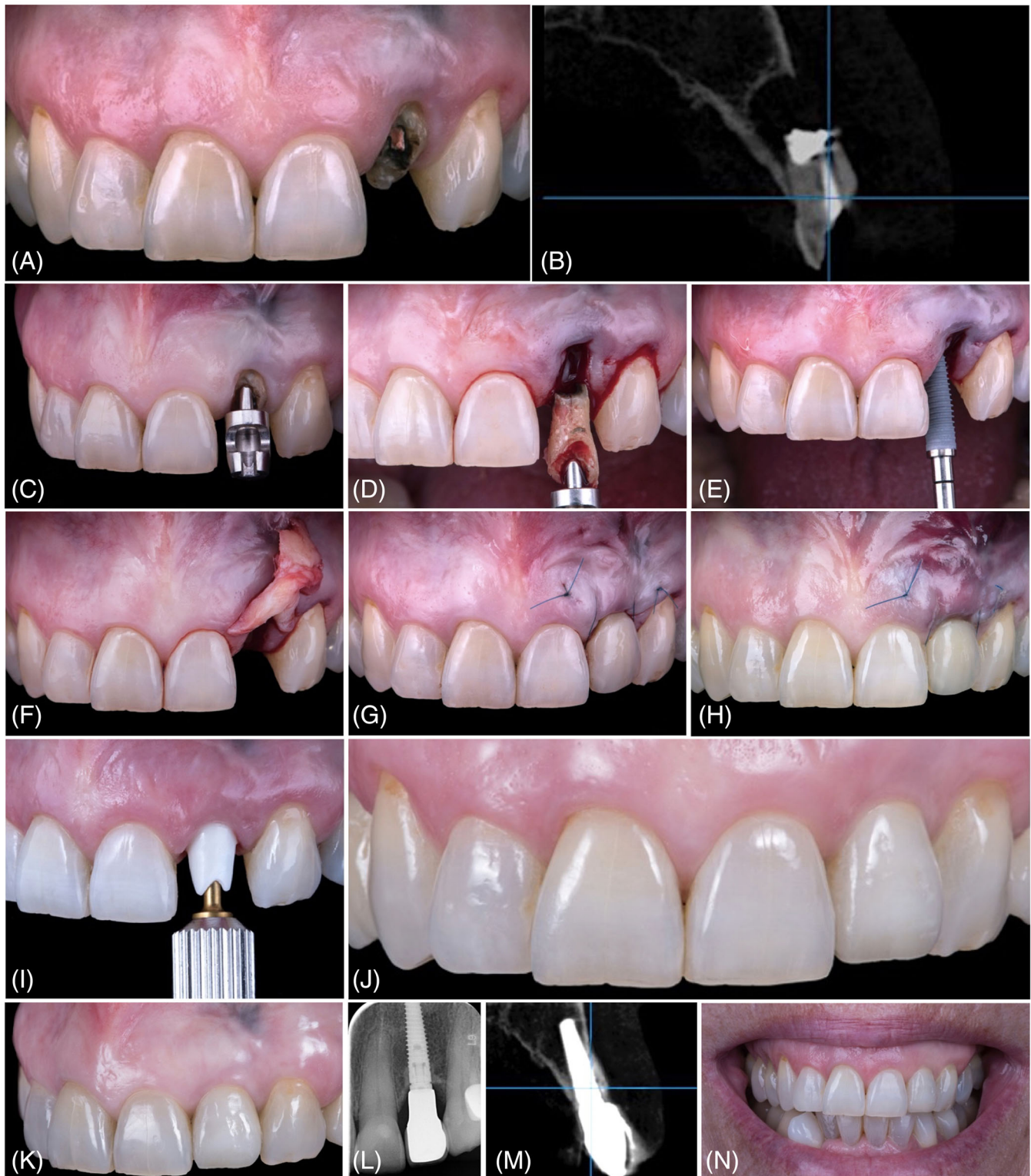
FIGURE 3 Immediate implant placement into type III extraction socket. (A) Initial clinical evaluation of the affected maxillary left lateral incisor. (B) A small volume CBCT scan confirmed the total absence of the buccal bone wall. (C) Atraumatic extraction of the hopeless tooth using Benex extraction system (Benex; Helmut Zepf Medizintechnik GmbH, Seitingen-Oberacht, Germany). (D) Confirmation of a vertical root fracture in the buccal aspect of the root. (E) Immediate implant (3.5 mm × 13 mm Nobel Biocare Replace Select tapered TiUnite®; Nobel Biocare, Guttenberg, Sweden) placed palatally with ideal 3D positioning. (F) Simulation of the final graft (corticocancellous bone and connective tissue from the tuberosity area) position. (G) Postoperative clinical situation with a chairside-made resin crown provisional crown splinted to the neighboring teeth. (H) Clinical situation at 7 days post-surgery. (I) At 6 months, the implant was restored with a titanium base zirconia abutment and all-ceramic crown. (J) Final situation at 4-year post-treatment. (K) Clinical control at 5 and a half years showing soft tissue stabilization. (L, M) Periapical radiograph and sagittal view of the CBCT at 6 years. (N) Facial view at 6-year follow-up

contours in a Type III extraction socket simultaneous with the implantation.

2.2.1 | Case report 2

A 55-year-old systemically healthy patient was referred to our surgical practice to receive treatment of a maxillary left lateral incisor. For months, the patient had complained of multiple debonding of the ceramic crown on the tooth due to retention loss. The remaining tooth had a coronal fracture, and no ferrule effect was present (Figure 3A). Periodontal examination revealed a left lateral incisor with signs of Miller grade 2 mobility, 9 mm of probing depth, and absence of buccal bone wall generating a functional defect that called for bone augmentation. Periapical radiography showed that besides a root canal treatment, the tooth had also received an unsuccessful surgical endodontic treatment. A small volume CBCT scan of the area of interest confirmed the presence of an apical lesion and the total absence of buccal bone wall (Figure 3B). The proposed treatment was a bone and soft tissue reconstructive procedure involving an immediate implant to improve the aesthetics and to shorten the treatment time.

The amount of basal bone was sufficient for the secure placement of an immediate implant in the correct 3D position but without being subjected to immediate functional loading. The hopeless tooth was atraumatically extracted by a flapless technique under local anesthesia using Benex extraction system (Benex; Helmut Zepf Medizintechnik GmbH, Seitingen-Oberacht, Germany) to preserve the surrounding bone architecture and the papillae area (Figure 3C). The extracted tooth presented a vertical root fracture and a root-end resection as a result of the previous endodontic surgery (Figure 3D). A supraperiosteal tunnel was made on the buccal and palatal area of the recipient socket. Then, the socket wall was probed to assess the degree of bone damage, and as supposed no buccal bone wall was present due to the vertical fracture on the buccal side of the root. The tuberosity area was also evaluated on the CBCT scan in order to guarantee sufficient graft, while a periodontal probe was used to measure the soft tissue thickness.

Taking the position of the adjacent teeth as a reference, the clinician immediately placed an implant (3.5 mm × 13 mm Nobel Biocare Replace Select tapered TiUnite®; Nobel Biocare, Guttenberg, Sweden) in the ideal 3D position (Figure 3E). Aware of the initial gingiva position (baseline), the clinician inserted the implant platform 2 mm apical to the buccal gingival margin. Then, the corticocancellous bone and connective tissue graft were harvested from the tuberosity area (Figure 3F), as described in Case Report 1. The block autograft was trimmed and inserted into the gap, filling the space between the implant surface and the buccal mucosa (Figure 3G–H). A partial thickness pouch was prepared in the buccal aspect close to the bony area. The coronal portion of the pouch was de-epithelialized in order to provide enough blood supply, stabilize the graft, and advance the gingival margin 3 mm coronally. The initial implant stability was 20 Ncm, so the immediate loading was not possible. The site was temporized with a chairside-made resin crown to provide aesthetics and to

support the soft tissue healing. The provisional crown was out of occlusion and splinted to the neighboring teeth using a palatal orthodontic wire bonded with composite resin.[28]

At 4 months post-surgery the soft tissue appeared normal, so a second stage surgery was carried out to expose the implant head. The implant was restored with a provisional screw-retained crown to profile the soft tissues. At 6 months, the implant was finally restored with a titanium base zirconia abutment and all-ceramic crown (Figure 3I). Clinical evaluation showed healthy and stable peri-implant tissues. At 6-year follow-up, no significant clinical alterations regarding the level of the gingival margin outline or papillae were found when comparing the treated area to the contralateral tooth (Figure 3J,K). Periapical radiographs and a CBCT scan showed a precise implant 3D position in relation to the adjacent structures, horizontal and vertical bone development, and reconstruction of the bone defect with no marginal bone loss (Figure 3L,M). The patient's aesthetic and functional expectations were achieved with respect to the early pre-treatment condition (Figure 3N).

2.3 | Treatment of horizontal bone defects with simultaneous implantation

When implants are placed resulting in a bone defect and leaving part of the endosseous surface of the implant exposed, guided bone regeneration is a reliable procedure for bone formation.[29–33] Horizontal bone defects are typified by reduced ridge width hindering the primary stability of the implant in the prosthodontically appropriate location. Autogenous bone blocks, whether alone or combined with a bone substitute and/or collagen membranes, are the most consistent and successful procedures for staged augmentations of large bone defects before implant placement.[34] This clinical case describes a procedure that uses a tuberosity maxillary block autograft for a primary horizontal ridge augmentation in a previous implant failure.

2.3.1 | Case report 3

A 50-year-old systematically healthy man was referred to our surgical practice for treatment of an abscess in an implant in position 26. The patient presented a ceramic-metal implant-supported cantilever fixed partial denture (FPD) from 24 to 26 with implants in position 25 and 26 (Figure 4A). Radiographic examination showed that implant 26 presented a complete bone loss. A small volume CBCT revealed 4 mm of marginal bone loss for implant 25 and 10 mm for implant 26 (Figure 4B,C). Both implants presented multiple sites with bleeding on probing. Pocket probing depth was 7 mm for implant 25 and 12 mm for implant 26. Both implants were diagnosed with peri-implantitis (inflammation in the peri-implant connective tissue and progressive loss of supporting bone) that made their maintenance unfeasible.

After local anesthesia, the clinician removed the prosthetic suprastructure and implant 26 simultaneously with no need to raise a
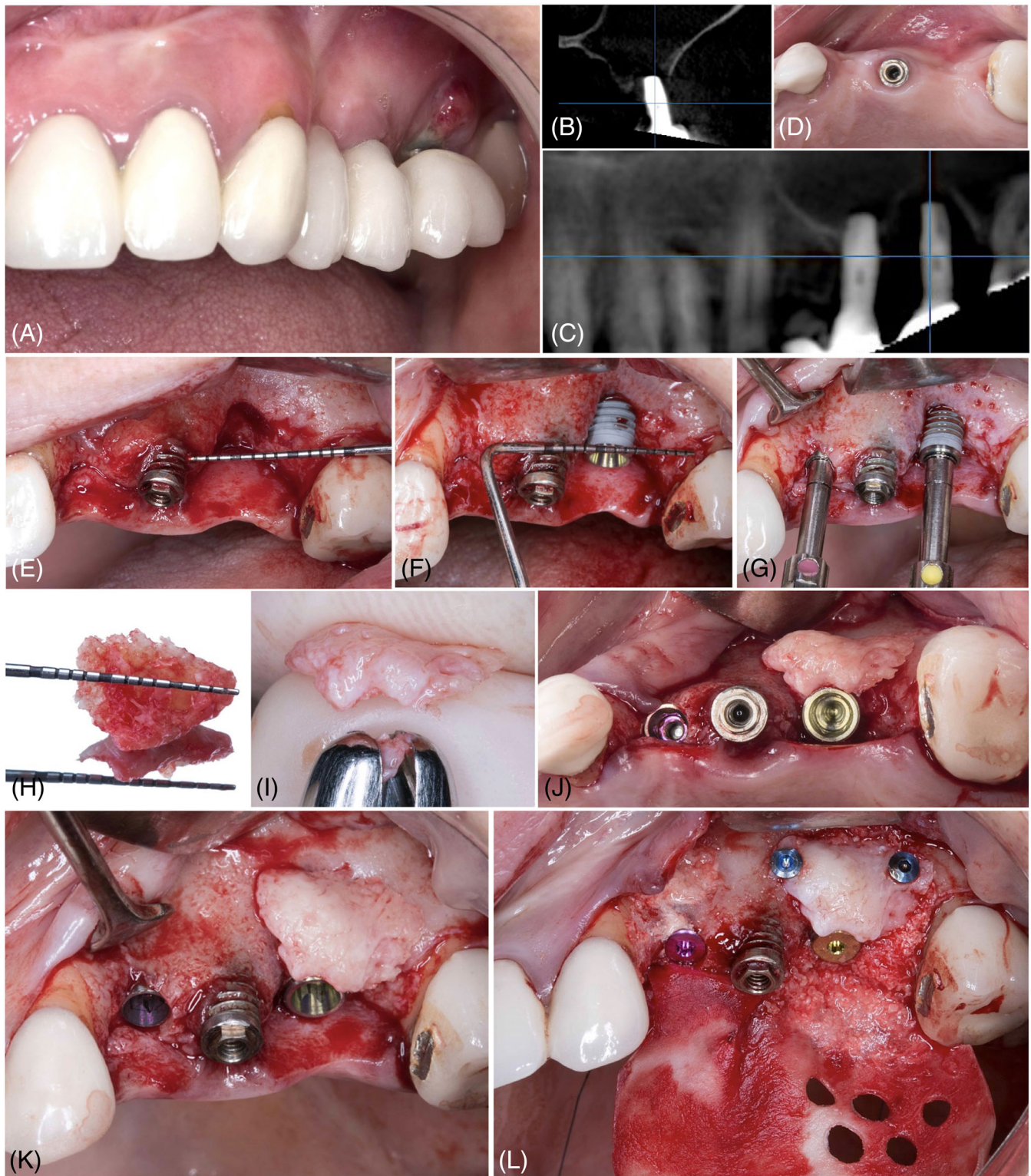
FIGURE 4   Treatment of horizontal bone defects with simultaneous implantation. (A) Intraoral examination showing a severe peri-implantitis with a complete loss of osseointegration of the implant that was in position 26. (B,C) A small volume CBCT revealing 4 mm of marginal bone loss at implant 25 and 10 mm for implant 26. (D) Clinical situation 3 months after removal of implant 26. Note the horizontal atrophy in sites 24 and 26. (E) Measurement of the remaining bone defect after spontaneous healing. Observe that the palatal wall was partially preserved, but there was no buccal wall. (F) Implant placement in position 26 (Nobel Replace CC PMC 4.3 mm × 10 mm (Nobel Replace CC PMC 4.3 mm × 10 mm) where the need for horizontal bone regeneration is indicated. (G) Implant placement in position 24 (Nobel Replace CC PMC 3.5 mm × 13 mm) maintaining parallelism. (H) Bone block obtained from the tuberosity area of the same quadrant. (I) Block morphology modified using gouge forceps. (J,K) Bone graft adapted to the alveolar ridge defect. (L) Bone block fixed and stabilized by using 5-mm metal pins (T-system; Curasan AG, Kleinostheim, Germany). Particulate bone substitute (Bio-Oss®; Geistilich, Sweden) and a resorbable collagen membrane (Creos®, Nobel Biocare, Cologne, Germany) in the palatal site of the defect. Note the perforations made in the buccal aspect of the collagen membrane to communicate the periosteum with the autologous bone

flap. The granulation tissue and implant 26 were removed from the peri-implant defect due to its clinical mobility. The FPD was kept free of occlusion and screwed on implant 25 while a spontaneous healing and tissue closure of the affected area took place (Figure 4D). At 3 months, horizontal atrophy was evident in zones 24 and 26, for which the treatment plan consisted of implant placement in position 24 and 26, combined with a guided bone regeneration. Implant 25 was left temporarily in place to support the interim prosthesis during implant and bone regeneration healing.

At 3 months healing, a mucoperiostal flap was raised after clinical and radiographic measurement of the bone defect (Figure 4E). The palatal cortical plate was partially preserved, but an absence of buccal wall at position 26 meant that it had to be regenerated in order to place an implant in a correct 3D position. Implants in position 24 (Nobel Replace CC PMC 3.5 mm × 13 mm Nobel BioCare, Kloten, Switzerland) and 26 (Nobel Replace CC PMC 4.3 mm × 10 mm) were placed maintaining them in parallel (Figure 4F,G). Subsequently, an autogenous bone block was harvested from the maxillary tuberosity and was adapted to achieve intimate contact between the graft and the bone at the recipient site and fixed tightly with 5 mm metal pins (T-system; Curasan AG, Kleinostheim, Germany) (Figure 4H–L). The palatal aspect of the defect was treated with particulate bone substitute (Bio-Oss®; Geistilich, Sweden), and a resorbable collagen membrane (Creos®, Nobel Biocare, Cologne, Germany).

A connective tissue graft from the same donor site was extracted to correct the gingival recession of tooth 23 (Figure 5A). The flap was coronally advanced by periosteal release, adapted and sutured to allow a tension-free primary closure at the augmented site (Figure 5B). The healing abutment was then removed, and the same permanent metal-ceramic FPD was placed with reduced occlusion to prevent loosening during the healing period (Figure 5C,D). At 6 months healing, a second surgical intervention was performed to remove the fixation screws as well as the old implant, in position 25, to shape the emergency profiles before placing definitive prosthesis (Figure 5E). After a clearly satisfactory graft integration, impressions were made to manufacture a 3-unit implant-supported interim prosthesis made of polymethylmethacrylate (PMMA) that would be screwed into implants 24 and 26 (Figure 5F–G). During fabrication of the provisional by the laboratory, the patient wore no provisional prosthesis, so 2 healing abutments were placed to complete the second surgical phase. Three months later, an implant-supported FDP was fabricated with zirconia frameworks layered with feldspathic porcelain (Figure 5H).

Follow-ups took place at 12, 36, and 60 months, when the patient reported no symptoms and expressed a high level of satisfaction with the treatment. Upon intraoral examination, the peri-implant mucosa was found to be firm and coral pink. No prosthetic mobility or bleeding on probing was observed, and probing depth ranged between 2 and 4 mm. A periapical radiograph and small volume CBCT were taken at 36 months (Figure 5I,J). Marginal bone levels remained stable at 60 months compared to the initial radiographic assessment (Figure 5K). No complications were noted regarding the zirconia framework itself (Figure 5L).

2.4 | Treatment of vertical and horizontal bone defects with simultaneous implantation

A challenge in rehabilitating large defects is that the deficit of bone dimension results in surgical interventions that are continual until a sufficient quantity of bone is achieved to place an implant. This is particularly relevant in the maxillary anterior region to accomplish an excellent aesthetic outcome.[35]

2.4.1 | Case report 4

This case involved a 46-year-old systemically healthy male complaining of mild discomfort and gingival problems in the right maxillary lateral and central incisors. The patient had high aesthetic expectations, a 1 mm smile line and a thick-flat gingival biotype. Clinical inspection of the oral cavity revealed a gingival swelling on the facial side of tooth 12, which was periodontally untreated (Figure 6A,B). Examination showed slight palpation, grade III mobility, percussive discomfort with a probing depth of 10-14-10 mm of the facial gingiva, and 8-9-8 mm of the palatal aspect (Figure 6C,D). The tooth also presented bleeding and suppuration at the probing depth, and a 2-mm extrusion. The right central incisor showed grade I mobility and a probing depth with bleeding of 9-5-4 mm in the facial aspect and 8-4-4 mm in the palatal aspect. CBCT cross-sectional images confirmed a vertical and horizontal bone defect in the maxillary lateral incisor with involvement of the distal aspect of the maxillary central incisor (Figure 6E). Immediate implant placement combined with corticocancellous bone, and a soft tissue graft harvested from the maxillary tuberosity was the suggested treatment because of the patient's desire both for a minimal quantity of surgical involvements and the preservation of an aesthetic appearance during the treatment procedures.

The first step consisted of splinting the anterior teeth to stabilize them and performing initial periodontal therapy (hygienic phase). Once the inflammation subsided, planning began for the extraction of tooth 12 and its replacement with an immediate implant. Tooth 12 was carefully extracted under local anesthesia using a 2% lidocaine solution with a vasoconstrictor. The extraction socket, thoroughly debrided with care to avoid infection, revealed an almost complete loss of the buccal plate (Figure 6F,G). Subsequently, the region of the tuberosity was exposed, and a block graft was extracted by using a 1 cm wide flat chisel (Bontempi; Quirurgical Bontempi; Barcelona, Spain) and a surgical hammer according to the dimensions of the bone defect (Figure 6H). A connective tissue graft was also extracted from the proximal palatal area for subsequent sealing of the surgical wound in the crestal region of the recipient area. The block autograft was simultaneously fixed by the implant placement (Nobel Biocare Active diameter 3.5 mm and length 13 mm) with an insertion torque of 35 Ncm (Figure 6I). An ideal 3D implant position was obtained mesiodistally, orofacially, and coronoapically (Figure 6J). To obtain primary stability, the recipient area was drilled 3–4 mm apically. Due to the good availability of bone in the tuberous region, a second block was harvested from the same region to achieve more volume in the
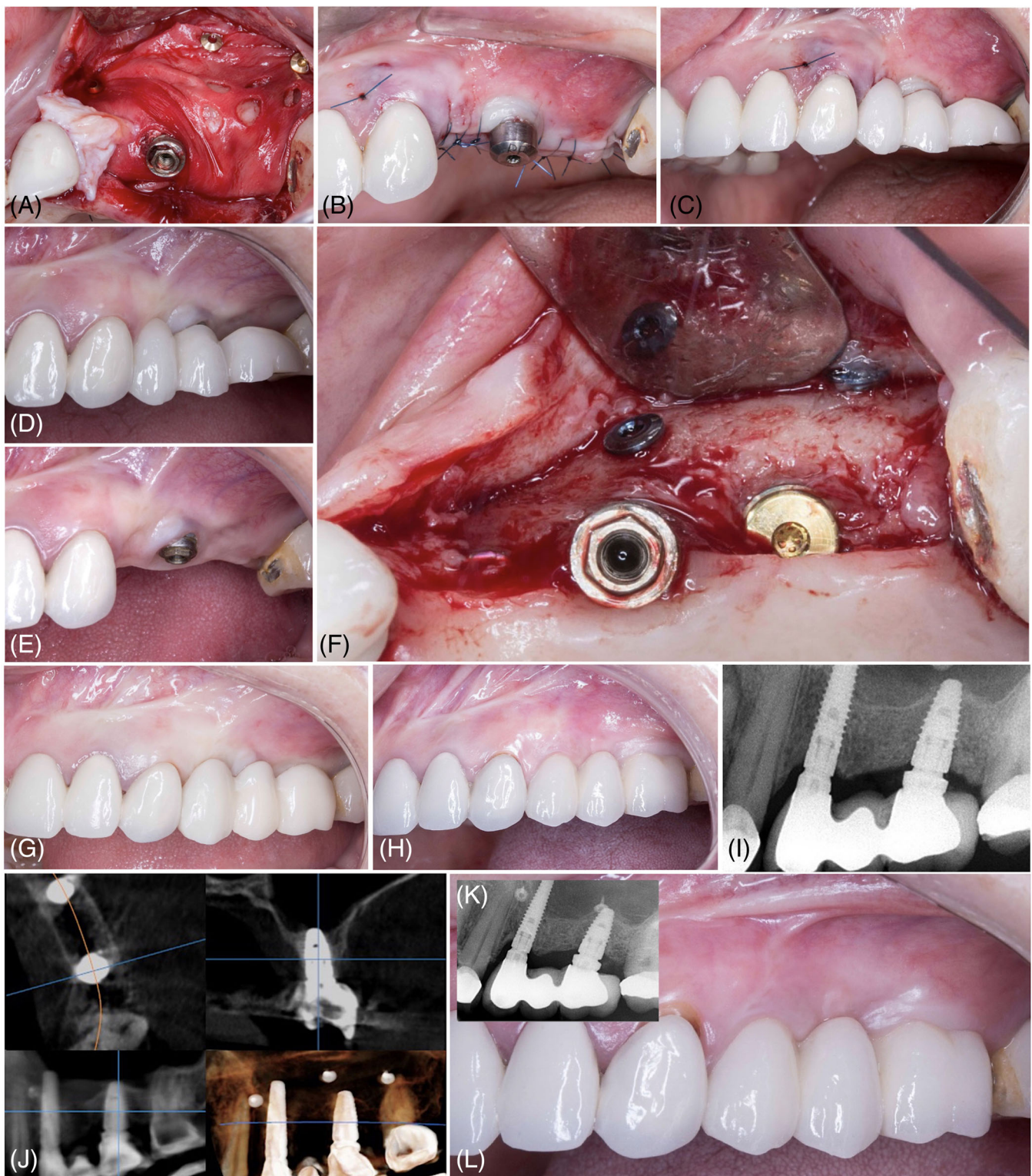
FIGURE 5 Treatment of horizontal bone defects with simultaneous implantation. (A) The membrane was fixed by metal pins to align the perforations exactly over the autologous bone. A connective tissue graft was harvested from the bone donor site to correct the gingival recession of tooth 23. (B) Primary wound closure without tension. (C) Placement of the same permanent metal-ceramic FPD with reduced occlusion. (D,E) Clinical situation 3 months after the graft and placement of the implants. (F) Reentry at 6 months showing the integration of the TAG. Removal of both the metal pins and the old implant. (G) Aspect of the tissue with a 3-unit implant-supported interim prosthesis. (H) Three years after implant-supported FDP placement. (I,J) Radiographic assessment of the implants at 3 years. (K,L) Clinical and radiographic control showing the maintenance of the soft tissue at 5 years

FIGURE 6 Treatment of vertical and horizontal bone defects with simultaneous implantation. (A) Gingival swelling on the facial side of tooth 12. (B) Patient's smile. (C,D) Probing depth of the affected tooth. (E) CBCT cross-sectional images showing the severe periodontal bone loss with minimal residual alveolar bone. (F) Vertical and horizontal bone defect after the maxillary lateral incisor extraction. (G) Distal attachment loss of tooth 11. (H) Distal incision and exposure of the tuberosity region before graft harvesting. (I) Fixing the corticocancellous block graft by the implant placement (Nobel Biocare Active 3.5 mm × 13 mm). (J) Occlusal aspect of the bone block graft and the implant placed in a correct 3D position
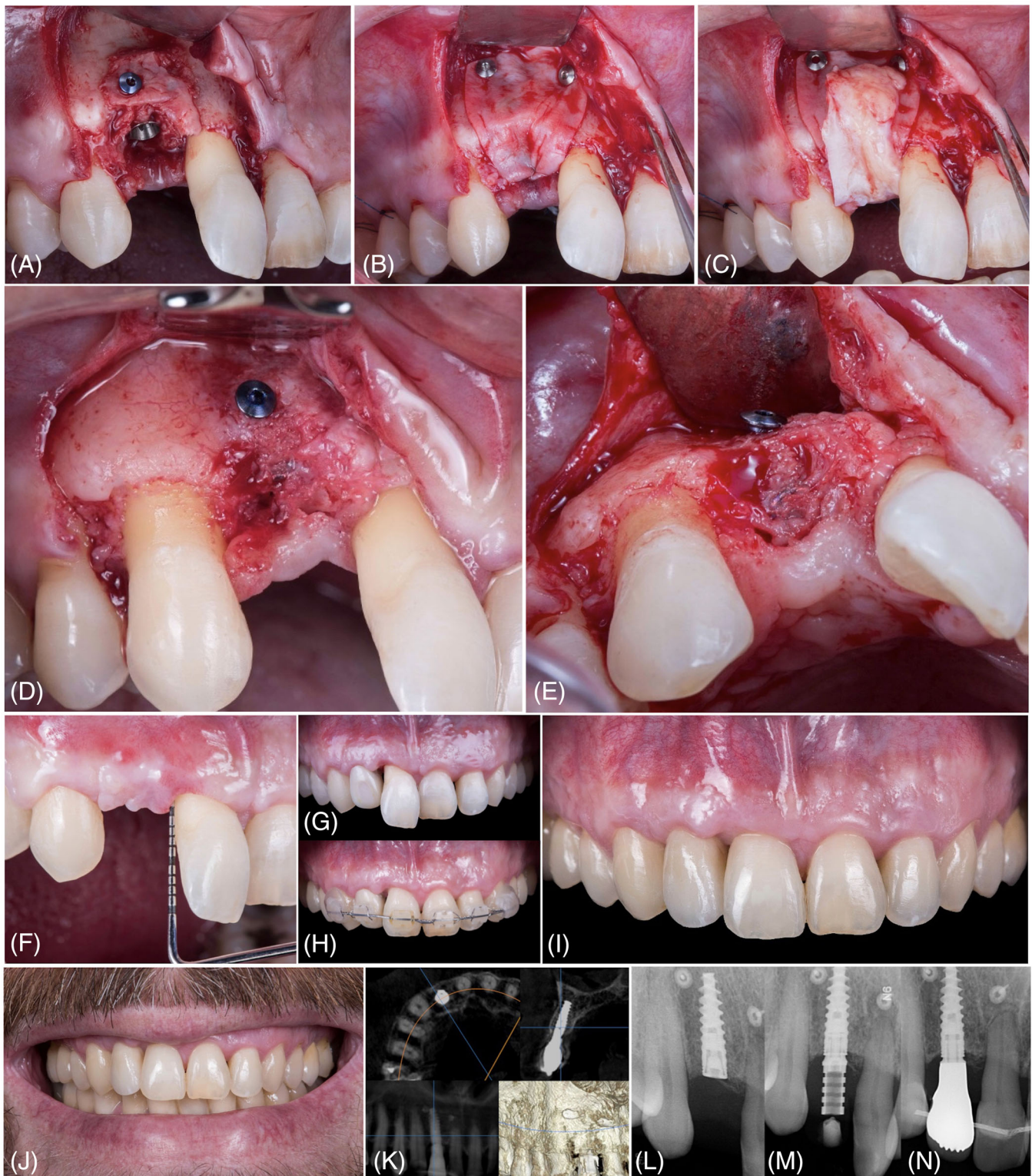
FIGURE 7 Treatment of vertical and horizontal bone defects with simultaneous implantation. (A) A second bone block fixed to the basal bone with a 5-mm pin (T-System). (B) Placement of a porcine origin collagen membrane (Creos™ Xenoprotect; Nobel Biocare, Gothenburg, Sweden). (C) A connective tissue graft placed in the crestal area. (D,E) Aspect of the bone 4 months post-surgery. Observe the complete integration of the bone block in the recipient site. (F) Clinical situation 3 months after the second connective tissue graft. (G,H) Orthodontic treatment to correct the position of tooth 11. (I,J) Three years post-treatment. (K) CBCT examination showing the reconstruction of the buccal bone after 3 years. (L) Implant placement and tissue reconstruction at 4 months. (M) Periapical radiograph with the interim restoration before orthodontic treatment. (N) Radiographic assessment at 3 years post-treatment
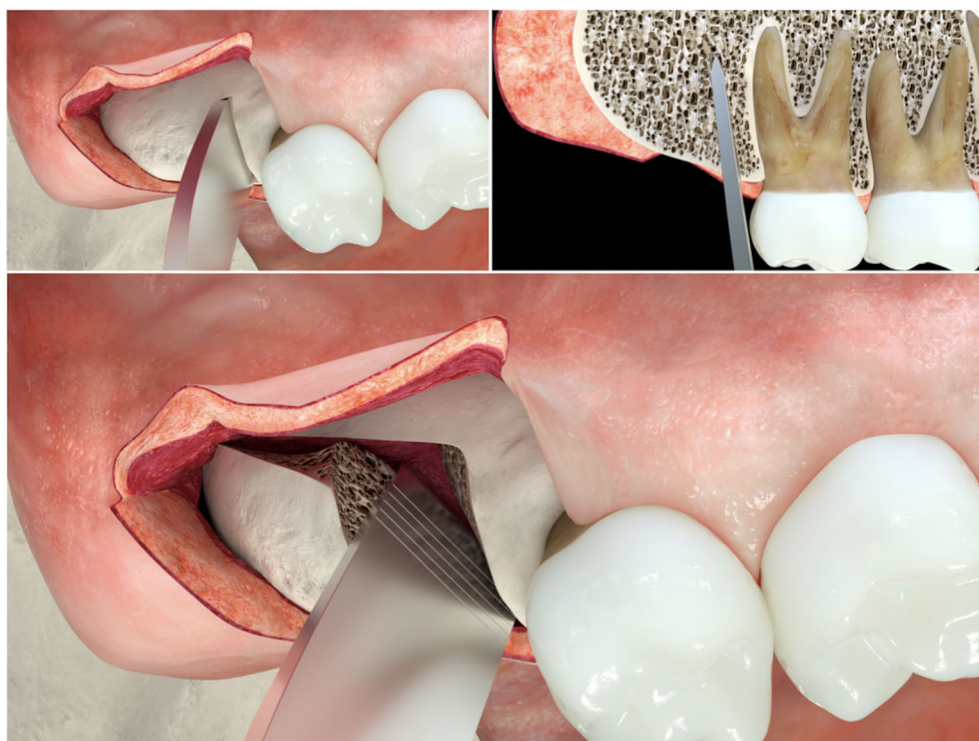
vestibular region (Figure 7A). This second block was fixed to the basal bone with a 5-mm pin (T-System).

Subsequently, a porcine origin collagen membrane (Creos™ Xenoprotect; Nobel Biocare, Gothenburg, Sweden) was placed to isolate the bone graft from the soft tissue.

(Figure 7B). The connective tissue graft harvested from the maxillary right palatal region was inserted in the labial and coronal sides of the socket to enhance the labial thickness of the soft tissue and achieve primary closure for long-term maintenance and improved.

aesthetics (Figure 7C). A cantilevered, all-ceramic (IPS e.max Press, Ivoclar Vivadent) resin bonded fixed partial denture (RBFPD) provided an interim solution during the healing time.

During the second surgical phase, at 4 months, the screw was removed, and a second connective tissue graft was performed since the first connective tissue graft was insufficient to achieve a satisfactory aesthetic result (Figure 7D–F). Following that surgical phase, a provisional crown was placed to shape the emergence profile, to expand the peri-implant soft tissues for the final restorative stage and to serve as an anchor for subsequent orthodontic treatment to correct the malposition of tooth 11 (Figure 7G,H). After orthodontic correction of tooth 11, a screw-retained zirconia frameworks layered with feldspathic porcelain over an angulated screw channel zirconia abutment (Nobel Biocare, Yorba Linda, CA) was delivered (Figure 7I). The 3-year follow-up demonstrated that the gingival architecture maintained the form and the definitive implant-supported crown was provided (Figure 7J). Radiographic assessment showed the reconstruction of the buccal bone and revealed the stable marginal bone level (Figure 7K–N). Peri-implant aesthetics was accomplished and maintained, which additionally met the patient's expectations.

Figure 8 illustrated the surgical technique step by step to obtain a maxillary tuberosity block autograft.

3 | DISCUSSION

There is a global trend toward minimally invasive health procedures that provide better results while fulfilling patient expectations, which includes dental implant procedures, techniques and resources. Minimally invasive procedures are possible through the synergy of treatment planning, CBCT imaging, guided surgery, and updated prosthetic methods. A large series of animal research and human clinical studies have reported that guided bone regeneration is a successful approach for augmenting bone for endosseous dental implant placement.[30-34] For severely atrophic ridges, block grafting procedures are acknowledged for their expected outcomes, especially with the utilization of autogenous bone, which is the current gold standard for its osteoconductive, osteoinductive, and osteogenic properties.[36,37]

Intraoral bone blocks (ramus, symphysis, and tuberosity grafts) can offer surgeons with an enough autogenous intramembranous bone with minimal morbidity for a successful clinical outcome. When choosing the optimal donor site, it is crucial to accurately assess the average quantity and quality of bone available needed for the recipient site and the potential difficulties. However, systematic reviews have yet to find evidence that one grafting method is superior to others.[34]

According to a radiographic evaluation of the maximum dimensions, volume, and bone quality values of different intraoral donor sites, Ataman-Duruel et al. found that the volume and CBCT-HU of the maximum bone block harvesting from the symphysis was greater

in comparison with the ramus, palatal, and tuberosity bone blocks.[7] When harvesting the maxillary tuberosity, the clinician must consider the low values of bone density, which may hinder bone block stability and might tend to resorb during healing after augmentation. However, to increase the density and to decrease possible resorption, Khojasteh et al. added resorbable membranes and growth factors to a maxillary tuberosity graft.[23] The maxillary tuberosity is often small and problematic to access, particularly in small mouth openings and/or where there are third molars.[38] All these factors may have overshadowed the use of a tuberosity block graft, which, among other advantages, includes fewer complications and, due to its malleability,[14] ease of graft adaptation in the receptor bed.[15] The lower density of the tuberosity block is characterized by its versatility when being adapted to the defect in the recipient area. This is mainly achieved by using stabilization systems such as screws, pins and even the implant itself.

The use of the maxillary tuberosity, if large enough and proper for a block graft, appears to be a relatively simple and helpful alternative. Its advantages include intraoral a corticocancellous autogenous graft with fewer intraoperative complications, no need to restore the donor site, and an excellent capability to improve localized alveolar ridge defects. The maxillary tuberosity is a source of both block and particulate autogenous bone suitable for regenerating horizontal or vertical defects of limited size. In addition, when a regeneration of the posterior maxilla is required, the same surgical area also serves to harvest donor bone, reducing costs. Hence, it is related with less morbidity and reduced treatment time. However, it is noteworthy that bone grafts harvested from the maxillary tuberosity have not been used broadly because they are regarded as poor quality.[7] Recently, da Rosa et al. examined clinically, tomographically and histologically a case in which block and particulate autogenous bone grafts were harvested from the maxillary tuberosity for dental implant placement.[39] In that study, advanced bone remodeling was observed during implant placement and buccal bone plate thickness was maintained. Despite the cancellous and thin cortical shape of the maxillary tuberosity, cancellous bone may be condensed mechanically when graft crushing or screwing. This procedure augments graft bone density while preserving bone volume during remodeling, even in vertical bone defects as shown in these clinical cases.

However, the maxillary tuberosity block autograft has certain limitations such as difficult access due to the presence of third molars, and inadequate size of the tuberosity for restoring large defects. In addition, the potential occasional complications associated with tuberosity harvesting are oroantral communication, bleeding (formation of a hematoma), and tethering of the pterygoid muscles.[15] Thus, it is crucial to study the maxillary tuberosity in detail before harvesting. Manzanera et al. showed wide variations of the maxillary tuberosity in morphology (width, length, and height) and that its dimensions depend on patient age and sex.[40] Likewise, Gapski et al. demonstrated through histomorphometry examination that specimens obtained from women had a statistically significant lower percentage of bone surface area when compared to those from men.[5] In the event that a reconstruction of localized defects of the alveolar ridge is required, the clinician should routinely examine the maxillary tuberosity region

of the patient as possible source of intraoral bone block. Modern and small volume CBCT can offer in depth anatomy of the maxilla and mandible that can assist in making a 3-dimensional preoperative evaluation of the most excellent source of block graft.

4 | CONCLUSIONS

The use of intraoral bone block for bone augmentation has numerous pitfalls due to the surrounding vital anatomical structures. Surgeons should contemplate all factors and perform a precise CBCT assessment. According to the clinical cases presented herein, tuberosity alveolar bone block grafts may offer a valuable bone source for treating small and moderate localized defects of the alveolar process around implants and teeth. The main advantage of maxillary tuberosity block autograft over other intraoral donor sites is fewer postoperative complications, such as nerve injury and oroantral communication. It can be used in both particulate and block form for treating localized bony defects and for sinus augmentation procedures. However, further research comparing different intraoral bone block grafting sites for implant treatment would help to weigh up the benefits against the shortcomings of one graft over another.

DATA AVAILABILITY STATEMENT
Data sharing not applicable to this article as no datasets were generated or analyzed during the current study. The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID
Francesc Abella Sans https://orcid.org/0000-0002-3500-3039

REFERENCES
1. Chiapasco M, Zaniboni M, Boisco M. Augmentation procedures for the rehabilitation of deficient edentulous ridges with oral implants. *Clin Oral Implants Res*. 2006;17(2):136-159.
2. Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. The efficacy of horizontal and vertical bone augmentation procedures for dental implants - a Cochrane systematic review. *Eur J Oral Implantol*. 2009;2(3):167-184.
3. Fu JH, Wang HL. Horizontal bone augmentation: the decision tree. *Int J Periodontics Restorative Dent*. 2011;31(4):429-436.
4. Rabelo GD, de Paula PM, Rocha FS, Jordão Silva C, Zanetta-Barbosa D. Retrospective study of bone grafting procedures before implant placement. *Implant Dent*. 2010;19(4):342-350.
5. Gapski R, Satheesh K, Cobb CM. Histomorphometric analysis of bone density in the maxillary tuberosity of cadavers: a pilot study. *J Periodontol*. 2006;77(6):1085-1090.

6. Sàndor GK, Nish IA, Carmichael RP. Comparison of conventional surgery with motorized trephine in bone harvest from the anterior iliac crest. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2003;95(2): 150-155.

7. Ataman-Duruel ET, Duruel O, Nares S, Stanford C, Tözüm T. Quantity and quality of intraoral autogenous block graft donor sites with cone beam computed tomography. *Int J Oral Maxillofac Implants*. 2020; 35(4):782-788.

8. Spin-Neto R, Stavropoulos A, Dias Pereira LA, et al. Fate of autologous and fresh-frozen allogeneic block bone grafts used for ridge augmentation. A CBCT-based analysis. *Clin Oral Implants Res*. 2013;24(2): 167-173.

9. Zeltner M, Flückiger LB, Hämmerle CH, et al. Volumetric analysis of chin and mandibular retromolar region as donor sites for cortico-cancellous bone blocks. *Clin Oral Implants Res*. 2016;27(8):999-1004.

10. Reininger D, Cobo-Vázquez C, Rosenberg B, López-Quiles J. Alternative intraoral donor sites to the chin and mandibular body-ramus. *J Clin Exp Dent*. 2017;9(2):e1474-e1481.

11. Hassani A, Khojasteh A, Shamsabad AN. The anterior palate as a donor site in maxillofacial bone grafting: a quantitative anatomic study. *J Oral Maxillofac Surg*. 2005;63(8):1196-1200.

12. Khojasteh A, Eslaminejad MB, Nazarian H, et al. Vertical bone augmentation with simultaneous implant placement using particulate mineralized bone and mesenchymal stem cells: a preliminary study in rabbit. *J Oral Implantol*. 2013;39(1):3-13.

13. Weibull L, Widmark G, Ivanoff CJ, Borg E, Rasmusson L. Morbidity after Chin bone harvesting - a retrospective long-term follow-up study. *Clin Implant Dent Relat Res*. 2009;11(2):149-157.

14. Khojasteh A, Behnia H, Shayesteh YS, Morad G, Alikhasi M. Localized bone augmentation with cortical bone blocks tented over different particulate bone substitutes: a retrospective study. *Int J Oral Maxillofac Implants*. 2012;27(6):1481-1493.

15. Tolstunov L. Maxillary tuberosity block bone graft: innovative technique and case report. *J Oral Maxillofac Surg*. 2009;67(8):1723-1729.

16. Khojasteh A, Soheilifar S, Mohajerani H, Nowzari H. The effectiveness of barrier membranes on bone regeneration in localized bony defects: a systematic review. *Int J Oral Maxillofac Implants*. 2013;28(4):1076-1089.

17. da Rosa JC, Rosa AC, da Rosa DM, Zardo CM. Immediate Dentoalveolar restoration of compromised sockets: a novel technique. *Eur J Esthet Dent*. 2013;8(3):432-443.

18. da Rosa JC, Rosa AC, Fadanelli MA, Sotto-Maior BS. Immediate implant placement, reconstruction of compromised sockets, and repair of gingival recession with a triple graft from the maxillary tuberosity: a variation of the immediate dentoalveolar restoration technique. *J Prosthet Dent*. 2014;112(4):717-722.

19. Tolstunov L. Management of biomechanical complication of implant-supported restoration of a patient with combination syndrome: a case report. *J Oral Maxillofac Surg*. 2009;67(1):178-188.

20. Younes R, Khairallah CM. The "one piece" autologous tuberosity graft: a contemporary concept in ridge preservation. *Case Rep Dent*. 2020;2020:3945076.

21. de Molon RS, de Avila ED, de Barros-Filho LA, et al. Reconstruction of the alveolar buccal bone plate in compromised fresh socket after immediate implant placement followed by immediate provisionalization. *J Esthet Restor Dent*. 2015;27(3):122-135.

22. Khojasteh A, Nazeman P, Tolstunov L. Tuberosity-alveolar block as a donor site for localised augmentation of the maxilla: a retrospective clinical study. *Br J Oral Maxillofac Surg*. 2016;54(8):950-955.

23. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. *Int J Oral Maxillofac Implants*. 2003;18(1):31-39.

24. Elian N, Cho SC, Froum S, Smith RB, Tarnow DP. A simplified socket classification and repair technique. *Pract Proced Aesthet Dent*. 2007; 19(2):99-104.

25. Touré B, Faye B, Kane AW, Lo CM, Niang B, Boucher Y. Analysis of reasons for extraction of endodontically treated teeth: a prospective study. *J Endod*. 2011;37(11):1512-1515.

26. Zadik Y, Sandler V, Bechor R, Salehrabi R. Analysis of factors related to extraction of endodontically treated teeth. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2008;106(5):e31-e35.

27. Olcay K, Ataoglu H, Belli S. Evaluation of related factors in the failure of endodontically treated teeth: a cross-sectional study. *J Endod*. 2018;44(1):38-45.

28. Cabello G, Rioboo M, Fábrega JG. Immediate placement and restoration of implants in the aesthetic zone with a trimodal approach: soft tissue alterations and its relation to gingival biotype. *Clin Oral Implants Res*. 2013;24(10):1094-1100.

29. Dahlin C, Linde A, Gottlow J, Nyman S. Healing of bone defects by guided tissue regeneration. *Plast Reconstr Surg*. 1988;81(5):672-676.

30. Dahlin C, Sennerby L, Lekholm U, Linde A, Nyman S. Generation of new bone around titanium implants using a membrane technique: an experimental study in rabbits. *Int J Oral Maxillofac Implants*. 1989;4(1): 19-25.

31. Lang NP, Hämmerle CH, Bragger U, et al. Guided tissue regeneration in jawbone defects prior to implant placement. *Clin Oral Implants Res*. 1994;5(2):92-97.

32. Lazzara RJ. Immediate implant placement into extraction sites: surgical and restorative advantages. *Int J Periodontics Restorative Dent*. 1989;9(5):332-334.

33. Jovanovic SA, Spiekermann H, Richter EJ. Bone regeneration around titanium dental implants in dehisced defect sites: a clinical study. *Int J Oral Maxillofac Implants*. 1992;7(2):233-245.

34. Jensen SS, Terheyden H. Bone augmentation procedures in localized defects in the alveolar ridge: clinical results with different bone grafts and bone-substitute materials. *Int J Oral Maxillofac Implants*. 2009;24: 218-236.

35. González D, Cabello G, Olmos G, López Hernández E, Niñoles CL. The three-layer technique for immediate implants on teeth without a buccal bone wall: a case report. *Int J Esthet Dent*. 2018;13(3): 358-376.

36. Albrektsson T, Johansson C. Osteoinduction, osteoconduction and osseointegration. *Eur Spine J*. 2001;10(2):s96-s101.

37. Galindo-Moreno P, Avila G, Fernández-Barbero JE, et al. Clinical and histologic comparison of two different composite grafts for sinus augmentation: a pilot clinical trial. *Clin Oral Implants Res*. 2008;19(8): 755-759.

38. Raghoebar GM, Meijer HJA, van Minnen B, Vissink A. Immediate reconstruction of failed implants in the esthetic zone using a flapless technique and autogenous composite tuberosity graft. *J Oral Maxillofac Surg*. 2018;76(3):528-533.

39. da Rosa JCM, Sotto-Maior BS, de Oliveira P, Rosa AC, LA VDP. Clinical, tomographic, and histologic evaluation of an autogenous bone graft harvested from the maxillary tuberosity for guided bone regeneration: case report with a 4-year follow-up. *Int J Periodontics Restorative Dent*. 2021;41(4):e183-e190.

40. Manzanera E, Llorca P, Manzanera D, García-Sanz V, Sada V, Paredes-Gallardo V. Anatomical study of the maxillary tuberosity using cone beam computed tomography. *Oral Radiol*. 2018;34(1): 56-65.