

CASE REPORT

A customized allogenic bone block for alveolar reconstruction quantitated by a 3D matching technique: A case report

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Abstract

After initial resorption, the bone volume showed long-term stability following loading of the implant. Furthermore, 3D matching was a suitable quantification method to analyze the volume development of bone augmentation.

KEYWORDS

3D matching, allograft, alveolar ridge augmentation, CAD/CAM, maxillary reconstruction, volume rendering

1 | INTRODUCTION

Allografts, which were individualized into precisely fitting bone blocks by CAD/CAM technology, were utilized for maxillary bone reconstruction. Six months after block insertion, an implant could be placed in an augmented alveolar ridge. The block's volume and successful application were verified using a 3D matching software.

Implants play a major role in modern dentistry as the desire for a fixed prosthetic restoration becomes increasingly common among patients. Therefore, bone augmentation is often an integral step in achieving functional and esthetic rehabilitation.^{1,2}

Bone augmentations in the anterior region of the maxilla can be particularly challenging, as there must be no loss of volume in the vertical dimension in order to restore or achieve an esthetic appearance.³

The gold standard for bone reconstruction is autografts, but they have some disadvantages compared to bone substitute materials (BSM), so allogenic bone grafts are an accepted alternative.⁴⁻⁶

Allografts are distinguished by the absence of a second surgical site, excellent biocompatibility and their ease of handling.

Today, cone beam computed tomography (CBCT) datasets allow the generation of three-dimensional (3D) digital models and the 3D visualization of the defect morphology. Thus, individualized allogenic bone blocks that fit precisely into the morphology of the defect can be designed by means of the computer-aided design/computer-aided manufacturing (CAD/CAM) technology.

The purpose of this research was to report a clinical case of an individualized allogenic bone block whereby the successful osseointegration and volume development were precisely quantified by a 3D matching software and confirmed by a long-term clinical follow-up.

2 | CASE DESCRIPTION

2.1 | History and examination

A 37-year-old fit and healthy man presented to a practice with a symptomatic left maxillary incisor (#9). His medical history was unremarkable, and he was a non-smoker. The tooth had failing endodontic treatment despite apicoectomy which were done 15 years prior (Figure 1). Together with residual periapical infection, the tooth was

given a poor long-term prognosis, and thus, extraction was the treatment option chosen by the patient.

The osteolysis had progressed so far that socket preservation was not possible. To preserve the soft tissue, a collagenic cone (collacone, botiss biomaterials GmbH) was inserted into the socket (Figure 2A). It was covered with a collagenic membrane (mucoderm, botiss biomaterials GmbH) and secured to the gingiva with resorbable 5.0 sutures (Vicryl 5.0) (Figure 2B).

The patient wished for an implant-supported prosthesis to restore an esthetic appearance. After a healing period of three months, a clinical and radiographic examination of the anterior maxilla was performed, which revealed a severe osseous defect that necessitated alveolar ridge reconstruction prior to implantation.

The patient was informed about all the therapeutic options available to him and declined the use of an autologous bone transplant. Therefore, treatment with a CAD/CAM manufactured allogenic bone block was chosen (maxgraft bonebuilder, botiss biomaterials GmbH). The origin of these blocks were femoral heads from living donors obtained during arthroplastic surgery carried out in accredited clinics and then transmitted to a tissue bank (Cells+Tissuebank Austria (C+TBA)). The patient gave his informed consent for inclusion in this case report



FIGURE 1 Initial diagnosis of tooth #9

before the start of the treatment. The case report was conducted in accordance with the Declaration of Helsinki.

2.2 | CBCT scans

On three different occasions, CBCT scans were performed with the patient's consent (KaVo 3D eXam, KaVo Dental, Biberach an der Riß, Germany; voxel size: 0.3 mm; field of view: 16.5 cm (diameter) × 13.50 cm (max. height); tube voltage: 120 kV; and tube current: 3–7 mA), limiting radiation exposure and keeping doses as low as reasonably possible. After a healing period of three months, a baseline CBCT scan (No.1) was taken to evaluate the morphology of the deficient maxillary bone and to acquire 3D data for the virtual planning process (CAD). After the surgical procedure, a second CBCT scan (No.2) was necessary to re-confirm the maximum contact of the recipient bone and the allograft, and to ensure the allogenic bone block is in the desired position as confirmed from pre-surgical planning. The timing of the second CBCT scan depended on the manufacturing process of the bone block, usually between 8 and 12 weeks after the first CBCT scan.

After 6 months, a third CBCT scan (No.3) was carried out with a surgical drilling guide to estimate the available bone tissue at the surgical site before implantation.

2.3 | Preparation of the block

The botiss biomaterials GmbH was responsible for the virtual design of the 3D shape of the bone block (Figure 3).

For this purpose, DICOM files (Digital Imaging and Communications in Medicine) derived from the CBCT scan were transferred.

The planning was presented to the patient to illustrate the necessity of alveolar ridge augmentation to correct the horizontal and vertical osseous deficiency and to allow implant placement in the correct, prosthetically determined position. After release, the individual block was milled from the pre-treated allogenic cancellous tissue (Allotec® process, Cells+Tissuebank Austria (C+TBA)).

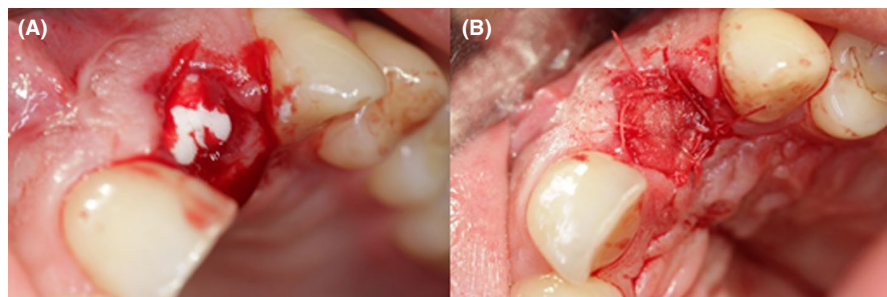


FIGURE 2 Soft tissue preservation: (A) insertion of a collacone; (B) covering the socket with a mucoderm

FIGURE 3 3D planning of the block graft: (A) defect situation; (B) simulation of the ideal implant position; and (C) design of the shape of the graft

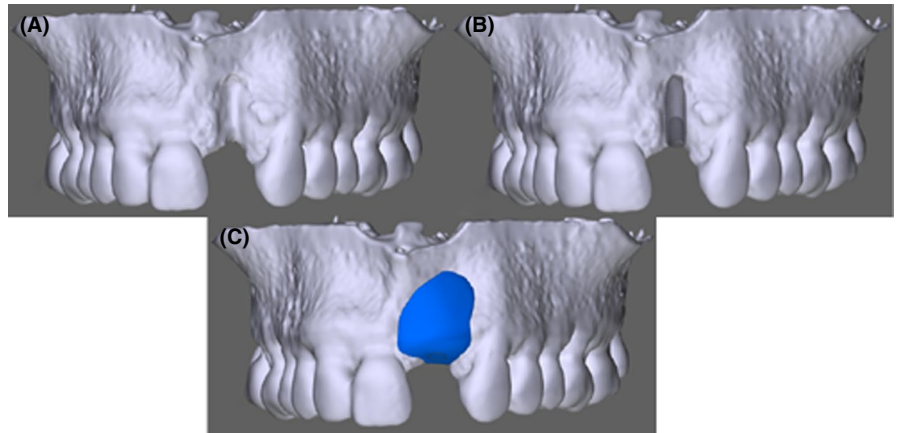
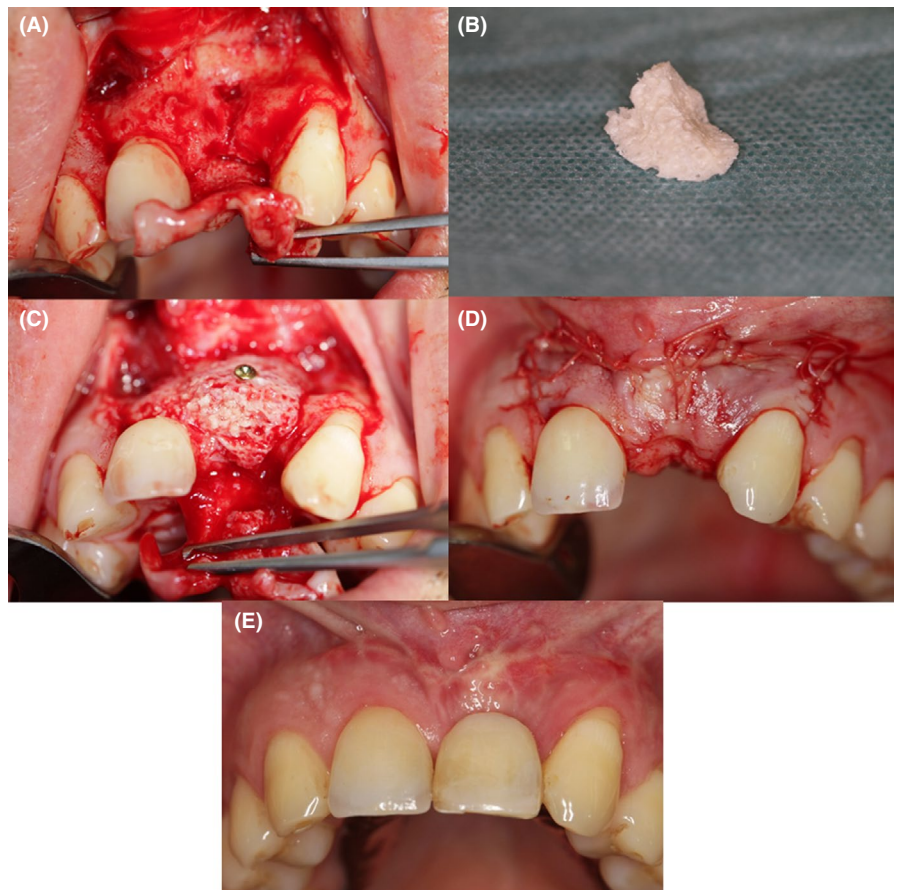


FIGURE 4 Surgical procedure: (A) pillar incision and elevation of the flap; (B) sterile bone block; (C) fixated bone graft; (D) sutured surgical site; and (E) augmented area four weeks after surgery



2.4 | Surgical Intervention

Autologous platelet-rich fibrin (PRF) matrices were prepared from the patient's blood sample before the bone augmentation.⁷ Due to the patient's wish, surgery was performed under general anesthetic with intravenous antibiotic prophylaxis of 600 mg Clindamycin. First, an incision was made with a recently developed "pillar" incision technique.³ For this, the incision was not made over the alveolar ridge, but 20 mm horizontally in the unattached mucosa, accompanied by two vertical relief incisions each

distal to the adjacent tooth. A marginal incision was carried out on the adjacent teeth #8 and #10. A mucoperiosteal flap was elevated from the maxillary bone, leaving the mucosa covering the defect intact (Figure 4A).

To improve graft integration, the cortical layer was perforated at various points with a diamond burr in order to deliberate bleeding. Exudate serum obtained from the patient's blood during the PRF procedure was used to rehydrate the sterile block (Figure 4B). No further modifications were necessary because the block precisely matched the defect's geometry. A hole with the diameter

of the intended screw was drilled through the block into the bone. A single titanium osteosynthesis screw with a diameter of 1.5 mm and a length of 9 mm (Medartis AG) was used to secure the graft (Figure 4C).

The block was first covered with a resorbable collagen membrane fabricated from native pericardium (Jason membrane, botiss biomaterials GmbH), which was fixed with titanium pins. A PRP membrane was then applied to improve soft tissue healing. The flap was sutured tension-free with single button pulley sutures using absorbable suture material 4.0 (Vicryl rapid 4.0) (Figure 4D). Postoperatively, the sutures could be removed after 14 days, and no complications, dehiscences, or inflammations were observed (Figure 4E).

2.5 | Implantation

After a healing period of six months, the same surgeon performed the implantation, under local anesthesia and oral antibiotic prophylaxis with 2000 mg amoxicillin (Figure 5A). This time a crestal incision was carried out to gain access to the augmented site and remove the fixation screws (Figure 5B). A dental implant (diameter: 4.3 mm; length: 11.5 mm; torque value: 50 Ncm; NobelActive, Nobel Biocare) was placed with a surgical drilling guide in position #9 (Figure 5C). The block graft appeared osseointegrated and perfused. The incision was closed with single button pulley sutures using an absorbable 6.0 suture material (Vicryl 6.0), which were left for one week.

A long cone periapical radiograph was taken to verify the implant position and then was repeated following uncovering of the implant three months later (Figure 5D,E).

2.6 | Cone-beam computed tomography data analysis

The CBCT scans were evaluated using an implant planning software (coDiagnostiX, Version 10.2.0.15659, Dental Wings Inc.,).

First, a segment of the upper jaw was created from every data set to narrow down the region of interest (ROI). Individual reference points were manually selected to align the three scans to match (Figure 6A,B).

The software created virtual 3D models of the individual ROIs, which allowed the clinical scenario to be represented in three dimensions. To analyze the block volumina, coDiagnostiX® overlaid two aligned 3D models. This way the software calculated the initial block volume V1 by matching CBCT scans No.1 and No.2 and the final block volume V2 by matching scans No.1 and No.3 (Figure 6C). The volume difference ($=V1-V2$) gave the resorption.

The block volume right after block insertion (V1) was 0,45 ml and the volume before implantation (V2) 0,34 ml, which resulted in a difference of 0,11 ml. The amount of volume lost was 24,4% of the block.

2.7 | Long-term follow-Up

A thorough follow-up examination took place after two (Figure 7) and six years (Figure 8).

The diagnostic investigations revealed that the maximum probing depth was 3 mm, no bleeding on probing occurred and there were no signs of inflammation such as pain, purulence, or swelling (Figure 7A), Figure 8A,C). In

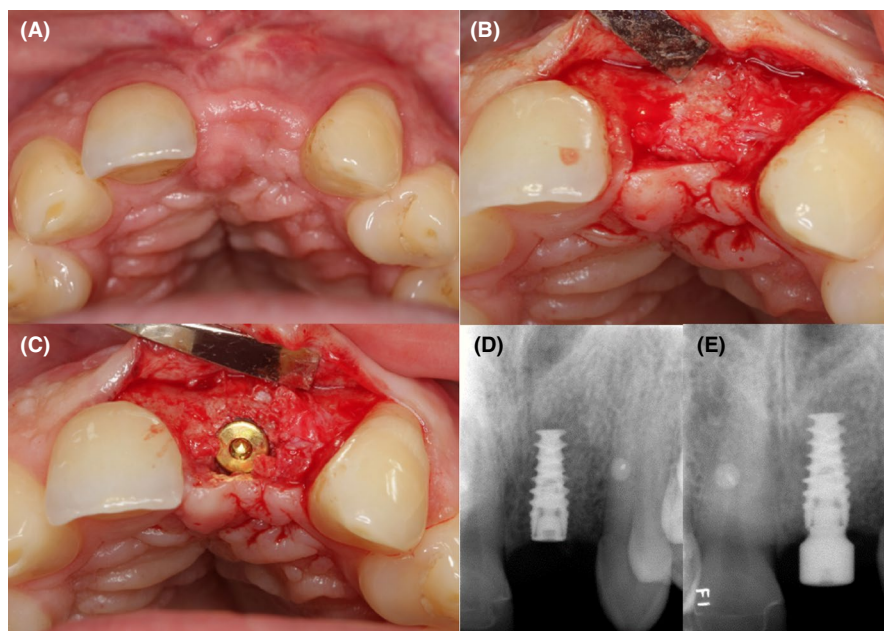


FIGURE 5 Implantation procedure: (A) clinical situation after the healing period of 6 months; (B) osseointegrated block without the screw; (C) final situation before suturing; (D) long cone periapical radiograph to control implant position; and (E) long cone periapical radiograph after uncovering the implant three months later

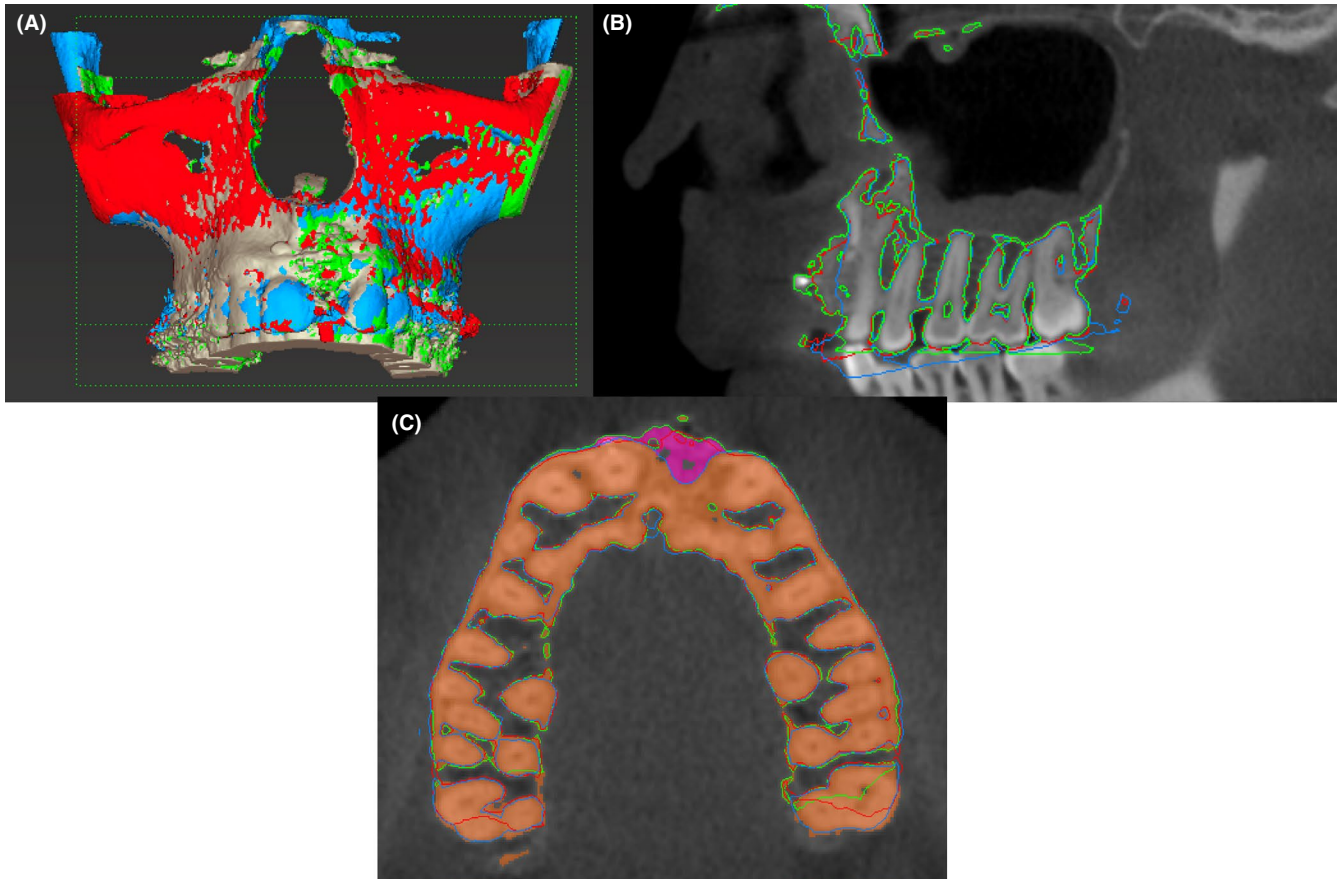
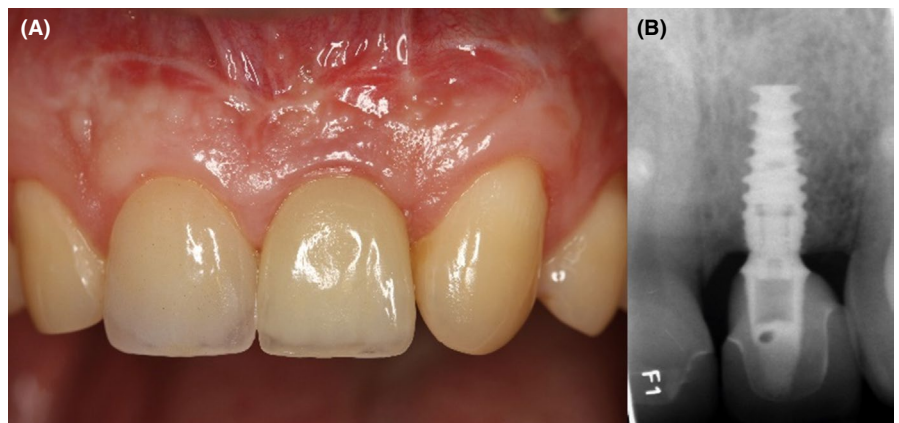


FIGURE 6 Analysis with coDiagnostiX, scan No.1 (blue color), scan No.2 (green color), and scan No.3 (red color): (A) 3D superimposition of the three 3D models; (B) two-dimensional superimposition of all three CBCT scans, sagittal view; (C) two-dimensional superimposition of all three CBCT scans, axial view, with highlighting of the block in pink

FIGURE 7 Follow-up after two years: (A) clinical situation; (B) long cone periapical radiograph



addition, the X-rays showed that there were no changes in the horizontal bone height (Figures 7B and 8B).

Moreover, the esthetic result was to the patients's complete satisfaction.

3 | DISCUSSION

The presented clinical case illustrated that the use of a customized allogenic bone block resulted in successful

extensive augmentation in the esthetic zone of the maxilla. Implantation in the osseointegrated block was possible.

The application of a 3D matching approach led to a more detailed understanding of the clinical observations. Together with the six-year follow-up, a stable result was confirmed.

The volume loss of the block was 24,4% during the healing period, but after implantation, the height of the alveolar ridge remained stable.

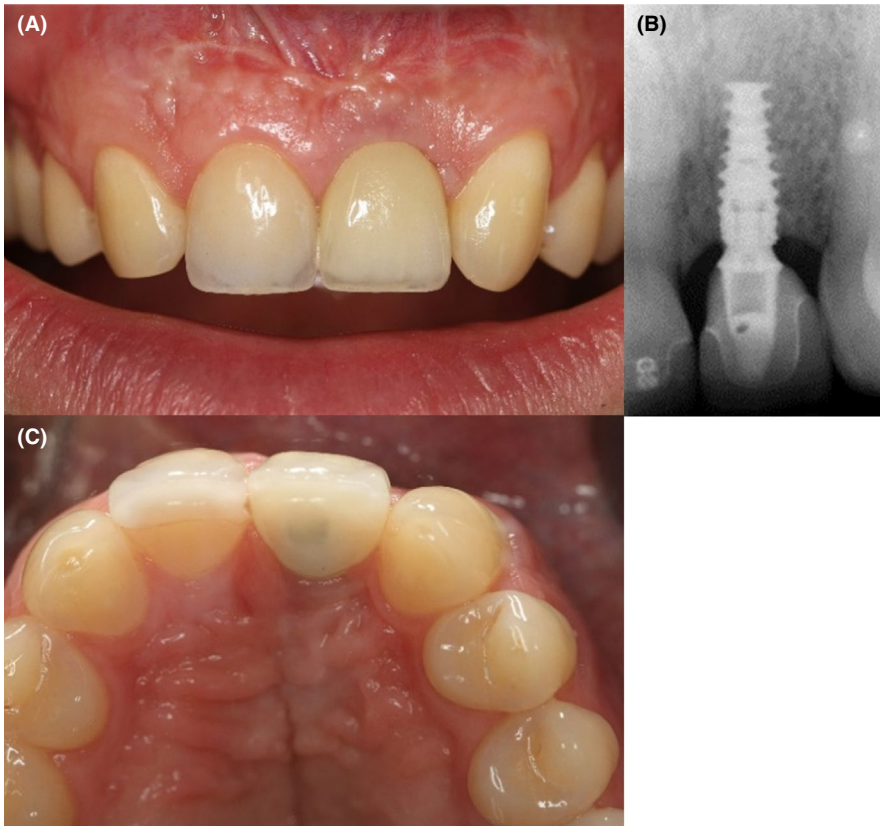


FIGURE 8 Follow-up after six years: (A) clinical situation; (B) long cone periapical radiograph; and (C) occlusal view

The ability to determine the volume of the block, instead of the previous vertical and horizontal measurements in 2D, allowed a much more accurate analysis of the transplant integration.

3D matching provided information on the size of the resorption, as well as on the position of the volume loss. Some volume loss below the screw head was observed. This discovery led to the insight that a countersink should be created underneath the screw head.

From experience, the initial resorption of the allograft is known; for this reason, the block was slightly overcontoured during the CAD process.

Cross-infectivity of allogenic material, immune response, and antigenicity are content of discussions in literature.⁸ Some remnants of organic cell residues and genetic information could be traced from allogenic bone grafts.⁹ Nevertheless, no inflammatory cells were detected next to the graft.^{10,11} Various allograft treatment methods, such as sterilization and gamma irradiation, are considered to reduce antigenicity and the risk of disease transmission.⁸

For safety reasons, the World Health Organisation conducted a study in which no transmission of any type of infection related to FDBAs was reported.¹²

Another commonly associated concern with allografts is the potential for post-surgical infection.

The risk does not relate to the allograft material itself, but to the handling during surgery when shaping of an allograft is required. This results in a longer operation time,

which increases the infection rate of the graft and the recipient site due to the many sources of contamination during manual fitting.¹³

In contrast, CAD/CAM technology ensures a perfectly fitting block, thus reducing operation time and subsequent complications to a minimum.

Moreover, the fitting process results in minimizing the distance between the graft and the recipient bone, allowing physical contact and thus ideal support for graft revascularization and rapid integration.^{3,5,14,15}

Insufficient soft tissue management is another reason for infections leading to perforation of the mucosa and opening of the incision line over the grafted bone.¹⁶

For that reason, the “pillar” incision technique was used. The soft tissue over the area of block where the tension is greatest was kept intact by moving the incision to the vestibulum, the area with highest perfusion. This reduced complications of the mucosa, such as infections and dehiscence.

Nowadays, guided bone regeneration (GBR) is widely used in clinical practice and is considered the gold standard.

However, in the anterior region of the maxilla, high dimensional stability of a bone graft is essential in order to achieve esthetic results. In this case, the extent of the osseous defect was too large to ensure volume stability with the help of GBR.¹⁷

An alternative approach is proposed by Tallarico et al.¹⁸ They used the CAD/CAM technology to customize a

titanium mesh membrane, and simultaneously with the augmentation, they inserted an implant. The rigidity of a titanium mesh membrane ensures that space is largely maintained and prevents the contour from collapsing.¹⁷ Nevertheless, the stiffness and sharp edges of the membrane can cause an increased number of exposures.^{19,20} Moreover, due to the voluminous defect, a conservative two-stage approach with a 6-month healing period after the grafting procedure was preferred. In particular, resorption of the graft after simultaneous implantation, which exposes the implant surface, had to be avoided.

More than 130 CAD/CAM blocks were inserted using the presented technique. The most common complication was dehiscence, followed in some cases by loss of the graft due to infection. The large number of dehisces healed after refreshing the wound and the graft, and the block was successfully osseointegrated.

The high number of successful cases demonstrates that individualized bone blocks made from cancellous allografts are osteoconductive and lead to new bone formation.

In this case, they enabled successful augmentation of the anterior region of an extremely atrophic maxilla and demonstrated a stable long-term result provided by data from a six-year follow-up. Nevertheless, a clinical trial with a larger patient group and long-term follow-up data is needed to validate these results and further evaluate graft volume.

Finally, 3D matching proved to be a suitable method for quantifying volume changes after augmentation procedures.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Oliver Blume involved in methodology, investigation, resources, writing-original draft, writing-review and editing, visualization, supervision, and project administration. Michael Back involved in investigation and resources. Kim Martin involved in methodology, writing-original draft, writing-review and editing, and visualization. Péter Windisch involved in supervision and project administration.

ETHICAL STATEMENT

All subjects gave their informed consent for inclusion before they participated in the case report. The case report

was conducted in accordance with the Declaration of Helsinki.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Cha H-S, Kim J-W, Hwang J-H, Ahn K-M. Frequency of bone graft in implant surgery. *Maxillofac Plast Reconstr Surg*. 2016;38:19.
2. Knöfler W, Barth T, Graul R, Krampe D. Retrospective analysis of 10,000 implants from insertion up to 20 years-analysis of implantations using augmentative procedures. *Int J Implant Dent*. 2016;2:25.
3. Blume O, Hoffmann L, Donkiewicz P, et al. Treatment of severely resorbed maxilla due to peri-implantitis by guided bone regeneration using a customized allogenic bone block: a case report. *Materials*. 2017;10:3.
4. Jacotti M, Wang H-L, Fu J-H, Zamboni G, Bernardello F. Ridge augmentation with mineralized block allografts: clinical and histological evaluation of 8 cases treated with the 3-dimensional block technique. *Implant Dent*. 2012;21:444-448.
5. Schlee M, Rothamel D. Ridge augmentation using customized allogenic bone blocks: proof of concept and histological findings. *Implant Dent*. 2013;22:212-218.
6. Khoury F. *Bone Grafts from the Mandible: Diagnosis, Instrumentation, Harvesting Techniques and Surgical procedure*. Quintessenz-Verlag; 2009:160.
7. Dohle E, El Bagdadi K, Sader R, Choukroun J, James Kirkpatrick C, Ghanaati S. Platelet-rich fibrin-based matrices to improve angiogenesis in an in vitro co-culture model for bone tissue engineering. *J Tissue Eng Regen Med*. 2018;12:598-610.
8. Spin Neto R, Felipe Leite C, Pereira LAVD, Marcantonio E. Is peripheral blood cell balanced altered by the use of fresh frozen bone block allografts in lateral maxillary ridge augmentation? *Clin Implant Dent Relat Res*. 2013;15:262-270.
9. Fretwurst T, Spanou A, Nelson K, Wein M, Steinberg T, Stricker A. Comparison of four different allogenic bone grafts for alveolar ridge reconstruction: a preliminary histologic and biochemical analysis. *J Oral Maxillofac Surg*. 2014;118:424-431.
10. Nissan J, Marilena V, Gross O, Mardinger O, Chaushu G. Histomorphometric analysis following augmentation of the anterior atrophic maxilla with cancellous bone block allograft. *Int J Oral Maxillofac Implants*. 2012;27:84-89.
11. Carlson ER, Marx RE, Buck BE. The potential for HIV transmission through allogeneic bone a review of risks and safety. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1995;80:17-23.
12. Hinsenkamp M, Muylle L, Eastlund T, Fehily D, Noël L, Strong DM. Adverse reactions and events related to musculoskeletal allografts: reviewed by the world health organisation project NOTIFY. *Int Orthop*. 2012;36:633-641.
13. Jacotti M, Barausse C, Felice P. Posterior atrophic mandible rehabilitation with onlay allograft created with CAD-CAM procedure: a case report. *Implant Dent*. 2014;23:22-28.

14. Eskow AJ, Mealey BL. Evaluation of healing following tooth extraction with ridge preservation using cortical versus cancellous freeze-dried bone allograft. *J Periodontol*. 2014;85:514-524.
15. Motamedian SR, Khojaste M, Khojasteh A. Success rate of implants placed in autogenous bone blocks versus allogenic bone blocks: A systematic literature review. *Ann Maxillofac Surg*. 2016;6:78-90.
16. Chaushu G, Mardinger O, Peleg M, Ghelfan O, Nissan J. Analysis of complications following augmentation with cancellous block allografts. *J Periodontol*. 2010;81:1759-1764.
17. Rakhmatia YD, Ayukawa Y, Furuhashi A, Koyano K. Current barrier membranes: titanium mesh and other membranes for guided bone regeneration in dental applications. *J Prosthodont Res*. 2013;57:3-14.
18. Tallarico M, Park C-J, Lumbau AI, et al. Customized 3D-printed titanium mesh developed to regenerate a complex bone defect in the aesthetic zone: a case report approached with a fully digital workflow. *Materials*. 2020;13:2-5.
19. Becker W, Becker BE, Mellonig J, et al. A prospective multicenter study evaluating periodontal regeneration for Class II furcation invasions and intrabony defects after treatment with a bioabsorbable barrier membrane: 1-year result. *J Periodontol*. 1996;67:641-649.
20. Watzinger F, Luksch J, Millesi W, et al. Guided bone regeneration with titanium membranes: a clinical study. *Br J Oral Maxillofac Surg*. 2000;38:312-315.

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