



Posterior Atrophic Mandible Rehabilitation With Onlay Allograft Created With CAD-CAM Procedure: A Case Report

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Prosthetic rehabilitation of the posterior atrophic edentulous mandible presents a common clinical problem.¹⁻⁶ The ideal therapeutic solution is a fixed implant supported prosthesis. However, this can be impeded by the deficiency in height and width of the residual alveolar bone, with the consequent superficialization of the inferior alveolar nerve, which can occur after tooth extraction. In this type of situation, it is difficult to insert an implant of adequate length.¹ The alveolar ridge can be rehabilitated with endosseous implants, but sufficient quality and quantity of alveolar bone are required to ensure the correct positioning of implants and an aesthetically good result.⁷ Tooth loss is always followed by a reduction in alveolar bone, leading to knife-edge ridges in severely atrophic cases.⁸⁻¹⁰

The knife-edge configuration of the residual bone crest does not provide sufficient base to contain particulate grafting material. Therefore, a strong rigid graft is required to allow fixation to the recipient site and 3-dimensional (3D) stability to withstand muscular

Aim: *Implant rehabilitation of the atrophic right posterior mandible in a 48-year-old woman using dehydrated homologous bone block, shaped with a computer aided design-computer aided manufacturing (CAD-CAM) system, to avoid harvesting of autologous bone block and to assure a perfect fitting of the block above the alveolar crest.*

Results: *After 7 months, 6.09, 7.36, and 8.08 mm (mean, 7.18 mm) of total horizontal bone gain was observed at sites 6, 12, and 18 mm*

posterior to the right mental foramen, respectively.

Conclusions: *The use of a bone block with CAD-CAM system for alveolar ridge augmentation is a valuable alternative to autograft because it reduces time, cost, and complications for the patients. Data from a computerized tomographic scan can be used to shape a precise 3-dimensional homologous bone block using a CAD-CAM system. (Implant Dent 2014;23:22-28)*

Key Words: *atrophy, posterior mandible, inlay technique*

force.¹¹ For all these reasons, when we require a graft that exceeds 3 mm in either width, height, or both in the posterior mandible, a bone block graft is recommended.¹¹⁻¹⁴

Several techniques are currently being used, including various vertical guided bone regeneration procedures,¹⁵ alveolar distraction osteogenesis,¹⁶⁻¹⁸ onlay bone grafting,¹⁸⁻²² and inlay.^{2-4,23,24} Although it has been shown that it is possible to vertically augment bone with different techniques, the number of complications and failures of the augmentation procedure is still too high (well over 20%) to recommend widespread use of such procedures.²²

The most widely applied grafting material is the autogenous bone, which is still considered as the “gold standard” for alveolar ridge augmentation because

of its osteogenic, osteoinductive, and osteoconductive properties that enhance bone formation.^{7,25,26}

Autogenous bone is harvested from intraoral²⁷⁻³² and extraoral sites,^{33,34} but sometimes it is not possible to harvest an adequate amount of bone from other donor sites on the same patient.³³ Furthermore, an autogenous bone graft necessitates additional surgery at the donor site and results in increased morbidity, operative time, and cost.^{7,28}

All these factors have lead clinicians to focus on the use of allogenic bone graft materials. Allogenic bone grafts, such as fresh-frozen, freeze-dried or demineralized freeze-dried and cryopreserved grafts, are all harvested from cadaveric sources and are then processed and stored in different ways.³⁶ The use of bone allograft offers numerous

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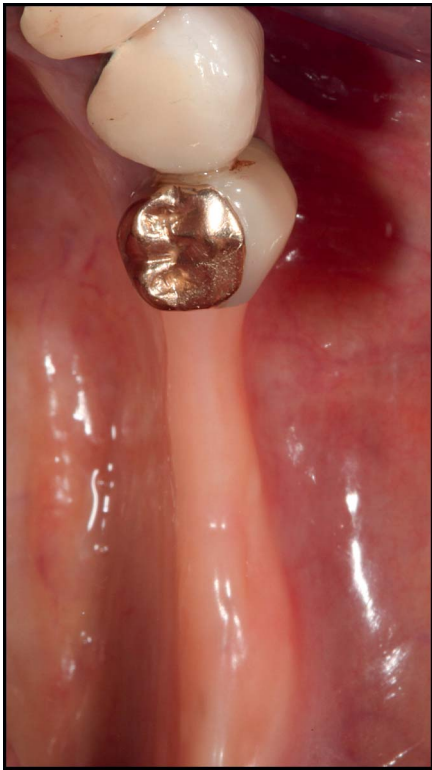


Fig. 1. Intraoral clinical image before surgical procedure showing alveolar bone horizontal deficit.

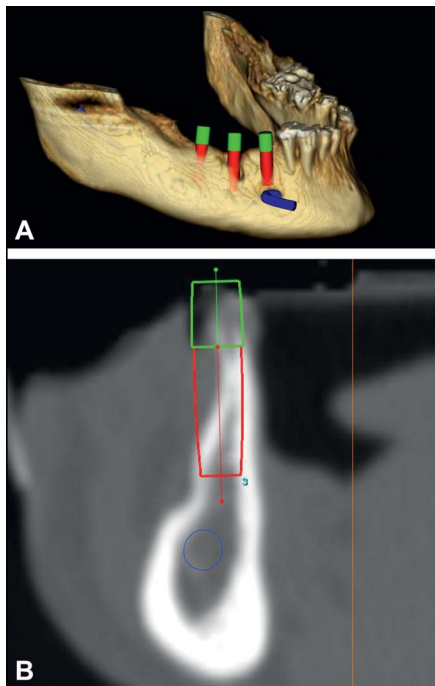


Fig. 2. 3D virtual reconstruction (A) and paraxial CT scan (B) showing alveolar bone horizontal deficit.

advantages by reducing operative time, cost, discomfort, and postoperative morbidity.^{28,33,37}

The use of a mineralized cortico-cancellous bone allograft can eliminate the additional surgical procedure required to harvest an autograft, but the precision modeling required to adapt the tissue to the defect site can add significant time and stress to the surgical procedure. This can result in a less-than optimal fit between the allograft and the ridge defect.³⁸ Therefore, the most frequent complication in using allograft or xenograft bone blocks is infection. Usually, infection occurs when there is an uncovering of the graft during the healing phase or from contamination of the block during the shaping phase. For this reason, the longer the shaping phase, the more likely the contamination of the graft.^{19,39}

Alternatively, data from a computerized tomographic (CT) scan can be used to shape a precise 3D homologous bone block using a computer aided design-computer aided manufacturing (CAD-CAM) system. In this way, the bone block can be transferred directly from its sterile packaging to the receiving site without the need to be touched or shaped.

This case report describes an onlay technique in the posterior atrophic mandible using dehydrated homologous bone block (Botiss, Berlin, Germany), shaped with a CAD-CAM system, to avoid harvesting of

autologous bone block and to assure a perfect fitting of the block above the alveolar crest. This technique can significantly shorten the actual surgical procedure for the patient and result in a better fitting graft than that the chair-side preparation allows and reduce the risk of infection to the bone graft.

CASE REPORT

A 48-year-old systemically healthy woman was referred to a private practice in Brescia for a fixed prosthetic rehabilitation of the second premolar and molar zone of her posterior right mandible (Fig. 1).

A preliminary CT scan was performed to plan the implant positioning and to evaluate alveolar residual bone anatomy (Fig. 2, A and B). The CT scan was saved on digital support in DICOM format, and data were analyzed and revised by OneScan3D software (3DMed, L'Aquila, Italy; www.3dmed.it). Preliminary clinical and radiographic (CT) evaluations showed horizontal posterior mandibular atrophy (Fig. 3).

Thus, it was decided to horizontally increase the right posterior mandible with a homologous dehydrated bone block (Botiss) preshaped with a CAD-CAM system to have a perfect fit to the residual alveolar bone, to reduce surgery time, and to avoid possible errors during the shaping of the bone block. The patient agreed to this form of treatment.

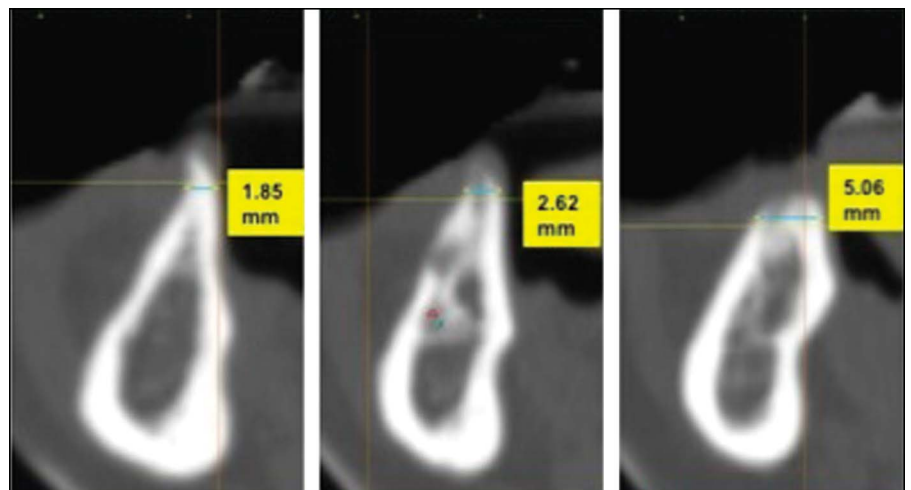


Fig. 3. Paraxial CT scans showing alveolar bone horizontal deficit.

CAD-CAM Procedure for Bone Block Manufacture

On 3D reconstruction of the atrophic jaw, a virtual bone block of known size ($3 \times 1.5 \times 1.5$ cm) was graphically represented. This is the original volume of dehydrated homologous bone block (Botiss) that was to be shaped with a 5-axis milling machine in a white room.

By means of the sliders, the parallelepiped block is placed on the bone surface receiving the graft. It is fitted inside the bone to leave a sufficient thickness of biomaterial on the buccal surface.

When the positioning of the virtual block is correct, the block can be fixed to the bone surface. With this process, the computer calculates the contact surface between bone and graft and automatically removes the excess portion (that which forms the remaining bone). The block changes color and is closely integrated with the bone. The next stage is the modeling of the outer surface of the

virtual graft using a “hand” tool where the material can be removed, spread, or added where needed. At the end of the modeling, the created graft can be viewed and the implant placement can be reviewed to assess whether the volume increased is satisfactory.

After the review, the volume of the graft is made into a Solid to Layer (STL) file. These files are used by CAM machines to make what has been created virtually into a real product, in this case, a veneer graft distally to #44. Following the above procedure, the file was sent through an email to the bone bank (Fig. 4, A–D).

Production of Maxgraft Allografts

Maxgraft (Botiss) is a sterile high safety allograft product derived from the cancellous bone of femoral heads. Femoral heads are collected in the course of total hip arthroplasty with informed patient consent following a detailed anamnesis.³⁷ The donor bone

is processed by the Cells + Tissuebank Austria (CTBA) that is certified, audited, and regulated by the Austrian Health Ministry in accordance with the regulating European directives (EU 2004/23 EC, 2006/17 EC, and 2006/86 EC) and by the Austrian Tissue Safety Act. The processing comprises ultrasonic, chemical, and oxidative treatments that remove all antigenic components and efficiently inactivate viruses and bacteria. The production process is followed by a specific lyophilization and freeze-drying procedure and sterilization by γ -irradiation. The Maxgraft bone replacement material comprises an inorganic fraction consisting of carbonated apatite and an organic fraction of structural type I collagen in physiological quantities. Similar to natural bone, Maxgraft is characterized by mutually communicating pores.⁴⁰

Patient Matched Bone Implants

Using 3D planning software (3DMed), a suitable bone implant is virtually designed based on CT or digital volume tomography scans of the patient's bone defect. At CTBA, the generated data set is converted into an STL-computer numerical control-milling file, and the allogenic bone implant is milled by a CORiTEC 340i milling machine (IMES-iCORE GmbH; Eiterfeld, Germany) under cleanroom conditions. All bone implants undergo lyophilization and final sterilization.⁴⁰

Clinical Procedure

The surgical procedure was performed under local anesthesia (Citocartin; articaine 4%, adrenaline 1:1,000,000).

After making a full-thickness crestral incision continuing into the adherent gingiva of the mesial teeth without involving their periodontal attachment, the lingual and buccal subperiosteal tissue was carefully dissected to gain adequate visibility of the underlying bone without applying tension to the ipsilateral mental nerve (Fig. 5).

The bone recipient site was perforated with a 1-mm round bur under copious saline irrigation to increase the blood supply from endosseous vessels (Fig. 6).

The dehydrated homologous CAD-CAM bone block (Botiss) (Fig. 7) was

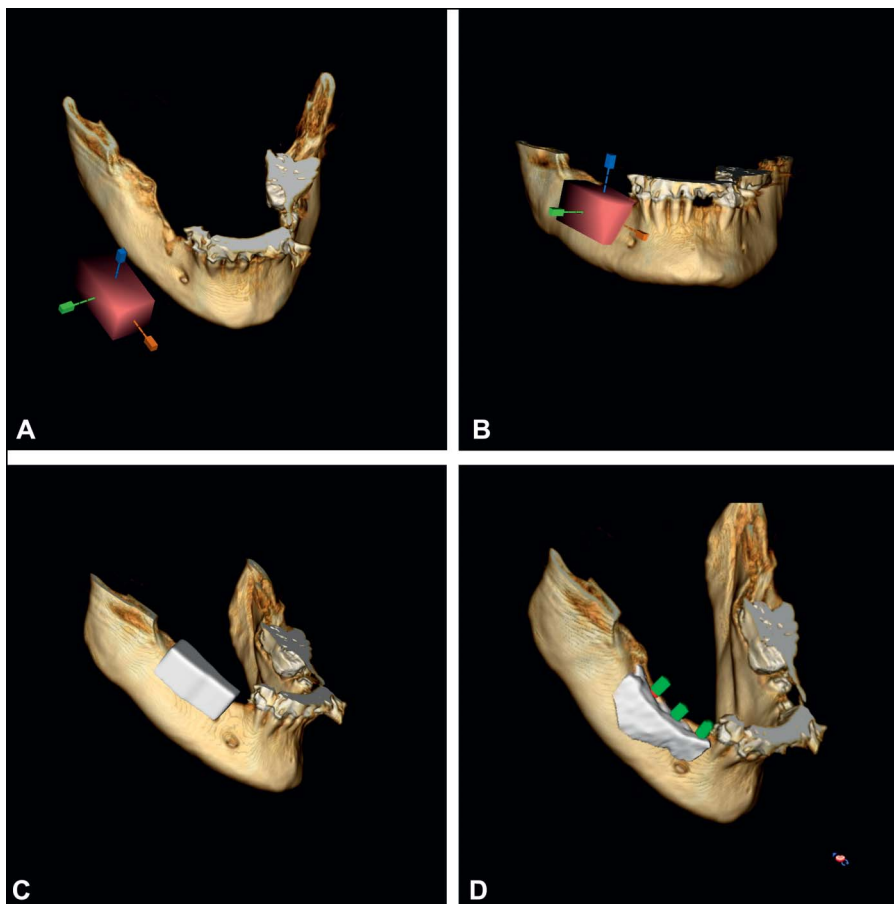


Fig. 4. A–D, Images showing the virtual workflow.

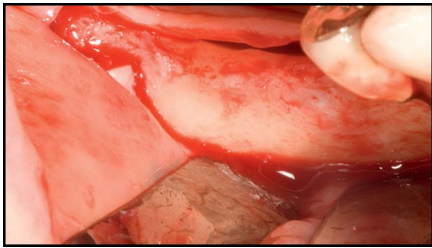


Fig. 5. Full-thickness crestral incision continuing into the adherent gingiva of the mesial teeth and dissection of buccal and lingual periosteum.

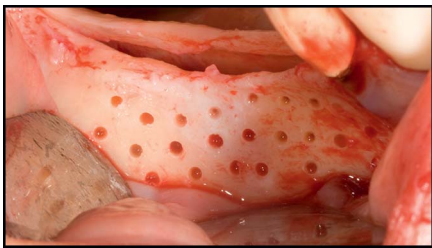


Fig. 6. Perforation of the bone recipient site with a 1-mm round bur.



Fig. 7. The dehydrated homologous CAD-CAM bone block.



Fig. 8. The bone block was fitted perfectly onto the recipient site and rigidly fixed on the mandibular ridge with 2-mm-diameter miniscrews.

fitted exactly onto the recipient site and rigidly fixed on the mandibular ridge with 2-mm-diameter miniscrews (Butterfly, Milan, Italy) (Fig. 8).

The grafted areas were covered with a resorbable barrier (Jason Collagen membrane; Botiss). After releasing the buccal periosteum, the flap was

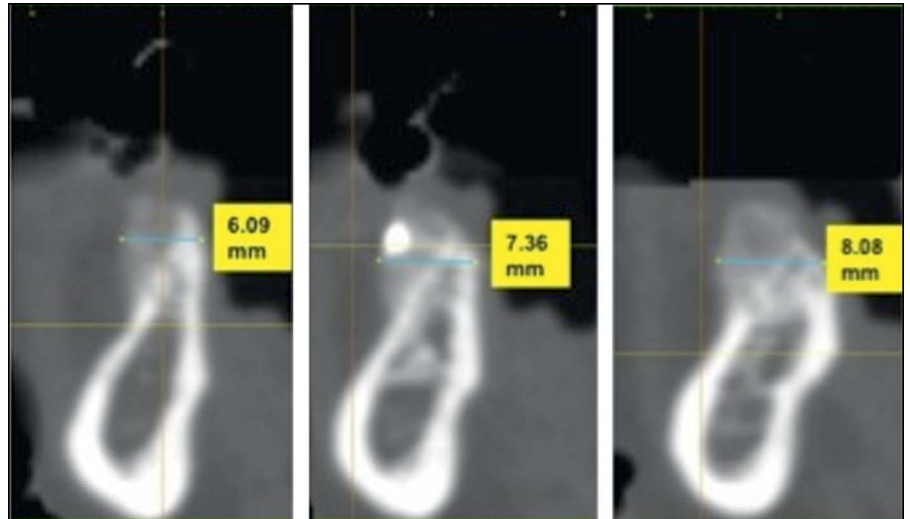


Fig. 9. Seven months after surgery, a CT scan demonstrated sufficient bone increase and density for implant insertion in the treated posterior mandible.

closed with an absorbable 4.0 suture (Caprosyn Syneture; Covidien; Dublin, Ireland).

In combination with a nonsteroidal analgesic, antibiotic therapy (ceftriaxone) was administered at a loading dose of 2 g, followed by 2 g/d for 10 days beginning the day after surgery. The postsurgical instructions included a soft-food diet for 2 weeks and appropriate oral hygiene, including twice daily rinsing with a 0.2% chlorhexidine digluconate mouthwash. The sutures were removed 15 days postoperatively.

The patient was clinically examined each week in the first month after surgery and twice in subsequent months before implant insertion. The healing process was uneventful and no neurosensory disturbance was recorded. The patient was not allowed to wear a removable denture before implant placement.

Implant Positioning and Prosthetic Procedure

Seven months after surgery, a CT scan demonstrated sufficient bone increase and density for implant insertion in the treated posterior mandible (Fig. 9).

Implants were inserted under local anesthesia by the same surgeon who had performed the grafting procedure. A full-thickness crestral incision was made, and the soft tissues overlying the reconstructed alveolar process were elevated in the posterior mandible.

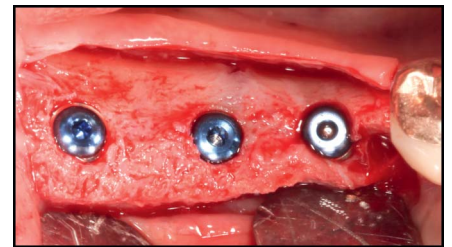


Fig. 10. Three implants were placed in locations #35, #36, and #37.

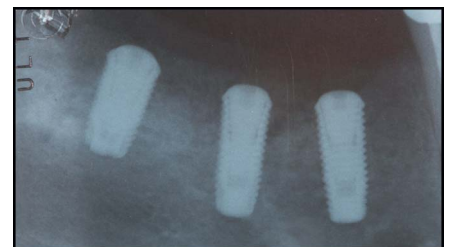


Fig. 11. Periapical radiograph after implant positioning.

Three EZ PLUS MegaGen implants (MegaGen Implant Co., Ltd., Gyeongbuk, South Korea) with internal connections were placed in locations #35, #36, and #37 (4 × 10-mm implant in locations #35 and #36 and 5 × 8.5-mm implant in location #37) (Fig. 10).

The flaps were sutured carefully with Vicryl 4.0 (Ethicon FS-2; Johnson & Johnson; New Brunswick, NJ). A periapical radiograph (Fig. 11) was taken after implant insertion to verify the correct implant position.

A 2-g dose of amoxicillin with clavulanic acid was administered preoperatively followed by 1 g twice daily for 5 days. Ibuprofen (600 mg) was prescribed to be taken as needed. A cold/soft diet and appropriate oral hygiene were recommended for 2 weeks. Sutures were removed 7 days after the surgical procedure. The patient was not allowed to wear removable dentures before implant uncovering. The postoperative recovery was uneventful.

RESULTS

Clinical Results

Horizontal bone augmentation was evaluated at the time of implant insertion by comparing the paraxial 1-mm slices on the preoperative CT scans with those obtained 7 months later. Using Onescan3D Software (3DMed), measurements were taken from the lingual cortical plate to the buccal cortical plate of the crestal ridge. After grafting and consolidation, 6.09, 7.36, and 8.08 mm (mean, 7.18 mm) of total horizontal bone was observed at sites 6, 12, and 18 mm posterior to the right mental foramen, respectively.

DISCUSSION

In the treatment of the atrophic posterior mandible, allograft bone block survival rate reported in the literature is quite good, ranging from 97.2% to 97.6%.^{39,41} However, it seems that allograft blocks were more technique sensitive than autografts and more susceptible to infection, which necessitated meticulous surgical technique and follow-up.³⁹ The main complication that occurs with the use of allografts or xenografts is the infection of the bone block.^{19,39} In a 2010 study, Chaushu reported that infection of the grafted site occurred in 18 (13%) of 137 bone blocks. In 7 (39%) of the 18 infected blocks, total graft failure was noted, and in 4 (22%) of the 18 partial graft failure was noted. Recipient site complications associated with block grafting were due to infection, membrane exposure, incision line opening, and perforation of mucosa over the grafted bone. Furthermore, infection

occurred more frequently in the posterior mandible than all other regions.³⁹

Probably, one of the most important causes of infection of the block graft depends on the time and procedure performed in shaping the graft to adapt it to the recipient site. In fact, whatever the nature of the material, there is the need to shape and model it to function with the osseous defect. Usually, the block is shaped during surgery with a bur, until a shape is obtained that fits perfectly to the receiving site. In this way, the bone block is subjected to numerous possible sources of contamination deriving from prolonged contact with the gloves of the surgeon, the oral fluids of the patient, the burs, and all such environmental factors.

So, it can be said that even with perfect execution of surgical treatment, the time taken to undertake the surgery influences the complication rate and the possible infection of the recipient site and the graft.

To decrease the contamination of the graft, some sophisticated techniques have been developed. Data from a CT scan can be used to create a sterile stereolithographic model, on which the surgeon can preshape the bone block before surgery. Another improvement has been the introduction of CAD-CAM systems. CAD-CAM systems, in the last few years, have completely revolutionized the world of dentistry.⁴²⁻⁴⁷

The accuracy of a project created using a computer is certainly greater than what could be achieved with manual systems, also the refinement of diagnostic procedures allowed by the use of CT scan, the use of dedicated programs for 3D reconstruction, and the combination with computer systems aided manufacturing has led to the creation of products of better quality and superior accuracy.⁴³

Through the CAD-CAM method, scaffolds can be created in an automated manner starting from the CT and customized to each patient and for each type of clinical situation. This greatly simplifies diagnostic and surgical procedures, reducing time and improving the precision in adapting the graft, which is critical to its integration with the surrounding bone.⁴²

Through the creation of a block exclusively using a CAD-CAM system, we had the opportunity to insert a bone block that perfectly fits the recipient site without any amendment required during surgery. The bone block arrives in the operating environment in sterile packaging and only needs to be positioned and fixed to the recipient point in the final step of the surgery. This results in a huge reduction in terms of surgical time, as the whole phase of modeling and testing of the bone graft being eliminated, allowing a more rapid closure of the surgical wound and reducing possible sources of contamination of the block, reducing the stress burden on surgical tissues that are often the cause of dehiscence and reopening of the wound, reducing all postoperative discomforts (swelling and pain) for the patient, which derive from long and difficult surgical procedures. This technique is considerably simplified, and so it is also more easily accessible to a less experienced surgeon.

CONCLUSIONS

The use of a bone block with CAD-CAM system for alveolar ridge augmentation is a valuable alternative to autograft because it reduces time, cost, complications, and morbidity for the patients. Data from a CT scan can be used to shape a precise 3D homologous bone block using a CAD-CAM system. This technique can significantly shorten the actual surgical procedure for the patient and result in a better fitting graft than that the chairside preparation allows and reduce the risk of infection to the bone graft.

To understand whether this new CAD-CAM technique can overtake chairside preparation of grafts, we are starting a randomized controlled clinical trial to compare the rehabilitation of atrophic posterior mandibles with a deproteinized homologous bone block manually shaped on the patient during surgery, versus a deproteinized homologous bone block made with the CAD-CAM system.

DISCLOSURE

The authors claim to have no financial interest, either directly or

indirectly, in the products or information listed in the article.

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