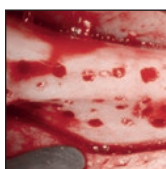


Ridge Augmentation Using Customized Allogeneic Bone Block: A 3-Year Follow-up of Two Case Reports



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A variety of surgical techniques and grafting materials for the purpose of ridge augmentation have been developed during the last three decades. Recently, the use of customized allogeneic bone blocks, prepared by CAD/CAM techniques, has been introduced. This new augmentation technology may significantly reduce surgical time and improve donor-recipient fit and adaptation. However, promising clinical and histologic results have been published in only a few short-term case reports. The 3-year follow-ups of these two case reports may provide more clinical data on the use of the customized bone blocks for horizontal and vertical ridge augmentation in the posterior mandible. Int J Periodontics Restorative Dent 2020;40:881–889. doi: 10.11607/prd.3354

Loss of alveolar bone volume is an inevitable outcome after tooth extraction.¹ Resorption occurs primarily on the buccal aspect and increases over time.² Ridge augmentation should be performed when appropriate 3D positioning of implants cannot be achieved in the residual bone.

Several techniques have been developed that allow for reconstruction of the deficient ridge. Guided bone regeneration, which uses particulate bone grafting materials, allows easy contouring but requires a complex membrane fixation for graft stabilization and isolation from surrounding soft tissues. Furthermore, membrane removal must precede implant placement and usually requires clinically demanding techniques.^{3–5} Resorbable membranes do not require removal. However, they lack adequate stability, particularly when used for vertical augmentation.⁶

In contrast to particulate materials, autogenous block grafts have the advantage of easy and stable fixation using osteosynthesis screws.⁷ In one study, dehiscences occurred in up to 50% of the patients when vertical alveolar onlay grafting was used.⁸ Furthermore, when extra- or intraoral donor sites are used, an increase in surgical time and patient discomfort may often be involved.^{9,10}

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As an alternative to autografts, various allograft materials have been developed, showing predictable results in different grafting indications.^{11,12} Short- and long-term studies show predictable bone regeneration at alveolar defect sites using dehydrated allogeneic bone blocks.^{7,13} However, blocks that were not perfectly adapted to the contour of the defect showed some resorptive changes.⁷

A new allograft augmentation technique was recently introduced that further reduces surgical time and significantly improves donor-recipient fitness and adaptation. The technique uses customized allogeneous bone blocks (CABBs) individually shaped for the recipient site and applies preoperative dental CT and a CAD/CAM technique.¹⁴ In two short-term studies using CABBs, it was clinically demonstrated that none or minimal postoperative block resorption occurred.^{15,16} Histologically, there was active bone remodeling of the augmentation material, similar to noncustomized bone blocks.¹⁷ Newly formed bone surrounded most of the individual bone substitute remnants. Normal bone marrow was visible between the bone trabeculae. Absorption of the material was regularly observed, directly connected with new bone apposition.^{15,16}

The aim of this case report is to demonstrate long-term clinical and radiographic observations of CABBs, as used for one horizontal and one vertical ridge augmentation procedure for functioning implant-supported restorations.

Clinical Case Reports

Case 1 Patient Presentation

A 52-year-old man was referred to the clinic requesting restoration of his mandibular left posterior dentition with an implant-supported restoration. The patient was systematically healthy and a nonsmoker. Clinical examination revealed loss of all mandibular left molars, resulting in typical horizontal and vertical ridge resorption. CT scanning demonstrated that approximately 5 mm of vertical bone height was missing for the safe placement of two 10-mm implants.

Planning and Manufacturing of the Block Graft

Human cancellous bone derived from the head of the tibia was used as block material. CT scans were performed as described by Shlee and Rothamel.¹⁵ To evaluate the ideal implant position, a waxed-up radio-opaque scan prosthesis was worn by the patient. Data was transferred to 3D planning software (SimPlant, Materialise). Ideal implant positions and respective defect morphology were defined when function and esthetics were considered. A special software tool was used to draw the missing bone area directly onto the 3D surface of the deficient ridge. The data providing 3D information about the bone graft morphology were converted into a standard tessellation language (STL) file and sent to the company (Materialise). There, computer numerical control programming was carried out, and the graft was milled out of

an allogeneic bone block. After cleaning, packaging, and sterilization, the individual bone block was delivered to the author's clinic.

Bone Block Grafting

The CABB was completely rehydrated with 0.9% saline solution using a sterile syringe for approximately 10 minutes.

Surgery was performed under infiltration with local anesthesia (lidocaine 2% with norepinephrine 1:100,000, Teva Pharmaceuticals). A midcrestal incision was made at the recipient site and extended intrasulcularly to the neighboring teeth. Releasing incisions were made only for the buccal flap, mesially to the mandibular left canine and distally at the end of the crestal incision. On the buccal side, a full-thickness flap was raised to the mucogingival junction. After separating the periosteum, a split-thickness technique was used to prepare the flap. Lingually, a full-thickness flap was prepared, and the periosteum was carefully separated at the base to allow for flap mobilization and tension-free soft tissue closure over the graft. Residual soft tissue was removed to obtain access to the bone. However, the immediate supracrestal Sharpey fibers were retained at the root surface neighboring the ridge defect. The recipient cortical bone was perforated with a fissure bur to support blood vessel outgrowth (Fig 1a). The reshaped and rehydrated bone block was applied and fixed in place using two osteosynthesis screws (Biomet Microfixation; Fig 1b). A 5-mm-diameter round diamond bur (H14B, Strauss) was used to round

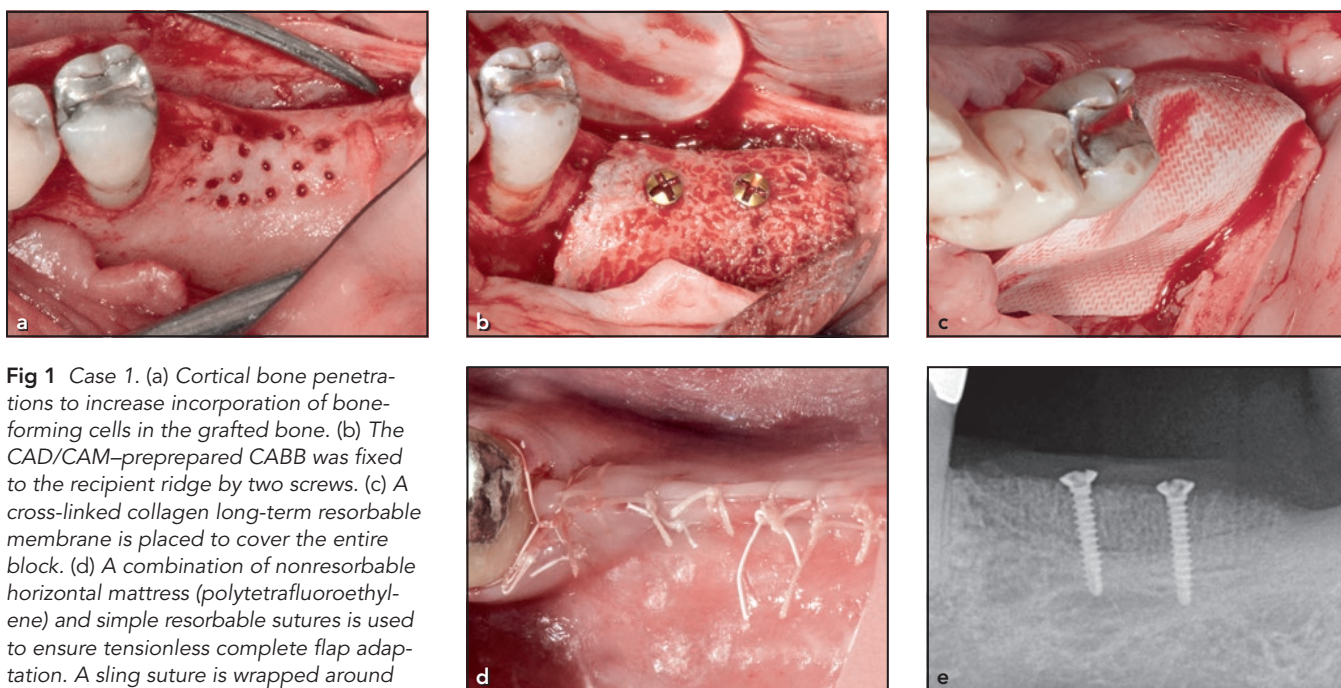


Fig 1 Case 1. (a) Cortical bone penetrations to increase incorporation of bone-forming cells in the grafted bone. (b) The CAD/CAM-prepared CABB was fixed to the recipient ridge by two screws. (c) A cross-linked collagen long-term resorbable membrane is placed to cover the entire block. (d) A combination of nonresorbable horizontal mattress (polytetrafluoroethylene) and simple resorbable sutures is used to ensure tensionless complete flap adaptation. A sling suture is wrapped around tooth 35 (FDI system) to ensure flap adaptation to the root surface. (e) Radiographic view of the block adaptation close to the recipient site with the help of the fixation screws.

and smooth the sharp bony edges of the bone block and to minimize the possibility of postoperative soft tissue dehiscence. A cross-linked membrane (OSSIX Plus, Datum Dental) was applied to cover the grafted block (Fig 1c). Flaps were repositioned and sutured passively with a combination of 4-0 polytetrafluoroethylene horizontal mattress sutures (PTFE Suture, Golnit) and simple interrupted 5-0 polyglactin sutures (Vicryl Rapide, Ethicon). Additionally, a sling/anchoring suture was applied around the second premolar to ensure close flap adaptation to the tooth surface (Fig 1d). Finally, a conventional periapical radiograph was taken, documenting the complete adaptation of the block graft to the recipient site (Fig 1e).

Post-Block Grafting Protocol

The patient was instructed to avoid any mechanical trauma of the wound. Tooth brushing in the treated area was not allowed for 2 weeks. Plaque control was achieved by rinsing the mouth with 0.2% gluconate chlorhexidine (Tarodent, Taro) twice a day for 1 minute. Narocin tablets (275 mg, Teva) were prescribed as a nonsteroidal and anti-inflammatory analgesic, four times daily for 3 days. Augmentin tablets (875 mg, SmithKline Beecham) were prescribed, twice daily for 5 days. Sutures were removed 2 weeks after surgery. Wound healing processes were carefully inspected every week for the first month, every 2 weeks for the next 2 months, and every 4 weeks for

the last 3 months before graft exploration.

Implant Insertion

After 6 months of uneventful healing, the ridge appeared well augmented and lined with healthy keratinized soft tissue (Fig 2a). CT scanning revealed no signs of vertical bone resorption. Using MSOFT software (Swissmeda), two 5-mm-wide and 10-mm-long implants were planned for sites 36 and 37 (FDI system). It was noted that while the site-37 implant was planned for positioning exactly where the distal fixation screw was located, the site-36 implant was positioned just mesially and close to the mesial fixation screw. A surgical stent for the preplanned bone drilling was fabricated

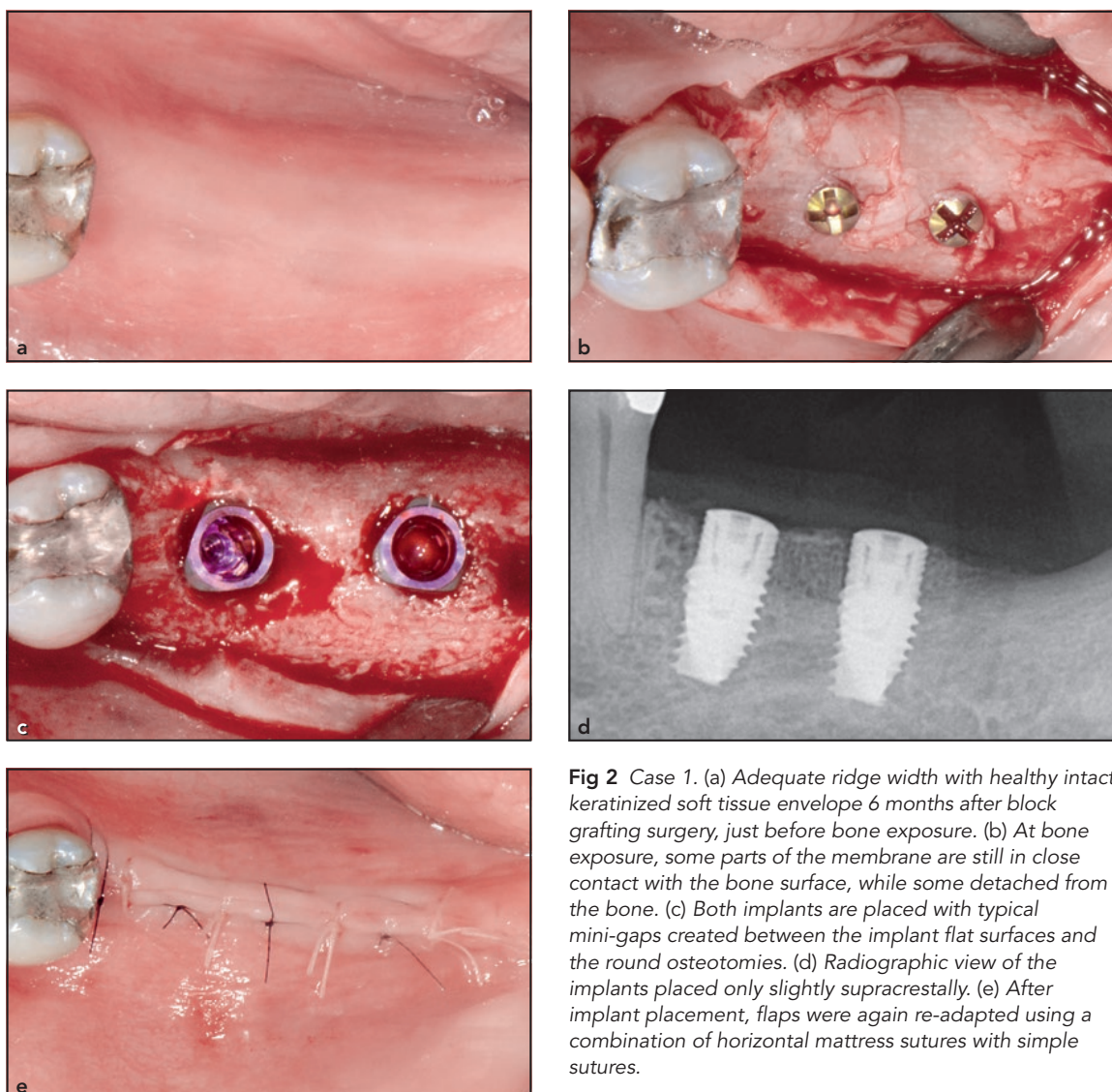


Fig 2 Case 1. (a) Adequate ridge width with healthy intact keratinized soft tissue envelope 6 months after block grafting surgery, just before bone exposure. (b) At bone exposure, some parts of the membrane are still in close contact with the bone surface, while some detached from the bone. (c) Both implants are placed with typical mini-gaps created between the implant flat surfaces and the round osteotomies. (d) Radiographic view of the implants placed only slightly supracrestally. (e) After implant placement, flaps were again re-adapted using a combination of horizontal mattress sutures with simple sutures.

(Mguide, Stratasys). Full-thickness flaps were elevated in the augmented area, which revealed a mostly intact membrane closely lining the bone block. Although not necessarily indicated, the membrane was peeled off from most parts of the underlying bone. The exposed bone graft was found well-incorporated with the recipient bone with no evidence of significant resorptive changes (Fig 2b). The two fixation screws were removed. Drilling of the im-

plant sites was initiated, the insertion torque of which indicated a type 2 bone quality of the integrated block. As planned, the two wide-diameter implants (V3, MIS) were inserted in a two-stage protocol (Fig 2c). The aim was to position the implants slightly subcrestally. However, due to unforeseen bone resistance, the final positioning became slightly supracrestal (Fig 2d). To allow for more bone maturation, it was decided to place the implants in a two-

stage surgical protocol. Care was taken to ensure close flap adaptation using a combination of horizontal mattress 6-0 polyamide sutures (Ethicon) with simple interrupted 5-0 polyglactin sutures (Vicryl Rapide; Fig 2e).

Abutment Connection and Final Restoration

As expected, the covering soft tissue remained healthy and intact over the following 2 months, at

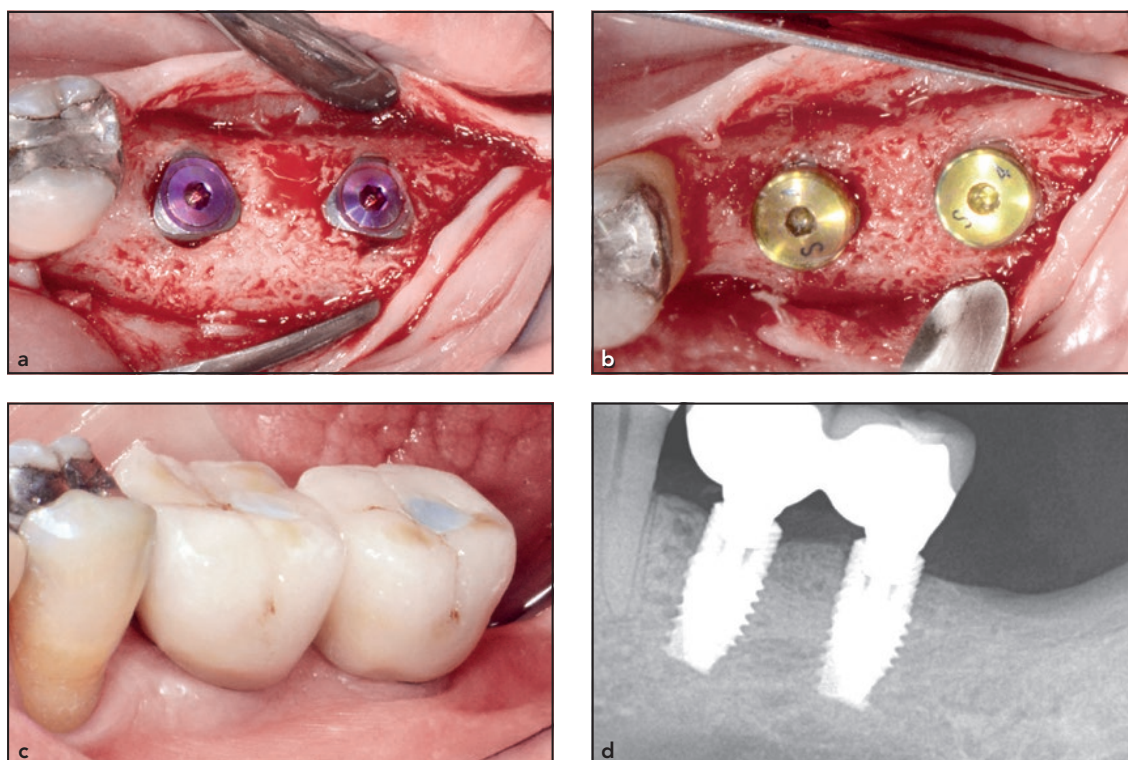


Fig 3 Case 1. (a) At 2 months after implant placement, there is slight narrowing of the mini-gaps at most implant aspects. (b) Abutment screws are connected. (c) Clinical view 3 years after connection of the porcelain screw-retained restoration. Note the stability of the peri-implant soft tissues. (d) Radiographic view 3 years after connection of the porcelain screw-retained restoration. Note the stable density of grafted bone with minimal crestal resorption.

which time a midcrestal incision was made, taking care to maintain at least 2 to 3 mm of keratinized tissue at each flap edge. Full-thickness flaps were slightly elevated, exposing well-integrated implants with most surfaces in close proximity to the surrounding osteotomy walls. However, the mini-gaps between the implants and the osteotomy walls were not completely filled with newly regenerated bone (Fig 3a). Two healing abutments were connected (Fig 3b), and the flaps were sutured. After 1 month, the abutments were completely surrounded by healthy attached keratinized tis-

sue. After 3 additional months, a screw-retained, implant-supported partial denture was placed. To allow for improved accessibility of brushing devices and continuous maintainability of cleanliness and health around the implants, care was taken to place the crown margins slightly above tissue level and to maintain wide, open embrasures. A clinical follow-up 3 years later demonstrated healthy and stable appearance of the peri-implant soft tissues (Fig 3c). A periapical radiograph revealed stable grafted bone density with minimal crestal resorption (Fig 3d).

Case 2

A 58-year-old woman presented to the clinic with a request to restore her partially edentulous mandibular left side with a fixed implant-supported restoration.

Planning and manufacturing of the CABB as well as grafting of the bone at the recipient site were basically performed as discussed in Case 1 (Figs 4a and 4b). The post-bone grafting protocol also followed similar guidelines. Following 6 months of uneventful healing, the full body of the grafted bone was exposed with no noticeable resorp-

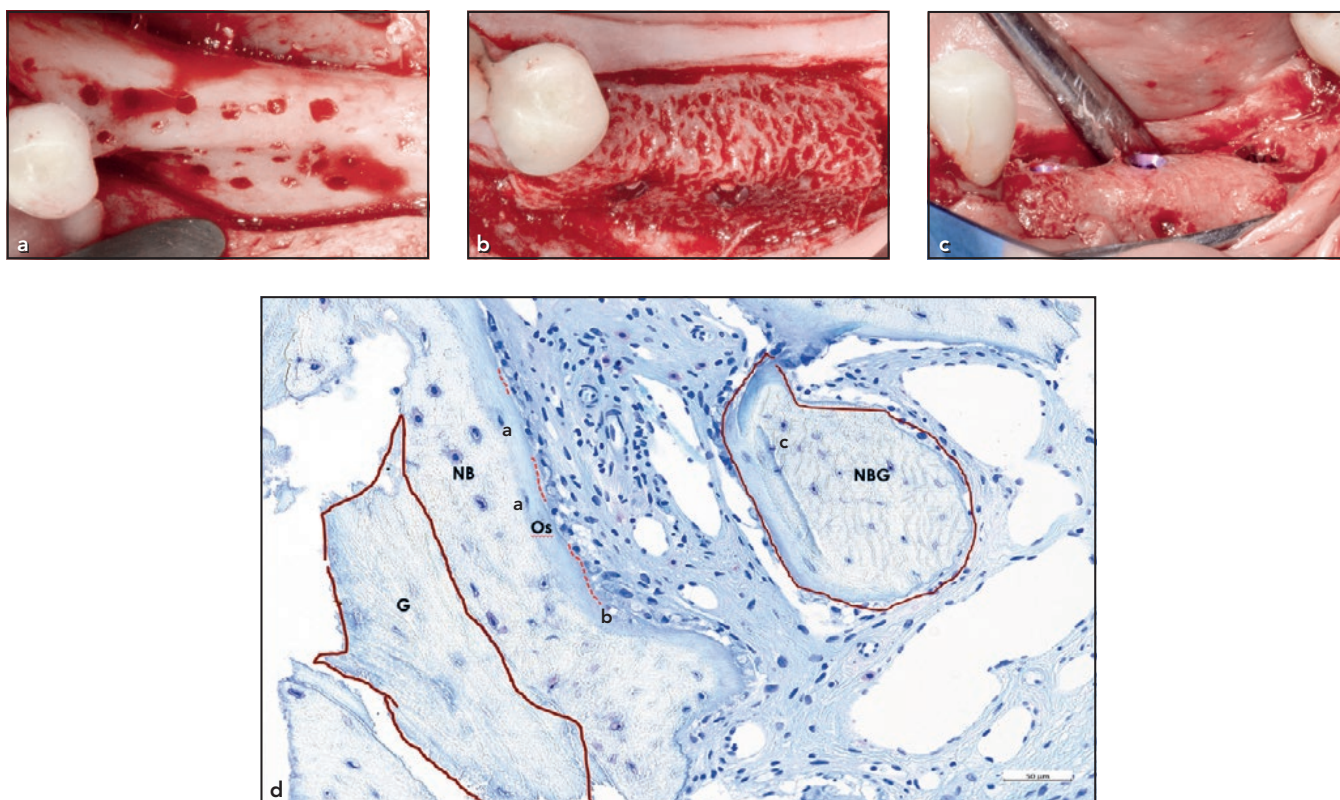


Fig 4 Case 2. (a) The occlusal view shows a thin, horizontally resorbed ridge with cortex penetrations. (b) The allogeneic bone block is fixed to the recipient ridge by two screws. (c) Implant exposure 3 months after implant placement. (d) Histologic sample demonstrating bone remodeling activity. G = graft particles; NB = new bone; NBG = graft particles replaced by new bone (note the few residing osteocytes); Os = osteoids; a = osteoblasts trapped between osteoid and new bone; b = osteoblast in osteoid production layer; c = osteocytes; dotted line = osteoid line, lined by osteoblasts; solid line = particle borders.

tive changes. Using the same technology for the fabrication of the surgical guide and the same surgical protocol as described in Case 1, three implants (11.5 mm long, 4.1 mm wide; Seven, MIS) were slightly subcrestally placed. After 3 months, implants were surgically exposed (Fig 4c), and a bone biopsy sample from the periphery of the graft was taken for histologic analysis; it demonstrated clear bone remodeling activity (Fig 4d). Three healing abutments were connected, and a

screw-retained porcelain-unit partial denture was connected 2 months later. Clinically, the partial denture presented with wide embrasures and a healthy—albeit narrow and somewhat thin—band of keratinized marginal soft tissue, reflecting the darkish color of the titanium abutments (Fig 5a). Radiographically, bone profiles were found to be solid with minor crestal resorption (Fig 5b). A clinical follow-up 3 years after delivery of the final partial denture demonstrated slight marginal tissue

recession, and a radiographic examination indicated stable bony profiles (Figs 5c and 5d).

Discussion

Extensive augmentation of the severely compromised alveolar process is often treated with autogenous blocks from intra- or extraoral donor sites.^{9,18} The use of allogeneous mineralized collagen blocks may avoid donor site morbidity, thus reducing

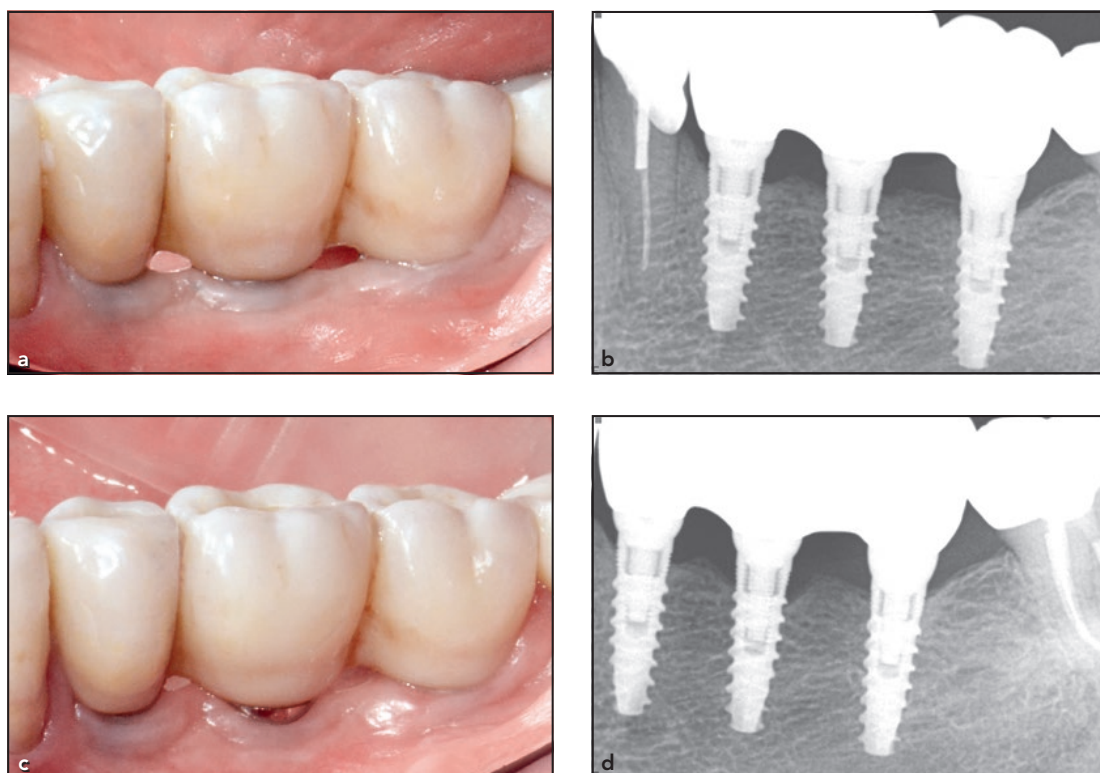


Fig 5 Case 2. (a) Final screw-retained restoration placed 1 year after block placement, 6 months after implant placement, and 3 months after the abutment connection. Note the open embrasures ensuring accessibility and maintainability. (b) Radiographic view of the final screw-retained restoration. Note the minor crestal bone resorption. (c) Clinical view 3 years after connection of the screw-retained porcelain restoration. Note the minimal tissue recession at implant site 36. (d) Radiographic view 3 years after connection of the screw-retained porcelain restoration. Note the stable density of grafted bone with minimal crestal resorption.

the risk of complications and peri-operative discomfort for the patient.^{17,19}

The allograft material used for the production of CABBs is well established for dental and orthopedic applications.^{15–17,19–21} Particles of this material are nearly completely absorbed and replaced by new vital bone in the maxillary sinus within 8 to 10 months.^{22,23} It has also been successfully used for a variety of periodontal defects.^{24,25} Implants placed in extraction sockets after

grafting with this material had a 3-year survival rate of 97.6%.²⁶ After tumor resection, large defects exceeding 100 cm³ have been successfully reconstructed with this material.²⁷ Additionally, articles published in 2013 and 2019 on the use of CABB demonstrated histologic evidence of resorption and replacement of the mineralized grafted bone block by newly regenerated bone.^{15,16} This is further supported by histologic evidence of bone remodeling activity as demonstrated

in Case 2 in the present article. Stabilization and close contact of the block surface to the recipient bed are considered crucial for a successful outcome. Since individually performed blocks do not need to be trimmed chair-side, they fit perfectly to the recipient site, thereby significantly reducing surgical time and the possibility of graft contamination.

As with particulate graft materials, the use of a membrane barrier placed between the block and the flaps seems to be crucial for pre-

venting connective tissue-forming cells to participate in the graft healing. A long-term resorbable membrane could efficiently serve this purpose. Since graft fixation is facilitated using CABB, it may be unnecessary to fixate the membrane. However, a tensionless flap design is mandatory to retain a closed flap during healing. In addition to mattress sutures used for close adaptation of the connective-tissue flap edges, it is advised to use a sling suture wrapped around the tooth to ensure close contact between the flaps and the tooth surface facing the grafted site.²⁸

The present author prefers to allow a minimum of 6 months for allogeneic bone blocks to mature before implant placement and to submerge the implants under the flaps for an additional 3 months (two-stage surgery), as with particulate bone grafts.^{29–31} This will probably allow for increased maturation of the crestal bone graft. Crestal bone resorption after implant installation, a recognizable phenomenon when using most implant systems, is owed to the remodeling around the implant or further remodeling of CABB. It was also shown that implants placed in preexisting bone show crestal bone loss. Several theories have been stated about this phenomenon, including microleakage at the implant-abutment connection,³² inflammatory effects based on sealing material,³³ natural development of the biologic width,³⁴ and presence of a thin layer of mucosa.³⁵

Conclusions

In the present two cases, it may be assumed that the relative crestal stability around the implants could be attributed to multiple factors, such as quality of materials used, implant placement in a two-stage surgery, presence of attached keratinized tissue around the implants, maintainable restorations, adequate occlusal schemes, and meticulous plaque control. However, the role and relative significance of these factors to the overall result as presented in this article remains to be studied. Finally, the author finds it necessary to investigate the long-term clinical and histologic results of the presented treatment modality.

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