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The Use of Cancellous Bone-Block Allograft for Reconstruction of the Atrophic Alveolar Ridge

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1. Introduction

The remarkable success of the traditional Brånemark implant protocol (Adell et al., 1981; Albrektsson et al., 1981; Branemark, 1983) revolutionized dentistry. The presence of uncompromised bone of adequate volume at the implant site is a major factor in the functional success of the procedure. In addition, by providing predictable support both for the implant itself and for the gingival margin and papillae, it contributes to a pleasing esthetic outcome (Belser et al., 2004; Grunder et al., 2005; Palacci & Ericsson, 2001). A good functional result is also impossible without proper biomechanics, as occlusal overload by the final prosthesis can lead to biological or mechanical complications (Rangert et al., 1995). The forces applied along the axis of the implant are distributed around the implant, resulting in high load-bearing on the peripheral supporting bone, especially in the premolar–molar region of the jaws. Furthermore, in the anterior maxillary area, the forces are exerted in significantly transverse direction which leads to a bending momentum that may adversely affect both the implant and the supporting tissues (Rangert et al., 1989). Narrow implants, implants tilted buccally, and implants with oversized clinical crowns can all be detrimental (Hsu et al., 2007).

Therefore, augmentative bone surgery is frequently a prerequisite of implant placement (Belser et al., 2004; Grunder et al., 2005; Palacci & Ericsson, 2001; Sethi & Kaus, 2001). Unlike the sinuses, the alveolar ridge does not provide a natural cavity to contain particulated grafting material (Chaushu et al., 2009); therefore, the graft must be have sufficient strength and rigidity to fixate at the recipient site and three-dimensional stability to withstand muscular forces (Moy & Palacci, 2001). Autogenous bone harvested from either extraoral or intraoral sites is regarded as the "gold standard" by some authors (Lundgren et al., 2008), and it remains the material of choice for cortical-cancellous blocks (D'Addona & Nowzari, 2001; Hunt & Jovanovic, 1999; Misch et al., 1992; Verhoeven et al., 1997). However, its use is limited by risks of donor site morbidity: immediate postoperative pain and edema, infections, hematomas, and neurosensory deficits (Nkenke et al., 2001; Nkenke et al., 2002; Raghoebar et al., 2001). A variety of alternative allogeneic, alloplastic and xenogeneic bone-grafting materials have been proposed in recent years, based on wound-healing mechanisms and bone regeneration principles, such as tissue engineering, and the

osteoinductive and osteoconductive potential of different scaffolds (McAllister & Haghighat, 2007). Although cancellous bone-block allografts have been used for alveolar ridge augmentation with clinical success (Keith Jr., 2004; Keith Jr., et al., 2006; Leonetti & Koup, 2003; Lyford et al., 2003; Nissan et al., 2008; Petrungaro & Amar, 2005), there is still lack of histological evidence regarding the biological healing process.

The aim of this chapter is to describe the technique and long-term (6 years or more) outcome of dental implants placed in the atrophic alveolar process following augmentation with freeze-dried cancellous block allografts. The histological and histomorphometric findings are reported as well. The studies were performed at the Tel Aviv University in 2005 to 2011.

2. Procedure and clinical outcome by anatomical area

2.1 Anterior maxilla

2.1.1 Surgical technique

Block grafts were indicated for bony deficiencies measuring at least 3 mm horizontally and up to 3 mm vertically on computed tomography (CT) para-axial reconstruction, as recommended (Chiapasco et al., 1999). Surgery was performed under local anesthesia. The shape and size of the defect on preoperative imaging were corroborated at the recipient site (Figs. 1-3).

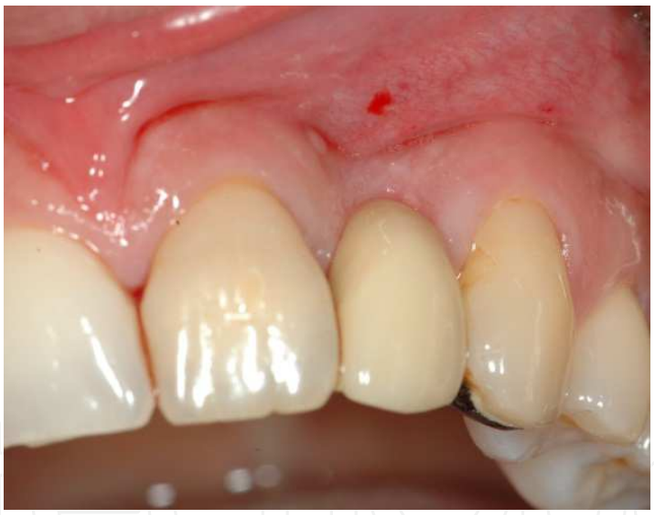

Fig. 1. Anterior maxilla. Preoperative clinical view.

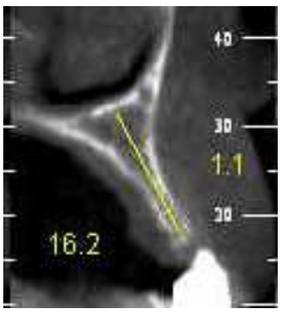

Fig. 2. Anterior maxilla. Preoperative CT.

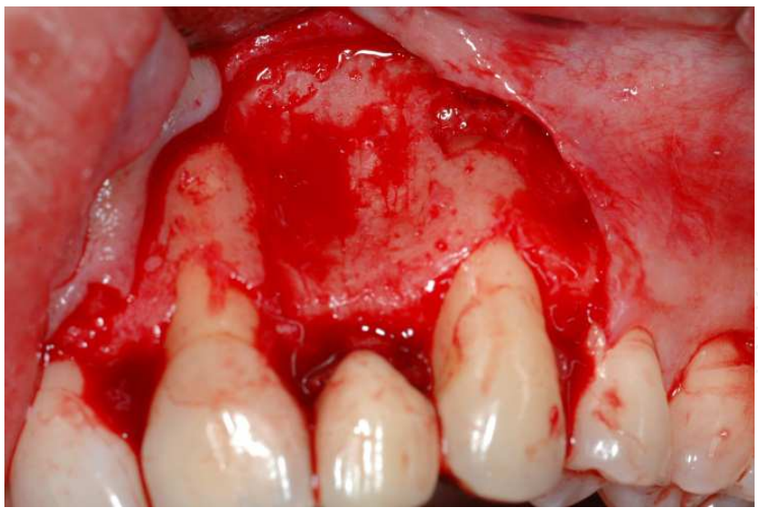

Fig. 3. Anterior maxilla. Clinical view demonstrating bone defect.

A vasoconstrictor (1:100000) was administered subperiosteally for easier separation of the bone and periosteum, and surgery was initiated about 10 minutes later. A midcrestal incision was made on the basis of the missing teeth and extended intrasulcularly around the cervical margins of the adjacent teeth up to the canines. Two releasing incisions were made on the labial aspect distal to the canines, including the papilla between the canine and the first premolar and extending away from the esthetic zone into the mobile mucosa. This exposed the buccal aspect of the alveolar ridge so the defect could be visualized directly in three dimensions. Because these maneuvers are accompanied by excessive bleeding, periosteal releasing incisions were made already at this stage, with at least 1 cm of overlapping tissue, so the site could be primarily closed under clear direct vision without the need for hemostasis.

Several techniques were used to ensure the broadest communication possible between the grafted bone and the bone marrow cavity. In the presence of noticeable cortical bone, we made multiple perforations through the cortical plate with a round bur. If the cortical bone was dense, decortication was performed. No additional preparation was used in cases presenting after trauma or surgery without evident cortex and profound bleeding.

Freeze-dried cancellous block-allografts were rehydrated in a solution of sterile saline for 45 minutes. A high-speed water-cooled fissure bur, in a handpiece was used to shape the graft to approximate the recipient bed and provide sufficient height and width. The graft was then thoroughly rinsed with sterile saline to remove residual bone particles.

The width and height of the ridge were measured with periodontal probes scaled in millimeters, and the cancellous block-graft was fitted into the defect. Once it was seated and stable, it was fixed with 1.6 mm x 10 mm bone screws (Fig. 4).

The bur was reapplied to round any sharp cortical edges and shape the block to completely conform to the defect site, and width and height measurements were repeated. Deficiencies at the edges of the graft were filled with particulate bone. The graft was covered with long-term resorbable collagen membrane (Fig. 5).

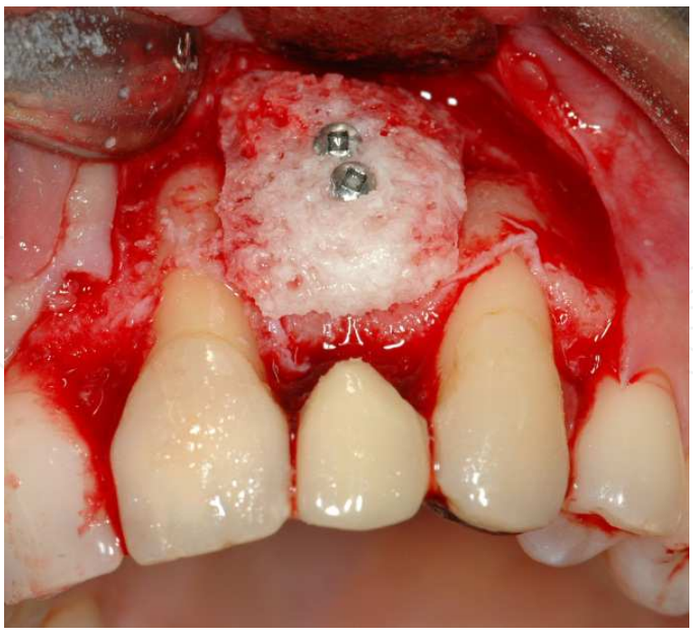

Fig. 4. Anterior maxilla. Bone block fixation.

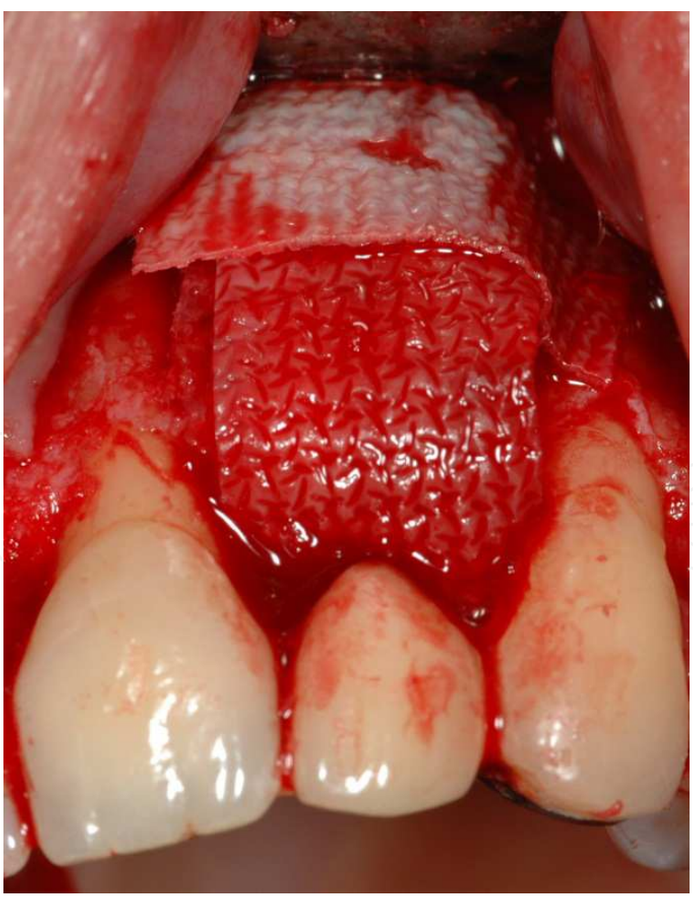

Fig. 5. Anterior maxilla. Membrane coverage.

The midcrestal incision was initially closed with interrupted or horizontal mattress sutures, as needed, and the interdental papillae and vertical incisions were secured with interrupted sutures. Patients were prescribed oral antibiotics and analgesics for 5 days postoperatively and antiseptic solution for 2 weeks. Provisional restorations were modified to prevent pressure on the healing tissues and fitted and delivered to the patient immediately after surgery.

The grafted sites were allowed to heal for 6 months. Patients were seen weekly during the first postoperative month and monthly thereafter until second-stage surgery. Each visit included a thorough clinical search for soft tissue dehiscence or color change and an overall view of the grafted ridge contour. Periapical radiographs were taken immediately after surgery and again before implant placement to corroborate graft incorporation.

For the second-stage surgery, access to the augmented ridge was obtained via incision, similar to the one used during graft placement. Surgical exposure revealed a well-integrated block graft into the surrounding bone. The fixation screws were removed, and the post-augmentation ridge was measured again to confirm bone gain. The dental implant was then placed (Fig. 6).

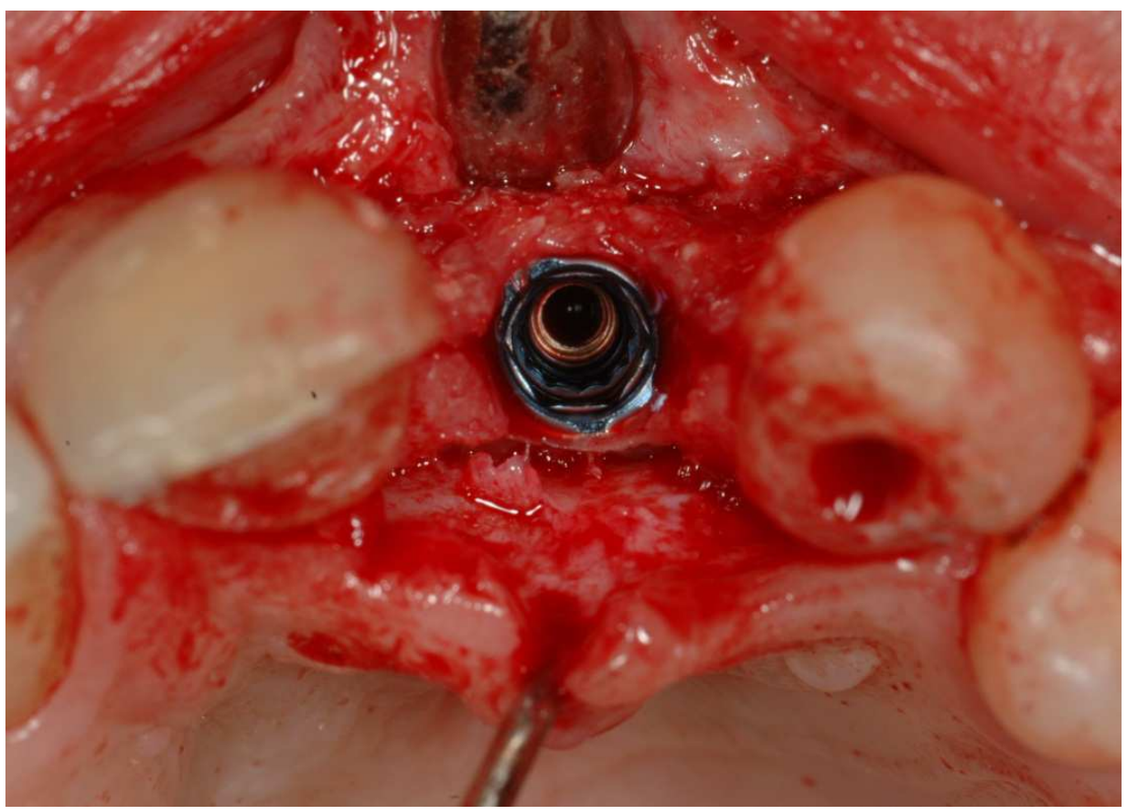

Fig. 6. Anterior maxilla. Implant placement 6 month after bone grafting.

The residual buccal thickness was measured to assess bone resorption and buccal bone dimensions. The soft tissues were allowed to mature for 3 weeks following implant exposure (Fig. 7).

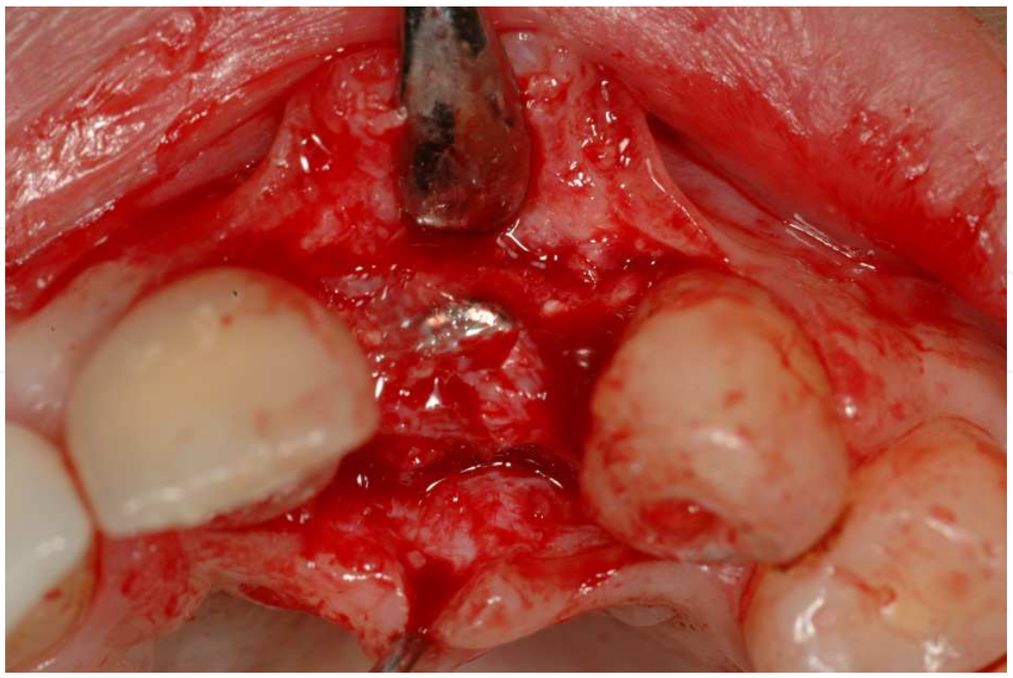

Fig. 7. Anterior maxilla. Soft tissues at second-stage surgery.

A cement-retained fixed-cement prosthesis was fabricated, and the implants were restored (Fig. 8).

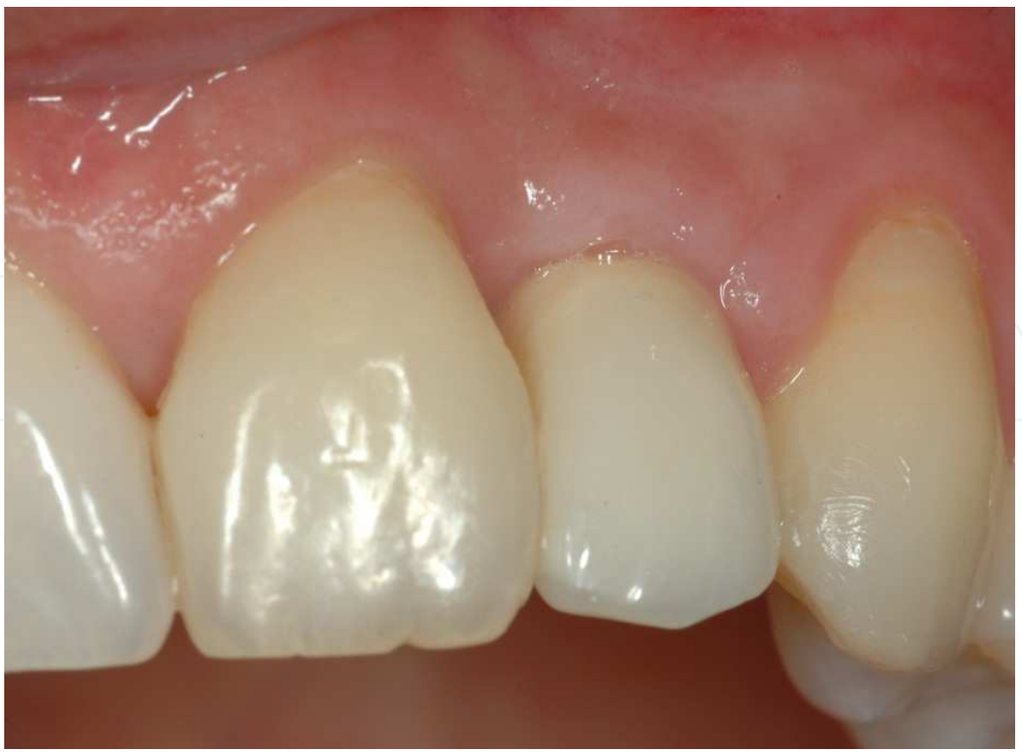

Fig. 8. Anterior maxilla. Final restoration.

Clinical and radiographic examinations were carried out at the time of restoration, every 6 months during the first year, and once a year thereafter (Fig. 9).

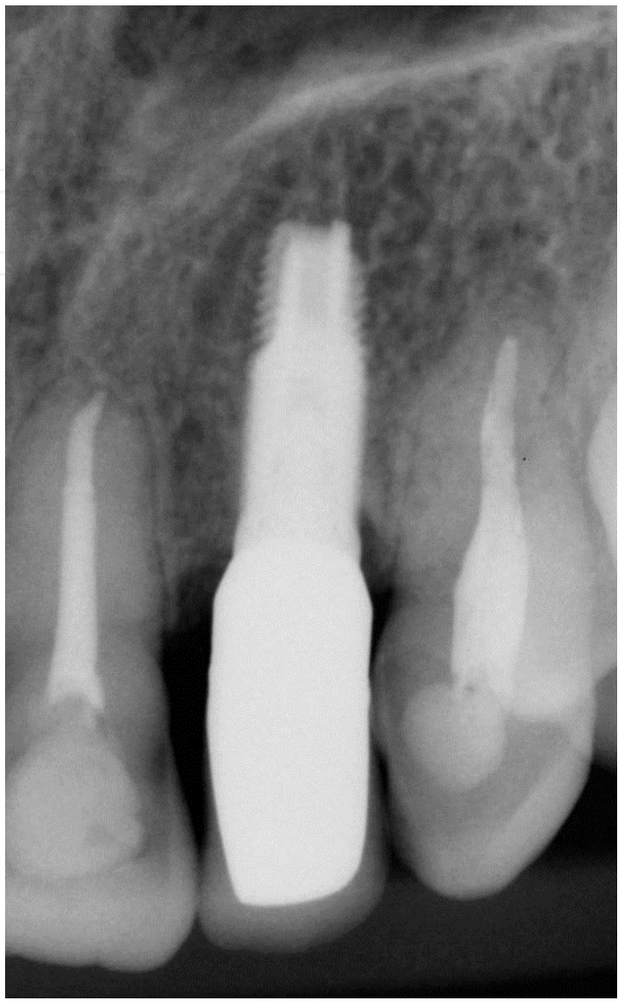

Fig. 9. Anterior maxilla. Periapical view at 4-year follow-up.

2.1.2 Clinical outcome

Use of this technique by our group yielded a greater bone gain in the horizontal dimension (5 ± 0.5 mm) than in the vertical dimension (2 ± 0.5 mm) (Nissan et al., 2011a). The buccal bone resorption rate was 0.5 ± 0.5 mm at implant placement and 0.2 ± 0.2 mm at the second-stage surgery; bone thickness buccal to the implant neck was 2.5 ± 0.5 mm at implant placement and 2.3 ± 0.2 mm at second-stage surgery. There was no evidence of vertical bone loss between the two time points. All patients received a fixed implant-supported prosthesis Two bone grafts failed, for a survival rate of 95.6%. One implant failed, caused by a vehicular accident. The implant was reinserted after 3 months and successfully osseointegrated (98% survival rate). All implants remained clinically osseointegrated at the end of the follow-up. There was no crestal bone loss around the implants beyond the first implant thread.

2.1.3 Comment

The use of dental implants in the anterior maxilla is well documented in the literature, and numerous controlled clinical trials report high overall implant survival and success rates (91.1% to 100%) (Belser et al., 2004). The bone volume in the anterior maxilla is essential from an esthetic perspective (Grunder et al., 2005): To achieve a satisfactory long-term result, the available bone thickness buccal to the implant neck should be at least 2 mm and preferably 4 mm (Spray et al., 2000). When this is not taken into consideration, the buccal bone may resorb, resulting in loss of buccal bone height followed by gingival recession. Since such bony thickness dimensions cannot be found routinely on the buccal side, augmentation procedures are indicated in almost every esthetically demanding case. Thus, even if the entire implant bony envelope is intact without thread exposure, bone grafting will be needed (Grunder et al., 2005). We found that a 2-3 mm buccal bone thickness was maintained at the second-stage surgery when cancellous block-allografts were used.

2.2 Posterior maxilla

2.2.1 Surgical technique

Cancellous block-allografts were indicated for posterior atrophic maxillas of ≤4 mm (Fig. 10).

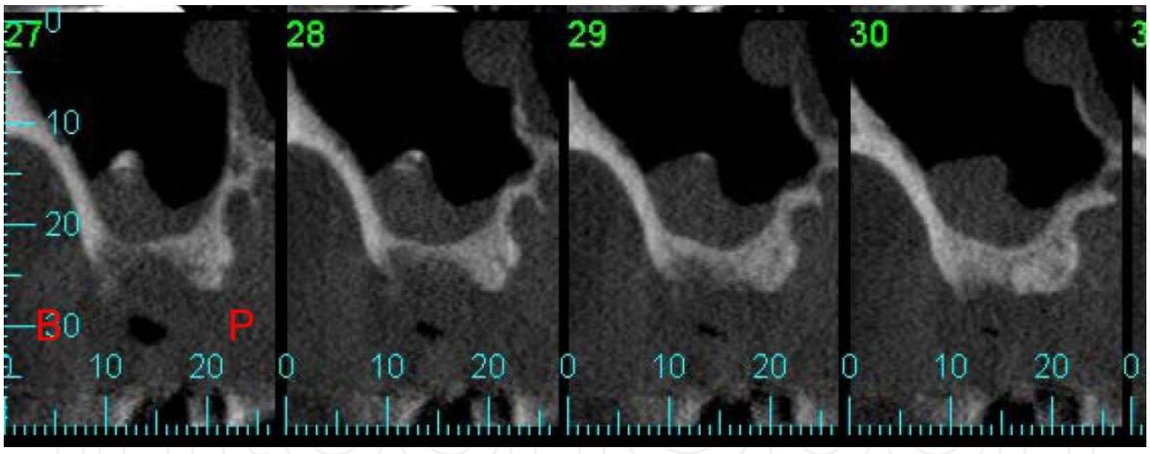

Fig. 10. Posterior maxilla. Preoperative CT demonstrating <4 mm residual alveolar ridge.

Surgery for sinus floor augmentation was performed under local anesthesia. Oral antibiotics and analgesics were administered one hour before surgery, and antiseptic mouthwash was used immediately before surgery. Two vertical releasing incisions were made to define a mucoperiosteal buccal flap extending up to the mucogingival line. The flap was raised to expose the labial bony antral wall, and a round high-speed bur with copious irrigation was used to establish a buccal window (trapezoid, rectangular or oval) for complete visibility of the entire block and the implants (Fig. 11). The membrane was then released without tension to provide an adequate compartment for the implants and the block graft. Membrane tears, if present, were left untreated.

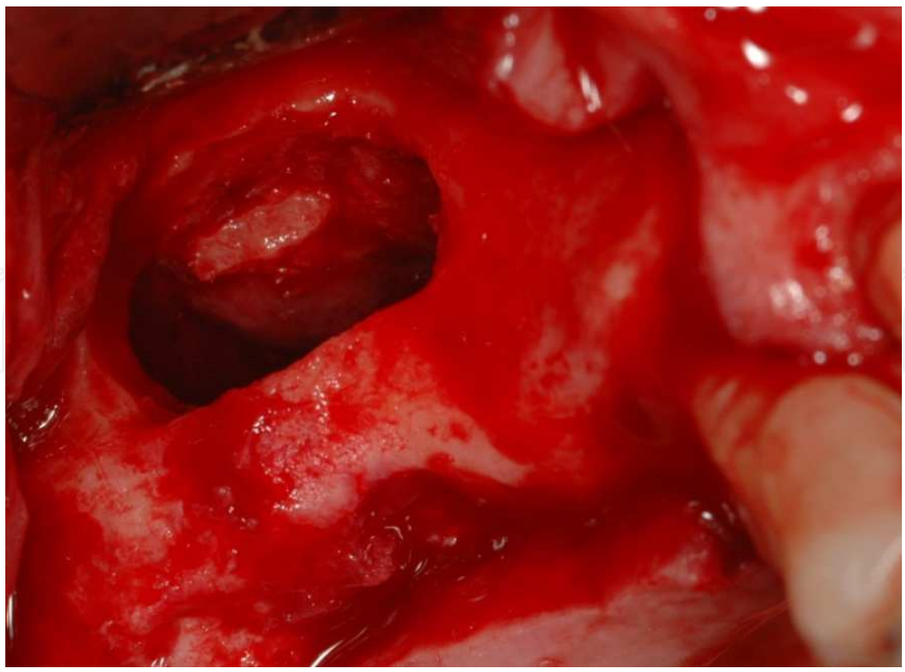

Fig. 11. Posterior maxilla. Lateral window.

Prior to graft insertion, particulate grafting material was placed against the medial and crestal aspects of the compartment created in the sinus cavity to completely adapt the block to the medial wall and floor of the sinus cavity (Fig. 12).

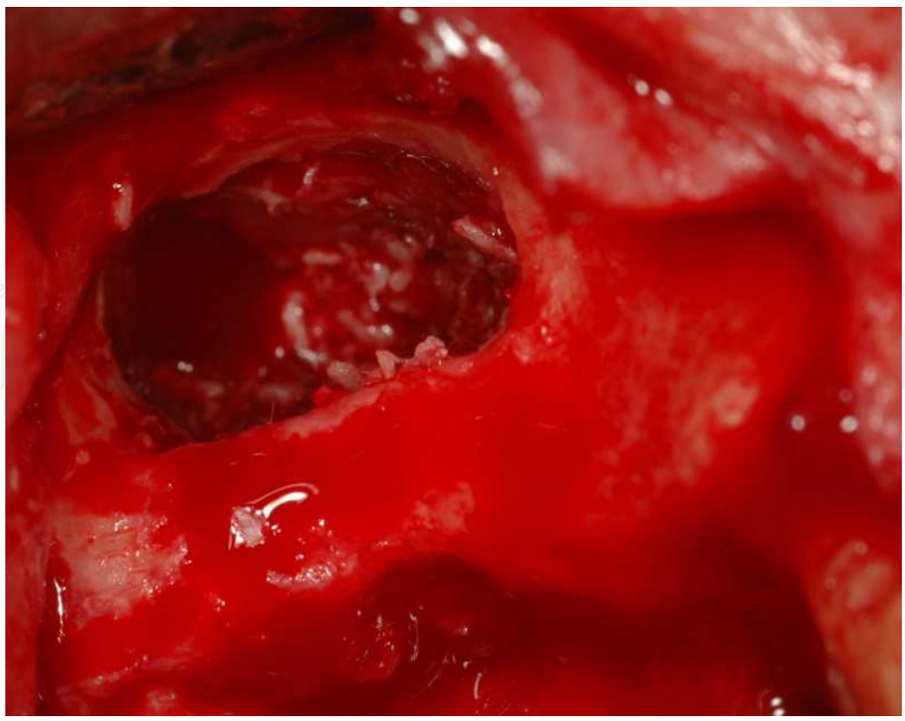

Fig. 12. Posterior maxilla. Particles prior to block insertion.

The prefabricated block (Fig. 13), soaked in sterile saline, was trimmed to adjust it to the lateral opening, inserted in a gentle-press-fit fashion into the prepared area in the sinus cavity, and pushed maximally up to the palatal wall.

Fig. 13. Posterior maxilla. Block graft following trimming.

The block was stabilized with the window frame. The implant sites were marked with a surgical stent, and osteotomies were performed according to the manufacturer's recommendation. The implants were inserted into the osteotomy sites prepared in the alveolar crest and grafted cancellous block. This locked the block to the alveolar crest on all sides, preventing its migration or a change in its position. Excessive cancellous block graft protruding lateral to the sinus bony walls was removed with a high-speed bur, and particulate grafting material was placed into any remaining voids between the block graft and the window frame. The lateral window was covered with a long-term bioresorbable collagen membrane, and the mucoperiosteal flap was closed primarily over the graft and implants.

Patients were prescribed systemic antibiotics and analgesics for 10 days postoperatively and antiseptic mouthwash twice daily for 2 weeks. They were seen weekly for the first postoperative month and monthly for the next 8 months until soft- tissue healing was complete. At 9 months, surgical re-entry was performed for implant exposure. Healing abutments were placed, and 4-6 weeks were allowed for soft tissue maturation. Impressions were made and master casts fabricated. The implants were restored with fixed partial metalloceramic.

2.2.2 Clinical outcome

All implants showed primary stability. Relatively small (5-10 mm) membrane tears were detected in 21.4% of cases, but were not treated owing to the use of the block graft. No clinical or radiological complications were recorded in any of the sinuses, including those with membrane tears, during the 9 months' healing period.

Radiographic evaluation (panoramic and periapical) prior to exposure of the implants showed what appeared to be a dense homogenous bony mass embedded in a radio-opaque area. On repeated radiographic images at the last follow-up, mean height of the augmented bone within the sinus measured 12.3 mm; no adverse reactions were noted. Implant survival rate was 94.4%. Failing implants were removed and replaced after 3 months of spontaneous healing, and all successfully osseointegrated. All patients received a fixed implant-supported prosthesis. There was no crestal bone loss around the implants beyond the first implant thread (Fig. 14) (Chaushu et al., 2009).

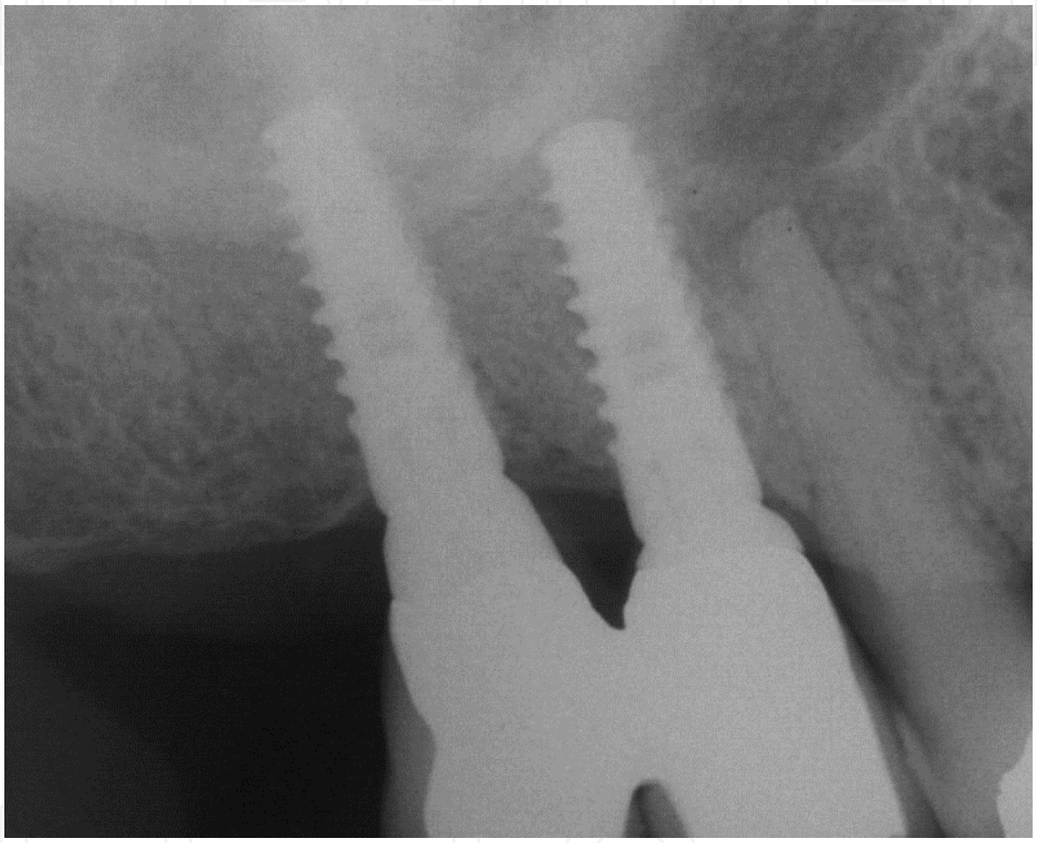

Fig. 14. Posterior maxilla. Periapical view at 3-year follow-up.

2.2.3 Comment

Simultaneous implant placement and sinus floor augmentation is advantageous to the patient because it minimizes the number of surgical interventions and shortens the time to completion of the implant-supported prosthesis (Khoury, 1999). It was once limited to cases with a minimum of 4-5 mm of alveolar bone coronally because of concerns about implant stability and accurate implant location, inclination, and parallelism (Hurzeler et al., 1996; Peleg et al., 1998; Smiler et al., 1992; Tatum et al., 1993). More recent research suggests that no specific bone height limit is necessary so long as primary implant stability is assured (Achong & Block, 2006). Nevertheless, in cases of severely atrophic posterior axillary ridges of ≤4 mm, simultaneous implant placement and sinus floor augmentation may pose a challenge (Mardinger et al., 2007). To prevent technical problems and complications, the use

of cancellous block-allografts is recommended (Fig. 10). In our experience, their placement with rough surface implants was associated with a high success rate (94.4%), similar to the standards documented in the literature. Their use also abolished the need to repair membrane perforations.

2.3 Posterior mandible

2.3.1 Surgical technique

Surgery in the posterior mandible was performed under local anesthesia (Figs. 15,16). A crestal incision was centered in the remaining keratinized tissue and extended through the edentulous span, allowing for a minimum of 1-2 mm of keratinized gingiva on both sides of the flap, in most cases, slightly to the lingual side. A distal oblique releasing incision was made into the buccinator muscle posteriorly, and a vertical releasing incision mesial to the most distal tooth, on the labial aspect. A full-thickness mucoperiosteal lingual flap was initially reflected with extreme caution to prevent tears in the periosteum (Fig. 17) and then further mobilized lingually, away from the mylohyoid line.

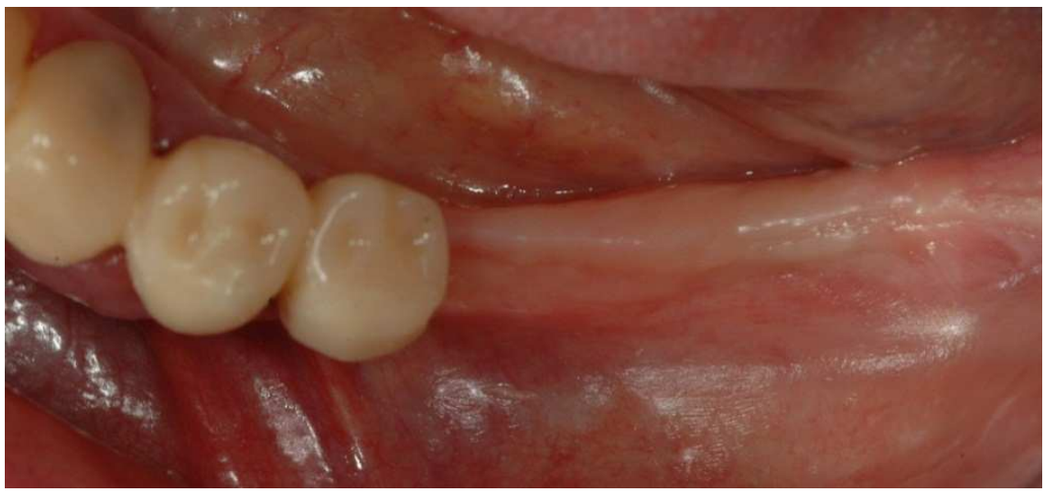

Fig. 15. Posterior mandible. Preoperative clinical view.

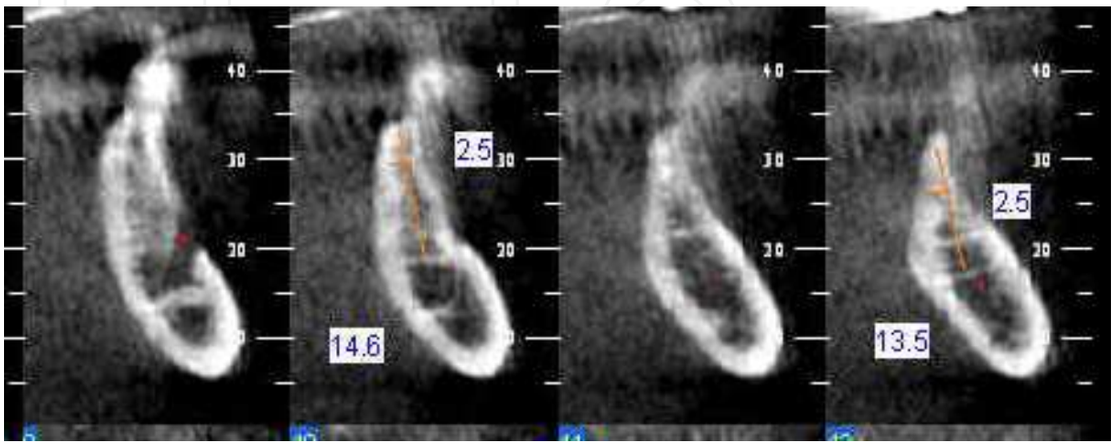

Fig. 16. Posterior mandible. Preoperative CT.

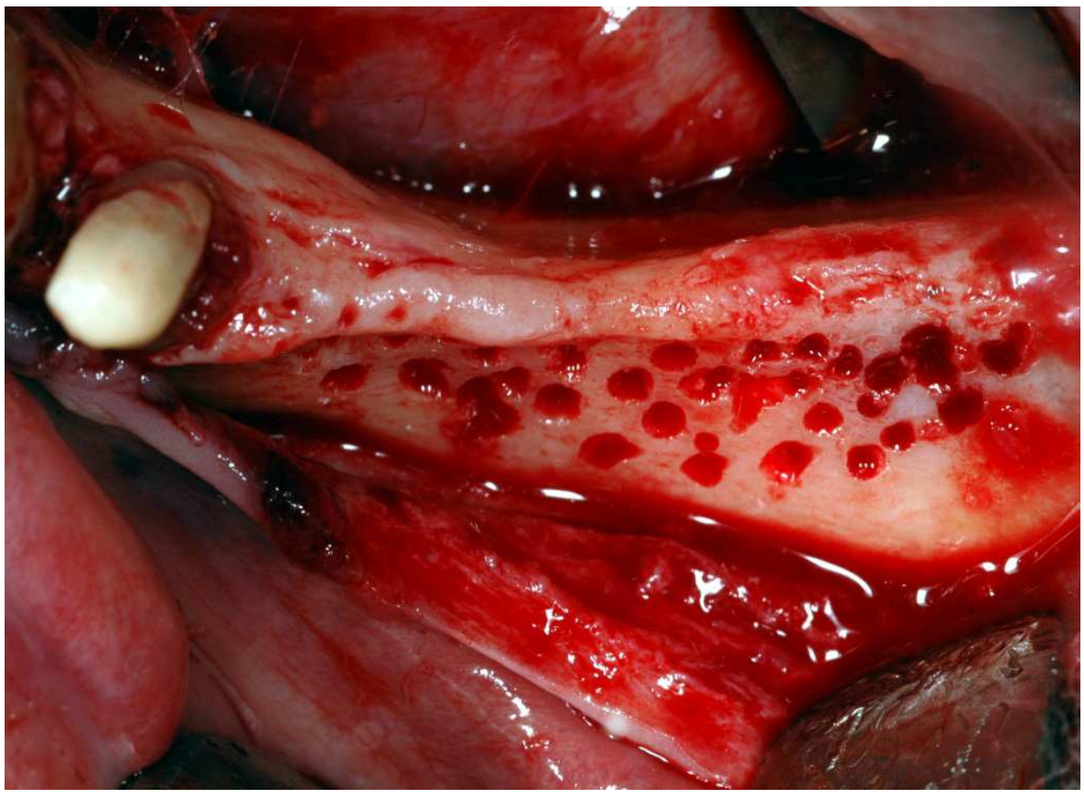

Fig. 17. Posterior mandible. Clinical view demonstrating bone defect.

The buccal aspect of the alveolar ridge was exposed via subperiosteal dissection so the defect could be visualized in three dimensions. (Visualization of the mental neurovascular bundles is mandatory.) A freeze-dried cancellous block graft was refined to fit into the defect. Once it was seated and stable, the graft was fixed with 1.6 mm x 10 mm bone screws (Fig. 18). A large round bur was used to round any sharp edges and shape the graft to completely conform to

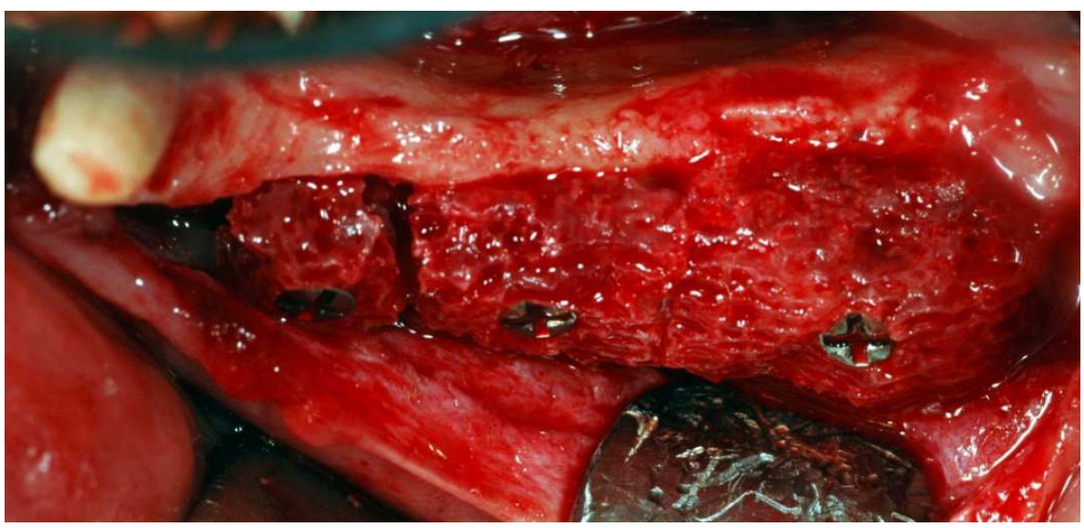

Fig. 18. Posterior mandible. Bone block fixation.

the defect site. Deficiencies at the edges of the graft were filled with particulate bone, and the graft was covered with a long-term resorbable collagen membrane (Fig. 19). The width and height of the augmented ridge were measured with a periodontal probe. The midcrestal incision was initially closed with interrupted and horizontal mattress sutures, and the vertical incision was closed with interrupted sutures.

Fig. 19. Posterior mandible. Membrane coverage.

Patients were prescribed antibiotics and analgesics for 5 days postoperatively and an antiseptic solution for 2 weeks. When possible, fixed partial provisional restorations were fitted and delivered to the patient immediately after surgery. Removable provisional restorations were not used.

Patients were seen weekly during the first postoperative month and monthly thereafter for 6 months, until healing was complete. Periapical radiographs were taken immediately postoperatively and 2-3 months after surgery and evaluated particularly for signs of soft tissue dehiscence, color changes, and the overall appearance of the grafted ridge contour.

Before the second-stage surgery at 6 months, new panoramic radiographs and CT scans were obtained to determine implant width and length (Fig. 20). Access to the augmented

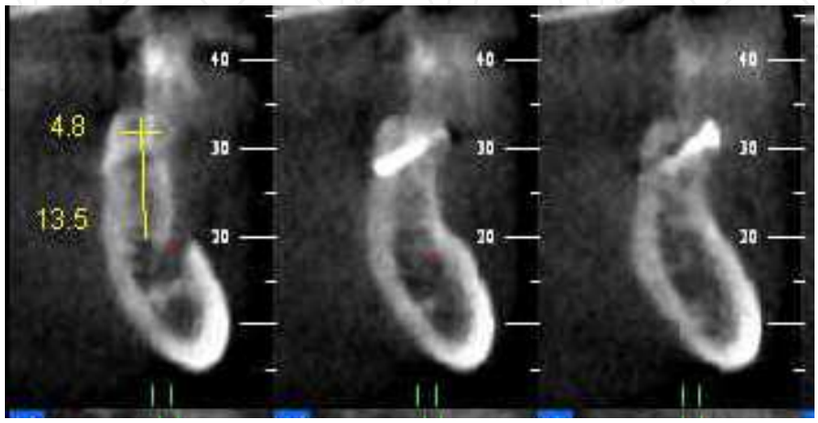

Fig. 20. Posterior mandible. CT at 6 month following bone grafting.

ridge was achieved via the initial incision. The fixation screws were removed, and the width and height of the ridge were measured with a periodontal probe. The implant sites were selected with a diagnostic template (Fig. 21). Residual buccal thickness measurements were repeated after implant placement to further evaluate bone resorption and determine the horizontal bone dimension.

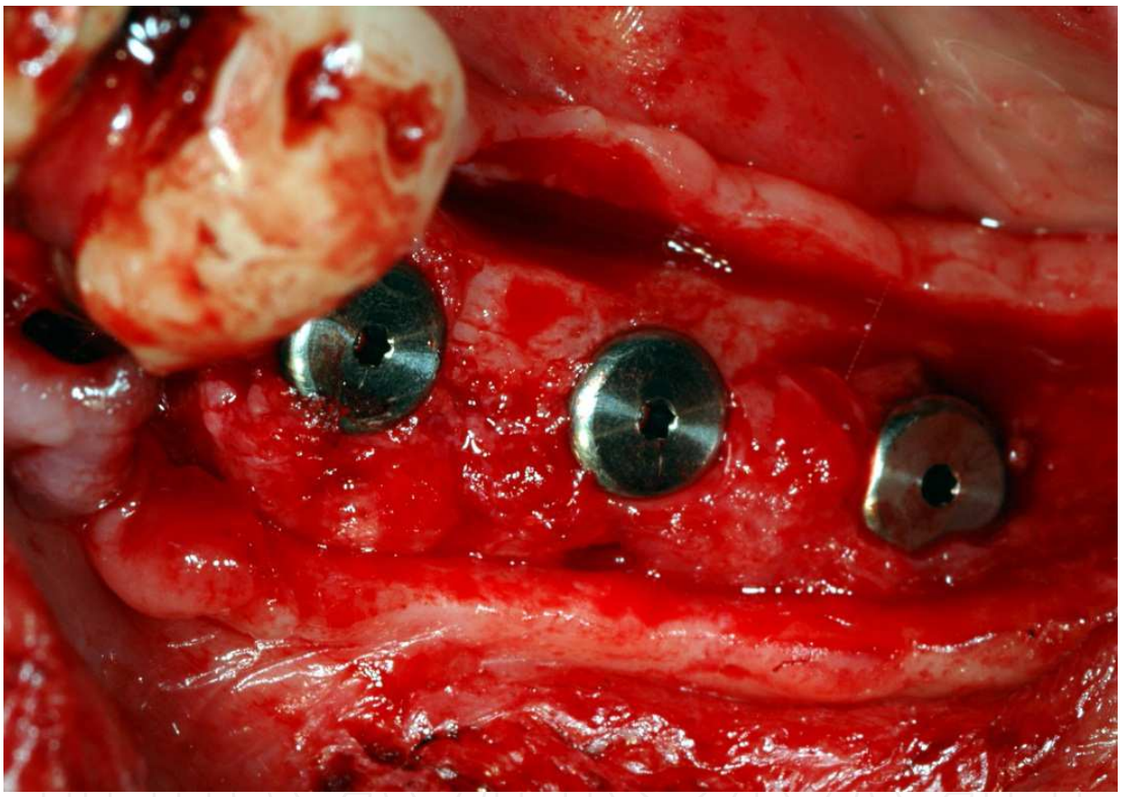

Fig. 21. Posterior mandible. Implant placement 6 months after bone grafting.

The implants were exposed 3 months later. The soft tissues are allowed to mature for 3 weeks prior to the definitive restorative phase. The implants were restored with fixed cement-retained ceramic prostheses (Fig. 22). Clinical and radiographic examinations were performed at the time of restoration, every 6 months during the first year, and once a year thereafter (Fig. 23).

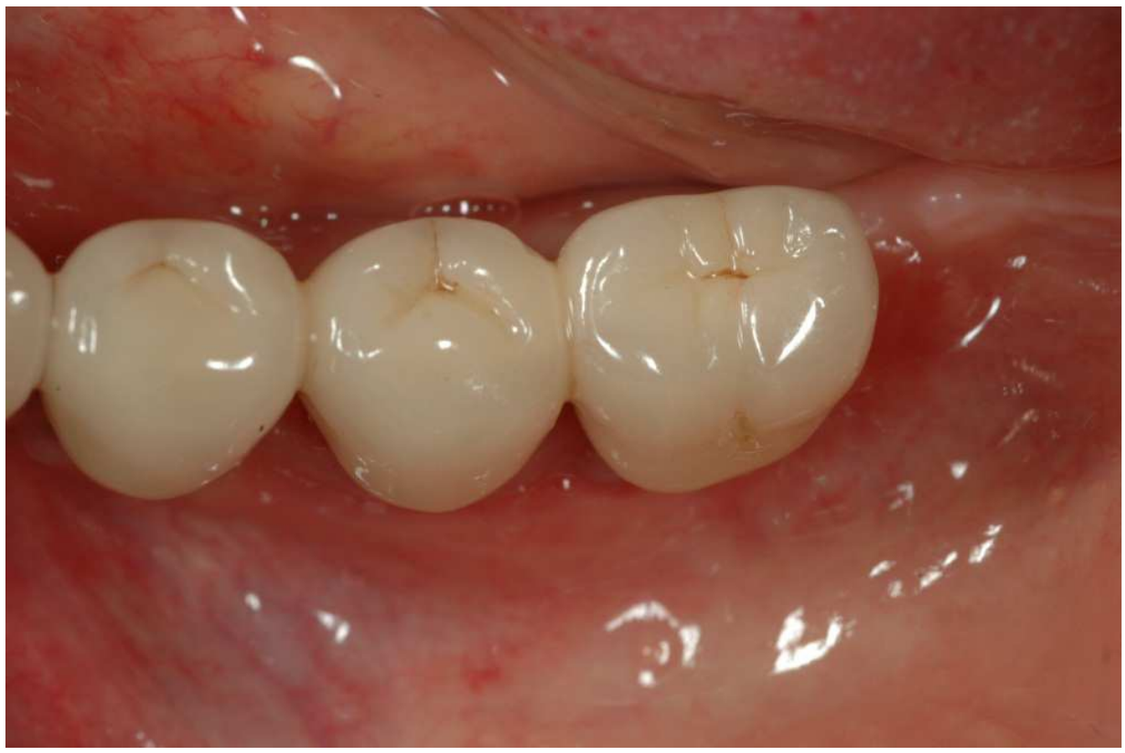

Fig. 22. Posterior mandible. Final restoration.

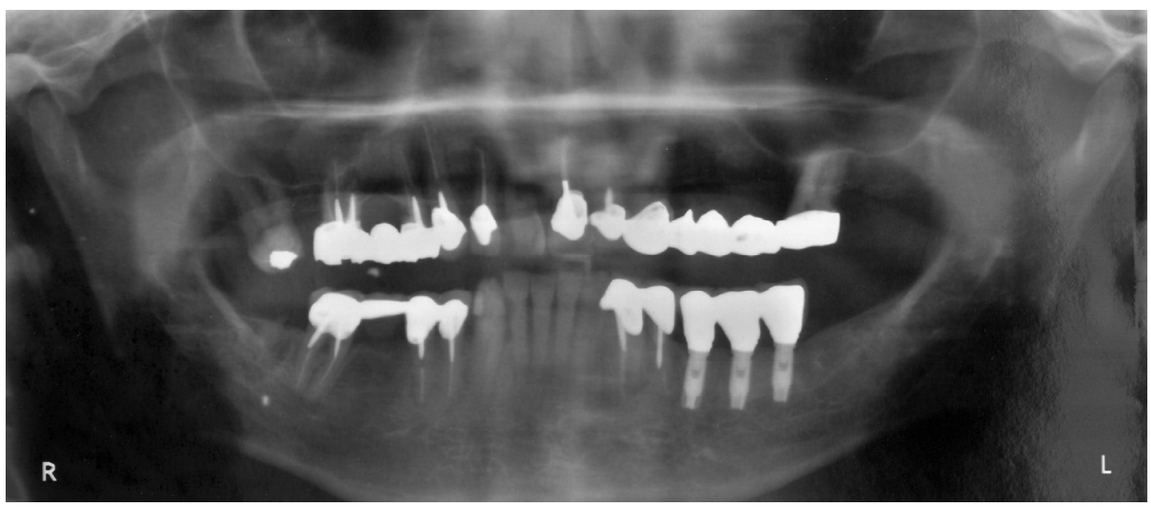

Fig. 23. Posterior mandible. Panoramic view at 5-year follow-up.

2.3.2 Clinical outcome

This technique was associated with a 79.3% block survival rate (Nissan et al., 2009). Bone width at implant placement was 7.9 ± 0.5 mm, and bone gain in the vertical dimension was 4.3 ± 1.6 mm. A nonsignificant resorption of 5% was noted from graft placement to implant placement. Mean implant diameter was 3.9 ±0. 2 mm , and mean implant length was 10.4 ± 0.7 mm (Nissan et al., 2009). Implant survival rate was 95.2%. In all cases of failure, the

implants were reinserted after 2 months and successfully osseointegrated. All patients received a fixed implant-supported prosthesis. There were no late cases of loss of function. The mean crown-to-implant ratio was 0.96 ± 0.16 (Nissan et al., 2009).

2.3.3 Comment

A biomechanically stable bone implant foundation is indispensable for the long term success of fixed implant-supported prostheses in the posterior mandible (Bahat & Fontanessi, 2001b; Pikos, 2000). The increased biting forces in this region can create excessive stress (Devlin & Wastell, 1986; Gibbs et al., 1981; Mericske-Stern et al., 1995) that lead to crestal bone loss, screw loosening, occlusal material fracture, prosthesis wear and fracture, and implant failure (Goodacre et al., 2003; Misch et al., 2005, 2006; Nissan et al., 2011a, 2011b). Therefore, special attention needs to be addressed to the opposing arch and the crown-to-implant ratio (Misch et al., 2005, 2006). Treatment planning should take several factors into account: eliminating lateral interference during excursive movements; decreasing the occlusal table relative to the implant diameter or maximizing the implant diameter to minimize off-axis forces; shortening or eliminating cantilevers; increasing the number of implants (Pikos, 2000; Mische et al., 2005, 2006). Ridge augmentation enables the use of longer and wider implants that increase the surface area over which the occlusal force stresses are distributed (Bahat & Fontanessi, 2001b; Pikos, 2000). Block grafting is indicated for mandibular alveolar ridge atrophy of >3mm in the vertical and/or lateral dimension on para-axial CT reconstructions (Figs. 15,16).

3. Histological and histomorphometric observations

3.1 Histological findings

We observed newly formed vital bone, residual cancellous block-allograft bone, and connective tissue in all augmented sites. The residual cancellous block-allograft bone was identified by the presence of empty lacunae and separation lines. Newly formed bone containing viable osteocytes demonstrated intimate contact with the residual cancellous block-allograft bone. Osteoblasts were present in conjunction with newly formed bone around the residual cancellous block-allograft bone (Fig. 24).

There was no evidence of acute or chronic inflammatory infiltrate (Chaushu et al., 2010b; Nissan et al., 2011d; Nissan et al., 2011e).

3.2 Histomorphometric findings

Histomorphometric analysis of the anterior maxilla yielded the following results: mean fraction of newly formed bone, 33 ± 18%; residual cancellous block-allograft, 26 ± 17%; marrow and connective tissue, 41 ± 21%. When patients were divided by age (less or more than 40 years), statistically significant between-group differences were found for newly formed bone (younger patients: 38.6%, older patients: 19.8%, $P = 0.04$) and residual cancellous block-allograft (younger patients: 20.1%, older patients:. 38.4%, $P = 0.05$). Age had no effect on the mean fraction of marrow and connective tissue (41.3% and 41.8%, respectively, $P = 0.49$) (Nissan et al., 2011e). In another study, histomorphometric analysis of the posterior maxilla yielded the following results: fraction of newly formed bone, 26.1 ±

15%; residual cancellous block-allograft, 24.7 ± 19.4%; marrow and connective tissue, 49.2 ± 20.4%. There were no statistically significant differences in the fraction of newly formed bone by patient sex or age, presence/absence of membrane perforations, or residual alveolar bone height (Chaushu et al., 2010b). In the posterior mandible, the fraction of the newly formed bone was 44 ± 28%; residual cancellous block-allograft, 29 ± 24%; and marrow and connective tissue, 27 ± 21%. Division of the patients by age (less or more than 45 years) yielded statistically significant differences in the percentage of newly formed bone (69% vs. 31%, respectively; $P = 0.05$), but not in the percentage of residual cancellous block-allograft (17% and 5%) or marrow and connective tissue (14% and 34%). There were no statistically significant histomorphometric differences in percentage of newly formed bone by patient sex or presence/absence of soft tissue dehiscence (Nissan et al., 2011d).

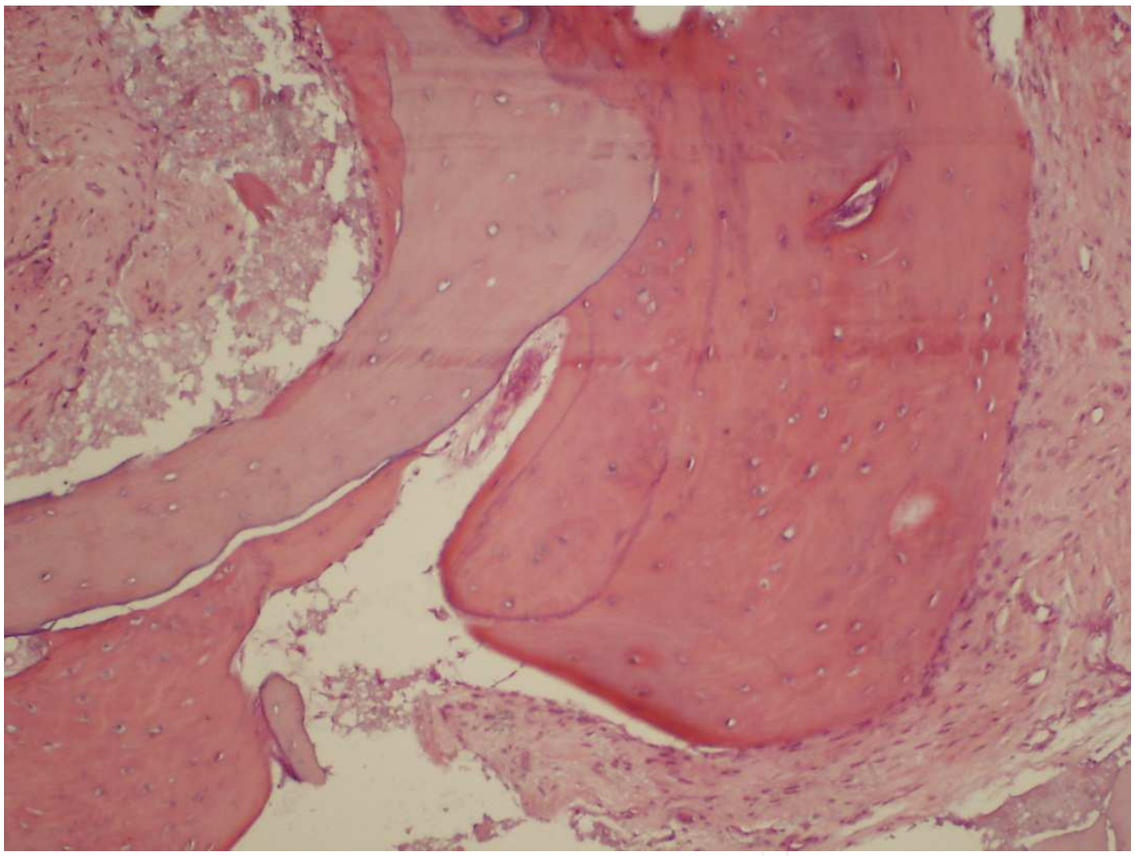

Fig. 24. Posterior mandible. Histological view of block allograft surrounded by new bone.

3.3 Comment

Our histomorphometric findings for cancellous bone allografts were close to those reported in earlier studies on the use of freeze-dried bone allograft (FDBA) materials for ridge augmentation in the atrophic anterior maxilla (28% new bone, 35% connective tissue, and 37% residual graft material; Iasella et al., 2003) and for sinus augmentation (29.1% new bone, 51.9% connective tissue, and 19% residual graft material; Kolerman et al., 2011). Accordingly, Holmquist et al. (2008) reported a mean bone content of 31.8% after placement of a morselized

impacted bone allograft for reconstruction of the narrow alveolar crest in the anterior maxilla, and Froum et al. (2006), using mineralized cancellous bone allograft particles for sinus augmentation, reported rates of 28.3% new bone formation, 64.1% connective tissue and 7.6% residual graft. In the same study, using a split mouth design, values for bovine bone mineral were 12.4% new bone formation, 54.6% connective tissue, and 33% residual graft (Froum et al., 2006). Together, these results corroborate the osteoconductive property of FDBA.

The similarity between the rate of new bone formation (26.1%) in sinus augmentation with cancellous block-allograft and the reported vital bone proportion of pristine bone in the posterior maxilla (23% -28%) (Trisi & Rao, 1999; Ulm et al., 1999) may explain the high implant survival rates. Accordingly, in the posterior mandible, new bone formation following augmentation with cancellous block-allograft (44 ± 28%) was compatible to the vital bone proportion of pristine bone in the posterior mandible (56 ± 21%) (Todisco & Trisi, 2005).

Our findings of a significantly greater percentage of new bone formation in younger patients relative to older ones following remodeling with cancellous block-allograft in the anterior atrophic maxilla and posterior atrophic mandible (Nissan et al., 2011d; Nissan et al., 2011e) agree with earlier studies of the effect of age on new bone formation (Fisher et al., 2010; Matsumoto et al., 2001; Rando, 2006; Tanuka et al., 1996; Walboomers et al., 2006). Following induction of injury to the tibia marrow cavity in a rat model, MicroCT and histomorphometry revealed a reduced response with an increase in age, suggesting that the restoration of normal tissue is age-dependent (Fisher et al., 2010). Others also noted differences in the osteogenic properties of bone marrow-derived osteoblast-like cells by donor age (Walboomers et al., 2006). In a study of bone formation induced by recombinant human bone morphogenetic protein-2 in male Wistar rats, the total volume of newly formed bone declined with aging (Matsumoto, et al., 2001). The reasons for the age-related decline in tissue repair are not well understood. Suggested possibilities include impaired cellular activity (Tanaka et al., 1996) and a reduction in the total number of osteoblasts (Rando, 2006).

4. Complications

In our patients, cancellous bone block allografting was associated with soft tissue complications, namely membrane exposure (30.6%), incision line opening (30%), perforation of the mucosa over the grafted bone (14%), and infection (13%) (Chaushu et al., 2010a). Similar types of complications were reported by earlier studies as well (Bahat & Fontanesi, 2001a, 2001c; Li & Wang, 2008). Treatment was initiated as soon as possible. Necrotic soft tissue was removed, and the bone was leveled with the soft tissue using a high-speed bur. The area was immediately and thoroughly irrigated with chlorhexidine. Patients were prescribed an additional week of oral antibiotics and instructed to apply chlorhexidine gel over the affected area twice daily and to refrain from eating at the grafted site until mucosal healing was complete.

Overall, partial graft failure occurred in 7% of patients and total graft failure in 8%. The presence of complications significantly increased the risk of graft failure. In sites with membrane perforation, the total graft failure rate was 17% and the partial graft failure rate, 24%s. By contrast, total implant failure occurred in only 4% of non-membrane exposure sites and partial failure in 0%. These differences were statistically significant. Incision-line opening was associated with a 17% total graft failure rate and 20% partial graft failure rate,

compared to rates of 4% and 2% failure rates, respectively, for sites in which the incision line remained intact, and mucosal perforation over the grafted bone was associated with an 11% total graft failure rate and a 26% partial graft failure compared to 8% and 4%, respectively, for sites without mucosal perforation. At sites with infection of the bone block, the total graft failure rate was 39% and the partial graft failure rate 22%, compared to rates of 3.4% and 5%, respectively, at non-infected sites.

Analysis of the possible risk factors for complications revealed no significant association with patient age or sex. Complications occurred significantly more in the mandible than the maxilla. The presence of more than one complication significantly increased the risk of infection and graft failure. Specifically, combined membrane exposure with incision line opening led to infection in 44% of cases and to total graft failure in 17%. Our findings suggest that the graft failures were not attributable to use of the cancellous block graft per se but to procedural and technical factors.

Implant failure occurred in 4.4% of cases. None of the complications had a statistically significant effect on the occurrence of implant failure.

It is noteworthy that the rate of new bone formation was similar in sinuses with (25.5%) and without (27.3%) membrane perforations (Chaushu et al., 2010b). Membrane perforations can lead to the loss of graft particles into the air chamber of the sinus and have a reported incidence of 10% to 56% (Fugazzotto & Vlassis, 2003; Jensen et al., 1994; Pikos, 2008; Shlomi et al., 2004; van den Bergh et al., 2000; Wallace et al., 2007). A split-mouth study of perforated sinus membrane repair with a resorbable collagen membrane (Proussaefs et al., 2004) found that when bone particles were use, nonperforated sites demonstrated significantly more bone formation (33.58%) than perforated sites (14.17%), with a higher implant survival rate at second-stage surgery (100% vs 69.56%). The authors suggested that the technique or materials be changed to lessen the risk posed by perforation and repair of the sinus membrane. Our histomorphometric results indicate that allogeneic block grafts may offer a good solution (Chaushu et al., 2010a,b). Using a block graft, we were able to leave membrane perforations untreated (Pikos, 1999) without compromising either survival or new bone formation and without interrupting the operative procedure.

5. Conclusions

Cancellous freeze-dried blocks can serve as a satisfactory allografting material for sinus floor augmentation and for initial stabilization of both grafts and dental implants during simultaneous procedures, even in the presence of membrane perforation. In posterior mandible reconstruction, bone grafts can increase the number, length, and diameter of implants that can be placed. The use of cancellous block allografts allows for the placement of implants of standard length and diameter, thereby improving long-term prognosis of the implant-supported reconstruction. More attention to detail and meticulous technique may prevent the progression of complications to graft failures.

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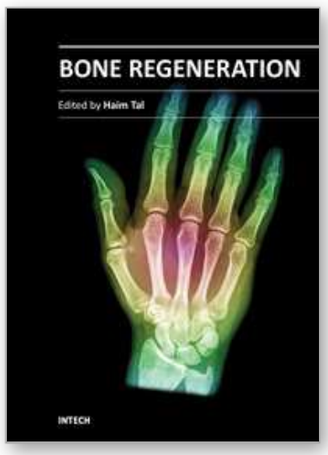

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Bone is a specialized connective tissue, most prominently characterized by its mineralized organic matrix that imparts the physical properties that allow bone tissue to resist load, to support functional organs, and to protect highly sensitive body parts. Bone loss and bone damage may occur as a result of genetic conditions, infectious diseases, tumours, and trauma. Bone healing and repair, involves integrative activity of native tissues and living cells, and lends itself to the incorporation of naturally derived or biocompatible synthetic scaffolds, aimed at replacing missing or damaged osseous tissues. There are several modalities of bone regeneration including tissue engineering, guided bone regeneration, distraction ontogenesis, and bone grafting. This book concentrates on such procedures that may well be counted among the recent outstanding breakthroughs in bone regenerative therapy.

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