The Use of Cancellous Block Allograft for Sinus Floor Augmentation With Simultaneous Implant Placement in the Posterior Atrophic Maxilla

Gavriel Chaushu,* Ofer Mardinger,* Shlomo Calderon,* Ofer Moses,† and Joseph Nissan‡

Background: The simultaneous placement of dental implants during sinus augmentation is advocated in cases in which ≥4 to 5 mm of alveolar bone exists coronally to the sinus floor. The aim of the present study was to assess the survival rate of dental implants placed during sinus augmentation and stabilized by the use of cancellous freeze-dried block allograft. Residual alveolar ridge height ≤4 mm was an inclusion criteria.

Methods: Twenty-eight consecutive patients (13 females and 15 males) aged between 25 and 65 years (mean, 54 ± 9 years) were referred for implant-supported reconstruction of the posterior atrophic maxillae. Seventy-two implants (two to four per patient) were placed. No case presented difficulty in achieving initial stabilization. Relatively small membrane tears (5 to 10 mm) were observed in 21.4% of the sinuses. There were no other clinically evident complications of the sinuses. Sixty-eight implants were clinically osseointegrated, yielding a 94.4% success rate, whereas four implants were noted to be failed at the second stage. Three months later, implants were inserted at the previously failed implant sites; after 3 additional months, at the second stage, they were diagnosed as osseointegrated. All patients received a fixed implant-supported prosthesis.

Results: The mean follow-up was 27 months (range, 11 to 46 months). Radiographs taken at the last follow-up demonstrated that the vertical augmented bone within the sinus ranged from 11 to 14 mm (mean, 12.3 mm). The histologic evaluation showed newly formed bone containing viable osteocytes merged with residual grafted bone, characterized by empty lacunae devoid of osteocytes.

Conclusion: The cancellous block allograft seems to possess potential as a grafting material for sinus floor augmentation with simultaneous implant placement. J Periodontol 2009;80:422-428.

KEY WORDS
Allograft; maxilla; sinus.

The placement of dental implants in the posterior maxilla presents a challenge in many cases. Frequently, there is an insufficient volume of bone caused by the combination of alveolar bone resorption and pneumatization of the maxillary sinus. Surgical procedures for augmenting the maxillary sinus have evolved during the last decade to give adequate solutions in cases in which insufficient bone volume rendered implant placement impossible.1,2

The simultaneous placement of dental implants during sinus augmentation was limited to cases in which ≥4 to 5 mm of alveolar bone was present coronally to the sinus floor. This was chosen arbitrarily as the minimal amount of bone, most likely because of its ability to provide initial implant stability and accurate implant location, inclination, and parallelism.3-5 The clinical predictability of performing sinus floor augmentation with simultaneous implant placement in patients with alveolar bone height of only 1 to 2 mm was also reported.6 Currently, it is suggested that there is no specific bone height limit for a simultaneous procedure.7 A crucial factor for the osseointegration of dental implants is primary implant stability immediately after placement during sinus lift procedures.7

Compared to the staged approach to sinus augmentation, simultaneous...
Implant placement and sinus floor augmentation is more challenging to the operator. However, it is advantageous to the patient because of the smaller number of surgical interventions and the reduction in the time required to complete the implant-supported prosthesis.

A recent study showed that maxillary sinus floor augmentation with simultaneous implant placement, using autogenous corticocancellous block bone grafts, is superior to autogenous corticocancellous particulate bone grafts for bone healing around dental implants.

The successful use of bone blocks, either autologous or xenogenic, to allow simultaneous implant placement by enhancing initial implant stabilization has been reported. Nevertheless, autogenous bone harvesting is accompanied by considerable morbidity, and the reported use of non-autogenous blocks is sporadic.

Sinus floor augmentation with simultaneous implant placement in the severely atrophic maxilla may pose technical problems and complications. The present study aimed to use the advantages of cancellous block allografts to avoid the technical problems and complications associated with simultaneous dental implant placement during sinus augmentation in cases with posterior atrophic maxillary ridge height ≤4 mm.

MATERIALS AND METHODS

Patient Selection
Twenty-eight consecutive patients (13 females and 15 males), aged between 25 and 65 years (mean, 54 ± 9 years), were referred to the Implantology Unit, Tel Aviv University Dental School, for implant-supported reconstruction of posterior atrophic maxillae between 2004 and 2008. All patients were selected after a meticulous evaluation of their medical histories and dental examinations that included panoramic and orthoradial periapical radiographs and dental computerized tomography (CT) scans. Serial buccal-lingual CT scans (Fig. 1) revealed vertical residual ridge height ranging from 1 to 4 mm (mean, 2.7 mm) and alveolar ridge thickness ranging from 5 to 8 mm (mean, 6.3 mm). Postoperative panoramic and orthoradial periapical radiographs were taken to compare to the preoperative ones. All procedures were fully explained to the patients, who signed an informed consent; the Ethics Committee of Tel Aviv University approved the study protocol.

Inclusion criteria for sinus floor elevation, grafting with cancellous block allograft, and simultaneous implant placement were good health, no regular use of medication, smoking ≤10 cigarettes per day, posterior atrophic maxillary ridge height ≤4 mm in at least one implant site, ≥8 weeks since last extraction in this region, absence of pathology and/or repeated sinusitis known in the maxillary sinus, and signing an informed consent.

One hour preoperatively, oral antibiotics (amoxicillin, 1,000 mg, and etodolac, 600 mg) were administered. Antiseptic mouthwash (0.2% chlorhexidine gluconate) was used immediately prior to surgery.

Sinus Floor Augmentation Technique
Patients were treated under local anesthesia. The surgical procedures were performed using the technique described by Kent and Block. Briefly, a mucoperiosteal buccal flap, defined by two vertical releasing incisions extending up to the mucogingival line, was raised to expose the labial bony antral wall. A round high-speed bur was used with copious irrigation to outline a buccal window that was trapezoidal, rectangular, or oval in shape. The average dimensions of the window were 9 mm (height) × 15 mm (width) at the maxillary sinus lateral wall, extending from the medial sinus border, to allow complete visibility of the entire block and the implants (Fig. 2). Care was taken not to perforate the sinus membrane. Once the outline was completed, a delicate dissection, using blunt sinus curets, was performed to push the sinus membrane inward and upward. The membrane was released without any tension to provide an adequate compartment for the implants and the block graft. The distance between the alveolar crest and the inferior border of the window was measured to allow future orientation at second-stage surgery. This ensured harvesting of the core bone biopsy only from the augmented bone.

Membrane tears, when noticed (5 to 10 mm), were left untreated because of the use of a block graft.

The complete adaptation of the block to the medial wall and floor of the sinus cavity was achieved using particulated grafting material that was placed against the medial and crestal aspects of the compartment created in the sinus cavity to fill the mismatches between the block and the inferior and medial sinus bony walls (Fig. 2).

The grafted area was measured three dimensionally. The actual window width and height and sinus depth were measured prior to cancellous block allograft insertion to allow trimming of the graft material. The prefabricated grafted block (1.5 × 1.5 × 3.0 cm) was soaked in sterile saline for 45 minutes before placement and was trimmed with a high-speed bur until adjusted to the lateral opening size. Then it was inserted in a gentle press-fit fashion to the prepared sinus cavity area. The cancellous block allograft was pushed maximally up to the palatal wall of the sinus cavity. In most cases it reached two-thirds of its pre-fabricated depth (Fig. 3). Stability of the block was
achieved with the window frame. Implant sites were marked using a surgical stent, and the osteotomies were performed according to the manufacturers’ recommendation. Seventy-two rough-surface titanium implants were placed: 35 4.2 × 13 mm;** 29 4 × 13 mm;†† and eight tapered 3.7 × 13 mm.‡‡

Implants were inserted into osteotomy sites prepared in the alveolar crest and in the grafted cancellous block. Bone quality upon insertion felt like type 3 bone. The locking of the block to the alveolar crest by the implants allowed implant stabilization in all directions. There was no migration or change in the position of the implants. Finally, any cancellous block graft protruding laterally to the sinus bony walls was removed using a high-speed bur (Fig. 4).

Particulated grafting material was placed to fill voids remaining between the block graft and the window frame.

A bioabsorbable membrane§§¶¶ was applied to cover the lateral window. The mucoperiosteal flap was closed primarily over the graft and the implants using 3/0 polyglactin 910 sutures.##

Postoperative systemic antibiotics, amoxicillin, 500 mg, three times a day,** were administered for 10 days; etodolac, 600 mg, twice a day,††† was used as needed for analgesia. Antiseptic mouthwash, 0.2% chlorhexidine gluconate,‡‡‡ was used twice daily for 2 weeks.

Patients were seen weekly for the first postoperative month and monthly for the next 8 months. Soft tissue healing was uneventful. At 9 months, surgical reentry was performed for implant exposure. Prior to implant

---

** MIS Implant Technologies, Shlomi, Israel.
†† BIOMET 3i, Palm Beach Gardens, FL.
‡‡ Zimmer Dental, Carlsbad, CA.
§§ OraPharma, Carlsbad, CA.
¶¶ Bio-Gide, Geistlich Pharma, Wolhusen, Switzerland.
## Rapid Vicryl, Ethicon, Piscataway, NJ.
### Moxypen Forte, Teva Pharmaceutical Industries.
††† Etopan, Taro Pharmaceutical Industries.
††‡ Tarodent, Taro Pharmaceutical Industries.
exposure, patients were evaluated radiographically. Panoramic and orthoradial periapical radiographs were used for assessing the radiographic features of the block graft, the newly formed bone, and their close relationship to the implants. Clinical criteria at the time of implant exposure included implant stability in all aspects, crestal bone resorption, and any reported pain or discomfort. The reflection of the buccal mucoperiosteal flap was extended to the peripheral augmentation area. The previous window location was located by remnants of the bioabsorbable barrier membrane. By careful orientation, a trephine bur was used to collect a cylindrical sample core, 6 to 8 mm in depth, from the augmented site in a superior diagonal outward–inward direction to verify new bone formation, followed by healing abutments connection. All specimens were prepared for histologic examination.

Healing abutments were placed, and 4 to 6 weeks were allowed for soft tissue maturation. Impressions were made, and master casts were fabricated. The implants were restored with fixed partial metalloceramic restorations.

**Histologic Processing**
Harvested bony cores were fixed in 10% neutral buffered formalin for ≥1 week, decalcified with 5% formic acid for 2 weeks, and then embedded in paraffin. Serial transverse sections, 5 μm in width, were prepared by microtome. Slides were stained with hematoxylin and eosin.

**RESULTS**
Sinus floor augmentation procedures with simultaneous implant placement were performed successfully in all of the consecutively enrolled cases. Between two and four implants were placed in each patient (total = 72). All implants showed primary stability when placed immediately prior to soft tissue closure. Relatively small (5 to 10 mm) membrane tears were diagnosed in six (21.4%) of the cases. They were left untreated because of the use of a block graft. No clinical or radiological complications were recorded in any of the sinuses, including those with membrane tears, during the 9 months of healing.

Prior to exposure, radiographic evaluation (panoramic and periapical) showed the implants embedded in a radiopaque area that appeared to be a dense homogenous bony mass. Radiographic evaluation at the latest follow-up demonstrated that the vertical
augmented bone within the sinus ranged from 11 to 14 mm (mean, 12.3 mm). No adverse reactions were noted radiographically (Fig. 5). Sixty-eight of 72 implants were clinically osseointegrated (non-mobile, dull to percussion, asymptomatic, and without marginal bone loss). Four implants did not demonstrate osseointegration at implant exposure (yielding a 94.4% success rate) and were removed and replaced after 3 months of spontaneous healing. These implants were successfully osseointegrated and restored after 4 months. All patients received a fixed implant-supported prosthesis. The mean follow-up was 27 months (range, 11 to 46 months). 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 (Fig. 6).

A photomicrograph of the biopsy is presented in Figure 7. Histologic evaluation demonstrated new bone formation in all hard tissue cores. Newly formed bone containing viable osteocytes merged and had direct contact with residual cancellous block allograft bone, characterized by empty lacunae devoid of osteocytes.

**DISCUSSION**

The sinus augmentation procedure is becoming a well-established, predictable procedure for the placement of dental implants in the posterior atrophic maxilla. A variety of graft materials, ranging from autogenous, intraoral, or extraoral bone to various combinations of allografts, xenografts, and alloplastic materials, with predictable results were reported.\(^2\)\(^,\)\(^17\)\(^-\)\(^19\) It was shown that sinus augmentation with simultaneous implant placement in the severely atrophic maxilla is predictable when sufficient crestal bone exists to stabilize the implants.\(^20\)

The overall survival rate of implants placed in grafted maxillary sinuses is 91.5%. The survival rate varies depending on the grafting material: autogenous, 87.7%; combination of autogenous and bone substitutes, 94.88%; and bone substitutes alone, 95.98%. The survival rate of simultaneously placed implants (92.17%) is similar to delayed procedures (92.93%). Although the rates for smooth-surface implants reach 85.64%, rough-surface implants achieve 95.98% survival rates.\(^2\) The use of simultaneous cancellous block grafts and rough-surface implants in the present study resulted in an outcome (94.4%) similar to the standards documented in the published literature.

However, sinus floor augmentation with simultaneous implant placement in the severely atrophic maxilla may pose technical problems and complications,
such as releasing the mount from the implant (10.2%), which might cause the dislocation of the implant from its original implantation axis, and bone fractures between the sinus-augmentation window and the implant osteotomy site (3.4%).

The present study proved the merits of using cancellous block allograft in performing sinus augmentation with simultaneous implant placement and the resulting advantage of shortening the course of treatment to a one-stage procedure, performed under local anesthesia in the dental office.

The radiographic evaluation noted the presence of what appeared to be a dense homogenous bony mass supporting the implants and the radiographic vertical dimensional stability of the blocks. The histologic sample was harvested intentionally from an area within the sinus without any existing bone, and the location was confirmed by remnants of the bioabsorbable barrier membrane. Thus, the only way vital bone could be present in the histologic specimen is by new bone formation.

There are two major concerns in the described one-stage procedure; the first is the initial stabilization of the bone graft allowing stability of the implants. Autogenous bone blocks were previously used to allow the stabilization of implants placed simultaneously with sinus augmentation. The volume of the harvested block is rather small and cannot fill the entire sinus cavity. Therefore, with the technique described in this study, the initial support that allows accurate implant placement and stabilization is achieved with the aid of a periosteal elevator and stabilizing pins in a rather complicated procedure.8

Second, a large space is left between the harvested block and the sinus floor, which requires the use of a large amount of additional non-autogenous graft. Nevertheless, in some cases, it was extremely difficult to stabilize the implants, which were placed 1 mm subcrestally and stabilized by wide cover screws to compress the bone graft onto the alveolar ridge.

In the present study, the volume of the cancellous allogenic block graft allowed filling of the sinus and gained initial support from friction between the graft and the bony window without the use of additional armamentarium. Initial stabilization of the block was gained from contact between the boundaries of the lateral window and the block graft. Stabilization of the block to the alveolar crest was enhanced by the insertion of the implant, which traversed the floor of the sinus into the cancellous bone block. Small amounts of particulated bone graft were used to create osseous continuity between the block graft and the bony walls. Therefore, the technique is easier to manipulate because no additional means of support is needed to stabilize the block graft during implant placement within the sinus.

In the same study,8 there were no adverse effects on the facial profiles. However, some patients experienced neurosensory deficits, which persisted for up to 1 year following the procedure.8 In another study,13 almost half of the patients reported decreased sensitivity in the harvesting area 1 to 3 years following bone harvesting from the chin bone. Therefore, donor site morbidity, immediate postoperative pain and edema, neurological disturbances, vascular complications, infection, scars, and organ deformity are complications that limit, to a great extent, the possible use of autogenous bone blocks.

The rate of membrane perforation was reported to range from 10% to 56%.21-26 This high rate can be minimized (piezosurgery)26 or managed by a variety of techniques: suturing, bioabsorbable membranes, sealants, and oxidized regenerated cellulose.21-26 Schneiderian membrane perforation during sinus-augmentation procedures may cause clinicians to pause and reevaluate the feasibility of performing simultaneous implant placement.21,22 The major problem following membrane perforation is difficulty in achieving three-dimensional stability of the grafting material because of the loss of graft particles into the air chamber of the sinus through the membrane perforations. We compared the regenerative outcome of sinus graft procedures in a group of patients who underwent repair of an intraoperatively diagnosed sinus membrane perforation (>5 mm) to that in a group of patients without sinus membrane perforations.22 In these cases, the perforation was sealed with a mineralized freeze-dried human bone sheet, and the grafting procedure was carried out as planned. The patients whose sinus membranes were perforated experienced no complications. No statistically significant differences in the radiographic parameters were found between the two groups. In no case did the sinus-augmentation procedure have to be abandoned. It was concluded that membrane elevation must be carefully executed to avoid membrane perforation, but that if it occurs, it is possible to continue the procedure safely after repair. Therefore, the use of an allogenic block graft, which is mineralized freeze-dried bone, allows the clinician to continue with the preplanned treatment and perform simultaneous implant placement even in cases of membrane perforation.

CONCLUSIONS
A block of cancellous freeze-dried allograft may be used as a grafting material for sinus floor augmentations and for the initial stabilization of dental implants when placed during this procedure. Its main advantage is its ability to provide initial stability for the implant and the grafting material, without the need for autogenous bone harvesting, even in the presence of...
membrane perforation. Further clinical and histologic studies are required before it can be recommended for routine use in sinus augmentation procedures with simultaneous implant placement.

ACKNOWLEDGMENT
The authors report no conflicts of interest related to this study.

REFERENCES

Correspondence: Dr. Gavriel Chaushu, Department of Oral and Maxillofacial Surgery, School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Fax: 972-3-962-4621; e-mail: gabi.chaushu@gmail.com.

Submitted August 27, 2008; accepted for publication October 3, 2008.