Deep-Frozen Allogeneic Onlay Bone Grafts for Reconstruction of Atrophic Maxillary Alveolar Ridges: A Preliminary Study

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Purpose: The purpose of this article was to evaluate the suitability of deep-frozen allograft for ridge augmentation procedures in severely atrophic maxillae and to evaluate the clinical success of dental implants inserted after grafting and before prosthetic rehabilitation.

Patients and Methods: This study included 13 patients (3 men and 10 women) aged 36 to 65 years. All the patients selected for this study required bone augmentation procedures because of severe alveolar ridge atrophy and were scheduled for onlay bone allograft and titanium implants in a 2-stage procedure. The dental implants were inserted 5 months after grafting. The follow-up period for the implants was 6 months after placement at the second stage of implant surgery.

Results: A total of 24 onlay block allografts were used to augment atrophic maxillae in 13 patients. Of the 24 onlay block allografts, 5 were scheduled for vertical alveolar ridge augmentation and the remaining 19 for horizontal alveolar ridge augmentation. Early exposure of the onlay bone graft was observed in 2 patients. All the block grafts showing early exposure had to be completely removed because of infection. All the observed complications were associated with onlay bone grafts placed to increase the vertical dimension of the alveolar ridges. Thirty-eight implants ranging in length from 10 to 15 mm were placed in the area of bone augmentation. All implants inserted achieved satisfactory primary stability. Two implants failed to integrate 6 months after placement during the second stage of surgery. The failed implants were successfully replaced without any need for additional bone grafting.

Conclusions: The use of block allografts to treat maxillary atrophy yielded successful outcomes. Moreover, the augmentation procedure allowed the insertion of implants in the grafted area 5 months after surgery. Therefore, on the basis of this preliminary study, deep-frozen bone allograft can be considered a promising treatment for severe maxillary atrophy, with more extensive follow-up studies being needed to confirm these preliminary data.

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Reliable rehabilitation of the alveolar ridge with endosseous implants requires sufficient quality and quantity of the alveolar bone to achieve both implant stability and a successful esthetic outcome of the rehabilitation. Bone resorption after tooth loss is usually progressive and irreversible and is more prominent in the first year.[1-3] Resorption can be either vertical or horizontal, or both. It contributes to the reduction of bone volume and an unfavorable maxillomandibular relation.[4]

Several different surgical techniques and augmentation materials were used to improve the alveolar ridge conditions that require bone augmentation to allow correct implant placement.[5-11] These techniques include the use of grafting materials, either alone or in combination with barrier membranes. The

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most widely applied grafting material is autogenous bone, which has been reported as effective in both edentulous and partially edentulous patients.[12] Autologous bone is considered the "gold standard" for ridge augmentation procedures because it possesses osteogenic, osteoinductive, and osteoconductive properties that enhance bone formation.[13] Autogenous bone is harvested from both extraoral and intraoral sites, thus requiring additional surgery. Patients affected by partial edentulism do not readily undergo surgery because it may entail hospitalization and general anesthesia. The harvesting procedure for autogenous bone requires surgery at a donor site and results in increased morbidity, operative time, and cost.[14,15] These shortcomings have therefore focused attention on the use of allogeneic bone graft materials. Allogeneic bone grafts, including fresh-frozen, freeze-dried or demineralized freeze-dried, and cryopreserved grafts, are all harvested from cadaveric sources and are successively processed and stored in different fashions.[16] Allografts have proven to be clinically useful when autologous bone is limited in supply because any size and shape of graft needed may be provided by tissue banks.[17-19] The use of bone allograft offers several benefits by reducing operative and anesthesia time, with less discomfort and morbidity to patients compared with autogenous bone grafts. Despite these benefits, the documented use of block allografts in the treatment of alveolar ridge atrophy is limited in the literature. However, long-term evaluation of the use of fresh-frozen allograft was reported by some authors.[20] They did not observe any significant allergic reactions, rejection, or any unexpected antibodies after allograft transplantation in a 30-year period.[20] Moreover, histologic and immune-response evaluations showed no signs of antigenic reaction to the use of fresh-frozen allograft in the treatment of large bone defects.[21]

The purpose of this study was to evaluate the suitability of deep-frozen allograft for ridge augmentation procedures in severely atrophic maxillae and to analyze the clinical success of dental implants inserted after grafting and before prosthetic rehabilitation.

Patients and Methods

PATIENT POPULATION

This study included 13 patients (3 men and 10 women) aged 36 to 65 years. All the patients selected for this study required bone augmentation procedures because of severe alveolar ridge atrophy and were scheduled for onlay bone allograft and titanium implants in a 2-stage procedure. The inclusion criteria were as follows: the need for alveolar ridge reconstruction and implant placement in a 2-stage procedure, the presence of severe maxillary bone atrophy, and the presence of healthy systemic conditions without any disease that would contraindicate reconstructive bone surgery.

Patients were not included in the study if any of the following criteria were present: immune system diseases; diabetes; pulmonary, renal, or cardiovascular diseases; blood diseases; malignant neoplasia; hepatitis; drug abuse; chemotherapy; or radiotherapy. In addition, patients smoking more than 10 cigarettes per day were excluded from the study. Patients smoking less than 10 cigarettes per day were asked to stop smoking before and after surgery; however, their compliance could not be monitored.

Each case was accurately evaluated by examination of diagnostic casts to assess the interarch relation; moreover, panoramic radiographs and computed tomography scans were obtained. After these analyses, all the patients underwent any dental treatment necessary to provide an oral environment more favorable to wound healing. All patients received and signed a consent form.

All the patients were partially edentulous; a procedure combining onlay bone grafting and sinus floor elevation was performed in 5 clinical cases (Fig 1).

SURGERY

In 5 of 13 patients surgery was performed under general anesthesia. All patients, 1 hour before surgery, were given 2 g of ceftriaxone and 8 mg of dexamethasone. Patients were instructed to rinse their mouths with chlorhexidine for 2 minutes just before surgery (Fig 2).

To create the recipient site, a crestal incision (at the top of the edentulous alveolar crest) and 2 vertical releasing incisions were performed; subsequently, a full-thickness flap was raised, and the palatal flap was

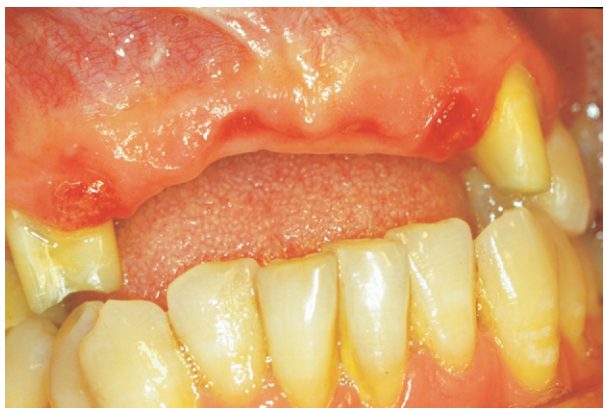

FIGURE 1. Corticocancellous bone allograft restored in a rifamycin solution.

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

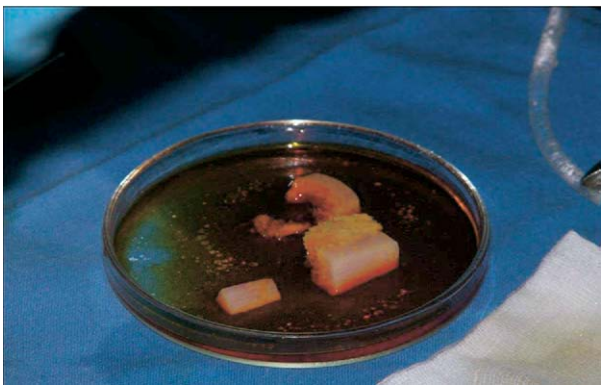

FIGURE 2. Corticocancellous bone allograft restored in rifamycin.

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

held with a No. 3 suture. The bone defect was evaluated to determine the size and shape of the block needed. The recipient site underwent recontouring if necessary to improve graft adaptation and was perforated with a fissure bur to induce bleeding and promote the revascularization of the graft. Then allogeneic corticocancellous bone that had been deep-frozen (Tissues Bank, Careggi Hospital, Florence, Italy) was restored in a rifamycin solution (Fig 2) and adapted to the atrophic maxilla. The allografts were obtained from the femoral diaphysis stored at −80°C according to standard bone bank guidelines.[20] The block allografts were positioned over the recipient site with the endosteal side facing the cortical bone. The blocks were stabilized on the residual ridge with self-tapping screws (Cizeta, Milan, Italy) until the head reached the surface of the bone allografts (Fig 3). Any sharp angles in the block grafts were smoothed to avoid perforation of the overlaying flap. Additional cancellous chips, obtained from the allogeneic bone (Fig 4), were placed at the periphery of the block

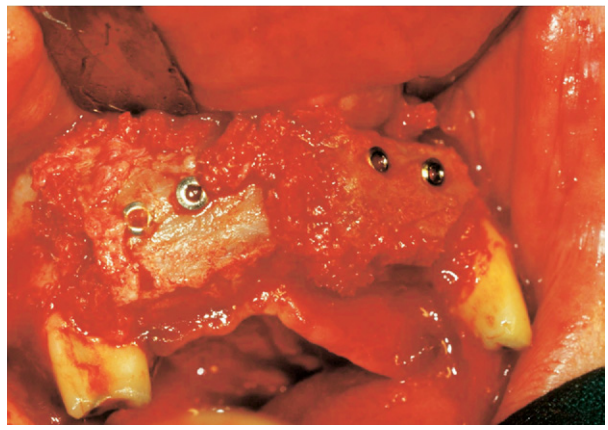

FIGURE 4. Allogeneic bone chips at periphery of block allografts to fill gap.

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

grafts to fill the gap between the grafts and the recipient site. Periosteal fenestration was performed at the base of the buccal flap to obtain a tension-free adaptation of the wound margins. The flap was then sutured with a resorbable suture that was removed after 2 weeks.

The following postoperative regimen was prescribed: ceftriaxone (2 g/d) for 5 days after surgery, dexamethasone (4 mg/d) for 2 additional days, and chlorhexidine mouthwash twice daily for 21 days. Provisional rehabilitation was accomplished with removable prostheses that were placed 30 days after surgery.

A bone graft was considered to be successful if the following criteria were met: *1*) absence of graft exposure and postoperative infection, *2*) incorporation of the graft with the recipient site, *3*) absence of bone radiolucency, *4*) bleeding from the bone graft after removal of the stabilization screws, and *5*) the possibility for implant placement.

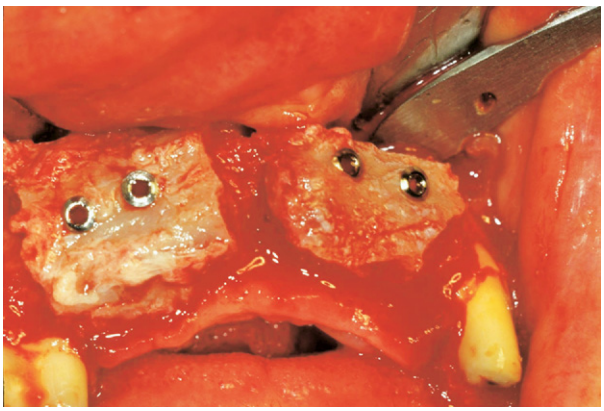

FIGURE 3. Horizontal onlay augmentation.

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

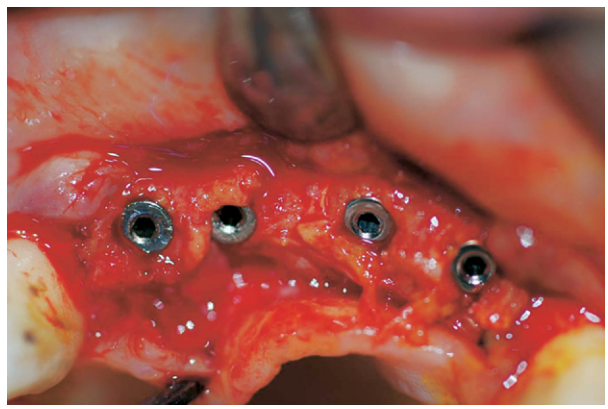

FIGURE 5. Implants placed in grafted bone.

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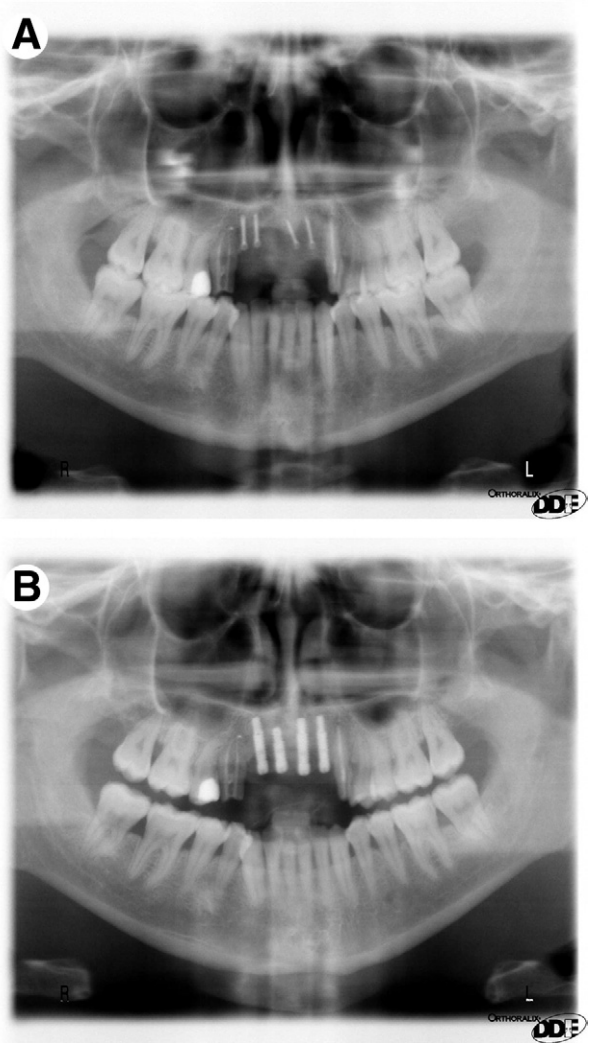

FIGURE 6. Panoramic radiographs 5 months after augmentation (*A*) and 6 months after placement (*B*).

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

DENTAL IMPLANT TREATMENT

The implant phase was begun 5 months after consolidation of the grafted sites.

An alveolar crest incision was made and mucoperiosteal flaps were elevated to expose the sites for implant placement. The fixation screws were removed, the implant sites were prepared, and the implants were placed by use of a surgical guide. All the implants in this study were inserted at the alveolar crest level and showed good primary stability (Fig 5). The flaps were subsequently closed with silk sutures.

Data were collected on the number of bone blocks, complications, and number of implants placed (Fig 6).

Results

A total of 24 onlay block allografts were used to augment atrophic maxillas in 13 patients. Of the 24 onlay block allografts, 5 were scheduled for vertical alveolar ridge augmentation and the remaining 19 for horizontal alveolar ridge augmentation (Table 1). The description of the bone maxillary reconstruction, as well as medical and smoking status, is shown in Table 2. Exposure of the onlay bone graft was observed in 2 patients, who showed exposure of block allograft occurring 3 to 5 weeks after grafting. The exposed part of the block's graft appeared necrotic (given the discoloration and soft consistency when examined) and was removed with a diamond bur under water cooling. All the block grafts showing early exposure had to be completely removed because of infection. All the observed complications were associated with onlay bone grafts placed to increase the vertical dimension of the alveolar ridges (Tables 3, 4).

During the re-entry procedures for implant placement, all the bone grafts were successfully incorporated and fixed at the recipient site (Fig 7). The fixation screws were removed, and bleeding from the bone graft was observed, indicating revascularization of the grafted bone. None of the fixation screws, used for bone block stabilization on recipient sites, showed marginal bone reabsorption around the head. The cancellous allograft chips placed at the periphery and over the grafts appeared well integrated with the recipient sites. Two patients required additional bone augmentation at the time of dental implant placement. Thirty-eight implants ranging in length from 10 to 15 mm were placed in the area of bone augmentation. All implants inserted achieved satisfactory primary stability.

The complete rehabilitation of the patients included in the study required implants being placed in

Table 1. CLINICAL CHARACTERISTICS OF 13 PATIENTS WHO UNDERWENT MAXILLARY RECONSTRUCTION USING BLOCK ALLOGRAFTS

	No. of Blocks	Complications	No. of Implants Placed	No. of Failed Implants
Block allograft				
Vertical augmentation	5	2	9	1
Horizontal augmentation	19	—	27	1
Total	24	2	38	2

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

Table 2. BONE MAXILLARY RECONSTRUCTIVE SURGERY/MEDICAL AND SMOKING STATUS OF 13 PATIENTS

Patient No.	Gender	Age (yr)	Medical Status	Smoking	Anesthesia	Bone	No. of Blocks	Sinus Lift
1	F	65	Hypertension	No	Local	Allograft	1	—
2	F	48	—	No	Local	Allograft	2	—
3	M	52	—	No	Local	Allograft	1	—
4	M	55	—	Yes	General	Allograft	2	Unilateral
5	F	63	Hypertension	Yes	General	Allograft	4	Bilateral
6	F	43	—	No	Local	Allograft	1	—
7	F	59	—	Yes	Local	Allograft	1	—
8	M	60	Hypertension	No	General	Allograft	3	Unilateral
9	F	39	—	Yes	Local	Allograft	1	—
10	F	36	—	No	Local	Allograft	1	—
11	F	57	Depression	No	General	Allograft	3	Unilateral
12	F	53	—	No	Local	Allograft	1	—
13	F	61	Hypertension	No	General	Allograft	3	Unilateral

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the augmented maxillary sinuses; those implants were not included in the study. Six months after implant placement, 2 implants failed to integrate and no signs of infection were noted during the healing period. The failed implants were successfully replaced at the time of exposure without any need for additional bone grafting. The remaining 36 implants were successful according to the criteria for success[22] and were fully surrounded by bone.

Discussion

The use of bone augmentation procedures for alveolar ridge augmentation is widely performed to allow rehabilitation with implant-supported prostheses. Allograft blocks can represent an attracting alternative treatment for alveolar ridge augmentation. The aim of this study was to report the clinical results of ridge augmentation in partially edentulous patients by use of allograft bone. Allografts provide the form and matrix of bone tissue; nonetheless, no viable cells were transplanted. Moreover, bone allografts are incorporated into the host more slowly than the autogenous bone, and they can induce an immune response, which may delay the phase of bone graft incorporation.[23] The use of allografts is well documented in several fields of medicine; they allow a shorter operative time, reduced blood loss, and lower cost to patients when compared with autogenous bone.[24-27] The findings of our study showed, with a high success rate of 99.2%, that deep-frozen allogeneic bone grafts represent a reliable treatment option for extensive rehabilitation of atrophic maxillae, consistent with findings reported with the use of autologous bone.[12,28,29] A previous clinical report indicated that fresh-frozen bone may be successfully used for the reconstruction of atrophic alveolar ridges.[17] Fresh-frozen bone was used alone and in combination with autogenous bone in 10 patients undergoing bone augmentation procedures to enable rehabilitation with implant-supported prostheses. At the time of implant placement, the bone grafts were found to be well incorporated in all patients. Several case reports provided encouraging results also with freeze-dried bone blocks in horizontal ridge augmentation procedures.[30-33] Freeze-drying (lyophilization) has been reported to attenuate the sensitization of the host tissue to graft-derived antigens, but it may also diminish the mechanical strength of the graft. Moreover, the allograft material used in these cases is incapable of osteoinduction because bone morphogenetic proteins are completely destroyed. Cryopreserved allografts are first washed with an antibiotic solution and then cooled to −80°C and are not subjected to any additional processing.

The extensive bone reabsorption that occurs after tooth loss may sometimes require vertical augmentation. In our study, 5 block grafts were used for vertical augmentation and were responsible for the 2 failures observed in the whole study. These results therefore

Table 3. NUMBER AND CHARACTERISTICS OF COMPLICATIONS OCCURRING AFTER ONLAY BONE GRAFTING

Patient No.	Block Graft	Type of Complication	Time of Occurrence	Outcome
1	Vertical	Graft exposure	3 wk	Block removal
2	Vertical	Graft exposure	5 wk	Block removal

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

might suggest that horizontal ridge augmentation has a more predictable outcome than vertical ridge augmentation.

When one is using the block graft approach for alveolar ridge reconstruction, firm stabilization of the grafts is of prime importance. The placement of dental implants simultaneously with the graft or the use of fixation screws has been advocated to achieve intimate contact of the bone block to the recipient site.[34,35] One-stage surgery can reduce the number of surgical interventions and reduce the healing time[36,37]; however, the 2-stage approach results in better outcomes.[38,39] It is conceivable that in the 2-stage situation, the revascularization of the graft after an initial period of healing allows for better incorporation of the transplanted bone to the recipient bed. Thereafter, when one is placing the implants, the surgical trauma stimulates an immediate healing response, similar to that of the native bone.[40]

Success rates of implants placed in regenerated bone, or placed at the time of bone regeneration, have been shown to be comparable to success rates of implants placed in pristine host bone.[41,42] It is reasonable to assume that when implants are placed in an adequate quantity of regenerated bone, these osseointegrated implants should show long-term success rates comparable to those of implants placed in pristine host bone.

Several studies on bone grafting technique reported that the rate of early implant failure was higher than the late failure rate.[43] In our investigation the failure rate was 5.3%. It should be taken into account that all the implant failures occurred during the first 6 months after placement and without any prosthetic treatment.

In conclusion, the use of fresh-frozen bone allografts for the reconstruction of severely atrophic maxillae has proved to be a good treatment modality for ridge augmentation. The success rate of the block grafts was comparable to that reported for autogenous bone. Moreover, the augmentation procedure allowed the insertion of implants in the grafted area 5 months after surgery. Therefore, on the basis of this preliminary study, cryopreserved bone allograft can be considered a promising treatment for severe maxillary atrophy, with more extensive follow-up studies being needed to confirm these preliminary data.

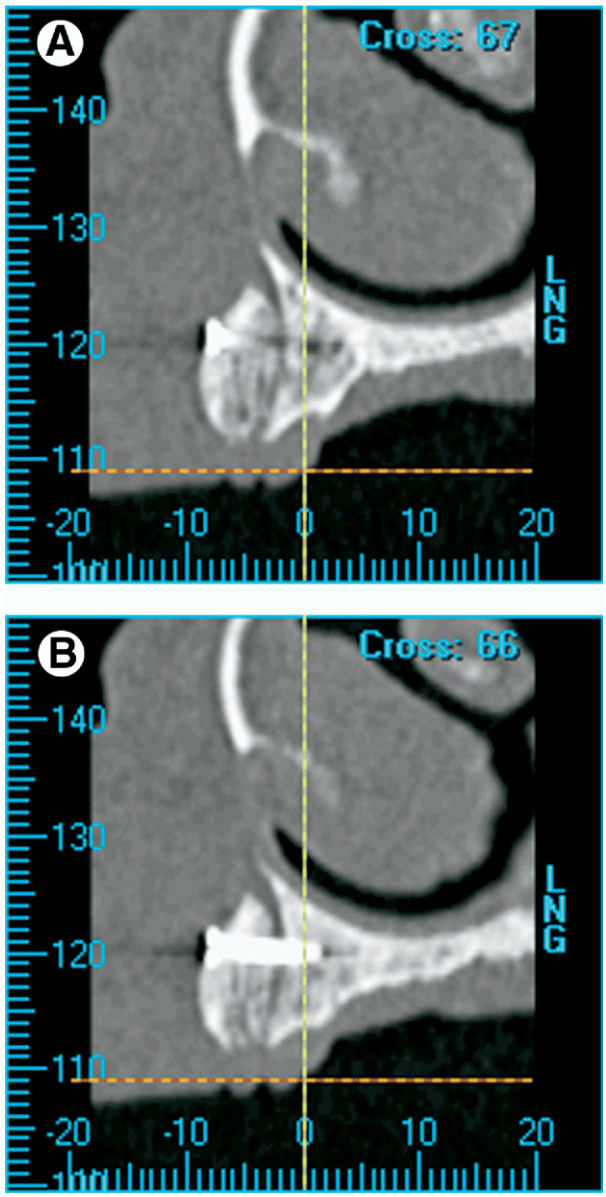

FIGURE 7. Cross-sectional images showing bone allograft incorporation before implant placement (*A*) and absence of bone resorption around the fixation screw before implant placement (*B*).

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

Table 4. ANATOMIC MAXILLARY AREA IN 13 PATIENTS UNDERGOING BONE RECONSTRUCTION WITH BLOCK ALLOGRAFTS

	No. of Blocks	Complications	Success Rate (%)
Anatomic region			
Anterior maxilla	13	1	7.6
Posterior maxilla	9	1	11.1
Total	24	2	9.3

Barone et al. Atrophic Maxillary Alveolar Ridges. J Oral Maxillofac Surg 2009.

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