Maxillary Alveolar Ridge Reconstruction With Nonvascularized Autogenous Block Bone: Clinical Results

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**Purpose:** The purposes of this study were to evaluate the clinical success of bone reconstruction of the severely atrophic maxilla using autogenous bone harvested from the anterosuperior edge of iliac wing and to analyze the clinical success and the marginal bone level of dental implants placed 4 to 5 months after bone grafting and before prosthetic rehabilitation.

**Patients and Methods:** Fifty-six patients (18 men, 38 women) aged 27 to 63 years were included in the study and required treatment for maxillary atrophy. All patients selected were scheduled for onlay bone graft and titanium implants in a 2-stage procedure. The dental implants were inserted 4 to 5 months after grafting.

**Results:** No major complications were observed from the donor sites. A total of 129 onlay bone grafts were used to augment 56 severely resorbed maxillas. Three out of 129 bone grafts had to be removed because of early exposure occurring with bone grafts placed to increase the vertical dimension of the alveolar ridge. One hundred sixty-two implants were placed in the area of bone augmentation. Seven implants failed to integrate and were successfully re-placed without any need for additional bone grafting. The clinical measurements for bone resorption around implants revealed a mean bone loss of 0.05 mm (± 0.2); the marginal bone level evaluated with periapical radiographies was 0.3 mm (± 0.4) at implant placement and 0.1 mm (± 0.3) 6 months after placement.

**Conclusion:** The success rate of the block grafts was very good. The clinical and radiographic bone observations showed a very low rate of resorption after bone graft and implant placement. Therefore, on the basis of this preliminary study, iliac bone grafts (from the anterosuperior edge of the iliac wing) can be considered a promising treatment for severe maxillary atrophy.

Implant-supported rehabilitation of the edentulous ridge require adequate volume and integrity of the alveolar bone. Loss of teeth leads to a pattern of bone resorption that can contribute to severe jaw atrophy and eventually to an unfavorable maxillomandibular relationship.\(^1,^2\) Reconstruction of severely resorbed jaws requires different surgical procedures depending on the severity of the bone atrophy. These procedures often involve the use of bone substitutes or the harvesting of autogenous bone from a donor site. Autogenous bone is believed to be the most effective bone graft material and is still regarded as the “gold standard” for augmentation procedures because of its osteogenic potential. However, this graft has a limited availability; furthermore, the surgical harvesting procedures might cause additional morbidity.\(^3,^5\) To minimize these risks, bone substitute materials such as synthetic scaffolds may be used to provide alternatives to autogenous bone to improve bone volume.\(^6\) Although excellent clinical and histologic outcomes have been reported,\(^7,^8\) some types of bone defects cannot be repaired with biomaterials because of local mechanical instability and defect size. Therefore, in cases where large amounts of bone are required, autogenous bone is considered the first choice and can be harvested from sites such as the iliac crest, tibia, skull, or mandible.\(^9,^12\) The onlay/inlay bone grafting techniques have been used in situations with a normal or acceptable maxillomandibular relationship.

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Some authors have reported the treatment of patients showing severe maxillary atrophy with using onlay bone grafts in combination with simultaneous insertion of endosteal implants. The survival rate of the implants after 3 years was 75%. It was concluded that, in spite of the high implant failure rate, onlay bone grafting to the maxilla was a valuable method in cases of severe maxillary atrophy.\(^{13}\)

The onlay block grafts, when compared with particulate bone marrow, have shown reduced osteogenic activity and slow revascularization.\(^{14,15}\) Revascularization is the key factor for successful incorporation and remodeling of the bone graft. The revascularization process is dependent on the vascular supply in the host area, and surgery should always be carried out as carefully as possible to preserve the supply of blood vessels.\(^{16-18}\)

Several studies have shown that intramembranous bone graft (calvaria and mandible), when compared with endochondral bone grafts (iliac crest), may have minimal resorption and better incorporation at the donor site.\(^{19,20}\) More recently, some other authors\(^ {21}\) have confirmed that bone resorption of the calvarial bone grafts was significantly less than that seen with iliac bone grafts. All these considerations could suggest that embryologic origins were responsible for differences in resorption patterns; however, it should be taken into account that the microarchitectural features (cortical/cancellous ratio) represent the main determinant in the volume maintenance of bone grafts in the craniofacial skeleton.\(^ {22,23}\)

The purposes of this study were as follows: 1) to evaluate the clinical success of bone reconstruction of severely atrophic maxillae using autogenous block bone before dental implant placement; and 2) to analyze the clinical success and the marginal bone loss of dental implants placed 4 to 5 months after bone grafting and before prosthetic rehabilitation.

**Patients and Methods**

**PATIENT POPULATION**

Fifty-six patients (18 men, 38 women) aged 27 to 63 years were included in the study. All patients selected for this study required bone augmentation procedures because of severe alveolar ridge atrophy and were scheduled for onlay bone graft 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; presence of severe maxillary bone atrophy; and presence of healthy systemic conditions without any disease that would contraindicate surgery under general anesthesia.

Patients were not admitted to the study if any of the following criteria were present: immune system dis-eases; diabetes; pulmonary, renal, or cardiovascular diseases; blood diseases; malignant neoplasias; hepatitis; drug abuse; chemotherapy or radiotherapy. In addition, patients smoking more than 10 cigarettes per day were excluded from the study; patients smoking fewer than 10 cigarettes per day were requested to stop smoking before and after surgery, although their compliance could not be controlled. Each case was accurately evaluated examining diagnostic casts to assess the interarch relationship; moreover, panoramic radiographs and computed tomography were taken. Following these analyses, all patients, when partially edentulous, underwent any dental treatment necessary to provide an oral environment more favorable to wound healing. All patients received and signed a consent form.

Thirty-eight patients were fully edentulous and were treated with onlay bone grafts in the anterior maxilla and maxillary sinus augmentation in the posterior area. The remaining 18 patients were partially edentulous and were treated with onlay bone grafts in the atrophic area. All patients included in this study had an atrophic area with bone thickness ranging from 2 to 3 mm.

**SURGERY**

In all patients, surgery was performed under general anesthesia. One hour before surgery, 2 g of ceftriaxone and 8 mg dexamethasone were administered intravenously.

The iliac bone was exposed and autogenous grafts were harvested with a slow-speed oscillating saw. Only the anterosuperior edge of iliac wing was harvested, keeping a safe distance of 2 cm from the anterosuperior iliac spine (Fig 1). After osteotomy, the corticocancellous bone blocks were harvested using chisels (Fig 2).

A second team of surgeons performed the augmentation of the atrophic maxilla. 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 held with a 3-0 suture. The recipient site was then recontoured to improve graft adaptation, if needed, and was perforated with a fissure bur to induce bleeding and promote the revascularization of the graft. The harvested corticocancellous blocks were adapted to the atrophic maxilla and attached to the residual ridge with self-tapping screws (Cizeta, Milano, Italy) until the head reached the surface of the bone graft (Fig 3). Any sharp angles in the block grafts were smoothed to avoid perforation of the overlaying flap. An additional mixture of corticocancellous porcine bone particle and collagen (Osteobiol; Tecnoss, Coazze, Italy) was placed at the periphery of the block grafts. Periosteal fenestration was performed at
The base of buccal flap to obtain a tension-free adaptation of the wound margins. The flap was sutured with a resorbable suture that was removed after 2 weeks.

The following postoperative regimen was prescribed: ceftriaxone (2 gr/day) for 5 days after surgery; dexamethasone (4 mg/day) for 2 additional days; and chlorhexidine mouthwash twice daily for 21 days. Provisional rehabilitations were made using removable prostheses which were placed 30 days after surgical procedure.

A bone graft was defined successful according to the following criteria: absence of graft exposure and postoperative infection; incorporation of the graft with the recipient site; absence of bone radiolucency; bleeding from the bone graft after removing stabilization screws; and possibility for implant placement.

**DENTAL IMPLANT TREATMENT**

The implant phase was begun 4 to 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 and the implant sites were prepared. Double acid-etched screw type implants (3I, Implant Innovations, West Palm Beach, FL) were placed using a surgical guide. All of the implants in this study were...
inserted at the alveolar crest level and showed good
primary stability. The flaps were subsequently closed
with silk sutures. The successive stage of surgical
procedures was performed 6 months after implant
placement for all experimental sites. At this stage the
clinical distance between the neck of the implants
(which were placed at the crestal level) and surround-
ing crestal bone was measured at 4 sites (buccal,
palatal, mesial, and distal) for each implant to evaluate
any rate, if present, of bone resorption around the
implants.

**RADIOGRAPHIC EVALUATION**

Routine panoramic radiographs were taken for all
clinical postgrafting procedures (before implant
placement). Moreover, to quantify the bone level
changes around implants inserted in grafted sites, the
periapical radiographs were evaluated immediately
and 6 months after implant placement (before pros-
thetic rehabilitation). The distance from the implant
shoulder and the first bone-implant contact (DIB) me-
sially and distally to the implant was measured using
periapical radiographs taken in a standardized man-
ner. All measurements were taken by 1 examiner
(A.B.). The bone level measurements performed im-
mediately after implant placement was considered
the baseline for further measurements (Fig 4).

Radiographic measurements of each implant were
calculated per patient by averaging the clinical param-
eter for the implants per patient because the intra-
subject variation was much lower than the intersub-
ject variation. Subsequently, the means and medians
were calculated per patient. The comparison between
baseline and 6-month data was performed with the Stu-
dent t test for paired data (the results were considered
statistically significant at the level $P \leq .05$).

**Results**

No major complications were observed from the
donor sites. One patient out of 56 required drainage
for a small hematoma. Six patients were still experi-
encing pain 1 week after graft harvesting. Two weeks
later, none of the patients had referred pain or diffi-
culties during walking. A total of 129 onlay bone
grafts were used to augment 56 severely resorbed
maxillas. Thirty-seven out of 129 onlay bone grafts
were scheduled for vertical alveolar ridge augmenta-
tion and the remaining 92 for horizontal alveolar ridge
augmentation (Table 1). The exposure of the onlay

![Figure 3](image-url)
bone graft was observed in 3 patients who received a full maxillary reconstruction. Each patient showed the exposure of 1 block occurring 3 to 5 weeks after grafting. The exposed part of the blocks graft appeared necrotic (given the discoloration and soft consistency when examined with the explorer) and was removed using a diamond bur under water cooling. Despite any treatments, all the block grafts showing an early exposure had to be completely removed because of infection. In another clinical case where signs of exposure appeared 3 months after grafting, a surgical procedure was performed to remove the surgical fixation screws and to place implants. A successful treatment of the exposure was observed with a soft tissues closure over the graft. No further infection or dehiscence was observed. Subsequently, 6 months after placement the implants showed evident marginal bone resorption. All the observed complications were associated with onlay bone grafts placed to increase the vertical dimension of the alveolar ridges (Table 2).

During the re-entry procedures for implant placement all the bone grafts were successfully incorporated and fixed at the recipient site. The fixation screws were removed and bleeding from the bone graft was observed, indicating revascularization of the grafted bone. Only 5 fixation screws out of 215 used for bone block stabilization on recipient sites showed a marginal bone resorption between 1.5 and 2 mm around the head. The mixture of cortico-cancellous porcine bone particle and collagen placed at the periphery and over the grafts appeared well integrated with the recipient sites. One hundred sixty-two implants ranging in length from 10 to 15 mm were placed in the area of bone augmentation. All implants were inserted with satisfactory primary stability.

The complete rehabilitation of the totally edentulous patients required implants placed in augmented maxillary sinuses and were not included in this study.

Six months after implant placement, 7 implants failed to integrate and no signs of infection were noted during the healing period. The failed implants were successfully re-placed at the time of exposure without any need for additional bone grafting. The remaining 155 implants were successful according to the criteria of success26 and were fully surrounded by bone. The clinical measurements for bone resorption around implants showed a mean marginal bone loss of 0.05 mm (±0.2). Moreover, the mean marginal bone level value, measured by periapical radiograph, was 0.3 mm (±0.4) at implant placement and 0.1 mm (±0.3) 6 months after placement. The reduction of the marginal bone level value from baseline to the 6-month evaluation could reflect differences in mineralization of the grafted bone, which within 6 months showed an increase in mineralization and incorporation at the recipient site (Table 3).

Table 1. CLINICAL CHARACTERISTICS OF 56 PATIENTS WHO UNDERWENT MAXILLARY RECONSTRUCTION USING BLOCK BONE GRAFTS

<table>
<thead>
<tr>
<th>Block Graft</th>
<th>No. of Blocks</th>
<th>Complications</th>
<th>No. of Implants Placed</th>
<th>No. of Implants Failed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical augmentation</td>
<td>37</td>
<td>4</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>Horizontal augmentation</td>
<td>92</td>
<td>—</td>
<td>115</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>129</td>
<td>4</td>
<td>162</td>
<td>7</td>
</tr>
</tbody>
</table>

FIGURE 4. Periapical radiographic evaluation: A, at implant placement and B, 6 months after placement.

Discussion

Autogenous bone grafts have been widely used to augment alveolar ridges affected by severe atrophy. Autogenous bone can be harvested from the intraoral and/or extraoral sites and can serve as a good treatment procedure for alveolar ridges augmentation. The present study showed that the corticocancellous block grafts, harvested from the anterosuperior edge of the iliac wing, was a reliable treatment with a high success rate for extensive reconstruction of atrophic maxillas. Morbidity was very low in all treated cases; moreover, the postoperative pain and gait disturbances were referred by only 6 out 56 patients until to the third week after surgery. The success rate of the autogenous grafts in this study (96.8%) was consistent with those reported by other authors.\textsuperscript{11,27,28}

Sometimes the resorption of the edentulous maxilla can create a reverse maxillomandibular relation or an increased vertical distance between the jaws. The latter situation may require a vertical augmentation. In the present study, 37 block grafts were used for vertical augmentation and were responsible for the 4 failures observed in the whole study. Therefore, from these findings it can be suggested that the failure rate for vertical augmentation was higher than for horizontal augmentation. The exposure of block grafts was observed in 4 patients. Three patients showed an early exposure that caused a partial necrosis of the graft and required complete removal, while the patient with the late exposure was easily treated with fixation screw removal and implant placement. Although the number of cases was limited, it might be suggested that the time of exposure is a determining factor in the outcome of this complication.

Some controversies still exist regarding the placement of implants simultaneously with bone grafting. Some authors have reported the placement of dental implants simultaneously with block grafts.\textsuperscript{11,29,30} One-stage surgery reduces the number of surgical interventions and the healing time. However, most of the authors have reported better results with the 2-stage than with the 1-stage approach.\textsuperscript{11,27,51,52} The findings from the above reported studies have shown that the condition for implant integration was improved after an initial period of healing for the bone graft.\textsuperscript{53} This has been associated with the revascularization process of the block grafts allowing a good integration to the recipient site. Thereafter, when implants are placed the conditions can be considered similar to those of nongrafted bone.

Several authors reported that membranous bone grafts maintain their volume to a greater extent compared with endochondral bone grafts.\textsuperscript{21,34,35} The reason for that could be that bone grafts of membranous origin have higher cortical bone quality than those of endochondral origin. Moreover, some other authors observed that cortical bone grafts will maintain their volume better than cancellous bone grafts, independent of embryogenic origin.\textsuperscript{22,23} The underlying mechanisms behind bone graft resorption are not still understood, but factors such as the microarchitecture of the graft, degree of vascularization during healing, and local trauma to the graft, might play a fundamental role. The cancellous portion of the bone grafts has an important function, stimulating the osteogenic cells and undifferentiated marrow cells to grow and lay down bone on their surface. Cancellous bone grafts revascularize much more quickly than cortical bone grafts; however, cortical bone is much stronger.\textsuperscript{56} The combination of cortical and cancellous bone in grafts promotes early vascularization and maximum graft maintenance. Corticocancellous bone grafts, harvested from the anterosuperior margin of the iliac wing, were used in this study. This is a different harvesting site compared with traditional sites such as the medial wall of the iliac crest. The present study showed reduced resorption for endo-
chondral bone grafts, evaluating the bone loss around the fixation screws (4 to 5 months after bone grafting) and the dental implants (6 months after placement).

Implant treatment of severely resorbed maxilllas is considered a demanding procedure showing a higher failure rate compared with the implant treatment of patients with adequate bone volume. The implant failure was divided into early (before loading) and late (after loading). Several studies on bone grafting technique reported that the rate of early implant failure was higher than the late failure. In the present investigation, the failure rate was 5.1%. It should be taken into account that all the implant failures occurred during the first 6 months after placement and without any prosthetic treatment. The marginal bone level of 0.3 mm at the baseline was higher than the value of 0.1 mm 6 months after placement, which suggested an increase of the bone level after 6 months. On the contrary, the clinical evaluation using a probe showed a stability of the bone level. One interpretation was that the bone adjacent to the implants increased the mineralization and incorporation at the recipient site through time.

In conclusion, the use of onlay block bone (harvested from the anterosuperior edge of iliac wing) for the reconstruction of severely atrophic maxilllas has been shown to be a reliable treatment procedure. The success rate of the block grafts was very successful and comparable with those reported by other authors. Moreover, the augmentation procedure allowed the insertion of implants in the grafted area 4 to 5 months after surgery. The clinical and radiographic observations showed a very low rate of bone resorption after bone graft and implant placement. Therefore, on the basis of this preliminary study, iliac bone grafts from the anterosuperior edge of the iliac wing can be considered a promising treatment for severe maxillary atrophy.

References