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# Tridimensional Reconstruction of Knife-Edge Edentulous Maxillae by Sinus Elevation, Onlay Grafts, and Sagittal Osteotomy of the Anterior Maxilla: Preliminary Surgical and Prosthetic Results

Matteo Chiapasco, MD\*/Eugenio Romeo, MD\*\*/Giorgio Vogel, MD\*\*\*

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The possibility of placing endosseous implants in the edentulous maxilla is frequently reduced by inadequate bone volume of the residual ridge. In totally edentulous maxillae with knife-edge conformation, insufficient thickness is frequently associated with insufficient height of the residual ridge in the posterior maxilla because of pneumatization of the maxillary sinuses. This surgical method combines grafting of the maxillary sinuses, onlay grafts on the buccal side of maxillary posterior segments, and sagittal osteotomy of the anterior maxilla with interpositional bone grafts. Five to six months after maxillary reconstruction, Brånemark implants were placed and, after osseointegration occurred, implant-supported dental prostheses were fabricated. Three patients have been treated with this method and 22 implants have been placed. The mean follow-up after final prosthetic rehabilitation has been 16 months; survival rate has been 100%. Despite the small number of patients and the short follow-up, preliminary results have shown very promising results.

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**Key words:** atrophic maxilla, bone graft, endosseous implants, preprosthetic surgery

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Osseointegrated implants are a very reliable means of achieving prosthetic rehabilitation of edentulous patients who have an adequate volume of residual bone.<sup>1</sup> Knife-edge edentulous maxillary ridges (Cawood and Howell Class IV<sup>2</sup>) lack thickness of the residual bone, which can render implant placement difficult or impossible and the survival of implants unpredictable. Moreover, pneumatization of the maxillary sinuses can further reduce the availability of residual bone for implant placement in the posterior

segments of the maxillary arch. Various methods have been proposed for reconstructing Class IV edentulous maxillae. Broadening of the anterior maxilla can be obtained by onlay grafts, guided bone regeneration, or sagittal osteotomy with interpositional bone grafts.<sup>3-7</sup>

Sinus floor elevation with autologous bone grafting<sup>8-10</sup> is a very reliable method for correcting vertical dimension of the posterior edentulous maxilla, but this method does not correct the transverse deficit that is typically associated with knife-edge ridges. In Class IV edentulous maxillae, anteroposterior lack of bone in the anterior maxilla and transverse and vertical lack of bone in the posterior segments, because of sinus pneumatization, can coexist.

The authors present a method to simultaneously correct this tridimensional deficit with a combination of autologous bone grafting of the maxillary sinuses, buccal onlay grafts of the posterior maxilla, and sagittal osteotomy of the anterior maxilla with interpositional bone grafts. Five to six months later, titanium self-tapping Brånemark implants are placed, and after osseointegration, the patients are rehabilitated using implant-supported prostheses.

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\*Assistant Professor, Head Unit of Oral Surgery, Dental School, S. Paolo Institute of Biomedical Sciences, University of Milano, Milan, Italy.

\*\*Assistant Professor, Head Unit of Prosthodontics, Dental School, S. Paolo Institute of Biomedical Sciences, University of Milano, Milan, Italy.

\*\*\*Professor and Chair, Department of Odontostomatology, Dental School, S. Paolo Institute of Biomedical Sciences, University of Milano, Milan, Italy.

**Reprint requests:** Dr Matteo Chiapasco, Via Carlo Crivelli 15/1, 20122 Milan, Italy. Fax: +39/2/8130200.

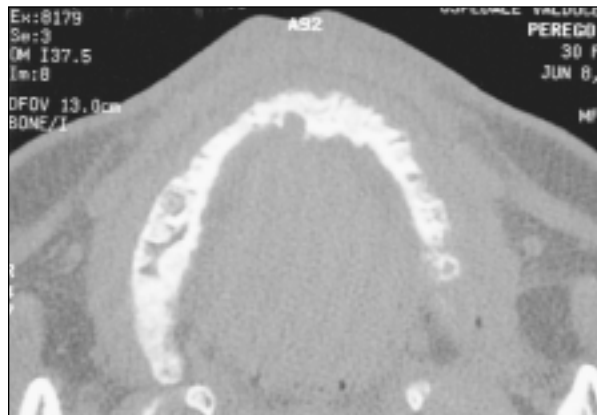
**Fig 1** Panoramic radiograph showing adequate height of the anterior maxillary ridge and insufficient height of posterior maxillary ridge with sinus pneumatization.



## Materials and Methods

**Patient Assessment/Inclusion Criteria.** This procedure is indicated for patients presenting total edentulism of the maxilla with a Class IV residual ridge (adequate height and inadequate width in the anterior maxilla and inadequate height and width of the posterior maxilla, because of pneumatization of the maxillary sinuses). Patients were selected by clinical examination and radiographic assessment using panoramic radiographs, lateral cephalometric radiographs, and computed tomography (Denta-scan, Elscint, Haifa, Israel) of the maxilla to obtain a detailed mapping of ridge morphology. Inadequate dimensions have been arbitrarily considered to be a residual ridge height of less than 7 mm and a residual ridge width of less than 4 mm. Patients with severe vertical resorption and altered intermaxillary relationship (Class V to Class VI) are not candidates for this procedure. In these situations, a horseshoe occlusal onlay graft or a Le Fort I osteotomy with interpositional bone grafts is indicated.<sup>11-13</sup>

Patients with general contraindications for general anesthesia, those presenting clinical and radiologic signs and symptoms of maxillary sinus disease, those with a history of alcohol abuse, heavy smokers, those who received radiotherapy for malignancies of the head and neck region, those affected by chronic renal and liver disease or by uncontrolled diabetes, those affected by hemophilia, bleeding disorders, or who are receiving coumarin therapy, immunocompromised patients including those who are HIV-positive, those under current steroid treatment, and those with insufficient oral hygiene were excluded from this procedure.



**Fig 2** Computed tomography scan showing insufficient width of the maxillary ridge.

**Surgical Technique.** The surgical procedure was performed under general anesthesia with nasal endotracheal intubation and controlled hypotension (mean systolic pressure below 90 mm hg) with patients in a supine position. A corticocancellous bone block of adequate dimensions was harvested from the medial side of the anterior iliac crest using a reciprocating saw and chisels. Spongiosa was also collected from the donor site for sinus floor grafting. Bleeding from the iliac crest was controlled with a packing of oxidized cellulose, and the surgical wound was closed with multilayered suture. A drain was positioned, and the incision was covered with a compressive medication.

Surgical access to the maxillary ridge was obtained by means of a crestal incision, with releasing incisions in the tuberosity areas bilaterally. A full-thickness mucoperiosteal flap was elevated in the lateroposte-

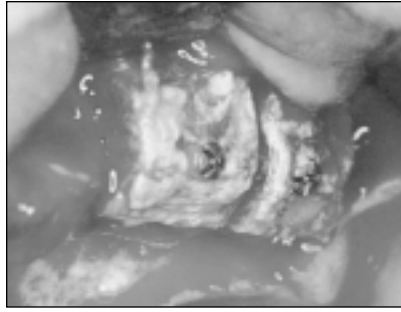


Fig 3a

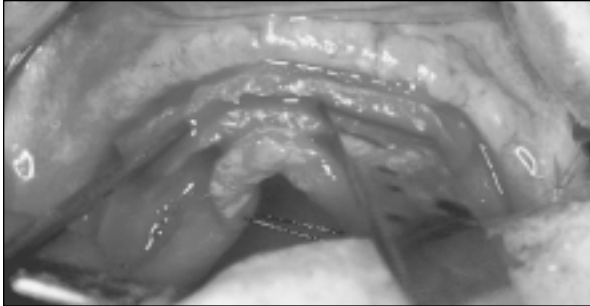


Fig 3b

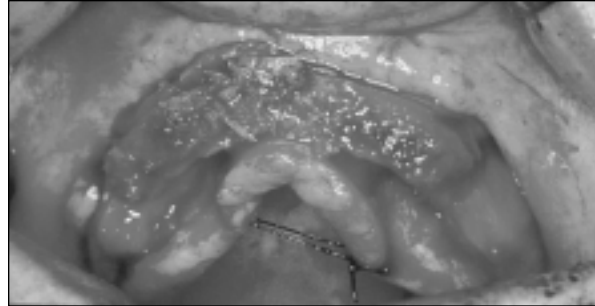


Fig 3c

rior area of the maxillary ridge, whereas a half-thickness flap was raised in the anterior region, leaving the periosteum attached to the bone. This was done to preserve vascularization of the buccal cortex of the anterior maxilla. A bilateral sagittal osteotomy was then performed by means of fine chisels with vertical bone cuts just medial to the maxillary sinuses. The outer cortex was then carefully elevated, and the gap was filled with corticocancellous blocks and chips harvested from the ilium. Normally, adequate stabilization was obtained without rigid fixation.

The next step involved exposure of the lateral wall of the maxillary sinuses; a bony window was outlined with a round bur, and careful elevation of the sinus mucosa was achieved with curved periosteal elevators. The mucosa and the bony window on both sides were then reflected upward, and the space obtained was filled with a mixture of autologous bone chips and hydroxyapatite granules (400 to 700  $\mu\text{m}$ ) with a 3 to 1 ratio between bone and hydroxyapatite. Finally, the transverse deficit was corrected by means of corticocancellous bone grafts, which were stabilized on the buccal cortex of the lateroposterior maxilla with titanium microscrews (Martin GmbH, Tuttlingen, Germany). Releasing incisions were made in the periosteum to obtain a tension-free closure.

Antibiotics (ampicillin) were delivered intravenously on induction of anesthesia and were then continued for 24 hours postoperatively. Seven to ten

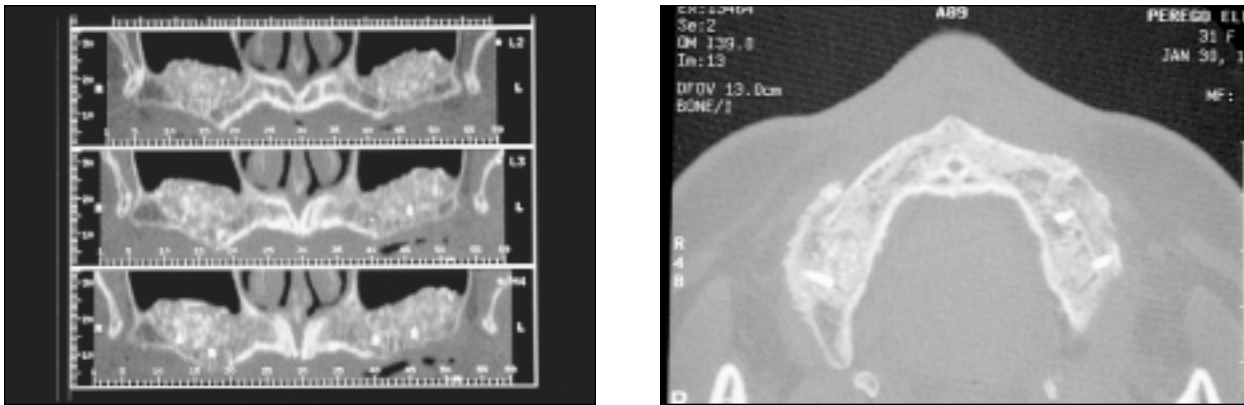
**Figs 3a to 3c** Intraoperative view showing bone grafts on the buccal side of the posterior maxilla; sagittal osteotomy of the anterior maxilla; and intraoperative situation at the end of the grafting procedure demonstrating broadening of the ridge.

days later, sutures were removed. Patients were not allowed to wear removable prostheses for 12 weeks; after this period, prostheses relined with soft materials were permitted. After 5 to 6 months, dental implants were placed under local anesthesia. The patients were given 3 g ampicillin per day for 3 days, starting 1 hour before implant placement. Following the previous incision, a full-thickness flap was raised to expose the ridge, and the microscrews were removed.

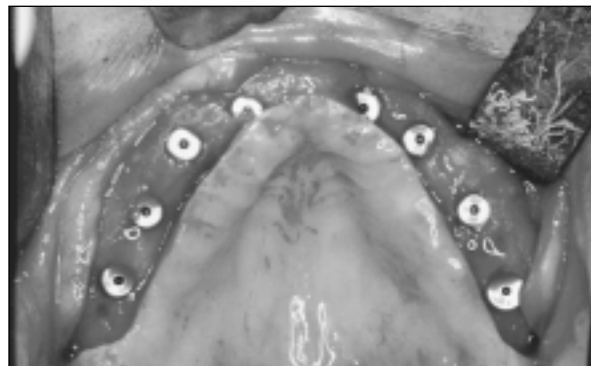
Each patient received six to eight Brånemark titanium implants (Nobel Biocare, Göteborg, Sweden), 3.75 mm in width and at least 10 mm in length. Implants were placed using a prefabricated surgical template. After a further healing period of 6 months, implants were uncovered, and prosthetic rehabilitation was started. The patients have been rehabilitated with implant-retained complete arch prostheses. A representative case is presented in Figs 1 to 6.

## Results

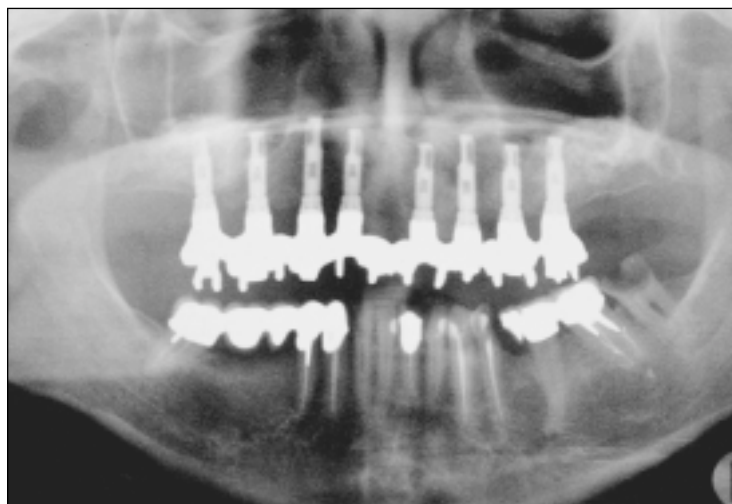
In a 2-year period (1994 to 1995), three patients have been treated with this technique, and 22 implants have been placed in the reconstructed maxillae. Postoperative recovery after the reconstructive procedure, as well as after implant placement, has been uneventful in all patients. The mean follow-up period following prosthetic rehabilitation has been 16 months (range = 9 to 22 months). The data relative to



**Figs 4a and 4b** Postoperative computed tomography scans showing (*left*) the vertical increase in the posterior maxilla after sinus floor elevation; and (*right*) the increase in ridge width in the anterior and posterior maxilla.



**Fig 5** Intraoperative view at second-stage surgery for placement of eight Brånemark implants in the reconstructed maxilla.



**Fig 6** Panoramic radiograph after final prosthetic rehabilitation.

**Table 1** Patients' Sex, Age, Number of Implants Placed, and Follow-up After Prosthetic Rehabilitation

Patient no.	Sex	Age (y)	No. of implants placed	Follow-up (mo)	No. of implants lost
1	F	27	8	9	—
2	M	48	6	17	—
3	M	53	8	22	—

sex and age of patients, number of implants placed, follow-up periods after prosthetic rehabilitation, and survival rates are presented in Table 1. At present, all of the implants placed are still in function, and implant-supported prostheses are functioning well. Success criteria proposed by Albrektsson et al<sup>14</sup> have been followed in these patients. Inadequate time in function does not permit success evaluation, although all implants comply with the criteria to date.

## Discussion

Rehabilitation of edentulous atrophic maxillae by means of implant-supported prostheses can be a challenging problem because of inadequate bone in terms of both quality and quantity. Several expedients have been proposed in the last few years to create more favorable conditions. However, most of the attention has been devoted to localized ridge augmentation<sup>3,4</sup> and to the reconstruction of severe atrophy (Class V to Class VI) with bone grafts and osteotomies.<sup>11–13,15–19</sup> On the contrary, few studies have been published concerning the reconstruction of totally edentulous Class IV maxillae.

In 1980, Boyne and James<sup>8</sup> described a technique to obtain sufficient quantities of bone in the posterior maxilla with bone grafting of the maxillary sinuses. This technique is very reliable, as demonstrated by a number of studies.<sup>9,10,20</sup> However, while it allows the correction of the vertical deficit related to sinus pneumatization, it does not address the transverse deficit that is typically present in Class IV maxillae. More recently, Richardson and Cawood<sup>5</sup> reported a sagittal osteotomy of the maxilla, which provides for broadening of the available residual ridge. All patients presented involved the anterior maxilla. Sagittal osteotomy of the posterior maxilla has been described,<sup>6,7</sup> but only in patients with adequate height of the residual ridge, where a sinus lift procedure was not indicated.

To the authors' knowledge, a one-stage tridimensional correction of a completely edentulous class IV maxilla has not yet been described in the literature. The technique described herein allows simultaneous

correction of vertical and transverse dimensions of the edentulous posterior maxilla and the anteroposterior dimension of the anterior maxilla. The interpositional grafting in the anterior maxilla appears to reduce the risk of bone resorption of onlay bone grafts,<sup>21</sup> although the long-term behavior of onlay and inlay grafts in this region has not yet been compared. Moreover, advancement of the labial plate of the anterior maxilla allows restoration for nasolabial support, with better esthetic results. Some difficulties can arise when the buccal and palatal plates are not separated by a sufficient amount of cancellous bone. In these situations, because of the risk of fractures of the buccal plate, onlay grafts are probably a more reliable solution.

Adequate preoperative information can be obtained with thorough examination of the radiographs, particularly computed tomography scans. The use of a crestal instead of a buccal incision, as proposed by Richardson and Cawood,<sup>5</sup> is indicated because by using a half-thickness flap, vascularization of the buccal plate is maintained and the same incision can be used for implant placement in a second stage. The choice of delayed placement of implants is indicated since primary stability of implants at placement is mandatory for long-term success, and this could be difficult to obtain in a one-stage procedure. Also, implant position is very important for optimal prosthetic rehabilitation, and this is more easily realized in a two-stage procedure with the use of prefabricated surgical guides. Moreover, in case of postoperative complications, such as wound dehiscence or bone infection, the presence of implants could further jeopardize results.

As for the grafting material and donor site, author choice has been the iliac crest (endochondral bone), although some studies have demonstrated better behavior of membranous bone, such as the calvarium.<sup>22</sup> This is particularly true with onlay grafts; when using interpositional grafting, endochondral bone has demonstrated practically no resorption in the authors' experience. Moreover, it offers the advantage of being more adaptable to the curvature of the anterior maxilla when compared to calvarial bone, which is more rigid.

## Summary

Despite the short follow-up and small number of patients, this technique appears to be a simple and reliable method for the reconstruction of Class IV totally edentulous maxillae. The success of treatment for this small group of patients, as evaluated according to the criteria proposed by Albrektsson et al,<sup>14</sup> is very encouraging.

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