# Maxillary Osteotomy with an Interpositional Bone Graft and Implants for Reconstruction of the Severely Resorbed Maxilla: A Clinical Report

Karl-Erik Kahnberg, DDS, PhD[1]/Lena Vannas-Löfqvist, DDS[2]

***Purpose:*** *The aim of this study was to report the outcome of using a maxillary osteotomy with an interpositional bone graft and implants in the treatment of extremely resorbed maxillae.* ***Materials and Methods:*** *Twenty-two consecutive patients (mean age 65.7 years) were included in the study. Bone grafts from the iliac bone were used. The patients were followed in a standardized clinical and radiographic method for up to 5 years.* ***Results:*** *A total of 176 Astra Tioblast ST implants were placed. Six implant losses occurred. All patients had fixed prostheses. Only minor bone resorption (1.0 to 1.5 mm) occurred in the bone graft, as well as a certain amount of marginal bone remodeling around the implants (1.0 to 1.9 mm) during periods up to 5 years. Remodeling and resorption in the bone graft and around the implants occurred during the first postoperative year. The results represent cumulative sucess and survival rates of 97%, which is comparative to implant integration in conventional maxillary bone.* ***Discussion and Conclusions:*** *The orthognathic surgical technique using maxillary osteotomy with interpositional bone graft and implants in a 2-stage procedure has been shown to be a predictable and reliable method for rehabilitation of patients with extreme resorption of the maxilla when conventional implant surgical methods cannot be used. Although the procedures are trying for the patients, overall satisfaction with the end result can be rewarding.* Int J Oral Maxillofac Implants 2005;20:938–945

**Key words:** *bone grafting, dental implants, maxillary osteotomy*

Implant rehabilitation of patients with loss of 1 or more teeth is now a routine treatment with very high predictability. The implant survival and success rates in normal bone have proven to be excellent in both the mandible and maxilla.[1,2] The mandibular anterior region is considered the most reliable site for implant placement, even with immediate or early loading.[3–5] In the maxilla, however, the challenge of osseointegration has always been greater in cases where bone resorption has reduced the volume of bone available beneath the maxillary sinus and the nasal cavities. Bone grafts have been used to increase the bone volume and augment the alveolar process. Onlay grafting with blocks of bone from the iliac bone adapted to the alveolar process in the maxilla was previously the primary technique for reconstruction of the severely resorbed edentulous maxilla. Implants were placed instead of retention screws simultaneously with graft placement to keep the bone block in place and to serve as anchors for the restoration after the healing period.[2,6–10] With attention to detail in both surgical and prosthetic techniques, survival rates of 70% to 80% were achieved. However, some technical problems were associated with this method.[2,6]

Using orthognathic surgical techniques, interpositional bone grafting in connection with Le Fort I osteotomy has developed as a reliable method both with regard to healing of the bone graft and implant survival.[11–14] Maxillary osteotomy can also be used to

[1]Professor and Clinical Director, Department of Oral and Maxillofacial Surgery, Faculty of Odontology, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden.
[2]Associate Professor, Department of Oral and Maxillofacial Radiology, The Sahlgrenska Academy of Göteborg University, Göteborg, Sweden.

**Correspondence to:** Prof Karl-Erik Kahnberg, Department of Oral and Maxillofacial Surgery, Faculty of Odontology, The Sahlgrenska Academy at Göteborg University, Box 450, SE 405 30 Göteborg, Sweden. Fax: +46 31 826091. E-mail: Karl-Erik.Kahnberg@odontologi.gu.se

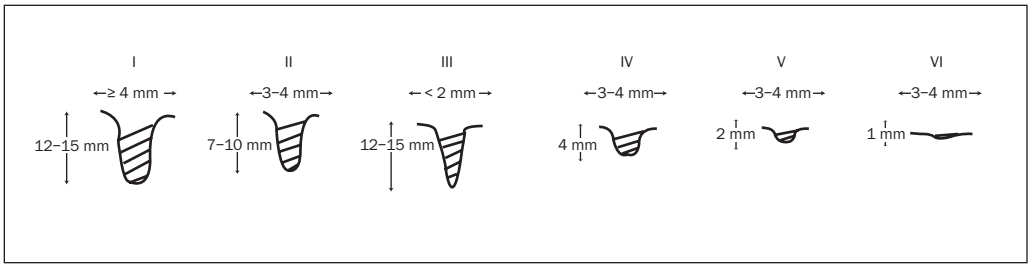



**Fig 1** Modified Cawood and Howell classification of the alveolar ridge. Traditionally, classes IV, V, and VI of the modified Cawood and Howell[15,16] shown would all be considered Cawood and Howell class IV.

**Table 1 Distribution of Patients in Relation to Modified Cawood and Howell Class and Age**

| | Anatomy of ridge | | | |
|---|---|---|---|---|
| Age (y) | III | IV | V | VI |
| 30–39 | | | | |
| 40–49 | | 1 | | |
| 50–59 | 3 | 3 | | |
| 60–69 | 2 | 1 | 5 | 1 |
| 70–80 | 1 | 1 | 2 | 2 |

**Table 2 Distribution of Patients in Relation to Modified Cawood and Howell Class and Length of Time Maxillary Denture Worn**

| | Anatomy of ridge | | | |
|---|---|---|---|---|
| Time denture worn (y) | III | IV | V | VI |
| < 10 | 2 | 1 | 1 | |
| 10–19 | 1 | 3 | 3 | |
| 20–29 | 2 | 2 | | 2 |
| 30–39 | | | 2 | 1 |
| ≥ 40 | | | 1 | 1 |

**Table 3 Distribution of Patients in Relation to Health Status, Smoking Habits, and Age**

| Age range (y) | Systemic diseases | Smoker (< 10 cig/d) | Heavy smoker (≥ 10 cig/d) | Somatically healthy |
|---|---|---|---|---|
| 30–39 | | | | |
| 40–49 | | | | |
| 50–59 | 1 | 1 | | 5 |
| 60–69 | 7 | 1 | 2 | 2 |
| 70–80 | 2 | 1 | | 5 |

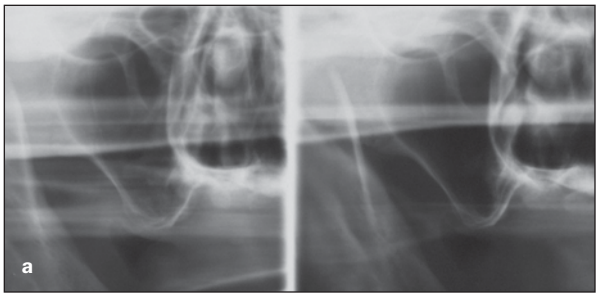
Systemic diseases included allergies, hormonal diseases, heart disease, and hypertension. Some patients had more than one condition.
Cig = cigarette.

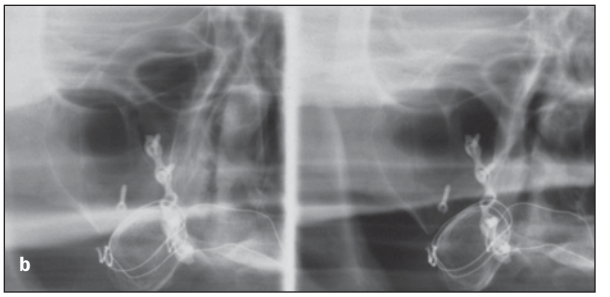
reposition the maxilla in both the horizontal and vertical directions, thereby correcting both sagittal and vertical discrepancies that may arise in conjunction with advanced atrophy of the jaws. The aim of this article was to present the results of a prospective study using maxillary osteotomy and interpositional bone grafting in the implant rehabilitation of patients with extremely resorbed maxillae.

## MATERIALS AND METHODS

Twenty-two patients were included in this prospective study using a maxillary osteotomy with concomitant interpositional bone grafts and Astra TioBlast ST implants (Astra Tech, Mölndal, Sweden) in a 2-stage implant rehabilitation procedure. All patients were referred to the oral and maxillofacial specialist clinic to solve implant surgery problems attributable to minimal residual bone volume. The patients included 15 women and 7 men. The average age was 68.9 years for female patients and 61 years for male patients, with an overall average of 65.7 years. All patients had extreme resorption of the maxilla (Fig 1; Tables 1 and 2). Some of the patients had a medical history of heart disease and/or hypertension (Table 3).

Radiographic examination was carried out with panoramic radiography, conventional tomography, frontal sinus scanograms (Scanora technique; Soredex/Orion, Helsinki, Finland), and lateral skull projection in a standardized manner by the Department of Oral and Maxillofacial Radiology at Göteborg University. The total height of the alveolar ridge was measured, the bone shape and available bone height of the edentulous regions were determined, and any maxillary sinus pathology was noted. Radiologic follow-ups were performed at the same time as clinical follow-ups (immediately postoperatively, after implant placement, after abutment connection, 1 year postoperatively, and once a year for up to 5 years). On each occasion, panoramic radiographs and frontal sinus scanograms, supplemented with a lateral skull projection, were obtained. The superior and lateral (posterior) borders of the bone grafting area were evaluated, and each implant was assessed



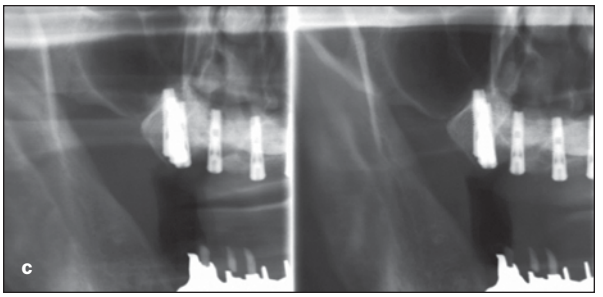




**Fig 2a** Preoperative Scanora tomogram of the posterior maxillary region showing a residual marginal bone volume of 1 to 2 mm.

**Fig 2b** Scanora tomogram after bone graft insertion in the posterior maxilla.

**Fig 2c** Scanora tomogram after implant placement in the grafted region.

regarding marginal bone height and changes over time. The marginal bone level was assessed at the distal and mesial surfaces of each implant by measuring the distance from a reference point on the implant to the bone crest. Any possible pathologic changes of the maxillary sinuses were also noted.

To classify the anatomy of the alveolar process, a modified Cawood and Howell anatomic classification was used[15,16] (Fig 1). None of the patients in the study had sufficient bone volume to be classified in Cawood and Howell classes I or II. Those in class IV had only 4 mm bone height and a base of 3 to 4 mm, whereas in classes V and VI the situation was only 2 or 1 mm of remaining bone volume, respectively. Patients in this study presented with bone volumes restricted to classifications III to VI (Fig 2). Occasionally patients were classified as class III in the anterior region with a thin but high alveolar process. In 20 of the patients, the maxilla was also skeletally retropositioned to some extent. In the most demanding cases with sagittal discrepancy, a workup was done prior to surgery to determine the desired movement of the maxilla both vertically and horizontally. In patients with only minor discrepancies in the sagittal direction, a surgical guide was used to place the implants.

## Surgical Procedure

An orthognathic surgical procedure using a maxillary osteotomy technique was performed in all patients. The surgery was carried out under general anesthesia at the Sahlgrenska University Hospital in Göteborg.

A conventional vestibular incision was made in the anterior region extending from the site of the right first premolar to the site of the left first premolar. The bony surface of the midface was exposed, and the nasal mucosa carefully lifted, exposing the bony nasal floor. After identifying the infraorbital nerve and dissecting back to the pterygoid process, the maxillary bone was cut with an oscillating saw and disconnected from the midface, beginning in the lateral bony nasal wall just beneath the inferior nasal concha. After sectioning of the lateral nasal wall, the nasal septum and the pterygoid process junction with the maxilla could be down-fractured very carefully by hand. The maxilla was then repositioned anteriorly and, if necessary inferiorly. The sinus membranes in the down-fractured maxilla were then removed, and the nasal mucosa was sutured and repaired by suturing if necessary. Meanwhile a bone graft was taken from the right iliac crest. An incision was made 7 to 8 cm above the crest. The fascia, lipid tissue, and muscle tissue were bluntly dissected until the crest was localized and covered only with periosteum layer and fascia. The necessary cuts were made with a sharp chisel stop, and a thin layer of the crestal bone with adjoining soft tissue pedicle was moved medially, exposing the iliac bone and the whole medial section of the ilium. The desired volume of bone graft could then be removed from the medial section using an oscillating saw and chisels. Both cortical and cancellous bone were collected in volumes sufficient for grafting the entire maxilla. The bone graft material was modeled and divided into pieces to fit the sinus cavities on both sides as well as the nasal floor. Additional cancellous bone grafts were used to fill out spaces between the cortical grafts. Using a small Lindemann drill, holes for osteosutures were prepared in the lateral and medial sinus walls

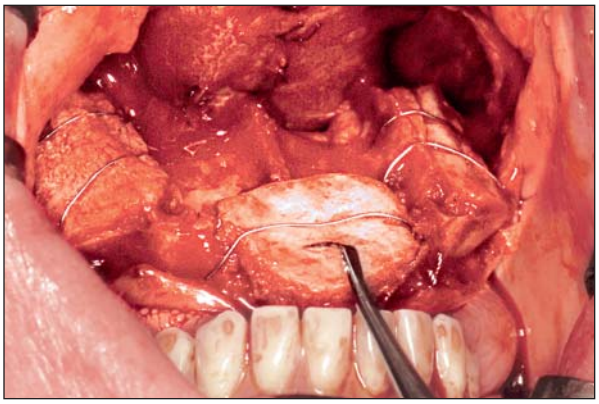


**Fig 3** The maxilla was down-fractured and the graft material secured with osteosutures.

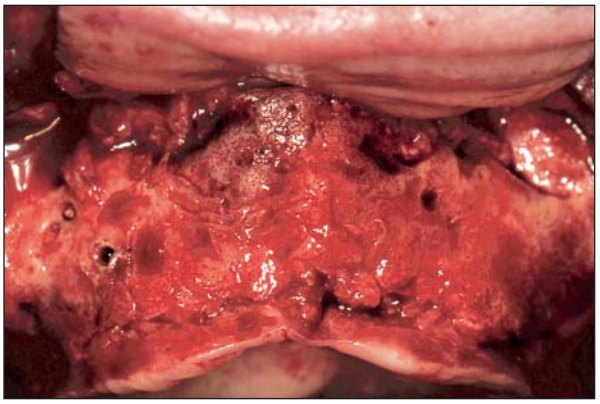


**Fig 4** Healing of bone grafts after 5 months.

**Table 4 Distribution of Implants in Relation to Implant Position and Length**

| Implant position | Implant length (mm) | | | | |
|---|---|---|---|---|---|
| | 9 | 11 | 13 | 15 | 17 |
| 5 (14) | 1 | | 12 | 6 | 3 |
| 6 (13) | | 1 | 13 | 5 | 3 |
| 7 (12) | | 2 | 13 | 3 | 4 |
| 8 (11) | | 4 | 12 | 3 | 3 |
| 9 (21) | | 5 | 10 | 4 | 3 |
| 10 (22) | | 1 | 12 | 7 | 2 |
| 11 (23) | | 1 | 16 | 4 | 1 |
| 12 (24) | | 3 | 11 | 7 | 1 |

and in the lateral nasal wall. Stainless steel wires with a diameter of 0.4 mm were introduced through the holes to form a loop over the sinus cavity and nasal cavity. Normally, a total of 5 osteosutures were used.

After remodeling the bone graft to fit the sinus and nasal cavities, cancellous bone was pressed into the sinus cavity, where all remnants of the sinus membrane had already been removed. The cortical pieces were placed in layers to build up a new base for the implants. The osteosutures were closed over the grafted material, totally immobilizing the bone graft (Fig 3). The maxilla was repositioned either back to its original position or to an anterior, inferior position. The reconstructed maxilla was attached to the midface using 2-mm-wide plates, 1 on each side of the nasal aperture, that contoured to fit the new position of the maxilla. If necessary, a bone graft was placed to cover the space between the grafted maxilla and the midface. It is very important that the plates were bent into a passive fit situation to maintain the maxilla without pressure. The soft tissue was closed with both interrupted and continuous sutures (Supramid, Alexandria, VA).

The patient was given cortical steroids for the first 2 postoperative days; the patient was also given antibiotics during the initial healing period, ie, the first 2 weeks postsurgery. Analgesics were prescribed supplementarily. The sutures were removed after 2 weeks; postoperative radiographs were taken at that time. Healing of the bone graft took between 4 and 5 months (Fig 4). In a second operation, under local anesthesia and using a crestal incision, the bone plates, screws, and osteosutures were removed, and 8 implants placed. In this series of patients, Astra Tech Tioblast ST implants were used. The length of placed implants was dependent on the bone volume available; it ranged from 10 to 17 mm (Table 4). Cover screws were adapted during the healing. The implants were always placed just palatal to the thin remaining crest and anchored in the superiorly positioned bone graft. After closure of the crestal incision, the patient remained in the healing phase for another 6 months. During this postoperative period after implant placement, the patient also had 5 days of antibiotic therapy. Abutment connection was done under local anesthesia, and healing abutments were normally used, although occasionally permanent abutments were placed, depending on positioning of the implants. All prosthetic treatment was carried out by specialists in prosthodontics or by a selected group of skilled general practitioners. Temporary prostheses were used for the first 6 months in all patients. After 6 months, gold/acrylic resin restorations were fabricated for all patients (Figs 4 and 5).

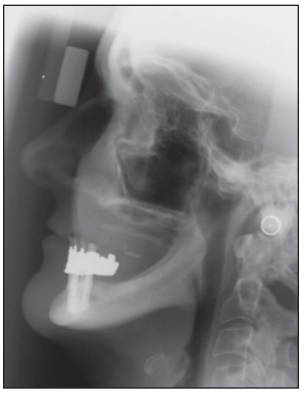


**Fig 5a** Lateral radiograph preoperatively showing retrognathic position of the maxilla and bone volume of 2 to 3 mm.

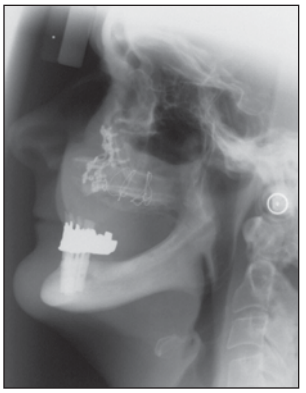


**Fig 5b** Lateral radiograph showing an anteriorly repositioned maxilla with interpositional bone graft and plate fixation.

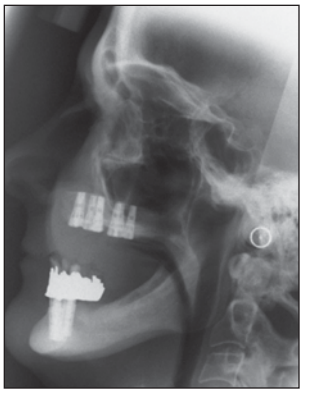


**Fig 5c** Implants placed in the bone-grafted maxilla. The sagittal relation was improved by repositioning.

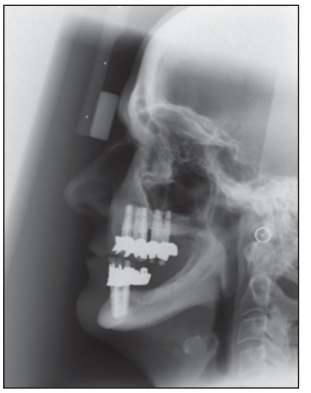


**Fig 5d** Lateral radiograph after prosthetic restoration with fixed prosthesis.

## RESULTS

All of the patients followed the follow-up protocol of clinical and radiographic examinations. Eleven of the patients were followed up for 5 years, 12 for 4 years, 14 for 3 years, 18 for at least 2 years, and 22 for at least 1 year after implant placement in grafted bone. One patient died in the interval between the 2- and 3-year follow-up. A total of 22 patients were followed with radiographic examinations-22 during the first year, 18 during the second year, 14 during the third year, 12 during the fourth year, and 11 for all 5 years. The maxilla was surgically repositioned to some extent in both the vertical and sagittal directions in most of the patients. The maxillae were sagittally repositioned by 0 to 9 mm, with a mean of 5.6 mm, and vertically repositioned by 1 to 8 mm, with a mean of 4.7 mm.

Preoperatively, the available bone height of the edentulous regions inferior to the maxillary sinus varied from 0 to 5 mm on the right side (mean 3.2), 0 to 8 mm (mean 3.9) in the anterior region, and 0 to 7 mm (mean 3.3) on the left side (Table 5; Figs 2a and 5b). No pathology in the maxillary sinuses was noted. The first postoperative examination was made approximately 1 week after surgery (Figs 2b and 5c). After grafting, the available bone height increased to an average height of 14.2 mm in the right posterior maxilla, 13.7 in the anterior region, and 13.9 in the left posterior maxilla. These figures varied to some extent during the first postoperative year: on the right side, bone height was an average 14.2 mm after implant placement and 12.5 a year later; in the anterior region, 13.7 mm after implant placement and 12.2 mm a year later; and in the left posterior region, 13.9 mm after implant placement and 12.5 a year later. Between the annual follow-up examinations only minor changes in bone volume occurred. At the 5-year postoperative examination, the average bone heights in the right, middle, and left regions of the maxilla were 12.6 mm, 12.0 mm, and 12.0 mm, respectively. Only very minor changes in the bone graft dimensions were noted up to 5 years (Table 5). The average time for bone graft healing was 4.5 months. Average healing of the implants after the second operation was 6 months (Figs 2c and 5d). The patients were allowed to have temporary dentures postoperatively 3 to 4 weeks postsurgery; they were instructed not to chew actively with the dentures but merely to use them for social purposes.

Healing of the interpositional bone grafts in connection with the maxillary osteotomy proceeded without complications in all of the patients. The sec-

**Table 5 Bone Height by Region of the Maxilla Preoperatively and at Different Follow-up Examinations for up to 5 Years**

| | Bone volume (mm) | | |
|---|---|---|---|
| Time period | RIght posterior | Anterior | Left posterior |
| Preoperatively | 3.2 | 3.9 | 3.3 |
| At bone graft procedure (postoperative) | 14.2 | 13.7 | 13.9 |
| At implant surgery | 14.2 | 13.7 | 13.9 |
| At abutment connection | 13.2 | 13.0 | 13.3 |
| 1 y after implant surgery | 12.5 | 12.2 | 12.5 |
| 2 y after implant surgery | 12.3 | 11.9 | 12.4 |
| 3 y after implant surgery | 12.2 | 11.8 | 12.3 |
| 4 y after implant surgery | 12.5 | 11.7 | 12.0 |
| 5 y after implant surgery | 12.6 | 12.0 | 12.0 |

ondary surgery for implant placement proceeded uneventfully in 19 of the patients. Three patients developed symptoms of sinusitis after a couple of weeks. In 2 of these patients, exploratory surgery showed loose bone graft material, which was removed. In 1 patient with previous symptoms of chronic sinusitis, the drainage from the left maxillary sinus was obliterated and an endonasal passage had to be constructed. These 3 patients were given antibiotics and recovered fully. Three of the total of 6 implant losses occurred in 2 of these patients. The remaining 3 implant losses occurred during the early prosthetic treatment phase. In all patients prosthetic rehabilitation involved fixed prostheses with gold/acrylic resin material (Fig 6). The prosthetic therapy was begun 2 weeks after abutment connection. The procedure was carried out in all respects according to the Astra Tech protocol.

Radiographic evaluation of bone graft remodeling at the superior and lateral borders of the graft showed that during the first year some resorption and remodeling occurred, with average loss of about 1 mm (Table 6). There were small individual variations in graft remodeling; lateral resorption was 1 to 2 mm at most. No further bone graft resorption was seen after the first postoperative year. No pathology of the maxillary sinus was noted at the follow-ups after the first postoperative year.

After implant placement, a total of 176 implants were evaluated. Seven implants were not covered with bone to the reference point. Observed bone loss ranged from 0.5 and 2.0 mm. After abutment connection, a total of 160 implants were evaluated. Forty-eight implants had a loss of marginal bone height with a variation of 0.5 to 6.0 mm (mean 1.91 mm). Osseointegration was lost in 3 instances. A year after implant surgery, a total of 152 implants were examined. Fifty-seven implants demonstrated a loss of marginal bone height of 0.5 to 5.0 mm (mean 1.49 mm). One implant had lost osseointegration. After 2 years, 144 implants were evaluated. Ten had a loss of marginal bone height of 0.5 to 2.0 mm (mean 1.80); osseointegration was lost in 1 case. After 3 years, 112 implants in 14 patients were examined clinically and radiographically. There were no further signs of marginal bone loss height or implant failure. No bone graft resportion or pathology of the maxillary sinus was seen. At the 4- and 5-year examinations, there were only very minor changes in marginal bone support and no changes in bone graft volume. At the 4-year examination, 13 patients with a total of 104 implants were examined; at the 5-year examination, 10 patients with a total of 78 implants were examined (Table 7).

All patients received fixed prostheses. Only 6 of the 176 implants were lost in patients followed up for 5 years. Thus, the cumulative survival rate was 97% (Table 7).

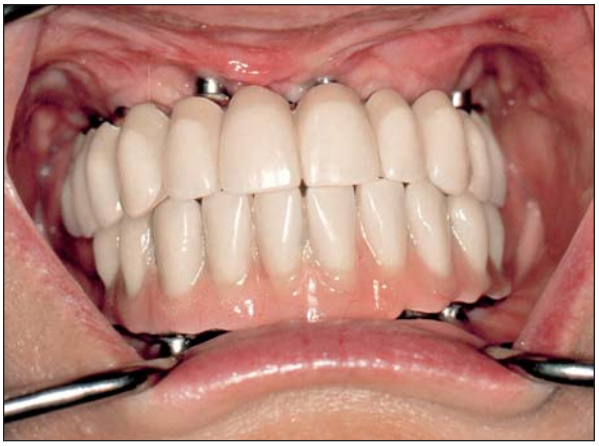


**Fig 6** Clinical view after prosthetic rehabilitation.

## DISCUSSION

In edentulous patients where the remaining bone volume is mainly categories V and VI according to the modified Cawood classification,[15,16] and between 2 and 4 mm in height (and in some patients even less), the treatment options for implant rehabilitation are limited. The bone volume has to be increased, either by onlay grafting or inlay grafting to accommodate implant placement.[2,6,8,9,12,13,17–23] Large onlay grafts have been successful with a good prognosis, provided that special precautions are taken not to traumatize the vulnerable covering mucosa. The problem with onlay grafting is the necessity of relaxed flap coverage with enough vascularization to be able to incorporate and integrate the graft specimen. Wound contraction, muscle forces, and chewing forces are factors that may interfere with healing of onlay grafts.[6,24,25] Another problem with the severely resorbed maxilla is that the sagittal relationship between the jaws often is affected, with retropositioning of the maxilla, making prosthetic rehabilitation problematic and less predictable.[7,10,26] Inlay grafting combined with maxillary osteotomy can also correct positioning of the maxilla to a certain extent, thus improving both the unfavorable sagittal relationship and the vertical dimension. Bone graft material that is not secured with screws or wires is prone to induce inflammation and may jeopardize the final result.

With a 1-stage technique, the bone graft is attached by use of the implants. However, to achieve

**Table 6 Marginal Bone Remodeling and Resorption in mm at Different Implant Positions at Implant Placement, Abutment Connection, and Annually for up to 5 Years**

| Time period | 5 (14) | 6 (13) | 7 (12) | 8 (11) | 9 (21) | 10 (22) | 11 (23) | 12 (24) |
|---|---|---|---|---|---|---|---|---|
| At implant placement | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −0.1 |
| At abutment connection | −0.6 | −0.6 | −0.5 | −0.5 | −0.4 | −0.3 | −0.4 | −0.6 |
| 1 y after implant surgery | −1.1 | −1.5 | −1.2 | −1.1 | −0.9 | −0.9 | −1.2 | −1.3 |
| 2 y after implant surgery | −1.2 | −1.6 | −1.7 | −1.5 | −1.1 | −1.1 | −1.4 | −1.4 |
| 3 y after implant surgery | −1.4 | −1.8 | −1.8 | −1.5 | −1.0 | −1.1 | −1.5 | −1.5 |
| 4 y after implant surgery | −1.4 | −1.8 | −1.9 | −1.7 | −1.5 | −1.3 | −1.6 | −1.8 |
| 5 y after implant surgery | −1.1 | −1.6 | −1.9 | −1.5 | −1.9 | −1.4 | −1.6 | −1.8 |

more predictable results and to position the implants optimally, the 2-stage technique is preferable.[11–13] A bone graft which is largely vascularized will faciliate osseointegration of the implants much more rapidly. It is also important for successful bone grafting that smoking be abandoned. Smoking affects capillary growth and is a clear risk factor in bone grafting procedures. In the present study, the patients had to stop smoking at least 6 months before the grafting was carried out. Originally, the group included 2 heavy smokers and 3 moderate smokers. The results for these patients were as good as those for the other patients after a preoperative nonsmoking period.

Sinusitus symptoms developed in a few patients. In 2 patients, the sinusitis was caused by loose bone graft material; in the third patient, who had previous chronic sinusitis, it was caused by lack of drainage. After treatment these patients too had acceptable final results. Caution was taken with denture loading after the surgical procedures. After an unloaded healing period of a couple of weeks, patients were allowed to chew with the dentures but were asked to chew soft food carefully and mainly use the dentures for social purposes. The patients were very understanding about these instructions and followed them carefully. All precautions which enhance the results are, of course, valuable. All patients were rehabilitated with fixed prostheses by selected groups of general practitioners with long experience in implant rehabilitation. Gold/acrylic resin prostheses were routinely fabricated; the harder porcelain materials were avoided.[26]

Bone volume was shown by radiographic analysis to have been increased by 4 to 5 times the initial volume, enabling placement of implants 13 to 15 mm long in most patients (Figs 2c and 5d, Table 4). During the annual clinical and radiographic examinations, excellent stability was noted. Marginal bone remodeling occurred to some extent, but seldom more than 1 to 2 mm, with individual variation. Many of the cases were previously considered hopeless, with no rehabilitation possible. However, this patient series clearly showed that by use of an orthognathic surgical technique with inlay grafting in a first stage and later implant placement, it is possible to achieve a cumulative survival rate of 97%, ie, results nearly as good as with conventional implant treatment in the maxilla. Using rough-surface implants in this study, (Astra Tech Tioblast implants) it was possible to increase the survival and success rate from 85% to 97%, as compared with the use of machined-surface implants.[13,27] The surface structure has beneficial effects in terms of osseointegration, as has been shown by research, and improved results have been realized in ongoing clinical studies, especially in complicated cases using bone grafting techniques.[13,27]

**Table 7 Life Table Analysis of the Implants**

| Time interval | No. of implants at interval start | Failed implants in interval | Failure rate in interval (%) | Cumulative survival (%) |
|---|---|---|---|---|
| −1 | 176 | 6 | 3 | 97 |
| −2 | 138 | 0 | 0 | 97 |
| −3 | 110 | 0 | 0 | 97 |
| −4 | 102 | 0 | 0 | 97 |
| −5 | 82 | 0 | 0 | 97 |

## CONCLUSIONS

The severely resorbed maxilla can successfully be rehabilitated using a maxillary osteotomy with interpositional bone grafting and Astra Tioblast ST implants in a 2-stage procedure. The results can be similar to those achieved with conventional implant treatment in the maxilla.

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