# Sinus Lift Procedure Using a 2-Stage Surgical Technique: I. Clinical and Radiographic Report up to 5 Years

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

***Purpose:*** *The aim of this study was to report the long-term results of a 2-stage sinus lift procedure with autologous bone graft and Astra Tech Tioblast ST implants (Astra Tech, Mölndal, Sweden).* ***Materials and Methods:*** *Sinus lift procedures were carried out in 36 patients, 25 unilateral and 11 bilateral. Bone grafts were obtained from the iliac crest, mandibular angle, or chin region. Healing time for bone grafts varied between 4 and 5 months. Implants were allowed to heal for 6 months. The patients were followed in a standardized clinical and radiographic method for up to 5 years. Patients with partial dentition in the maxilla and limited bone volume below the sinus cavity (6 to 7 mm) were consecutively included in the study. Smoking was a contraindication to inclusion in the study unless patients who smoked quit smoking for at least 6 months prior to surgery.* ***Results:*** *All patients have been successfully restored with fixed complete dentures. There was no implant loss. Radiographic examination showed minor changes in bone graft height (1 to 1.5 mm) over 5 years and moderate bone remodeling (1 to 2 mm over 5 years). Signs of sinus infection appeared in 8 patients. In 4 patients, partial loss of bone graft material occurred.* ***Conclusion:*** *Two-stage sinus lift procedure with autologous bone graft material in combination with Astra Tech Tioblast ST implants has a predictable outcome. The method is reliable and useful for patients with severe resorption of the posterior maxilla.* Int J Oral Maxillofac Implants 2008;23:876–884

**Key words:** *bone-implant interaction, bone regeneration, clinical research, sinus floor elevation, surgical techniques*

Implant rehabilitation has become a predictable treatment with very well-documented long-term follow-up, as presented in the literature.[1–5] This is especially true for situations where sufficient bone volume is available for conventional implant insertion and retention. In situations where there is bone deficiency the problem can be solved by the use of bone grafting, sometimes in combination with orthognathic surgical techniques.[6–10] Even in these more demanding cases the predictability is high, especially when implants with a modified surface structure are used.[10] The sinus lift technique may be used in the posterior maxilla.[11–20] The most frequently used technique is the buccal window technique.[21,22] The surgery has to be performed with high accuracy to avoid perforation of the sinus membrane, which may induce sinusitis and loss of bone graft material.

In some cases it is possible to perform the surgery in 1 stage, with placement of bone graft and implants at the same time.[22–26] However, in these cases it is important to have enough marginal bone to achieve good initial stability. In cases with a thin marginal bone of less than 5 mm, 2-stage surgery is recommended, with bone grafting in 1 stage and implant placement in a later stage.[8,19,20,23–25] The aim of this paper is to present the results of a prospective clinical study of sinus lift in a 2-stage procedure combined with Astra Tioblast ST implants (Astra Tech, Mölndal, Sweden).

[1]Professor and Chairman, Department of Oral and Maxillofacial Surgery, Institute of Odontology, The Sahlgrenska Academy at University of Gothenburg, Sweden.
[2]Associate Professor, Department of Oral and Maxillofacial Radiology, Institute of Odontology, The Sahlgrenska Academy at University of Gothenburg, Sweden.

**Correspondence to:** Dr Karl-Erik Kahnberg, Department of Oral and Maxillofacial Surgery, Institute of Odontology, The Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden. E-mail: k-e_kahnberg@odontologi.gu.se

## MATERIALS AND METHODS

A consecutive series of 36 patients with inadequate bone volume in the posterior maxilla were prospectively followed clinically and radiographically for up to 5 years after bone augmentation and implant rehabilitation. In all patients it was necessary to improve the bone volume in order to rehabilitate with implants and fixed partial dentition. The patient material consisted of 22 women and 14 men (Table 1). The average age was 59.9 years for the women and 59.8 years for the men. No medically compromised patients participated in this study. Three patients were medicated for high blood pressure. Smoking was a contraindication to inclusion in the study. Some of the patients (n = 4) were smokers, but they stopped smoking 6 months before stage 1 surgery.[26] The patients presented with uni- or bilateral loss of teeth in the posterior maxilla with a residual anterior dentition. The average remaining height of the alveolar crest below the sinus cavity was 5 to 6 mm. Astra implants with a Tioblast surface and conical marginal design (Astra Tech Tioblast ST-implants 4.5 mm, Astra Tech, Mölndal, Sweden) were used for the implant rehabilitation. In cases of bilateral sinus lift it was decided to use bone graft from the iliac bone, and in unilateral cases mandibular bone from either the chin region or the mandibular angle was used.

**Table 1 Number of Patients Subjected to Sinus Lift Procedure**

| Surgery | Male patients | Female patients | Total sinus lift procedures |
|---|---|---|---|
| Bilateral sinus lift procedures | 4 | 7 | 22 |
| Unilateral sinus lift procedure (right side) | 4 | 10 | 14 |
| Unilateral sinus lift procedure (left side) | 5 | 6 | 11 |
| Total | 13 | 23 | 47 |

### Surgical Procedures

*Bone Grafting.* The surgical procedure had to be done under general anesthesia when a bilateral operation was performed and the bone graft was taken from the iliac crest. It was possible to perform unilateral procedures under local anesthesia with concomitant sedation.

Bone grafts can be obtained from the iliac crest, tibia, symphyseal region, or mandibular angle region or bone substitute can be used. In this study, bone from the iliac crest was used in 17 patients, bone from the mandibular chin region was used in 2 patients, and bone from the mandibular angle region was used in 17 patients. Iliac bone grafts were taken from the medial aspect of the iliac crest. The medial wall of the iliac bone was exposed after lifting part of the crestal bone medially. This crestal bone cover could then be repositioned and tightened with plate screws, thus totally reconstructing the crestal anatomy. Cortical and cancellous grafts were taken from the medial part of the iliac crest in sufficient volume for the purpose.

When only a minor volume of bone was needed, the graft could be taken from the chin region. In these cases a buccal incision was made and the buccal cortex was exposed. With a round bur or a Lindemann drill, a suitable piece of bone was removed. A distance of 5 mm between the apices and the bone cut is recommended. It is not advisable to take the graft all the way through the alveolar process because of the risk of lacerating the sublingual space. The graft material obtained from the chin is mainly cortical bone and normally very hard. The limits in the horizontal direction are the mental foramen on both sides.

Another potential donor site for bone harvesting under local anesthesia is the mandibular angle region. The lateral cortical plate in the angle region can be split at varying lengths. Limiting extension will depend on the individual anatomy and the position of the inferior alveolar nerve. The mental foramen is the anterior border and just anterior to the angle is the posterior border for harvesting the graft. Larger grafts can be obtained from the mandibular angle region than from the chin. The bone quality is mainly cortical bone.

*Sinus Augmentation.* The buccal window technique was used in all cases. The incision was placed just medial to the alveolar crest, with a relaxation incision in the anterior part of the incision, usually just posterior to the canine tooth. The flap was raised, exposing the lateral sinus wall. The infraorbital nerve and foramen were located. A curved bone preparation was made in the inferior part of the sinus wall with a round steel bur or a round diamond drill, going carefully through the bone just to the sinus membrane without perforating it. At the end of the curved preparation a fracture line was made inferior to the infraorbital nerve. The buccal bone window was infractured into the sinus cavity to form a roof for the graft. The sinus membrane was released carefully from the inferior and lateral sinus walls and lifted superiorly (Fig 1a), leaving the bottom of the sinus cavity with a bone surface with no soft tissue remnants (Fig 1b). If wires (osteosutures) were used, these were introduced to form a loop within which the graft material was positioned. A piece of cortical bone

**Fig 1a** Preparation of a buccal window in the right posterior maxilla, exposing the intact sinus mucosa.

**Fig 1b** A gentle lifting of the maxillary sinus mucosa without perforating the mucosa. The sinus mucosa is lifted to make a space for the bone graft.

**Fig 1c** Cortical bone graft from the mandibular angle is adjusted and trimmed to fit into the sinus recess and attached with a circumferential wire.

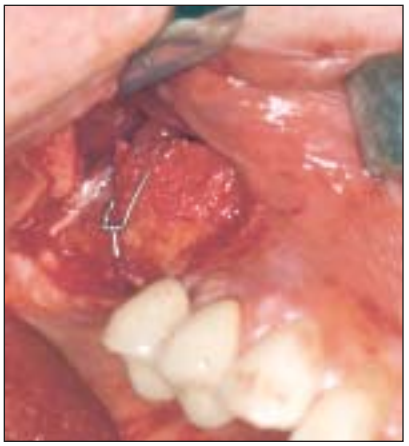

**Fig 1d** Particulated bone graft is placed below the cortical block, and the reconstructed sinus is secured with a wire.

**Fig 1e** The patient after construction of the partial prosthesis (maxillary right posterior).

block was first introduced, and the particulated graft or cancellous graft material was placed below the roof and packed together (Fig 1c). If the volume of bone material was insufficient, additional Bio-Oss (Geistlich Biomaterials, Wolhusen, Switzerland) was placed. The osteosutures were then tightened to immobilize the whole package (Fig 1d). The incision was closed, and the bone graft was left to heal for 4 months. After bone healing, implant surgery was carried out under local anesthesia, sometimes in combination with oral sedation (Halcion, Pfizer, New York, NY). Conventional crestal incisions were made, and the mucoperiosteal flap was raised as before. Osteosutures were removed, and the implant sites were prepared according to the manufacturer's manual. Three or 4 Astra ST implants were inserted on 1 side with lengths as long as the bone graft permitted. The incision was closed, and healing of the implants in the bone graft took another 6 months. The abutment connection was done under local anesthesia using small incisions over the cover screws and attaching healing abutments or permanent abutments before the prosthetic treatment. Prosthetic treatment was done according to the manufacturer's manual, and a fixed partial denture was delivered within 10 days (Fig 1e). In connection with prosthetic loading, implant stability was individually checked. The patients were medicated with penicillin V for 1 week after the grafting procedure and for 1 week after implant insertion. As much analgesia was provided (Ibumetin, Nycomed Pharma, Denmark) as was needed for pain relief.

## Radiographic Examination

The radiographic examinations were performed at the Department of Oral and Maxillofacial Radiology in Göteborg, Sweden. The patients were examined preoperatively with a panoramic radiograph, conventional tomography, and sinus scanograms (Scanora technique, Soredex, Orion, Helsinki, Finland).

**Fig 2a** Patient with a sinus cavity in the right maxilla filling out the entire alveolar process.

**Fig 2b** The same situation as in Fig 2a with an intrasinus bone graft secured with a wire.

**Fig 2c** The patient after partial prosthesis construction on 3 implants in the reconstructed maxillary sinus.

The superior and lateral (posterior) borders of the bone graft were evaluated, and each implant was evaluated regarding the marginal bone height and its change over time. The marginal bone level was assessed at the distal and mesial surfaces of each implant by measuring the distance between the coronal margin of the implant and the bone crest. The measurements were performed to the nearest 0.5 mm for images obtained with the extraoral techniques used. The radiographic evaluation was made by 2 oral radiologists, who discussed each case until consensus was reached.

The total height of the maxillary alveolar bone was measured, and available bone height of the edentulous regions was determined. The radiographs were also screened for maxillary sinus pathology. Radiologic follow-ups were performed on the same day as clinical follow-ups (ie, immediately postoperatively after bone grafting, after implant placement, and annually thereafter). At 5 years, panoramic radiographs supplemented with frontal and lateral sinus scanograms were used for radiographic examination (Figs 2 and 3).

### Follow-up

All patients were consecutively followed annually prospectively for up to 5 years (Fig 4). Clinical and radiographic examinations were made preoperatively, immediately after the grafting procedure, immediately after implant insertion, and annually thereafter after implant insertion.

## RESULTS

### Clinical Examination

Thirty-six patients with a total of 47 sinus lift procedures were followed clinically in a prospective manner. All patients included in the study fulfilled the follow-up. Twenty-seven patients were followed for 5 years, 32 for 4 years, and 36 for 3 years (Fig 4). In 17 of the patients bone was harvested from the iliac crest, and in 19 patients the bone graft was obtained from the mandible (Fig 5). The mandible graft was either chin graft (n = 2) or mandibular angle graft (n = 17). In 42 sinus lift procedures, cortical bone grafts were combined with particulate graft (Fig 6). In 5 cases

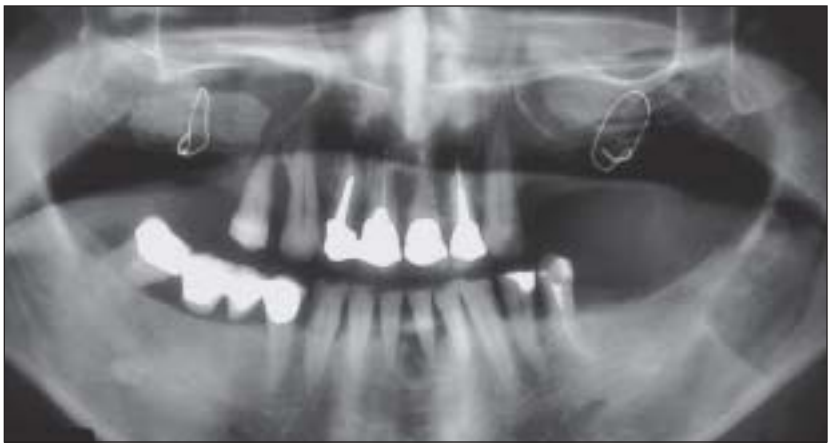

**Fig 3a** Panoramic radiograph showing bilateral sinus lift with particulated bone reconstructing the alveolar process with bone graft. The bone grafts are secured with wires, one on each side.

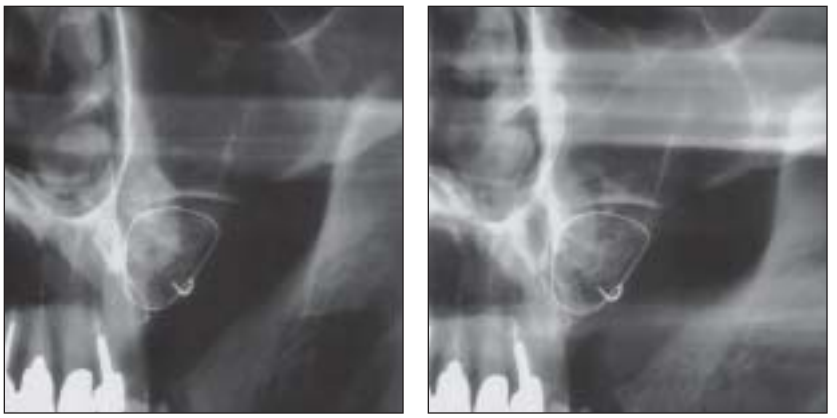

**Fig 3b** The same situation in a tomographic view clearly showing the infractured buccal window and the top of the bone graft.

only particulate bone graft was used (Fig 6). Additional Bio-Oss augmentation was required in 10 cases (Fig 6). The bone block graft was immobilized with osteosuture wiring in 25 cases, and plate screw fixation was used in 11 cases. In 8 cases the graft material was left without fixation of any kind (Fig 7). In another 3 sinuses fixation was made by means of both screw fixation and osteosutures.

The bone graft was allowed to heal for 4 months. The postoperative period was free from complications in all but 8 patients, in whom varying degrees of sinusitis symptoms occurred, from thickening of the sinus mucosa to a purulent infection (2 patients). These infections were treated with antibiotics and in 2 patients also with exploration and rinsing. Although part of the bone graft was lost in 4 patients, implant surgery could be carried out in all patients. The implant surgery procedure was performed after 4 to 5 months with insertion of 3 to 4 implants in unilateral cases using Astra Tech Tioblast ST implants 4.5 mm (Astra Tech, Mölndal, Sweden) with a conical design (Table 2). The implants were allowed to integrate for 6 months. The implant prosthetic rehabilitation was performed by both an experienced general practitioner and prosthodontic specialists. Three- or 4-unit fixed partial dentures were made in all patients. The clinical follow-up routines concerned monitoring oral hygiene, gingival health, and implant function. The patients were always subjected to radiographic examination before clinical examination. A healthy gingival situation was found in all patients at follow-up examinations. The survival rate was 100%.

## Radiographic Examination

Postoperative examination after the bone graft procedure showed available bone height of the edentulous regions measured from the superior part of the grafts of 13.9 mm on the right side and 14.1 mm on the left side on average (Table 3). At the time of implant placement, part of the bone grafts was lost in 2 patients. Thirty bone grafts showed resorption of less than 1 mm, whereas 17 showed loss of between 1 to 2 mm. The average bone height was 13.3 mm on the right side and 13.4 mm on the left side. During the annual radiographic follow-ups, a slight marginal bone reduction of 0.8 mm was observed during the

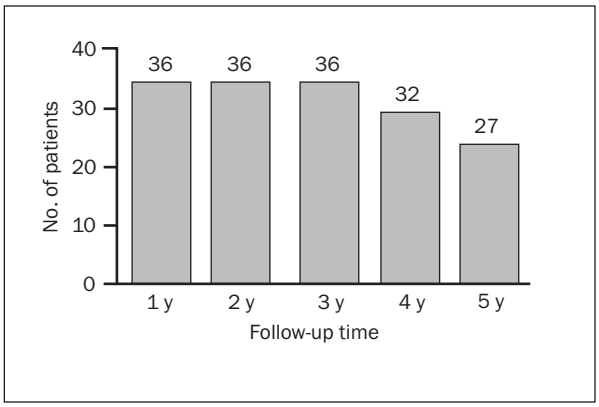


**Fig 4** Number of patients at annual follow-ups.

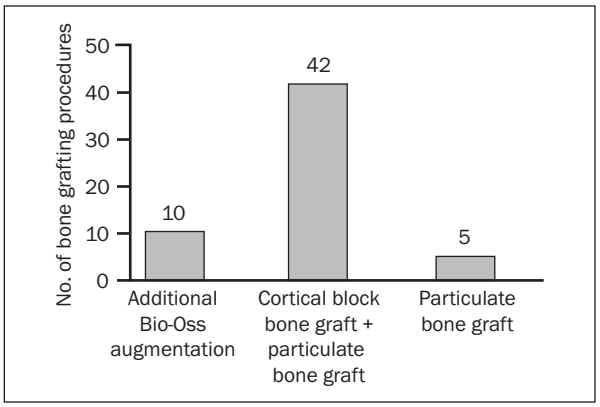


**Fig 6** Bone grafting procedures.

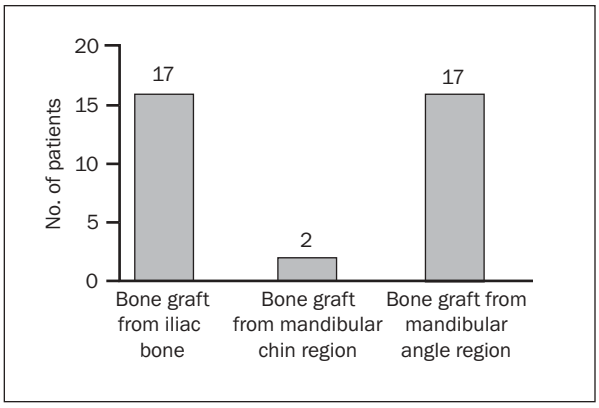


**Fig 5** Number of patients with bone harvesting from either iliac bone, chin region, or mandibular angle.

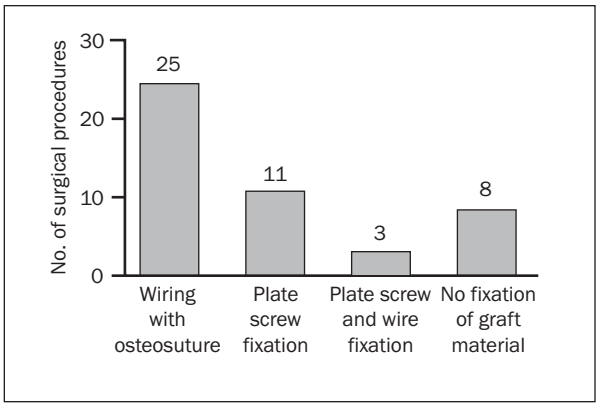


**Fig 7** Fixation methods in the patient group.

first postoperative year; bone height reduction of less than 1 mm was observed in most of cases. During the second year the average marginal bone resorption was 1.1 mm, and bone graft resorption was slightly more than 1 mm. In the third year there was a slight increase in marginal bone reduction (1.2 mm), and half of the patients showed bone resorption of more than 1 mm. Total bone height on the right side was 12.3 mm and on the left side 13.2 mm. At the 4- and 5-year follow-up examinations the marginal bone reduction underwent minor changes, with a mean of 1.5 mm reduction totally (1.4 mm at 4 years and 1.6 mm at 5 years). Only minor changes in the total height of the bone grafts at the 4- and 5-year follow-up examinations were noted (Tables 3 and 4).

Fifteen patients had radiographic changes in the sinuses. Six patients had changes, including thickening of the sinus lining, and 9 patients had complete

**Table 2 Implant Length**

| | 9 mm | 11 mm | 13 mm | 15 mm | 17 mm |
|---|---|---|---|---|---|
| Right | | | | | |
| Second premolar | | 1 | 6 | 4 | |
| First molar | | 3 | 12 | 8 | 1 |
| Second molar | 1 | 2 | 14 | 10 | |
| Third molar | | 3 | 8 | 11 | 3 |
| Left | | | | | |
| Second premolar | | 3 | 3 | 10 | 2 |
| First molar | | 3 | 8 | 10 | 1 |
| Second molar | | | 12 | 6 | |
| Third molar | | | 3 | 4 | 1 |
| Total | 1 | 15 | 66 | 63 | 8 |

**Table 3 Alveolar Bone Volume Before and After Grafting**

| Time period | Right posterior maxilla Mean | Right posterior maxilla SD | Left posterior maxilla Mean | Left posterior maxilla SD | Right + left posterior maxilla Mean | Right + left posterior maxilla SD |
|---|---|---|---|---|---|---|
| Preoperatively | 6.7 | 3.4 | 5.9 | 3.1 | 5.8 | 2.5 |
| After bone grafting | 14.0 | 1.4 | 14.1 | 1.3 | 14.3 | 1.1 |
| After implant placement | 13.3 | 1.8 | 13.8 | 1.4 | 13.9 | 1.6 |
| 1 year postoperatively | 12.9 | 1.5 | 13.3 | 1.6 | 13.3 | 1.5 |
| 2 years postoperatively | 12.6 | 1.7 | 13.0 | 1.4 | 13.2 | 1.7 |
| 3 years postoperatively | 12.7 | 1.8 | 13.1 | 1.7 | 13.1 | 1.1 |
| 4 years postoperatively | 12.5 | 1.8 | 12.8 | 1.3 | 13.1 | 1.1 |
| 5 years postoperatively | 11.6 | 2.5 | 13.5 | 0.7 | 13.1 | 1.1 |

**Table 4 Marginal Bone Level Alterations After Implant Surgery up to 5 Years**

| | Right posterior maxilla | | | | Left posterior maxilla | | | | Right + left posterior maxilla | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $R_4$ | $R_3$ | $R_2$ | $R_1$ | $L_1$ | $L_2$ | $L_3$ | $L_4$ | $R_4 + L_4$ | $R_3 + L_3$ | $R_2 + L_2$ | $R_1 + L_1$ |
| After implant surgery | 0.3 ± 0.6 | −0.1 ± 0.2 | 0 ± 0.2 | −0.1 ± 0.3 | 0.0 ± 0.2 | 0 ± 0 | 0 ± 0 | 0 ± 0 | −0.2 ± 0.6 | 0 ± 0.1 | 0 ± 0.1 | 0 ± 0.1 |
| 1 year postop | −1.2 ± 0.9 | −0.8 ± 0.7 | −0.8 ± 0.8 | −1.0 ± 1.0 | −1.0 ± 0.6 | −1.0 ± 0.7 | −1.1 ± 0.6 | −0.9 ± 0.6 | −1.1 ± 0.7 | −0.9 ± 0.6 | −0.9 ± 0.7 | −1.0 ± 0.8 |
| 2 years postop | −1.4 ± 1.2 | −0.8 ± 0.6 | −0.8 ± 0.7 | −1.1 ± 1.1 | −1.0 ± 0.7 | −1.2 ± 0.7 | −1.0 ± 0.7 | −1.0 ± 1.0 | −1.2 ± 1.1 | −1.0 ± 0.6 | −0.9 ± 0.7 | −1.0 ± 0.9 |
| 3 years postop | −1.4 ± 1.2 | −0.8 ± 0.6 | −0.9 ± 0.7 | −1.2 ± 1.1 | −1.3 ± 1.0 | −1.4 ± 1.0 | −1.0 ± 0.5 | −1.3 ± 1.0 | −1.4 ± 1.1 | −1.1 ± 0.6 | −1.1 ± 0.8 | −1.2 ± 1.0 |
| 4 years postop | −1.6 ± 1.2 | −1.4 ± 1.0 | −1.1 ± 0.6 | −1.5 ± 1.2 | −1.4 ± 1.0 | −1.9 ± 1.2 | −1.2 ± 0.5 | −1.0 ± 0.7 | −1.5 ± 1.0 | −1.3 ± 0.7 | −1.5 ± 0.9 | −1.3 ± 1.1 |
| 5 years postop | −2.0 ± 1.0 | −1.3 ± 0.5 | −1.1 ± 0.7 | −2.0 ± 1.0 | −1.0 ± 0 | −1.0 ± 0 | −1.0 ± 0 | −1.0 ± 0 | 1.5 ± 0.6 | −1.1 ± 0.5 | −1.0 ± 0.6 | −1.5 ± 0.8 |

**Table 5 Implant Survival and Frequency of Sinus Infection**

| Periods | No. of implants in grafted maxillary sinus | Implant loss: After abutment connection | Implant loss: After prosthetic loading | Sinus infection: Early (2 wks) | Sinus infection: Later (> 2 wks) | Loss of sinus graft material |
|---|---|---|---|---|---|---|
| After grafting surgery | 0 | 0 | 0 | 0 | 8 | 4 |
| After implant surgery | 153 | 0 | 0 | 0 | 0 | 0 |
| After abutment surgery | 153 | 0 | 0 | 0 | 0 | 0 |
| After prosthetic loading | 153 | 0 | 0 | 0 | 0 | 0 |
| 1 y after implant surgery | 153 | 0 | 0 | 0 | 0 | 0 |
| 2 y after implant surgery | 153 | 0 | 0 | 0 | 0 | 0 |
| 3 y after implant surgery | 153 | 0 | 0 | 0 | 0 | 0 |
| 4 y after implant surgery | 142 | 0 | 0 | 0 | 0 | 0 |
| 5 y after implant surgery | 118 | 0 | 0 | 0 | 0 | 0 |

obliteration of the maxillary sinuses at the bone grafted side. After treatment of the sinusitis, 7 had radiologic signs of inflammatory changes in the maxillary sinuses during the follow-up period (Table 5). No radiologic difference regarding bone graft resorption was observed between grafts from the iliac bone and mandibular bone grafts.

## DISCUSSION

The results from the present study are encouraging. Since the study extends over 5 years and with 75% of the patients who were annually examined for 5 years, the study clearly shows a long-term result. Although the 2-stage method means prolonged

treatment time, with bone healing in a first period followed by implant healing in a second stage, it does give a good end result. Although efforts were made to always maintain the sinus membrane intact, perforations still occurred, as did sinus infections. Despite these infection incidents, it was possible to provide all patients with implant-supported superstructures. No implants were lost in this series of consecutive patients. Experimental studies have shown that a modified surface structure of the implants is beneficial to osseointegration.[27]

Different bone graft sites were used in this study. The number of cases from the iliac bone compared to the other group receiving grafts from the chin region or the mandibular angle were almost equal. No difference could be found in the outcome of the implant rehabilitation. Radiographic evaluation showed that minor changes occurred in the bone graft height during the follow-up period. However, the slight resorption observed was mainly during the first postoperative year. The marginal bone reduction seen in the study around the implants between 1 and 2 mm during the follow-up time may be a consequence of implant loading and remodeling of the marginal bone. Stabilization of the bone graft and marginal bone seem to occur within the first postoperative year after implant insertion, which is in agreement with recent publications.[10,28]

Most patients got a combination of cortical bone and cancellous bone. In the group of patients where particulated graft was used alone, there was a stronger tendency toward resorption of graft material. Stabilization of the bone graft with osteosutures or plate screws is recommended in most cases, since the sinus membrane almost always is too soft and thin to keep the graft material in position. In those cases in the present study where no fixation was used, the window served as a roof for the graft material.

The posterior maxilla is a problematic area for implant rehabilitation, because the sinus cavity extends down in the alveolar process. Sinus augmentation is a technique-sensitive procedure in which there is always the risk of sinus membrane perforation. Due to the limited drainage from the sinus cavity, even small amounts of foreign material in the sinus cavity may cause inflammation and sinusitis. With use of resorbable collagen membranes such as BioGide (Geistlich Biomaterials, Wolhusen, Switzerland), it is possible to perform an initial repair and solve the problem. An infection, even if treated early with antibiotics and saline rinsing, can destroy the graft material. In this study, there were a number of patients with sinus infection. Three of them were treated with early antibiotics and rinsing, but in 4 of the cases some of the sinus graft material was lost and it was necessary to add Bio-Oss (Geistlich Biomaterials). To date, all our patients treated with sinus lift procedures have received fixed partial dentition and are successfully rehabilitated.

Different surgical techniques are available to solve problems with variation of both height and width of the residual alveolar crest. Sinus augmentation surgery and sinus impaction technique can both be used in cases with limited and or compromised alveolar bone support in the posterior maxilla.[29–31]

The results of the present study show that sinus augmentation using bone from either the mandible or the iliac crest in combination with Astra Tech implants has a predictable outcome.

## ACKNOWLEDGMENT

This study was partially supported by grants from Astra Tech, Sweden.

## REFERENCES

1. Albrektsson T, Zarb G, Worthington P, Eriksson A. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.
2. Albrektsson T, Dahl E, Enbom L, et al. Osseointegrated oral implants: A Swedish multicenter study of 8,139 consecutively inserted Nobelpharma implants. J Periodontol 1988;59: 287–296.
3. Adell R, Lekholm U, Gröndahl K, Brånemark P-I, Lindström J, Jacobsson M. Reconstruction of severely resorbed edentulous maxillae using osseointegrated fixtures in immediate autogenous bone grafts. Int J Oral Maxillofac Implants 1990;5: 233–246.
4. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
5. Lindquist L, Carlsson GE, Jemt T. A prospective 15-year follow-up study of mandibular fixed prostheses supported by osseointegrated implants. Clinical results and marginal bone loss. Clin Oral Implants Res 1996;7:329–336.
6. Sailer HF. A new method of inserting endosseus implants in totally atrophic maxillae. J Craniomaxillofac Surg 1989;17: 299–305.
7. Kahnberg K-E, Nilsson P, Rasmusson L. Le Fort I osteotomy with interpositional bone grafts and implants for rehabilitation of the severely resorbed maxilla: A 2-stage procedure. Int J Oral Maxillofac Implants 1999;14:571–578.
8. Keller EE, Tolman DE, Eckert SE. Maxillary antral-nasal inlay autogenous bone graft reconstruction of compromised maxilla: A 12-year retrospective study. Int J Oral Maxillofac Implants 1999;14:707–721.
9. Reinert S, Konig S, Bremerich A, Eufinger H, Krimmel M. Stability of bone grafting and placement of implants in the severely atrophic maxilla. Br J Oral Maxillofac Surg 2003;41:249–255.

10. Kahnberg K-E, Vannas-Löfqvist L. Maxillary osteotomy with interpositional bone graft and implants for reconstruction of the severely resorbed maxilla: A clinical report. Int J Oral Maxillofac Implants 2005;20:938–945.
11. Smiler DG, Johnson PW, Lozada JL, et al. Sinus lift grafts and endosseous implants. Treatment of the atrophic posterior maxilla. Dent Clin North Am 1992;36:151–186.
12. Chiapasco M, Ronchi P. Sinus lift and endosseous implants—Preliminary surgical and prosthetic results. Eur J Prosthodont Restor Dent 1994;3:15–21.
13. Smiler DG. The sinus lift graft: Basic technique and variations. Pract Periodontics Aesthet Dent 1997;98:885–893.
14. Khoury F. Augmentation of the sinus floor with mandibular bone block and simultaneous implantation: A 6-year clinical investigation. Int J Oral Maxillofac Implants 1999;14:557–564.
15. Cosci F, Luccioli M. A new sinus lift technique in conjunction with placement of 265 implants: 6-year retrospective study. Implant Dent 2000;9:363–368.
16. Krekmanov L, Heimdahl A. Bone grafting to the maxillary sinus from the lateral side of the mandible. Brit J Oral Maxillofac Surg 2000;38:617–619.
17. Cordaro L. Bilateral simultaneous augmentation of the maxillary sinus floor with particulated mandible. Report of a technique and preliminary results. Clin Oral Implants Res 2003;14:201–206.
18. Woo I, Le BT. Maxillary sinus floor elevation: Review of anatomy and two techniques. Implant Dent 2004;13:28–32.
19. Papa, F, Cortese A, Maltarello MC, Sagliocco R, Felice P, Claudio PP. Outcome of 50 consecutive sinus lift operations. Brit J Oral Maxillofac Surg 2005;43:309–313.
20. Wiltfang J, Schultze-Mosgau S, Nkenke E, Thorwarth M, Neukam FW, Schlegel KA. Onlay augmentation versus sinus lift procedure in the treatment of the severe resorbed maxilla: A 5-year comparative longitudinal study. Int J Oral Maxillofac Surg 2005;34:885–889.
21. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg 1980;38:613–616.
22. Kahnberg K-E, Ekestubbe A, Gröndahl K, Nilsson P, Hirsch J-M. Sinus lifting procedure. I. One-stage surgery with bone transplant and implants. Clin Oral Implants Res 2001;12:478–487.
23. Johansson B, Wannfors K, Ekenback J, Smedberg JL, Hirsch J. Implants and sinus-inlay bone grafts in a 1-stage procedure on severely atrophied maxillae: Surgical aspects of a 3-year follow-up study. Int J Oral Maxillofac Implants 1999;14:811–818.
24. Wannfors K, Johansson B, Hallman M, Strandkvist T. A prospective randomized study of 1- and 2-stage sinus inlay bone grafts: 1-year follow-up. Int J Oral Maxillofac Implants 2000;15:625–632.
25. Smedberg JI, Johansson P, Ekenback D, Wannfors K. Implants and sinus-inlay graft in a 1-stage procedure in severely atrophied maxillae: Prosthodontic aspects in a 3-year follow-up study. Int J Oral Maxillofac Implants 2001;16:668–674.
26. Levin L, Schwartz-Arad D. The effect of cigarette smoking on dental implants and related surgery. Implant Dent 2005;14:357–361.
27. Wennerberg A. On Surface Roughness and Implant Incorporation [thesis]. Göteborg, Sweden: Göteborg Univ, 1996.
28. Nyström E, Ahlqvist J, Legrell PE, Kahnberg K-E. Bone graft remodelling and implant success in the treatment of the severely resorbed maxilla. A 5-year longitudinal study. Int J Oral Maxillofac Surg 2002;31:156–164.
29. Hallman M. On Healing of Titanium Implants in Xenografts [thesis]. Umeå, Sweden: Umeå Univ, 2002.
30. Summers RB. Sinus floor elevation with osteotomes. J Esthet Dent 1998;10:164–171.
31. D'Amato S, Borriello C, Tartaro G, Itro A. Maxillary sinus surgical lift. Summers' technique versus lateral surgical approach. Minerva Stomatol 2000;49:369–381.