

The Endoscopically Controlled Osteotome Sinus Floor Elevation: A Preliminary Prospective Study

Emeka Nkenke, MD, DDS¹/Andreas Schlegel, MD, DDS¹/Stefan Schultze-Mosgau, MD, DDS, PhD²/
Friedrich W. Neukam, MD, DDS, PhD³/Jörg Wiltfang, MD, DDS, PhD²

Purpose: It was the aim of the present prospective study to quantify the gain in height of implant sites by endoscopically controlled osteotome sinus floor elevations (ECOSFE) with simultaneous implant placement and to report the number of sinus membrane perforations. **Materials and Methods:** From October 1999 to December 2000, of 92 sinus floor elevations, 18 were carried out endoscopically controlled with an osteotome technique. As augmentation material, β -tricalcium phosphate (β -TCP) or autogenous bone was used; 22 implants were placed. **Results:** The residual height of the alveolar crest in the posterior maxilla was 6.8 ± 1.6 mm on average. The implant lengths ranged from 10 to 16 mm (mean implant length 12.2 ± 1.4 mm). They were significantly larger than the residual height of the alveolar crests ($P < .0005$). Elevation of the sinus floor with an osteotome had to be supported by conventional sinus floor elevation instruments after a mean elevation of 3.0 ± 0.8 mm to prevent perforation of the sinus membrane. However, 1 perforation occurred, which was repaired with a periosteal patch. At stage 2 surgery, 2 implants were removed because of mobility. Endoscopic control revealed one case in which β -TCP could be found within the sinus; another case showed areas of polypoid mucosa on the sinus floor. **Discussion:** With the ECOSFE, perforations of the sinus membrane can be visualized; however, they cannot be avoided. Although this technique is less invasive than the lateral window technique, it cannot be recommended as a standard procedure in the posterior maxilla because of the large amount of additional equipment needed and the technically demanding procedure. **Conclusion:** The use of the ECOSFE should be confined to scientific trials. (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:557–566)

Key words: dental implantation, endoscope, maxillary sinus, membrane perforation, posterior maxilla, sinus floor elevation

The edentulous posterior maxilla generally provides a limited amount of bone volume because of atrophy of the ridge and pneumatization of the maxillary sinus.¹ The residual bone is often Type IV in quality.²⁻⁴ The excessive loss of implants in this region has been described.³ Surgical techniques are of particular importance to increase the success rates of dental implants in the posterior maxilla.⁵ The

osteotome technique has been reported to improve the survival rate of implants in the residual bone of the posterior maxilla.⁶ The osteotome sinus floor elevation can be carried out with an implant survival rate higher than 95%.⁷ However, when osteotome sinus floor elevation is applied without sinusoscopic control, a direct inspection of the sinus membrane is not possible,⁸ and during preparation of the implant site a perforation may not be recognized.

Antroscopy of the maxillary sinus is a well-established diagnostic tool. It can be performed in outpatients under local anesthesia with a minimum of discomfort.⁹ The use of sinuscopy in the perioperative care of patients who have undergone sinus floor elevations is a standard technique.¹⁰⁻¹² The intraoperative use of this technique has also been described.¹³⁻¹⁵ When an internal sinus floor elevation is combined with endoscopic control for the augmentation procedure, reduced invasivity and patient morbidity has

¹Resident, Department of Oral and Maxillofacial Surgery, University of Erlangen-Nuremberg, Germany.

²Associate Professor, Department of Oral and Maxillofacial Surgery, University of Erlangen-Nuremberg, Germany.

³Professor and Head, Department of Oral and Maxillofacial Surgery, University of Erlangen-Nuremberg, Germany.

Reprint requests: Dr Dr Emeka Nkenke, Glueckstrasse 11, 91054 Erlangen, Germany. Fax: +49-9131-8534219. E-mail: emeka.nkenke@mkg.imed.uni-erlangen.de

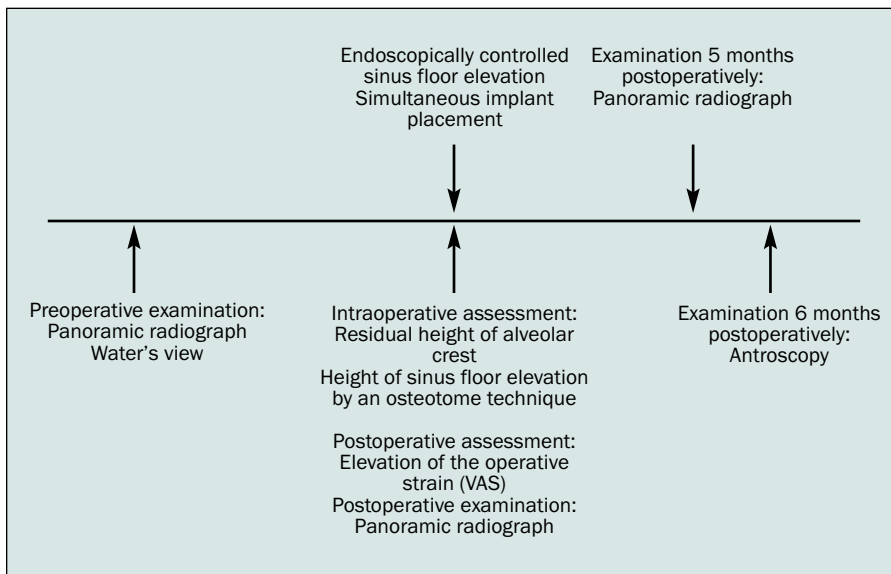


Fig 1 Prospective design of the study.

been claimed.¹⁴ Although the benefit of the osteotome technique for the internal sinus floor elevation has been described previously, there is only one report available on an endoscopically controlled procedure.¹³ However, this study did not have a prospective design.

The aim of the present prospective study was to quantify the gain in height of implant sites by endoscopically controlled osteotome sinus floor elevations (ECOSFE) and simultaneous implant placement, and to report the number of sinus membrane perforations. Moreover, control antroscopy of the maxillary sinus was carried out 6 months after implant placement to document the condition of the sinuses at the time of stage 2 surgery.

PATIENTS AND METHODS

From October 1999 to December 2000, 92 sinus floor elevations were carried out with different techniques at the Department of Oral and Maxillofacial Surgery of the University of Erlangen-Nuremberg, Germany. Fourteen patients (7 women, 7 men; mean age 51.4 ± 16.2 years, range 22 to 74 years, 2 edentulous, 12 partially edentulous patients, 18 sinuses) gave their informed consent to implant placement with the ECOSFE and an antroscopy during stage 2 surgery 6 months postoperatively. A prospective design was chosen for the study (Fig 1). Panoramic radiographs and Water's views were assessed preoperatively. Patients were excluded if they showed pathologic findings or had a history of maxillary sinus diseases or operations. A total of 22 dental implants were placed (5 Ankylos,

Degussa Dental, Hanau, Germany; 5 Brånemark Mk II, Nobel Biocare, Göteborg, Sweden; 4 Frialit-2, Friadent, Mannheim, Germany; 8 ITI, Straumann, Waldenburg, Switzerland) (Table 1).

The surgical procedure was performed using a standardized technique. Treatment of the posterior maxilla was carried out under local anesthesia with 2 mL Ultracain D-S (Hoechst Marion Roussel Deutschland, Frankfurt, Germany). No premedication or sedation was used. The maxillary sinus was punctured without flap retraction in the middle of the canine fossa with a trocar of 5 mm in diameter. Sinus scopes with view angles of 70, 90, and 120 degrees were used under video monitoring (Karl Storz, Tuttlingen, Germany). The continuous sinuscopy during the whole operation required an additional surgeon. Prior to sinus floor elevation, the sinus was examined and the natural ostium was inspected. An irrigation test with saline solution was performed to confirm communication with the nasal cavity. Inflammatory and allergic alterations of the sinus mucosa were documented. If no pathologic findings were encountered, the sinus floor elevation was carried out.

After a crestal incision, a mucoperiosteal flap was raised. To secure proper alignment of the implants, surgical templates were used. A 2-mm-deep primary pilot drilling was followed by preparation of the implant site with osteotomes of increasing diameter. The tips of the osteotomes were concave (Frialit-2 BoneCondenser, Friadent). The osteotomes D1, D2, and D3.8 were used when implants of 3.75, 3.8, or 4.1 mm in diameter were placed. For an implant diameter of 4.5 mm, the D4.5 osteotome was applied additionally. Each osteotome remained in

Table 1 Patient Data

| Patient no./initials | Sex | Age (y) | Type of implant(s) | Implant location | Implant diameter (mm) | Implant length (mm) |
|----------------------|-----|---------|--------------------|-----------------------|-----------------------|---------------------|
| 1/B.A. | M | 74 | Brånemark Mk II | Right second premolar | 4 | 12 |
| | | | | Right first molar | 4 | 12 |
| 2/B.Z. | M | 54 | ITI | Right second premolar | 4.1 | 12 |
| | | | | Left second premolar | 4.1 | 12 |
| 3/B.J. | M | 67 | Ankylos | Right second premolar | 4.5 | 12 |
| | | | | Left second premolar | 4.5 | 12 |
| 4/F.W. | M | 58 | Ankylos | Right second premolar | 4.5 | 12 |
| | | | | Left second premolar | 4.5 | 12 |
| | | | | Left first molar | 4.5 | 10 |
| 5/H.E. | F | 41 | Frialit-2 | Right first premolar | 3.8 | 13 |
| 6/K.A. | F | 63 | Frialit-2 | Left second premolar | 4.5 | 13 |
| 7/K.M. | F | 44 | Brånemark Mk II | Right second premolar | 4 | 10 |
| | | | | Left second premolar | 5 | 12 |
| 8/O.G. | M | 26 | ITI | Right second premolar | 4.1 | 16 |
| 9/P.G. | M | 58 | Frialit-2 | Right first molar | 4.5 | 13 |
| 10/R.A. | F | 67 | ITI | Left first molar | 4.8 | 10 |
| 11/S.R. | F | 43 | Brånemark Mk II | Right first molar | 4 | 10 |
| 12/S.G. | F | 66 | ITI | Left second premolar | 4.1 | 14 |
| | | | | Left first molar | 4.1 | 14 |
| 13/S.S. | M | 37 | ITI | Left second premolar | 4.1 | 12 |
| | | | | Left first molar | 4.1 | 12 |
| 14/T.S. | F | 22 | Frialit-2 | Left first premolar | 4.5 | 13 |

M = male; F = female.

Mean implant diameter: 4.3 ± 0.3 mm; mean implant length: 12.2 ± 1.4 mm.

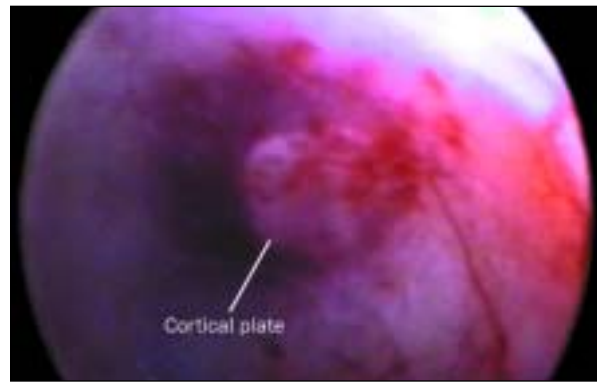
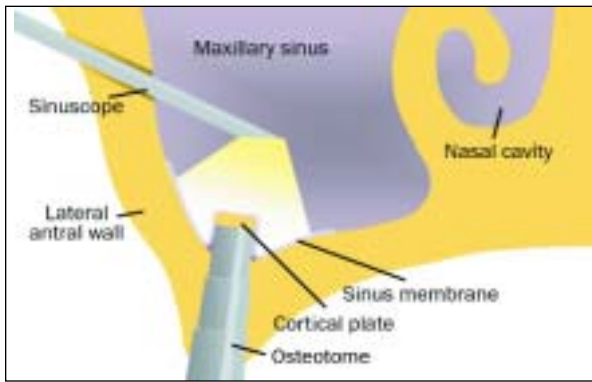
the implant site for 1 minute before the next diameter was used.

The initial osteotome was gently cut to depth with hand pressure or light malleting, without elevation of the sinus floor. Subsequently, with larger-diameter osteotomes, only a lateral compression of the spongy bone was carried out. When the final osteotome with the widest concave tip was used, the sinus floor elevation was performed under endoscopic control. The cortical plate was punched out of the sinus floor with the adherent membrane, and a tent-like formation was created (Figs 2a and 2b). The height of the residual alveolar bone was measured with a depth gauge as the distance from the sinus floor (endoscopic control) to the crest of the alveolar ridge. The cortical plate was lifted with the osteotome until no further concomitant spontaneous dissection of the sinus membrane from the sinus floor occurred in the periphery of the elevated region and visible tension of the sinus membrane revealed the risk of rupture. At this point, the height of the elevation was measured again with the depth gauge. Subsequently, the endoscopic view was used to control the dissection of the mucosa from the sinus floor, which was performed with a blunt eleva-

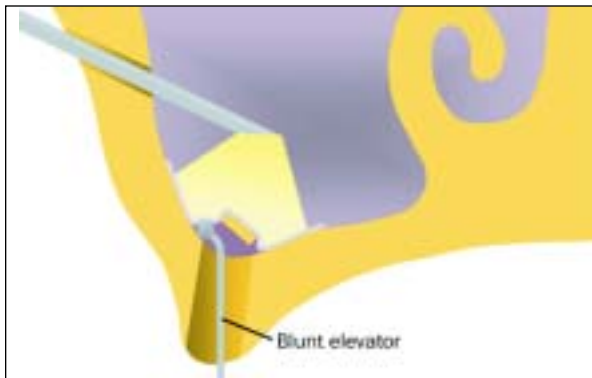
tor (Figs 3a and 3b). The extent of the dissection was limited by the geometry of the elevator and the diameter of the implant cavity. At the end of the procedure, all implant sites were tested for perforations of the sinus membrane by the Valsalva maneuver.

For the sinus augmentations, 0.5 cm^3 of particulated autogenous bone from the retromolar region (7 sinuses) or 0.5 cm^3 of β -tricalcium phosphate (β -TCP) granules (Cerasorb, Curasan Pharma, Kleinstheim, Germany; 11 sinuses) were applied. The largest osteotome was reinserted to position the grafting material in the newly formed space between the sinus membrane and the sinus floor (Figs 4a and 4b). Subsequently, the implant was placed. The mucoperiosteal flap was repositioned and sutured (Ethilon 4/0, Ethicon, Norderstedt, Germany). The operation time was measured from the mucoperiosteal incision until the final suture. A panoramic radiograph was assessed postoperatively.

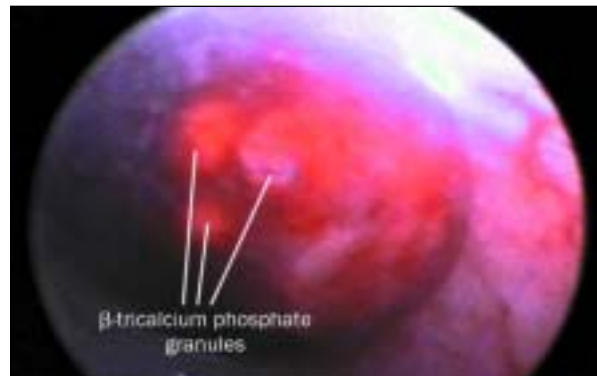
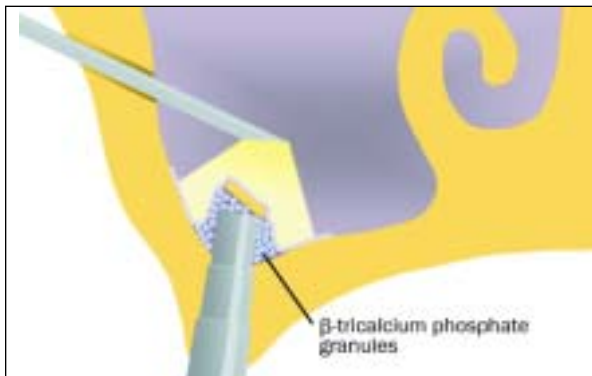
Perioperatively, an antibiotic was administered 6 hours before and 6 hours after surgery. The postoperative treatment comprised 400 mg ibuprofen (Tabalon, Hoechst Marion Roussel Deutschland) and the intranasal application of xylometazoline (Ortiven 0.1%, Novartis Consumer Health, Munich,



Figs 2a and 2b A cortical plate is punched out of the sinus floor and elevated with the adherent sinus membrane by an osteotome (*left*, schematic drawing; *right*, sinusoscopic view).



Figs 3a and 3b Dissection of the sinus membrane from the sinus floor with a blunt elevator (*left*, schematic drawing; *right*, sinusoscopic view).



Figs 4a and 4b Reinsertion of the osteotome with grafting material (*left*, schematic drawing; *right*, sinusoscopic view).



Fig 5 Endoscopic examination 6 months postoperatively. The sinus membrane shows no signs of inflammation or perforation.

COPYRIGHT © 2002 BY QUINTESSENCE PUBLISHING CO., INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.



Fig 6a Preoperative clinical situation—missing maxillary right first premolar.



Fig 6b Preoperative panoramic radiograph.



Fig 6c Direct postoperative panoramic radiograph.



Fig 6d Prosthetic restoration 6 months after surgery.



Fig 6e Panoramic radiograph 6 months after surgery.

Germany) for 3 days. The sutures were removed at the seventh postoperative day.

Five months after surgery, panoramic radiographs were obtained and assessed. At the time of stage 2 surgery 6 months postoperatively, sinuscopy was again carried out through the canine fossa. The natural ostium was inspected. Inflammatory alterations of the sinus mucosa were documented (Fig 5). The implants were uncovered and the abutment connection was performed with a torque of 20 Ncm. Implants that showed mobility were removed.

After 7 postoperative days, prosthodontic treatment was initiated (Figs 6a to 6e).

Statistics

Mean values are given with standard deviations. The Wilcoxon test was used for comparisons of paired samples when normality of the variables could not be assumed because of small case numbers; *P* values equal to or smaller than .05 were considered significant. All calculations were done using SPSS for Windows (SPSS, Chicago, IL).

Table 2 Intraoperative and Follow-up Data

| Patient no. | Region of placed implant | Vertical dimension of bone (mm) | Implant length (mm) | Elevation (mm) | Visible perforation | Valsalva maneuver | Augmentation of material | Duration of surgery (min) | Pathologic findings | |
|-------------|--------------------------|---------------------------------|-------------------------|----------------|---------------------|-------------------|--------------------------|---------------------------|---------------------|------------------|
| | | | | | | | | | 6 mo postop | Loss of implants |
| 1 | 15 | 8 | 12 | 2 | Yes | Negative | β-TCP | 115* | Yes* | At stage |
| | 16 | 8 | 12 | 3 | No | Negative | β-TCP | | Yes* | 2 surgery |
| 2 | 15 | 7 | 12 | 3 | No | Negative | A | 72 | No | No |
| | 25 | 8 | 12 | 2 | No | Negative | A | 80 | No | No |
| 3 | 15 | 9 | 12 | 3 | No | Negative | β-TCP | 89 | No | No |
| | 25 | 8 | 12 | 3 | No | Negative | β-TCP | 64 | No | No |
| 4 | 15 | 5 | 12 | 5 | No | Negative | A | 95* | No | No |
| | 25 | 7 | 12 | 4 | No | Negative | β-TCP | | No | No |
| | 26 | 6 | 10 | 3 | No | Negative | β-TCP | | No | No |
| 5 | 14 | 7 | 13 | 4 | No | Negative | A | 47 | No | No |
| 6 | 25 | 6 | 13 | 2 | No | Negative | β-TCP | 76 | No | No |
| 7 | 15 | 9 | 10 | 3 | No | Negative | β-TCP | 65 | No | No |
| | 25 | 7 | 12 | 3 | No | Negative | β-TCP | 60 | No | No |
| 8 | 15 | 9 | 16 | 3 | No | Negative | A | 39 | No | No |
| 9 | 16 | 4 | 13 | 3 | No | Negative | β-TCP | 35 | No | No |
| 10 | 26 | 8 | 10 | 2 | No | Negative | A | 69 | Yes† | No |
| 11 | 16 | 6 | 10 | 2 | No | Negative | β-TCP | 58 | No | No |
| | 25 | 5 | 14 | 4 | No | Negative | β-TCP | 56* | No | No |
| 12 | 26 | 4 | 14 | 3 | No | Negative | β-TCP | | No | No |
| | 13 | 25 | 5 | 12 | 4 | No | Negative | A | 62* | No |
| 26 | | 5 | 12 | 2 | No | Negative | A | No | | No |
| 14 | 24 | 8 | 13 | 3 | No | Negative | β-TCP | 41 | No | No |
| Means | | 6.8 ± 1.6 [‡] | 12.2 ± 1.4 [‡] | 3.0 ± 0.8 | | | | 66.9 ± 20.7 | | |

*Migration of grafting material.

†Polypoid mucosa.

‡ $P < .0005$.

Elevation = Height of elevation of the cortical plate by an osteotome until the concomitant dissection of the sinus membrane in the periphery stops;

β-TCP = β-tricalcium phosphate; A = autograft.

Region: 14 = right first premolar; 15 = right second premolar; 16 = right first molar; 24 = left first premolar; 25 = left second premolar; 26 = left first molar.

RESULTS

The residual height of the alveolar crest ranged from 4 to 9 mm (mean value 6.8 ± 1.6 mm). The increase in the height of the implant sites by an osteotome technique alone, up to the point where the concomitant spontaneous dissection of the sinus membrane in the periphery of the elevated region stopped and the tension of the sinus membrane revealed the risk of rupture, was 3.0 ± 0.8 mm (range 2 to 5 mm). After further sinus lifting by blunt elevators, implants 10 to 16 mm in length could be placed (mean length 12.2 ± 1.4 mm). They were significantly larger than the height of the residual alveolar crest at the implant sites (6.8 ± 1.6 mm; $P < .0005$). The chosen amount of 0.5 cm^3 of grafting material was found sufficient in all cases. The ECOSFE operations lasted an average of 66.9 ± 20.7 minutes from the first incision until the final suture (range 35 to 115 minutes) (Table 2).

A perforation of the sinus membrane occurred in 1 patient (#1) after a 2-mm elevation of the cortical plate with an osteotome (Table 2). However, the Valsalva maneuver was negative. Further sinus floor elevation was carried out with the blunt elevator. A periosteal patch harvested from the cranial aspect of the mucoperiosteal flap and applied through the implant cavity was used to cover the perforation. Subsequently, augmentation of the sinus floor was carried out with an alloplastic material (β-TCP) and the implant was placed. In another patient (#10; Table 2), bleeding within the sinus occurred and did not stop after copious saline irrigation. Therefore, the endoscopically controlled procedure was aborted and the sinus floor elevation was carried out by the lateral window technique below the puncture for the sinuscopy. The Valsalva maneuver did not reveal a perforation of the sinus membrane (Table 2). Two implants were placed successfully.

Table 3 Review of the Current Literature

| Authors | Patients | Osteotome technique | Endoscopic control | Perforations | Endoscopic follow-up | Prospective design |
|---|----------|---------------------|--------------------|--------------|----------------------|--------------------|
| Baumann and Ewers 1999 ¹³ | 10 | Yes | Yes | 1 | No | No |
| Deckwer and Engelke 1998 ⁴⁵ | 8 | No | Yes | 2 | Yes | No |
| Deporter et al 2000 ¹⁹ | 16 | Yes | No | ? | No | Yes |
| Engelke and Deckwer 1997 ¹⁴ | 8 | No | Yes | 0 | No | No |
| Horowitz 1997 ⁸ | 18 | Yes | No | ? | No | No |
| Ioannidou and Dean 2000 ²⁰ | 1 | Yes | No | No | No | No |
| Rosen et al 1999 ⁷ | 101 | Yes | No | ? | No | No |
| Wiltfang et al 2000 ¹⁵ | 18 | No | Yes | 0 | Yes | Yes |
| Yildirim et al 1998 ²² | 15 | Yes | No | ? | No | No |
| Zitzmann and Schärer 1998 ³³ | 20 | Yes | No | ? | No | No |

? = Not specified.

The postoperative healing period proceeded uneventfully in all cases. Acute sinusitis was not observed. A follow-up radiologic examination after 5 months (panoramic radiograph) revealed no pathologic findings. After 6 postoperative months, stage 2 surgery was performed. The healing abutments were mounted with a torque of 20 Ncm. Twenty implants showed no mobility. Two implants were removed because of mobility (patient #1; Table 2). The Valsalva maneuver did not reveal perforation of the sinus membrane. However, a soft tissue closure was carried out to reduce the risk of an oroantral fistula.

The sinusoscopic control revealed 16 sinuses without pathologic findings. Saline irrigation confirmed the communication between the maxillary sinus and nasal cavity in all cases. Perforation of the implants through the sinus membrane was not visible in these patients. Migration of the augmentation material within the sinus was found in 1 patient (#1; Table 2), in whom perforation of the sinus membrane occurred during the elevation procedure; this was covered by a periosteal patch. The sinus membrane showed no pathologic findings and the perforation was no longer visible. Copious saline irrigation of the sinus and aspiration of the β -TCP were performed.

In another patient, polypoid mucosal areas were visible on the sinus floor (patient #11; Table 2). Displaced augmentation material could not be found. The patient did not suffer from clinical signs of chronic sinusitis. Therefore, no further treatment was carried out.

DISCUSSION

The osteotome technique has been well established for implant placement in the posterior maxilla.¹⁶ Experimental animal trials have shown an improved bone-to-implant contact percentage compared to conventional implant placement in the early phase of the healing period.¹⁷ Whereas survival rates of 65% have been found for preparation of the implant site in the posterior maxilla with drills, results with the osteotome technique are much more favorable,³ ranging from 85.7% to 96%.^{6,7,18} Therefore, use of the osteotome technique seems to be a safe procedure in the posterior maxilla. The technique for the internal sinus floor elevation with and without bone grafts has been described previously (Table 3).^{6-8,13,18-22} Only one report could be found in the literature that refers to an osteotome sinus floor elevation technique with endoscopic control.¹³ However, it did not provide prospective data. Therefore, the present prospective study has been carried out to assess information on: (1) the limits in gain of the height of the sinus floor elevation by an endoscopically controlled osteotome technique, (2) the number of sinus membrane perforations, (3) the postoperative condition of the sinuses, and (4) the operation time.

Sinus floor elevation procedures are routinely performed, although the function of the maxillary sinus is not totally understood. Some of its functions might be adding resonance to the voice, some degree of olfactory function, warming and humidifying inspired air, and a reduction of the weight of the

skull.^{23,24} Therefore, it seems to be reasonable to confine the augmentation volume of the maxillary sinus to a minimum. With the lateral window technique, an average augmentation volume of $3.50 \pm 1.33 \text{ cm}^3$ has been considered necessary to place an implant of 13 mm in length when the residual bone height is 5 mm.²⁵ However, when the osteotome sinus floor elevation is performed, a minimum augmentation volume of only 0.5 cm^3 is required because of the local aspect of the augmentation. Therefore, with this technique, extensive changes in antral morphology and function have not been anticipated.

Another decisive factor that encourages the use of a minimally invasive sinus floor elevation technique is the desire for undisturbed vascularization of the grafting material placed in the sinus floor during the healing period. Vascularization is provided by an endosseous and an extraosseous anastomosis between the posterior superior alveolar artery and the infraorbital artery and branches of these vessels in the sinus membrane. With the osteotome sinus floor elevation, mucoperiosteal flap retraction can be reduced to a minimum, and only a puncture of the sinus through the bony wall of the canine fossa must be carried out.^{26,27} The risk of damaging the periosteum and the blood supply in the lateral antral wall is decreased. However, the present study shows that massive bleeding because of vessel vulnerability cannot be excluded (patient #10; Table 2).

Residual bone height less than 4 mm is associated with reduced primary implant stability.²⁸⁻³¹ A finite element analysis has shown that reduced augmentation volume, as should be expected with the osteotome sinus floor elevation, leads to further decrease of implant stability.³² Therefore, it is not surprising that during the follow-up in the present study, 2 implants were lost in sites with a reduced residual alveolar crest of 4 mm, of which 1 site showed an additional perforation of the sinus membrane with migration of the grafted material (patient #1; Table 2). In cases of severely resorbed maxillae, the minimally invasive sinus floor elevation seems not to be the method of choice; a 2-stage procedure with the conventional lateral window technique would be preferred.³³ However, many implant sites in the posterior maxillae show only mild degrees of bony resorption, allowing sufficient primary stability but not an implant length of 13 mm as recommended by Kent and Block³⁴; for example, in the present study where the average residual bone height was $6.8 \pm 1.6 \text{ mm}$. Such implant sites are suitable for the osteotome sinus floor elevation. A mean height in the elevation of $3.0 \pm 0.8 \text{ mm}$ could be attained by an endoscopically controlled osteotome technique alone until no further concomitant spontaneous dis-

section of the sinus membrane in the periphery of the elevated area occurred.

Finally, implants could be placed with a mean length of over 12 mm (Table 1). However, in some patients, the risk of rupture of the sinus membrane was encountered after an elevation of 2 mm because the spontaneous dissection stopped (patients #2, #6, #10, and #11; Table 2). When there is no visualization, further dissection with a blunt elevator is difficult without harming the integrity of the sinus membrane. Although it has been said that implants perforating the sinus membrane and penetrating the sinus will have no reduced survival rate, displacement of alloplastic material through the sinus membrane can lead to transient or chronic sinusitis in 10% to 20% of sinus elevation cases, prompting the need for further treatment.³⁵⁻³⁹ Dislocated bone chips may also initiate local inflammation and subsequent severe resorption of the bone graft.⁴⁰ Spread of the grafting material can be prevented by using block grafts.^{41,42} Unfortunately, in these cases, a larger lateral window has to be created, which may harm the blood supply in this region. With the lateral window technique, rates of membrane perforation during bone grafting of the maxillary sinus of 35% have been reported.⁴²⁻⁴⁴ When using the ECOSFE, perforations of the sinus membrane cannot be excluded. They have been encountered by previous investigators and in the present study.^{13,45}

In attempting the osteotome sinus floor elevation, the pressure at the tip of the osteotomes can increase the risk of perforation of the sinus membrane.⁸ It has been proposed to take advantage of hydraulic forces created during the osteotome sinus floor elevation to avoid rupture of the sinus membrane.^{7,18} With this technique, the osteotomes do not enter the sinus. After the graft is placed into the osteotomy, it exerts pressure on the sinus membrane by reinsertion of the osteotome so as to elevate the sinus floor. However, this procedure is based only on a hypothesis that has never been proved either in experimental or in clinical studies because of the lack of an appropriate method for visualization. Intraoperative endoscopic examination will help determine whether this hypothesis is acceptable or not. In the present study, this technique was not adopted because autogenous bone from the mandible was used that had been particulated in a bone mill. With these potentially sharp-edged bone chips, perforation of the sinus membrane seemed likely to occur if the particulated material had been used to elevate the sinus membrane.

When the internal sinus floor elevation is carried out without visualization, there is little opportunity to detect perforations. In these cases, elevation

should be confined to an average height of 3 mm.^{8,33} Before insertion of the augmentation material, the Valsalva maneuver is one of the few possibilities for recognition of perforations. However, in the present study the perforation that was visible by endoscopy was related to a negative Valsalva maneuver, which shows the limited effectiveness of this test.

It has been claimed that special training is necessary before the time-consuming endoscopically controlled procedure is used.⁴⁵ The additional endoscopic equipment, the need for a second surgeon, and the technically challenging, time-consuming procedure all seem to limit the use of this technique to scientific trials. It is not surprising that previous investigators have only treated small numbers of patients.^{13–15,45} To date, the shortcomings of the ECOSFE procedure seem to outweigh the advantage of the minimally invasive aspect.

REFERENCES

- Zinner ID, Small SA. Sinus lift graft: Using the maxillary sinuses to support implants. *J Am Dent Assoc* 1996;127:51–57.
- Fugazzotto PA. Success and failure rates of implants in type IV bone. *J Periodontol* 1993;64:1085–1087.
- Jaffin RA, Berman CI. The excessive loss of Brånemark fixtures in type IV bone: A five-year analysis. *J Periodontol* 1991;62:2–4.
- Lekholm U, Zarb GA. Patient selection. In: Brånemark P-I, Zarb GA, Albrektsson T (eds). *Tissue-Integrated Prosthesis: Osseointegration in Clinical Dentistry*. Chicago: Quintessence, 1985:233–240.
- Bahat O. Brånemark system implants in the posterior maxilla: Clinical study of 660 implants followed for 5 to 12 years. *Int J Oral Maxillofac Implants* 2000;15:646–653.
- Glauser G, Naef R, Schärer P. The osteotome technique—A different method of implant placement in the posterior maxilla. *Implantol* 1998;2:103–120.
- Rosen RP, Summers R, Mellado JR, et al. The bone-added osteotome sinus floor elevation technique: Multicenter retrospective report of consecutively treated patients. *Int J Oral Maxillofac Implants* 1999;14:853–858.
- Horowitz RA. The use of osteotomes for sinus augmentation at the time of implant placement. *Compend Contin Educ Dent* 1997;18:441–452.
- Fisher EW, Croft CB. Antroscopy: Current practice—A survey of UK otolaryngologists. *J Laryngol Otol* 1989;103:747–749.
- Deckwer I, Engelke W, Jakobs HG. Video endoscopic findings concerning sinus floor elevations. *Zeitschr Zahnärztl Implantol* 1996;12:201–205.
- Wiltfang J, Merten HA, Becker HJ. Clinical radiological and sinusoscopic follow-up after sinus floor elevations. *Zeitschr Zahnärztl Implantol* 1996;12:80–84.
- Wiltfang J, Merten HA, Ludwig A, Engelke W, Arzt T. X-ray, endoscopy, and ultrasound evaluation of the maxillary sinus following combined sinus floor augmentation and implant insertion. *Mund Kiefer Gesichtschir* 1999;3(suppl 1):61–64.
- Baumann A, Ewers R. Minimally invasive sinus lift. Limits and possibilities in the atrophic maxilla. *Mund Kiefer Gesichtschir* 1999;3(suppl 1):70–73.
- Engelke W, Deckwer I. Endoscopically controlled sinus floor augmentation. *Clin Oral Implants Res* 1997;8:527–531.
- Wiltfang J, Schultze-Mosgau S, Merten HA, Kessler P, Ludwig A, Engelke W. Endoscopic and ultrasonographic evaluation of the maxillary sinus after combined sinus floor augmentation and implant insertion. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;89:288–291.
- Summers RB. A new concept in maxillary implant surgery: The osteotome technique. *Compend Contin Educ Dent* 1994;15:152–162.
- Nkenke E, Kloss F, Schultze-Mosgau S, Radespiel-Tröger M, Loos K, Neukam FW. Histomorphometric and fluorescence microscopic analysis of bone remodelling after installation of implants using an osteotome technique. *Clin Oral Implants Res* 2002;13(in press).
- Summers RB. The osteotome technique: Part 3—Less invasive methods of elevating the sinus floor. *Compend Contin Educ Dent* 1994;15:698–710.
- Deporter D, Todescan R, Caudry S. Simplifying management of the posterior maxilla using short, porous-surfaced dental implants and simultaneous indirect sinus elevation. *Int J Periodontics Restorative Dent* 2000;20:476–485.
- Ioannidou E, Dean JW. Osteotome sinus floor elevation and simultaneous, non-submerged implant placement: Case report and literature review. *J Periodontol* 2000;71:1613–1619.
- Summers RB. The osteotome technique: Part 4—Future site development. *Compend Contin Educ Dent* 1995;16:1090–1099.
- Yildirim M, Edelhoff D, Hanisch O, Spiekermann H. The internal sinus lift—An adequate alternative to sinus floor augmentation? *Zeitschr Zahnärztl Implantol* 1998;14:124–135.
- Blanton PL, Biggs NL. Eighteen hundred years of controversy: The paranasal sinuses. *Am J Anat* 1969;124:135–148.
- Ritter FN, Lee D. The paranasal sinuses: Anatomy and surgical techniques. In: Ritter FN, Lee D (eds). *St Louis: Mosby, 1978:6–16.*
- Uchida Y, Goto M, Katsuki T, Akiyoshi T. A cadaveric study of maxillary sinus size as an aid in bone grafting of the maxillary sinus floor. *J Oral Maxillofac Surg* 1998;56:1158–1163.
- Solar P, Geyerhofer U, Traxler H, Windisch A, Ulm C, Watzek G. Blood supply to the maxillary sinus relevant to sinus floor elevation procedures. *Clin Oral Implants Res* 1999;10:34–44.
- Chanavaz M. Anatomy and histophysiology of the periosteum: Quantification of the periosteal blood supply to the adjacent bone with 85 Sr and gamma-spectrometry. *J Oral Implantol* 1995;21:214–219.
- Hirsch JM, Ericsson I. Maxillary sinus augmentation using mandibular bone grafts and simultaneous installation of implants. A surgical technique. *Clin Oral Implants Res* 1991;2:91–96.
- Misch CE. Maxillary sinus augmentation for endosteal implants: Organized alternative treatment plans. *Int J Oral Implantol* 1987;4:49–58.
- ten Bruggenkate CM, van den Bergh JPA. Maxillary sinus floor elevation: A valuable preprosthetic procedure. *Periodontol* 2000 1998;17:176–182.
- Van den Bergh JPA, ten Bruggenkate CM, Krekeler G, Tuinzing DB. Sinus floor elevation and grafting with autogenous bone from the iliac crest. *Clin Oral Implants Res* 1998;9:429–435.

32. Tepper G, Haas R, Krach W, Watzek G. 3D-FEA of implant stability after sinus lift. *Clin Oral Implants Res* 2001;12:418.
33. Zitzmann NU, Schärer P. Sinus elevation procedures in the resorbed posterior maxilla. Comparison of the crestal and lateral approaches. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998;85:8-17.
34. Kent JN, Block MS. Discussion of augmentation of the maxillary sinus with autologous bone for placement of endosseous implants: A preliminary report. *J Oral Maxillofac Surg* 1993;51:1203-1205.
35. Block MS, Kent JN. Sinus augmentation for dental implants: The use of autogenous bone. *J Oral Maxillofac Surg* 1997;55:1281-1286.
36. Brånemark PI, Adell R, Albrektsson T, Lekholm U, Lindström J, Rockler B. An experimental and clinical study of osseointegrated implants penetrating the nasal cavity and maxillary sinus. *J Oral Maxillofac Surg* 1984;42:497-505.
37. Doud Galli SK, Lebowitz RA, Giacchi RJ, Glickman R, Jacobs JB. Chronic sinusitis complicating sinus lift surgery. *Am J Rhinol* 2001;15:181-186.
38. Hessling KH, Neukam FW, Scheller H, Günay H, Schmelzeisen R. The extreme atrophy of upper and lower jaw. Clinical aspects of the supply with endosseous implants. *Zeitschr Zahnärztl Implantol* 1990;6:35-39.
39. Tidwell JK, Blijdorp PA, Stoeltinga PJW, Brouns JB, Hinderks F. Composite grafting of the maxillary sinus for placement of endosteal implants. *Int J Oral Maxillofac Surg* 1992;21:204-209.
40. Raghoebar GM, Batenburg RHK, Timmenga NM, Vissink A, Reintsema H. Morbidity and complications of bone grafting of the floor of the maxillary sinus for the placement of endosseous implants. *Mund Kiefer Gesichtschir* 1999;3 (suppl 1):65-69.
41. Raghoebar GM, Brouwer TJ, Reintsema H, van Oort RP. Augmentation of the maxillary sinus with autologous bone for placement of endosseous implants: A preliminary report. *J Oral Maxillofac Surg* 1993;51:1196-1203.
42. Raghoebar GM, Vissink A, Reintsema H, Batenburg RHK. Bone grafting of the floor of the maxillary sinus for the placement of endosteal implants. *Br J Oral Maxillofac Surg* 1997;35:119-125.
43. Jensen J, Sindet-Pedersen S, Oliver AJ. Varying treatment strategies for reconstruction of maxillary atrophy with implants: Results in 98 patients. *J Oral Maxillofac Surg* 1994;52:210-216.
44. Small SA, Zinner ID, Panno FV, Shapiro HJ, Stein JI. Augmenting the maxillary sinus for implants: Report of 27 patients. *Int J Oral Maxillofac Implants* 1993;8:523-528.
45. Deckwer I, Engelke W. Minimally invasive endoscopically supported sinus floor elevation. *Zeitschr Zahnärztl Implantol* 1998;14:17-20.