Maxillary sinus floor elevation surgery
A clinical, radiographic and endoscopic evaluation

Maxillary sinus floor elevation surgery with autogenous bone grafts has been proven to be a reliable preimplantology method to enable insertion of endosseous implants in a severely resorbed edentulous maxilla (Raghoebhar et al. 2001). An often mentioned drawback of this procedure is the development of maxillary sinusitis after augmentation (Timmenga et al. 1997, 2001).

Maxillary sinus floor elevation may involve the potential hazard of compromising the sinus physiology. After all, the maxillary physiology is affected by the al-
tered anatomic relation of the antral floor. In addition to the altered anatomy, mucosal injury and postoperative swelling may lead to reduction of the patency of the ostio-meatal unit, which plays a key role in the development of sinusitis, viz. impairment of the mucociliary cleansing system [Buiter 1976; Terrier 1991]. If the patency of the maxillary ostium is reduced, or the maxillary sinus is [partly] filled up by postoperative hematoma or seroma, the development of a postoperative maxillary sinusitis may compromise the success of the sinus graft and/or implants and the patient’s sense of general physical well-being [Tos & Mogensen 1984; Melen et al. 1986; Dawes et al. 1989; Schow 1991; Stierna et al. 1991; Norlander et al. 1993; Nord 1995; Lanza & Kennedy 1997].

The clinical diagnosis of sinusitis is characterized by a typical triad of symptoms, i.e. nasal congestion, pathological secretion or obstruction, and headache [Williams & Samel 1993; Yonkers 1995]. Detection of post-augmentation maxillary sinusitis on conventional radiographs is difficult. Misinterpretation may easily occur, for example due to altered pneumatization and sinus depth as a result of the grafting procedure [Illem et al. 1972; Larenne et al. 1992; Wiltfang et al. 2000]. Conversely, close inspection of the antral mucosa (the Schneiderian membrane) with fiber-endoscopic tools nowadays is the standard method in Ear, Nose and Throat [ENT] surgery and facilitates other diagnostic modalities such as histology, cytology and microbiology [Herberhold 1973; Buiter 1976; Howard & Lund 1986; Pfeiderer et al. 1986; Smith & Cable 1988; Kamel 1989; Terrier 1991; Babek et al. 1997; Bonifazi et al. 1997; Westergren et al. 1998]. Direct observation of the ostio-meatal unit and antrum is beyond doubt of great importance in the evaluation of sinus [clearance] pathology and diagnosing maxillary sinusitis.

The aim of this study was to prospectively evaluate the effects of maxillary sinus floor elevation surgery on maxillary sinus performance, applying anamnestic and clinical investigations, radiodiagnostic evaluation, and endoscopy.

Material and methods

Patients

Seventeen consecutive patients (11 women, 6 men; mean age 53 ± 15 years at time of surgery, range 22–73 years) participated in this prospective study. All patients needed elevation of the maxillary sinus floor with autogenous bone grafts. Informed consent was obtained from all patients. For details with regard to planning of treatment see Raghoebhar et al. (2001).

To become included in this study, patients had to suffer from (partial) denture problems related to a severely resorbed posterior part of the maxilla. The denture problems were evaluated by a team of two experienced prosthodontic surgeons and two experienced oral surgeons. Surgery and prosthodontics were performed within the same clinic. The maxilla was edentulous in 15 patients, and partially dentulous in two patients. In the mandible the edentulous patients wore implant-supported overdentures (n = 5) or full dentures (n = 4). Eight patients were (partially) dentulous in the mandible.

In case of a history of a disturbed clearance function of the maxillary sinus, patients were only included if both clinical inspection and preoperative conventional radiographic examination (Waters’ projection) did not show signs of maxillary sinus pathology. In case of medical compromising factors, e.g. diabetes mellitus, internal screening and regulation was performed preoperatively. The endoscopic examination of the maxillary sinus performed in all patients was not part of the inclusion criteria, but was part of the experimental setup in this prospective study.

Clinical and radiographic examination

As part of the inclusion criteria, all patients were preoperatively subject to screening on sinusitis by applying a standardized extensive anamnestic questionnaire on sinus clearance compromising factors. Orthopantomograms and lateral cephalograms were done to assess the height of the maxillary alveolar bone, the dimensions of the maxillary sinus, and the antero-posterior relationship of the maxilla to the mandible. The vertical height of the alveolar bone between the most caudal part of the maxillary sinus and the oral cavity was on average 3 ± 2 mm (range 1–5 mm). Occipito-mental projections (Waters’ projection) were done to detect swelling of the maxillary mucosa.

Both the clinical and radiographical examinations were repeated at 3 [at insertion of the implants] and 9 months [at uncovering of the implants] after augmentation.

Endoscopic examination of the maxillary sinus

In general anesthesia, after decongestion of the nasal vestibulum that did not contain the nasotracheal tube, endoscopic examination of the nasal cavity and the infundibular area, with special interest in the ostio-meatal unit, was performed. Subsequently, via the inferior meatus, after medial luxation of the inferior turbinate, a trocar was inserted into the antral cavity (Fig. 1). Endoscopic examination was performed with a rigid fiber endoscopic optic (30° fiberscopic, Storz, Germany). For documentation of the endoscopic views we used a Panasonic CCD camera, linked to a Sony video printer. As source of light a 160-W Xenon light fountain was used. After removing the trocar, the inferior turbinate was lateralized to its normal position. All endoscopic procedures were performed by the same experienced ENT surgeon.

Assessment of the mucosal aspect of the augmentation area of the maxillary sinus was based on a modification for endoscopic sinus evaluation proposed by Petruson (1982). A normal aspect of the sinus mucosa showing its delicate vascular aspect, without any sign of discharge or swelling, was scored as grade 0 mucosal aspect. A hyperemic aspect of the sinus mucosa was scored as grade 1, mucosal swelling as grade 2, and existence of discharge as grade 3. Grade 4 was scored if the antral mucosa showed an aspect of severe inflammation with polypiosis.

Endoscopic examination was performed during maxillary sinus floor elevation surgery [preceding the elevation surgery], and 3 [at insertion of the implants] and 9 months [after uncovering of the implants] after augmentation.
9 months [at uncovering of the implants] after elevation.

Maxillary sinus floor elevation surgery and insertion of implants

In all cases, the patients were treated under general anesthesia and iliac crest bone grafts were used. Large autogenous cancellous bone grafts were harvested from the superior anterior medial part of the iliac crest. In all cases a two-stage procedure (first stage: bone grafting; second stage: placement of implants) was performed bilaterally. After elevation of the sinus floor, the width of the alveolar crest was increased by placing monocortical cancellous bone blocks buccal to the cortex of the alveolar defect, with the cancellous side of the bone graft in contact with the jaw (Raghoebar et al. 1993; 1997). Latter grafts were fixed with titanium screws to the alveolar bone. Cancellous bone particles were used to fill the small gaps between the bone graft and the alveolar crest.

Before harvesting the iliac crest bone grafts, the patients received broad spectrum antibiotics (Cephradine 1 gram, 3 times daily), starting 1 h preoperatively (intravenously) and continued orally for 48 h after surgery. Postoperatively, the patients received a 0.2% chlorhexidine mouthrinse (1 min, 5 tid) for 2 weeks, and nasal decongestion (Xylomethazoline 0.1%) for 1 week. One month postoperatively, the edentulous patients were allowed to wear dentures if possible, after relieving them in the operated areas and relining them with a soft liner. In the partially edentulous cases, there was no need for a temporary prosthesis.

After a total of 3 months, 85 titanium implants (Brånemark®, Nobel Biocare, Göteborg, Sweden) were inserted in the posterior region using a surgical template. At 6 months after insertion, the implants were uncovered, the oral mucosa thinned, and the abutments connected.

Prosthodontics

The patients were rehabilitated with implant-supported overdentures \( n = 15 \) or partial bridges \( n = 2 \).

Results

Anamnestic and clinical examinations

Preoperatively

Anamnestic evaluation revealed that 5/17 patients had a history of sinus clearance

Fig. 2. Conventional radiographic examination [X-Waters']. A) Preoperative situation showing a normal aspect of the maxillary sinus. B) Situation 3 months postelevation showing postgrafting opacity of the maxillary sinus floor. Note the parietal maxillary mucosal thickening (see arrows), observed in four patients. C) Situation 3 months postelevation. Chronic maxillary sinusitis, showing nearly complete opacity of the left maxillary sinus (observed in one patient). D) Mucosal cyst formation in the left maxillary sinus. E) Same patient as [C] and 9 months postelevation. Left-sided opacity of the maxillary sinus. Atelectasis of the latero-caudal part of the left maxillary sinus related to a former period with sinusitis (see arrows).
compromising factors. In agreement with the inclusion criteria, prior to the elevation procedure none of these five patients showed any sign of acute or chronic maxillary sinusitis. Two of these five patients had a history of obstructive lung disease, two patients had a proven allergy for house dust mite, and one patient had an extensive history of cleft surgery.

Postoperatively
At 2 weeks’ postoperatively, one patient suffered from severe maxillary sinusitis at the left side which had not been evaluated endoscopically. This patient was not known to have a history of sinus clearance compromising factors. A middle meatal antrostomy and endonasal anterior ethmoidectomy were carried out at the ENT department to treat this complication. At the 3-month evaluation some mild left-sided pricking sensations existed, at the 9-month evaluation all complaints had ceased. In the other 16 patients, no sinus pathology was observed either anamnestically or clinically.

During the 9-month observation period, five implants (5.9%) were lost. All implants had a good primary stability, and there were no known clinical problems that might explain why these implants were lost. The lost implants were equally distributed over the left and right sinus regions and not related to the endoscopic procedures.

Radiographic examination
Preoperatively
Waters’ projection showed in all 17 patients a clear maxillary sinus [Fig. 2A].

Postoperatively
At 3 months’ postelevation, Waters’ projection showed postgrafting opacity of the maxillary sinus floor in all patients. Parietal maxillary mucosal thickening was observed in four patients [Fig. 2B]. Of these, two patients were known to have a history of a compromised sinus clearance. The patient in whom maxillary sinusitis had developed post grafting showed complete opacity of the left maxillary sinus [Fig. 2C]. In addition, retention cysts of the maxillary sinus were observed in two patients [Fig. 2D].

At 9 months postelevation, Waters’ projection showed parietal mucosal thickening in three patients, but with postgrafting opacity of the maxillary sinus. All three patients had a history of sinus clearance compromising factors. In two of them, the mucosal thickening was also present at the 3-month evaluation. The patient who had suffered from maxillary sinusitis early postgrafting still showed complete maxillary sinus opacity and atelectasis of the left maxillary sinus [Fig. 2E]. Both cysts had persisted.

Endoscopic examination
Preoperatively
In 14 patients endoscopic unilateral examination showed a normal mucosal aspect (Table 1, Fig. 3A). In three patients, antrostoscopic evaluation showed an abnormal mucosal aspect of the maxillary sinus. Two of them were known to have a history of a compromised sinus clearance (Fig. 3B, C).

Postoperatively
Three months’ postoperatively, unilateral endoscopic evaluation showed a mucosal divergent aspect in four patients (Table 1). A grade 0 endoscopic score was found in two patients with prior existing preoperative pathological maxillary sinuses, indicating complete recovery of the maxillary sinus [Fig. 3D]. Of the four patients with a mucosal divergent aspect, three had a history of a compromised clearance.

At 9 months’ postelevation, grade 2 mucosal aspect could be detected in two patients, which in one of them was also observed preoperatively and at the 3-month endoscopic evaluation (Table 1).

Comparison of Waters’ projection and unilateral endoscopy
Preoperatively, subclinically sinus pathology was not detected on radiographs in three patients, while at the 3 and 9 months’ evaluation disagreement between the endoscopic and radiographical results existed in one and three patients, respectively.

Discussion
This study is the first study reported in literature investigating the effects of elevation of the floor of the maxillary sinus with autogenous bone grafts on maxillary sinus performance applying clinical, radiographical and endoscopical techniques. From this prospective study it is obvious that maxillary sinus floor elevation surgery results in negligible signs of sinus pathology. In most cases, no clinical problems occurred, and in the one patient who developed sinusitis, the symptoms vanished after treatment.

A maxillary sinus floor elevation procedure reduces the volume of the maxillary sinus. As a result of the iatrogenic damage caused by raising the maxillary membranous lining, a transient or persisting effect on the ciliated antral mucosa can be expected. Among other effects, when the maxillary sinus is filled up with blood, structural delay of the maxillary sinus

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Endoscopic score: normal = 0, hyperemia = 1, swelling = 2, discharge = 3, polyposis = 4.

*L: left maxillary sinus; R: right maxillary sinus.

Table 1. Antrostoscopic results. preoperative, 3- and 9-month evaluations. Preoperative anamnestic clearance compromised factors were observed in patients 1–5, viz. COPD (patients 1, 2), allergy (patients 1, 4, 5), paranasal surgery (patient 1, 5) and cleft lip and palate (patient 3).
clearance is thought to occur. This could result in blocking of the ostio-meatal unit, which is a potential risk on development of sinusitis. However, the results of this study show clinical signs of sinusitis development in only one patient. This indicates that a normal maxillary sinus at the time of surgery seems to have a high potential for regaining its function postsurgery.

Although no clinical signs of sinus pathology were observed in most patients, endoscopic examination revealed that in a few patients the surgical procedure apparently resulted in changes at the level of the maxillary mucous membrane, mostly of a mild character. Such mild deviations of the maxillary mucous membrane may be a result of the dynamic course of the maxillary sinus mucosal activity as a function of the innate airway tissue defense system (Wanner et al. 1996; Erjafelt et al. 1997; Tomee et al. 1997; Kauffman & Tomee 1998; Tomee 1999). The mucosal airway defense of healthy individuals in general is a highly efficient system for the elimination of inhaled small particles and/or microorganisms. The ciliated epithelial lining of the maxillary sinus is not only a first line physical barrier preventing penetration, the coordinated ciliary movement of ciliated epithelial cells transports an epithelial lining fluid in which impacted particles and highly efficient microorganisms are eliminated. Release of nitric oxide by ciliated epithelial cells reinforces the defensive effectivity (Kauffman et al. 1998; Jeong et al. 2001). Mucosal injury and postoperative swelling as can be expected after sinus floor elevation surgery may influence the mucociliary barrier function and effectiveness of the cleansing system, resulting in divergent radiographic and/or endoscopic findings. Specially in clearance compromised patients, this balance system of aggressive and defensive forces is expected to be vulnerable, as represented by endoscopic findings grade 3 and 4. A proper anamnestic assessment of pre-existing sinus clearance impairment may detect patients who are at risk for an impaired recovery of the maxillary sinus (mucosa) following elevation. However, this is no conditio sine qua non, two patients with pre-existing, endoscopically detected subclinical changes of the antral mucosa but without clinical and radiological signs of sinus pathology at the time of surgery, showed complete recovery of the antral mucosa, at the 3- and 9-month postelevation endoscopic evaluation. Therefore, the existence of a [very] mild inflammatory mucosal aspect as observed by endoscopy is not a strict contraindication for surgery, but should be interpreted as a normal activity of the mucosal airway defense system, as can be observed in healthy, nonoperated humans, in general. In addition, endoscopic mucosal appearances do not always correspond to the histopathologic changes of the maxillary mucosa (Mann & Trong 1979; Kamel 1989; Stierna et al. 1991), and even the fact that the maxillary sinus in the healthy state is not sterile supports the discrepancy between endoscopic findings and mucosal pathology (Hartog 1997; Posawetz et al. 1991; Rong et al. 1999).

Summary

The results of this study support the following guidelines for planning sinus floor elevation surgery in patients without anamnestic or clinical signs of sinusitis:

- In the case of a clear Waters’ projection, sinus floor elevation surgery can be performed.
- In the case of maxillary sinus opacification as assessed on a preoperative Waters’ projection, endoscopical examination indicated. This to rule out structural sinus clearance impairment. If a normal, or mild mucosal inflammatory aspect of the antral mucosal is found, without any sign of pathology in the infundibular area (containing the ostio-meatal unit), sinus floor elevation surgery can be performed.

Résumé

Bien que l’épaississement du plancher sinusal maxillaire obtenu avec des greffons osseux autogènes soit devenu un processus préimplantaire bien établi, son effet sur la
Zusammenfassung

Obwohl die Sinusbodenelevation mit Hilfe eines autologen Knochenschilds ein geläufiger praimplantärer Behandlungsgrund schritt geworden ist, fehlen prospektive Studien am Menschen, die den Einfluss dieser Behandlung auf die Funktions des Sinus maxillaris untersuchen. Diese Einflüsse der Sinusbodenelevation auf die Funktionsstichtigkeit der Kieferöhle werden hier nun untersucht.

17 Patienten, die einer Sinusbodenelevation mit autologem Knochen aus der Beckenkammregion zustimmten, nahmen bei dieser Studie teil. Sie alle unterzogen sich einer ausführlichen Anamnese und klinischen Untersuchung bezüglich Sinusitis, einer konventionellen radiologischen Untersuchung (Water’s Projektion) und einer unilateralen endoskopischen Untersuchung der Kieferöhle. Diese Untersuchungen erfolgten präoperativ, sofort nach der Operation (d.h. endoskopisch zu untersuchende Kieferöhle wurde zufällig ausgewählt), nach 3 Monaten (anlässlich der Implantation) und nach der Augmentation (bei der Freigabe der Implantate).


Resumen

Aunque la elevación del suelo del seno maxilar con injertos de hueso autólogo se ha convertido en un procedimiento de gran importancia en la evaluación del aparato respiratorio y del sistema digestivo, no ha sido objeto de estudios prospectivos para el análisis de las consecuencias de esta intervención. Los datos de este estudio, que se realizaron en 17 pacientes, indican que el procedimiento de elevación del suelo del seno maxilar no se ha sometido a estudios prospectivos en humanos. En este estudio prospectivo de la elevación del suelo se evaluaron los efectos sobre el funcionamiento del seno maxilar.

17 pacientes consecutivos que accedieron a participar en este estudio, se sometieron a elevación del suelo del seno maxilar con injertos de hueso autólogo de la cresta ilíaca. A todos los pacientes se les realizó una investigación extensa anamnésica y clínica sobre sinusitis, radiografía convencional (proyección de Water) y 3. inspección unilateral endoscópica del seno maxilar. Esta triada de evaluaciones se llevaron a cabo preoperatoriamente, inmediatamente antes del procedimiento de elevación (se seleccionó aleatoriamente la inspección endoscópica del seno) y al mes (al insertar el implante) y 6 meses al descubrir los implantes) tras la elevación.

5 de 17 pacientes tenían una historia de aclaramiento impedito del seno, pero no mostraron signos clínicos o radiológicos de patología actual del seno preoperatoriamente, tampoco tuvieron las otras 14 pacientes. En cambio, la evaluación endoscópica unilateral reveló una patología subclínica mucosa preexistente en 2 los 5 pacientes con una historia de aclaramiento impedito del seno y en 1 de los otros 12 pacientes. 5 meses tras la elevación, el examen clínico y radiológico mostró sinusitis maxilar crónica en 1 paciente no comprometido. Mas aún, la evaluación endoscópica serialmente unilateral reveló patología subclínica mucosa maxilar en otros 4 pacientes (3 tenían historia de aclaramiento impedito del seno), confirmada por proyección de Water en 3 de esos 4 pacientes. Nueve meses tras la elevación, solo se detectó patología subclínica mucosa maxilar en 2 pacientes (1 comprometido, 1 no comprometido), confirmado por la proyección de Water en el último paciente. 5 implantes se perdieron durante el período de observación de 9 meses. Como es obvio de esta evaluación prospectiva, los efectos del procedimiento de elevación en el rendimiento del seno maxilar no son de significancia clínica.

References


