RESEARCH STUDIES

Complications in oral implantology associated with maxillary sinus lifting

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Abstract

Objectives: The aim of this study is to evaluate the complications with the elevation of maxillary sinus bottom in dental implantation and identify the factors, that may contribute to the occurrence of these complications, and propose different therapeutic approaches. **Material and methods**: The studied population has consisted of 685 patients (971 sinuses) with severe posterior maxillary atrophy treated with sinus bottom elevation by means of the lateral window access by one/two stage technique. For unilateral procedures 399 patients have been appointed and for bilateral procedures – 286 patients. The sinus elevation has been performed with the usage of deproteinized bovine bone material (DBBM) only or its 1:1 mixture with autogenous bone as well as β-tricalcium only or its 1:1 mixture with autogenous bone. The complications have been evaluated clinically and radio graphically. **Results**: The most common intraoperative complication has been the sinus membrane perforation which has been observed in 44 sinuses operations (4.5%). Severe intraoperative bleeding has been observed in 42 operations on sinuses (4.3%), 22 sinuses (2.3%) of 22 patients have acquired sinus graft infection, twelve of the patients have been smokers. The implant migration into maxillary sinus has been reported in two cases (0.2%). Wound dehiscence has been observed in 13 cases (1.3%). Periimplant infection has been observed in 23 patients with 54 implants, 8 of them have been removed (0.67%). **Conclusion**: The clinical outcome confirms the fact that sinus bottom elevation to improve the conditions for installing the dental implants can be considered as a safe treatment with a low frequency of complications. Proper patients' selection and treatment planning as well as the application of the sinus elevation technique are the prerequisites to minimize the risk of complications.

Key words: dental implantology, sinus bottom elevation, maxillary sinus grafts.

Осложнения при зубной имплантации с поднятием дна верхнечелюстной пазухи

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Реферат

Цель. Выявление частоты, причин возникновения и разработка методов лечения осложнений при поднятии дна верхнечелюстной пазухи в зубной имплантации. **Материал и методы**. У 685 пациентов (971 пазуха) с выраженной атрофией заднего отдела верхней челюсти было проведено поднятие дна верхнечелюстной пазухи латеральным доступом, техникой в один или два этапа. В качестве пластического материала использована депротеинизированная бычья кость или её смесь (1:1) с костным аутотрансплантатом, а также трикальций фосфат в чистом виде или его смесь (1:1) с костным аутотрансплантатом. Одностороннее поднятие дна пазухи проведено у 399 пациентов, двустороннее – у 286. Анализ осложнений проведен клинически и радиографически. **Результаты.** Во время операции наиболее частым осложнением была перфорация мембраны верхнечелюстной пазухи. Она возникала при вмешательствах на 44 (4,5%) пазухах. Выраженные кровотечения имели место во время 42 (4,3%) операций. В 22 (2,3%) пазухах у 22 пациентов, из которых 12 были курильщиками, пластический материал инфицировался. В двух случаях (0,2%) произошла миграция имплантантов в верхнечелюстную пазуху. Расхождение раны произошло в 13 (1,3%) случаях. Явления периимплантата выявлены у 23 пациентов с 54 имплантами, 8 из них удалены (0,67%). **Выводы.** Клинические наблюдения подтверждают, что поднятие дна верхнечелюстной пазухи с целью улучшения условий для установки зубных имплантатов, является эффективным методом с низкой частотой осложнений. Умелый выбор пациентов, правильное планирование лечения и безукоризненное проведение операции с применением метода поднятия дна верхнечелюстной пазухи являются необходимыми условиями уменьшения риска возникновения осложнений.

Ключевые слова: дентальная имплантология, поднятие дна верхнечелюстной пазухи, осложнения.

Introduction

The rehabilitation of the posterior teeth of the maxilla with implant-supported restoration represents a unique clinical challenge. Posterior maxillary bone is typically soft due to its thin or very spongiotic trabeculae or the absence of cortex, which may lead to the implant's primary stability but ultimately to its failure [6]. To overcome this biomechanical disadvantage different therapeutic strategies have been developed. These include under drilling protocols, modified implant designs, the usage of different bone condensers. Following the tooth loss an initial buccopalatal reduction of bone volume occurs due to the interruption of blood supply to the bone plate and the absence of occlusal loads [7-8]. The process of resorption takes place in an apical direction and occurs together with an increase of sinus pneumatization [9, 10]. As a consequence, the sinus floor is located in close proximity to the alveolar ridge [11]. Various therapeutic alternatives have been proposed to overcome this limitation including lifting the vertical bone and sinus floor. However, the maxillary floor grafting is a method of attaining sufficient bone height for

posterior maxillary implant placement and is regarded as a predictable and highly successful procedure. Since it was first described by Boyne & James (1980) [12] this technique has proven its efficacy and reliability in a variety of clinical cases with the usage of different grafting materials and modifications of the original surgical protocol [13, 14]. This technique (lateral sinus floor elevation LSFE) is currently the most common surgery technique that includes drilling a window in the wall of anterolateral maxillary sinus bone and the dissection of Schneiderian membrane and the placement of bone graft. Implants are placed at the same stage or several months later depending on the residual ridge height. Nevertheless, a number of less invasive alternative methods of lateral wall approaches, such as tilted implants, zygomatic implants, pterygoid implants, short implants (less than 10 mm), restorations in cantilever or Summer's technique (also known as osteotomy of sinus floor elevation OSFE), which is routinely performed by surgeons when the alveolar ridge height exceeds 5-6 mm [15], have been indicated. Even a graftless transcrestal sinus floor elevation and sometimes a flapless one have been described as suitable methods to rehabilitate the posterior maxilla with implant-supported prosthesis [6, 17]. The sinus lifting is generally considered to be a safe surgical procedure with a high success rate unless the complications occur [18, 19, 20]. The complications related to sinus surgery are rarely reported in detail and their effects have been investigated even to a lesser extent [22]. The complications associated with the procedure and their impact on the implant successfulness and survival have been described. The most common surgical complication is the perforation of Schneiderian membrane which occurs in 7-44% of procedures [23-25]. The most experienced clinicians estimate their perforation rate to be approximately 25%. A higher frequency of perforation has been reported in smokers. Membrane perforations according to the literature are strongly associated with the appearance of postoperative complications leading to the acute or chronic sinus infections, loss of grafting material and the disruption of normal sinus physiology [22, 25]. The perforation should be treated immediately to avoid the displacement of the graft material into the sinus cavity and subsequent sinusitis. Although Khoury and Proussaefs et al.[24, 26] assume that there is a correlation between an implant failure and a sinus membrane perforation, no association between the membrane perforation and the implant survival has been found [22, 24]. Yet, both anatomical and technical factors have influenced the membrane perforation [27]. Sinus septa, a transient mucosa swelling, mucoceles, a narrow sinus, an osteotomy design, an increased lateral wall can complicate the membrane elevation and enhance the risk of perforation during the surgery [25, 27-29]. Several attempts have been made to classify the membrane perforations. The famous classification has been proposed by Vlassis and Fugazzotto [27], who have proposed five classes based on the location and the difficulty of repairing [25]. The authors proposed several protocols to repair the membrane perforation intraoperatively using a variety of techniques and materials, including suturing and the usage of a fibrin adhesive [26, 27]. Small perforations usually do not need a special treatment because the membrane folds on itself during the elevation. A proper understanding of the blood supply system of the maxillary sinus can be crucial in many instances. An intraoperative bleeding is the result of severing or damaging the branches of the vascular supply of the lateral wall of the sinus and the surrounding soft tissue. This bleeding is usually minor and of relatively short duration, but in some instances it can be profuse and difficult to control in time. The bleeding may come either from the soft tissue (extra osseous branch) during the flap elevation or directly from the lateral bone wall (intraosseous branch) during the osteotomy of the lateral window, especially with a rotary instrumentation. There is also a possibility of bleeding from the medial wall of the sinus if the posterior lateral nasal artery is damaged. Severe hemorrhages during maxillary sinus grafting are rather rare. Small vessels may be broken; if these are located in the exposed Schneiderian membrane it is better to allow the hemostasis to occur naturally, applying gauze under slight pressure. It is not recommended to use an electrocoagulator which may in fact cause membrane necrosis. The displacement of dental implants to adjacent anatomic structures such as the maxillary sinus is a rare complication but may have serious consequences (e.g. sensory disturbance, maxillary sinusitis, oroantral fistula). Since the case of implant migration inside the sinus cavity was already reported [30], other authors have depicted the occurrence of this adverse reaction in the maxillary and other paranasal sinuses. Most articles include a limited number of implants [30-33] and only a few articles include a slightly larger number of cases [34]. The migration of such implants in the ethmoid, sphenoid sinuses, orbit, nose and anterior cranial fossa is much more sporadic [35-37]. The displacement of dental implants during sinus surgery can be related to the poor bone quality or quantity, the poor surgical experience of the operator, the presence of an uncured perforation, too much implant tapping or the application of an excessive force [38]. The lack of implant preparation or its displacement or the presence of poor quality bone that have previously suffered an alveolar infection and consequent destruction may cause the implant migration. Different theories have been proposed to explain the mechanism by which implants migrate into the sinus, one of them being the selection of an inadequate treatment modality to rehabilitate the posterior maxilla (e.g. the lack of proper implant site), which, if not done properly, may lead to this serious complication [34]. The changes in the intrasinusal and nasal pressures [32] are proposed as a primary factor referring to this complication. The autoimmune reaction to the periimplant bone destruction caused by the implant, which leads to the loss of integration, [30] may result in this complication. Various treatment modalities from a conservative approach (i.e. leaving the migrated implant untreated under a monitoring) [32] to endoscopic transnasal procedures or a conventional Caldwell-Luc technique have been proposed to cure this complication. The implant migration into the maxillary sinus, which acts as a foreign body, may lead to maxillary

sinusitis and a chronic infection or the patient may remain asymptomatic. Rhino sinusitis, a well-known complication associated to the sinus lifting procedure [39, 40], is considered a major but infrequent complication requiring an urgent treatment in order to prevent some more serious complications, as the infection can spread throughout the graft and the sinus cavity or the adjacent anatomical structures and cause a life threatening risk [41]. Soft inflammatory mucosal changes do occur immediately after the operation. According to the literature, acute postoperative sinusitis occurs as a complication in up to 4.7% of sinus graft procedures [42]. Most often the infection appears after more than one week after the surgery. This disorder should be taken into consideration if the patient postoperatively complains of any of the following symptoms: headache, tenderness pain in the area of the maxillary sinus and rhinorrhea. The studies have supported the fact that the patients who have predisposing factors for sinusitis are more at risk of developing postoperative transient sinusitis. The wide range of reported percentages (3% to 20%) may be the result of different methods used for the diagnosing (i.e. clinical, radiographic, endoscopic). To date, in the modern literature no general treatment protocol for sinus graft infections that has been followed and evaluated in serial cases is described [43].

It is difficult to treat infected sinus grafts as the graft itself lies within the sinus cavity underneath the elevated sinus membrane. Yet, the previous experience in treating sinus graft infections with antibiotics usually has not resulted in the elimination of the graft infection, and a further complete graft removal has been necessary. Urban and colleagues [43] have described a treatment modality with the usage of surgical and pharmacological protocol to treat the sinus graft infection complication that salvages the graft and does not necessitate a complete removal of the graft. Mahler et al. [44] have reported a new "dome phenomenon" which has been observed in the infected lifted sinuses. The patients have undergone a surgical debridement followed by a complete healing. They have observed a dome of dense, solid material which has been located in the most superior place of the grafted area. Antral septum is the most common osseous anatomical variant seen in the maxillary sinus [5]. The prevalence of septa has been reported to be as much as 22% in the edentulous patient. The septa may be complete or incomplete on the floor, depending on whether they divide the bottom of the sinuses into sections. The sinus septa may create an extra difficulty at the time of surgery causing the membrane perforation. The wound dehiscence or the incision line opening occurs more commonly when a horizontal-ridge lifting is performed at the same time as a sinus graft surgery, or when the implants are placed above the residual crest and covered with the soft tissue. It may also occur when a soft tissue-supported prosthesis compresses the surgical area during its functioning before the suture removal. The consequences of the incision line opening are: a delayed healing, the leaking of the graft into the oral cavity and an increased risk of infection [46]. Overfilling the sinus can result in the blockage of the ostium, especially if the membrane inflammation or the presence of thickened sinus mucosa exists. The majority of sinus graft overfills do not have postoperative complications. If however, a postoperative sinus infection occurs without the initial resolution, the reentry and removal of a portion of the graft and changing the antibiotic protocol may be appropriate [46]. Postoperative maxillary surgical cysts have also been reported in the literature after the sinus graft surgery, however, they are extremely rare. In 1991 Misch et al. [45] reported one incidence of maxillary surgical cysts associated with the past sinus graft and blade implant. The complete enucleation was accomplished, and the healing was uneventful. The occurrence of a postoperative maxillary cyst following the sinus grafting is exceptionally rare. Usually the cyst is asymptomatic. The removal of the implants and the cyst is indispensable with the following re-grafting of the created empty space. The aim of the present study is to evaluate the complications associated with the maxillary sinus lifting and their impact on the subsequent implant treatment. In addition, this study is aimed to identify the factors that may contribute to the occurrence of those complications and suggest different therapeutic approaches to resolve them.

Material and methods

Patients

Within a 15-year period (1997-2012) 685 generally healthy patients, 318 males and 367 females, aged from 22 to 82 (average age 58.5), who have had partially or totally edentulous maxilla associated with various degrees of alveolar ridge atrophy and sinus pneumatization that have not allowed the placement of standard implants, have been selected for the surgical treatment of the bone deficiency to allow implant placement for fixed implant supported prosthesis. The patients have been initially examined and evaluated for the data collection, this has included:

a) A general health status;
b) The analysis of the oral status including inter-arch relationship and natural residual dentition of the opposite arch;
c) A radiographic evaluation with panoramic radiograph and CT-scans;
d) Dental study casts and a wax-up;
e) An informed consent before the beginning of the treatment after giving the information about the treatment plan, including risks and complications of the treatment, which may occur as well as the potential benefits, and alternative treatment procedures.

A total of 1184 implants have been consecutively placed for restoration of partially edentulous sites or a single tooth of the posterior maxilla. Table 1 shows the patients distribution related to the gender and age.

It has been mandatory to thoroughly review the patients' medical history. A special attention has been paid to the patient related factors that might affect a bone healing prior to determining the suitability of a patient for this kind of procedures. All the patients have met the requirements of a

Table 1

Distribution of Patients with Regard to Gender and Age								
	Age							
Gender	< 20	21-30	31-40	41-50	51-60	61-70	> 71	Total
Female	36	38	37	76	78	64	38	367
Male	32	35	36	66	63	53	33	318
Total	68	73	73	142	141	117	71	685

strict selection protocol (tab. 2).

Table 2

Criteria Used for the Patient Selection	
Inclusion	
	Presence of at least 1 mm residual bone height (RBH)
	Good general health and patients with controlled health condition
	Stable mental health condition
	Ability to complete at least 24 months of clinical follow-up
	Willingness to provide a signed informed consent
Exclusion	
	Uncontrolled diabetes
	Evidence of sinus pathology e.g., chronic or acute sinusitis, cysts, tumours
	Presence of immunodeficiency
	Taking immunosuppressants
	Taking bisphosphonates
	Radiation therapy on the head and neck including maxilla
	Chemotherapy during 12-months period prior to the proposed therapy
	Heavy smokers – more than 20 cigarettes a day

The candidates for sinus floor elevation (SFE) who have presented any condition that would affect the bone healing, either locally or systemically have been rejected. All the patients have been selected according to the specific inclusion criteria: an edentulous posterior maxilla, the posterior residual height at least 1mm to the sinus floor and no diagnosed bone disease or medication known to affect the bone metabolism. The patients have been in particular tested for seasonal allergies, allergic rhinitis or a sinus congestion, all of which may indicate a potential sinus pathosis. A patient with sinusitis, a sinus disease or invasive lesions has been referred to an ear-nose-throat (ENT) specialist for the treatment before the surgery. The current standard for radiographic imaging to identify a sinus disease is the CT scanning. All the patients have been clinically free of any pathology in the maxillary sinus. The individuals have been included in this study if they have been medically able to withstand the procedures and have possessed the insufficient residual bone to allow the placement of standard implants, and could receive the reconstructive procedures. The known factors that may influence the healing process of the bone graft, such as a general health condition, a current medication and tobacco smoking have been documented. The tobacco taking has not been considered as an absolute contraindication for the SFE procedure. It has been mandatory to inform those patients about the increased risk of the implant loss and a peri-implant bone infection. They have been motivated to refrain from or at least reduce their smoking habits. The patients with any kind of abuse problems have been examined carefully. In many cases, some alternatives to implant therapy including the SFE procedure have been preferred. 125 patients have stated that they smoke 1 to 10 cigarettes a day, and those smoking more than 10 cigarettes per day have been asked to stop smoking before the surgery.

After a detailed clinical and radiographic examination all the patients have been given the detailed information about two treatment options:

– a sinus grafting procedure by lateral access with a simultaneous implant placement;
– a sinus grafting procedure by lateral access with a delayed implant placement.

586 patients have had partially edentulous maxilla (394 – unilateral, 192 – bilateral) and 99 patients – totally edentulous maxilla. Of the latter, 94 patients have presented a bilateral deficiency and 5 patients – a unilateral deficiency. The residual alveolar ridge height and width have been measured clinically by caliber and radio graphically using the panoramic radiographs and CT-scans. The preoperative CT scans have not managed to be made for all the patients since the CT scans are expensive and are difficult to access at the time many of these patients are treated. A residual height of 4 mm has been arbitrarily chosen as a "cut-off" measurement to determine the kind of surgical technique. If this has corresponded to the adequate bone width of at least 5 mm and adequate bone quality, these can be considered sufficient to provide the primary stability of the implants placed simultaneously by means of the sinus grafting procedure. Whereas there have been lower values (4 mm), generally, the elevation of the sinus with 6 months delayed implantation after this procedure has been needed. The appraisal of bone quality has been performed according to the classification of Lekhonm and Zarb [47]. The stability of the implant has been evaluated objectively by the application of torque and perio-test measurement (Gulden, Laurrtal, Germany). The length of the implant has been used as a reference for the measurement of the peri-implant bone resorption, which has been expressed as a percentage of the implant length.

Grafting material

Two different grafting materials have been used: deproteinized bovine bone material (DBBM, Bio-oss, Geistlich Pharma, Wolhusen, Switzerland) and β-Tricalcium-phosphat, cerasorb (Curasan, Kleinostheim, Germany). The above have been employed as particulate grafting materials beneath resorbable collagen membrane (Epi-Gide, Geistlich Pharma, Wolhusen, Switzerland). The research patients have been divided into 4 groups according to the material used for the sinus lifting.

For 125 patients in β-Tricalcium phosphate group (T) β-Tricalcium phosphate has been used in the form of cerasorb sized 1000 to 2000 mm. For 108 patients in β-Tricalcium phosphate + autogenous bone group (TA) β-Tricalcium phosphate mixed with the autogenous bone taken from the same surgical sites of the maxillary tuberosity has been used. The autogenous bone has been harvested using bone scrubbers and combined with β-Tricalcium phosphate, which has made up 50% of the mixture. For the next 285 patients only deproteinized bovine bone has been used, Bio-oss spongiosa type, with a particle size 1 to 2 mm. For 167 patients in the group using deproteinized bovine bone + autogenous bone (DA) 50 % of autogenous bone has been added to the deproteinized bone substitute like in group TA. During the surgical procedures all the combinations of graft materials have been mixed with patients' blood taken from the operation site. The authors have chosen to study β-tricalcium phosphate (β-TCP) for the sinus grafting. This allopast is a derivate of hydroxyapatite, which is the mineral or inorganic component of bone. Hydroxyapatite is nonresorbable and acts as a scaffold for osteoconduction. As it lacks the growth factors, it has no osteoinductive properties, however, it does have osteoconductive properties. Among the xenografts, the natural bone material Bio-Oss (Geistlich Pharma, Wolhusen, Switzerland) has shown excellent osteoconductive properties and promising results in sinus floor elevation procedures.

Implant systems and characteristics

Titanium screw implants of 3.3, 3.75, 4.2 or 5 mm in diameter and of various lengths – 8, 10, 11.5, 13 and 16 mm, with internal hexagonal legs from Alpha Bio tech, MIS, Alpha Gate, Adin Israel have been used for all the patients.

Surgical technique

A total of 971 sinus grafting procedures with simultaneous and delayed implant placement using a window technique have been performed. All the patients have been subjected to the prophylactic antibiotic coverage. The patients have orally received 1.5 g clavulanate-potentiated amoxicillin (Augmentin 875 g) 1 hour before the surgical procedure; the penicillin allergic patients have received 450 mg clindamycin, which continued for 10 days of post surgery period. Immediately before the surgery, the patients have undergone a 3-minute mouth rinse with 0.2 % chlorhexidine gluconate. After the anesthesia by 2% Lidocaine with 1:100000 epinephrine a crested incision, slightly off the palatine level, has been made through the entire length of the edentulous area. At the level of the proximal aspect of the tooth that has mesially bordered the edentulous area an anterior releasing incision has been made. Posteriorly, the releasing incision has been located in front of the tuberosity. A full thickness flap has been reflected to expose the lateral wall of the sinus. The mucoperiosteal flap has been reflected superiorly to the level of the molar buttress to expose the complete lateral wall of the maxilla. The elevation of the periosteum adjacent to the implant site has been minimized to preserve a blood supply to the alveolar crest. The periosteom has been reflected superiorly to the anticipated height of the lateral maxillary wall in fracturing. The soft tissues, overlying the cortical bone of the buccofacial wall of the maxillary sinuses, have been removed entirely to expose the bone surface in the required area. The antrostomy has been outlined with a 5 or 6 round bur in a straight hand piece at 2000 rpm under a copious external irrigation. Once the access has been delineated, the bur has been used to continue outlining the osteotomy until a bluish hue has been observed all around the access windows, indicating the closely underlying Schneiderian membrane. It has been obligatory to estimate the thickness of the buccofacial wall of the maxillary sinus to minimize the occurrence of a mucoperiosteal perforation during the antrotomy. The extra precautions have been required for the thick buccofacial wall to keep the mucoperiosteum of the sinus wall intact. To make sure that the outlined bone has been penetrated, it has been tapped gently all around the osteotomy with a blunt instrument until a movement has been visible, creating a rectangular window with rounded or elliptically shaped angles, ensuring that the inferior border is at least 2 to 3 mm superior to the sinus floor. The out fracture osteotomy or "off-the-wall" technique for sinus grafts, in which the complete 360 – degree osteotomy is performed, has been used. This opening is measured on average 6 mm in vertical dimension and 15 mm in the mesiodistal dimension. The location of the lateral window and its size affect the clinician's ability to elevate the membrane safely. The anterior portion of the sinus can be very narrow, requiring the coordination and vision possibility to prevent the membrane perforation. The ideal location for the window has been defined 3 mm superior to the sinus floor and 3 mm distal to the sloping anterior wall. The care has been taken of the sharp edges of an elevated bone window which may cause a laceration of the membrane. When bone scrapers were used to perform the lateral antrostomy, the lateral wall of the sinus was scraped and by itself provided the autogenous bone grafts. Working directly against the membrane has been avoided to decrease the risk of the membrane perforation. In twelve cases a discontinuity of the lateral wall has been known to exist as a result of an aggressive extraction, therefore a thickness flap dissection over the site has been performed to avoid a laceration of the sinus membrane. Once the lateral window was created, the sinus membrane was carefully peeled off the sinus floor and medial sinus wall until it became completely detached from the lateral and inferior walls of the sinuses, and the compartment for grafting material was created. Once there was a sufficient exposure, the membrane was examined for perforations. If no visible perforations have been observed, the space has been filled with saline, and the patient has been

asked to gently perform Valsalva maneuver. Air bubbles have indicated the presence of the perforation. The overlapping resorbable collagen membrane (Bio-Gide, Geistlich, Wolhusen, Switzerland) has been used to repair the perforations. After the sinus membrane has been elevated until it has become completely detached from the lateral and inferior walls of the sinus, the preparation of the implant sites has been undertaken in case the simultaneous implantation was planned. The implant sites have been marked using a surgical template and then drilled in the required areas. After filling the grafting material, the fenestrated lateral wall of the maxillary sinus has been covered with a resorbable collagen membrane, and the mucoperiosteal flap has been repositioned and sutured.

Results

A total of 685 patients (367 female and 318 male) have been treated. They have received 1184 implants and 971 sinuses have been elevated in one and two stage surgery. 399 unilateral (206 right and 193 left maxillary sinuses) and 286 bilateral sinus elevation procedures have been performed. The surgery has been carried out by the same surgeon. Normal clinical healing has occurred in most patients and has been characterized by maintaining the postoperative swelling for 48 hours that has decreased gradually and disappeared completely after 10 days. Any discomfort has been primarily associated with tension from the swelling or haematomas. The postoperative recovery has been uneventful in 923 out of 971 reconstructive procedure cases (95%). The healing period following the 923 procedures of sinus lifting has passed without complications. Minor nasal bleedings occurred in 120 cases. 125 patients have claimed to be light smokers (less than 10 cigarettes a day). Although they all were informed about the negative effects of smoking on bone regeneration, none of them has stopped their habits.

1122 of 1184 inserted implants have resulted to be osseo integrated after 5 years of prosthetic loading (cumulative survival rate 94.7%). In this study, the RBH has ben 1-2 mm for 23.5% of the placed implants, 2-4 mm for 49.0% of the placed implants and 4-6 mm for 27.5% of the placed implants. The bone resorption has been mainly seen apically, but in some cases – also marginally.

Implants survival and success rates

The average follow-up period of implants lasting after the beginning of prosthetic loading has been 59 months. Out of 1184 implants placed in grafted sinuses, 23 implants in 10 patients have been removed due to the loss of integration, untreatable peri-implantitis or chronic pain. Of these, 8 have been removed before the abutment connection, while 15 have been removed after the start of prosthetic loading. A total of additional 12 implants in 12 sinuses have failed to integrate prior to uncovering, and those have been removed by the second-stage surgery. Five of them have been successfully replaced with larger diameter implants (5 mm) at the time of their removal without any additional bone grafting; another 16 implants were lost between the second stage surgery and the first year follow-up examination.

Totally 11 implants were lost between the third and fifth following years. For the failed implants the pre-surgical height was respectively 4 and 5 mm and the implant diameter was 3.75, 4.2 mm, and a perio-test value was -5 and -4. These implants have been substituted by the 5.0 mm diameter implants at the same surgical stage and restored after an additional three months healing.

Eighteen implants placed in the grafted sinus, although still in function, have not answered the success criteria due to the peri-implant bone resorption rates higher than those proposed for the successful implants [1]. The overall survival and success rates of implants placed in grafted sinus have been 97.8% and 94.7%.

The main cause of implant failure (67.2%, n = 42) has been infection followed by the loss of integration (12.8%) (n = 8) and severe bone loss (20%, n = 12). The bone loss because of the infection has also been reported.

A total of 162 single implants have been placed in 123 patients in isolated grafted maxillary sinus sites. All the implants placed have had the length of at least 11.1 and 13 mm to achieve an implant-crown ratio ≥ 1.0.

The followed peri-implant conditions such as radiographic marginal bone resorption, pocket depth and perio-test values of all the implants evaluated at the last examination have been recorded.

The residual ridge height has ranged between 1 and 6 mm. The mean RBH has been 4.8 mm.

All the patients included in the study have fulfilled the follow-up. 288 patients were followed for 5 years, 210 – for 4 years and 187 – for 3 years. Xenograft (DBBM Bio-Oss, Gestlich Pharma) has been the most frequently used grafting material (22.5% of cases). It has been used in both large (39.4% of cases) and small (47.0% of cases) granules or in combination of the both (13.5% of cases). Autogenous bone in combination with DBBM and β-TCP has been used in 9.5% and 5.0% of cases respectively. Another bone substitution, β-TCP alone, has been used in 13% of cases after SFE surgery; here the patients have reported only a moderate discomfort in the surgical sites during the first week of healing. All the patients with fixed prostheses have been rehabilitated. The implant surgery procedure has been performed in two stages after 6 months healing by insertion of a single implant or 2 to 4 implants in unilateral cases.

The postoperative examination after the bone graft procedure has showed an available bone height of the edentulous regions measured from the crest to the superior part of the graft 14.2 mm on the right side and 13.8 mm graft on the left side.

Of the implants placed after graft consolidation 38.0% have been placed by a single stage procedure and 62% have been placed by a two-stage procedure.

The perio-test values for the evaluated implants at 6^{th} and 12^{th} months examination ranged from -7 to +5 and every time the values decreased, ranging from -8 to +3 for the 1184 implants evaluated at the 5^{th} year examination. To summarize the clinical and radiographic results, all remaining 1122 implants were considered successfully integrated at the 5^{th} year examination. With respect to the given procedure, 953

implants (80.5%) have been placed in grafted sinuses without any other associated procedures, 142 implants (12.5%) have been placed in sinus lifted regions along with horizontal bone grafts, and 89 implants (7.5 %) have been placed in the sinuses by cortical split technique. The five-year implant survival rate for these groups have been 94.6%, 93.1% and 91.0% respectively. Clinically all 1122 followed implants have showed no signs of major peri-implant infection or detectable mobility throughout the healing period. All the implants have exhibited the preferable position, which allowed the abutment connection to the implant for the further prosthetic rehabilitation.

Intraoperative complications

Intraoperative Bleeding

Vascular bleeding has been observed in 52 sinus elevation procedures. In these clinical cases a number of techniques to control the vascular bleeding have been used – electro-cautery and the use of a vasoconstrictor (1:50000 epinephrine) for controlling the soft tissue bleeding that occurs in some cases while releasing incisions before the elevation of the mucoperiosteal flap are made. A care was taken not to damage Schneiderien membrane by the electro-cautery.

If the bleeding has occurred from intraosseous vessels, crushing the bleeding channel to compress the bone and vessel has been made to stop the bleeding. Because of the small size of the artery the bleeding has been usually controlled by pressing it with a gauze pad for several minutes resulting in a clot formation within the bone channel around the artery. We have been especially concerned about finding a possible compromise regarding the vessel because of the large size of the intraosseous artery for fourteen young patients (30-35 years old). In those young patients the incidence of bleeding has been reduced by performing the osteotomy of lateral window not to the full height due to the location of the intraosseous artery.

Schneiderian membrane perforation

In 44 sinuses, where the sinus membrane has been torn or perforated (fig. 1), the fragility of the remaining membrane has been increased, and care and delicacy has been required to complete the elevation. The perforated membrane has been elevated around the perforation site carefully from the floor, medial and anterior bony walls to allow the blood supply from the bony walls to vascularize the graft, and a resorbable collagen membrane (Bio-Gide; Geistlich, Wohlusen, Swizerland) has been placed over the area to facilitate the sinus membrane dissection and elevation. In 18 patients small perforations of the sinus membrane have not been treated, as these defects have been closed by folding of the lifted membrane or a self-repair with a small blood clot has been accomplished. To avoid the shifting tendency we have used a large membrane (20 x 30 mm size) and left a portion of it outside the folding on the lateral wall in superior direction. A total of 224 implants have been placed in the sinus perforated cases. Fourteen failures have occurred in the given cases. The implants have been removed prior to the loading. In these cases the areas have been re-augmented and the implants have been placed after additional 6 months of healing. In 16 cases where the septa have been the lateral window has been lengthened in the anterior and posterior directions so that the window has been located both anterior and posterior to the septum. This has allowed the membrane elevating from the both sides of the septum, and it has been impossible to elevate the membrane from a septum without perforating it. In 26 cases a large membrane perforation has been observed after unsuccessful repair and suturing. The repair has been accomplished according to the technique introduced by Proussaefs and Lozada [24] to repair extra large perforated membrane. The collagen membrane surrounds the graft material and seals the lateral access window. In no case it has been necessary to cancel the grafting procedure and subject the sinus membrane to healing. The grafted material has been placed against the medial wall, and implants have been placed by means of the surgical procedure according to the manufacturer's protocols. It has been critical to accomplish the primary stability for the residual bone and for the remainder of the graft material to fulfill the compartment to the contour of the lateral wall. A bio absorbable membrane has been used to close the lateral wall. There have been 5 punctual lesions, which have not required any special treatment. These perforations have been classified according to the simplified classification of the membrane perforation made by Fuguzzotto and Vlassis [27].

After the sinus floor elevation with perforation one dehiscence of the gingival wound has taken place, the fact that has extended the healing time but has caused no further graft or implant loss as there has been no connection to Schneiderian membrane.

Migration of implants into the maxillary sinus

In our research in 2 cases dental implants have displaced into the maxillary sinus cavity. One of them was displaced at the time of surgery and the other migrated several years after the placement due to a spontaneous implant loss (fig. 2). Case 1: A 53-year-old woman has been referred to our private practice to undergo the sinus elevation with simultaneous implantation. While being inserted during the surgery the dental implant was displaced into the sinus lumen. A panoramic radiograph has revealed the presence of the implant within the superior region of the maxillary sinus. The maxillary sinus has been carefully inspected until the migrated implant could be visible and removed. This manipulation is not questioning the completion of the surgical procedure as planned. Case 2: A 56 year-old woman has undergone the grafting with simultaneous implantation of 3 implants in the right sinus. No complications have occurred during the surgery. The implants have been considered to be stable at the surgery time. Prior to the second-stage surgery the panoramic radiograph has detected a displacement of the implant into the right maxillary sinus. The patient has been in a good health state and had no sinus complains. A thorough history, clinical and radiographic examinations including the CT scan have revealed neither history nor actual sign of sinus related pathology. The implant has been located in the region of the ostium. The patient has been prepared for the implant removal. To remove the implant in the right maxillary sinus, the lateral wall of the sinus has been fenestrated with a round

bur; a care has been taken to preserve as much grafting material as possible. A small part of the placed grafting material has been removed to reach the raised sinus membrane. A one cm incision has been made through the membrane and the inspection of the maxillary sinus has been performed. Thereafter, the implant has been visible and could be removed with forceps. The perforation site in the sinus membrane has been sutured with vicryl (Ethicon, Germany) and covered with absorbable collagen membrane (Bio-Gide). After grafting the space underneath the sutured membrane the mucoperiostal flap has been repositioned and sutured with monofilament. The postoperative period has been uneventful. The patient has received a broad spectrum antibiotic and a nasal decongestant for one week and has been instructed to use a 0.2% chlorhexidine mouth rinse for 2 weeks. No complication has been observed postoperatively. Four months after the second

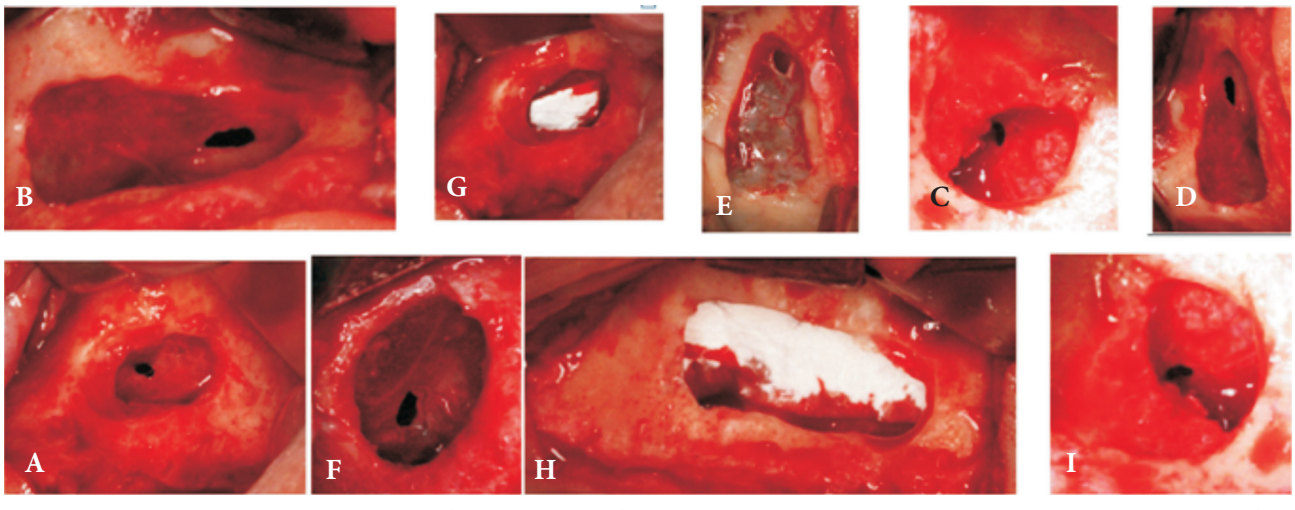

Fig. 1. Membrane perforation of different sizes (A, B, C, D, E, F, I) sealed with resorbable collagen membrane and graft material (G, H).

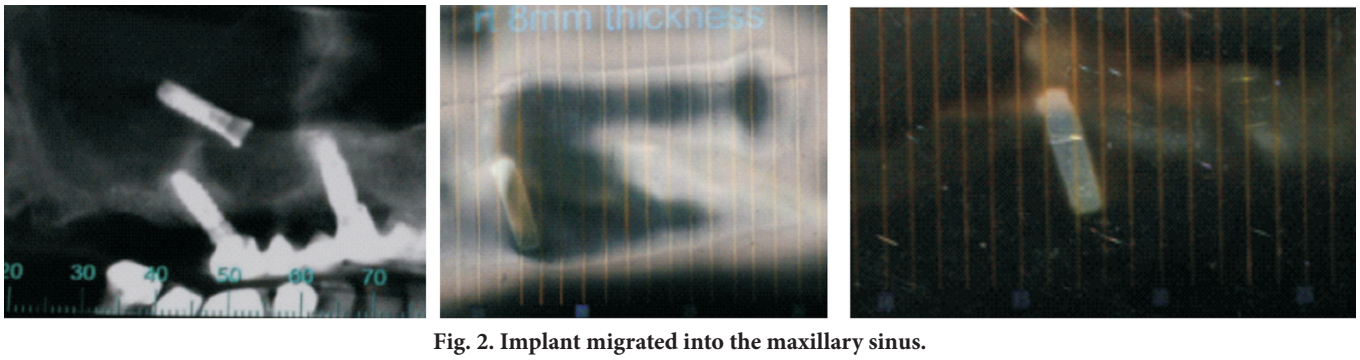

Fig. 2. Implant migrated into the maxillary sinus.

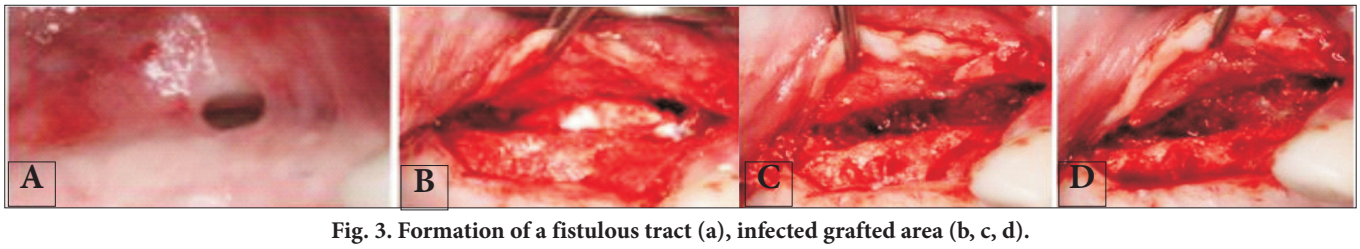

Fig. 3. Formation of a fistulous tract (a), infected grafted area (b, c, d).

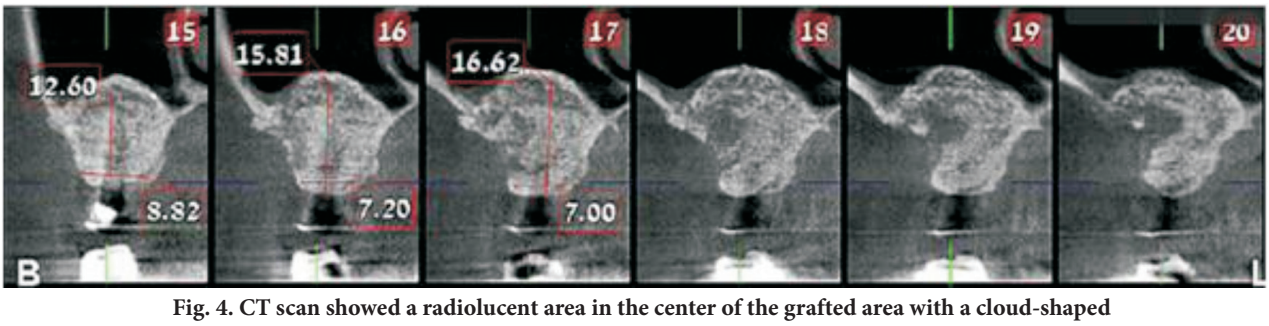

Fig. 4. CT scan showed a radiolucent area in the center of the grafted area with a cloud-shaped radiopacity at the most superior border of the sinus cavity.

bone grafting and implant removal the bone consolidation has seemed to be sufficient for the placement of an implant. Three months after the prosthesis has been made and during the follow-up period of 5 years no maxillary sinus complains have been noted and no implants have been lost.

"Dome phenomenon"

The "dome phenomenon" has been observed in infected lifted sinuses of one patient. A 56 year-old man has undergone the sinus lifting with simultaneous implant placement. The sinus has been grafted with DBBM (Bio-oss, Geistlich, Swizerland) and covered with collagen membrane (Bio-Guide, Geistlich, Swizerland). Schneiderian membrane has been intact. The patient has received antibiotics (Augmentin 875 mg) for 10 days and has been instructed to use the mouth rinse of 0.2 chlorhexidine. Four weeks postoperatively, suppuration with fistulous tract into the oral cavity (fig. 3A) has been seen as well as a facial swelling, a severe pain, an abscess and a loss of graft particles through the fistula. The additional antibiotics have been prescribed: 1.5 g/d Amoxicillin clavulanate (Augmentin 875 mg, Smithkline, Beecham, Brentford, Fliddlesex) and 1 g Metronidazole (Haupt pharma, Livron-Sur-Drome, France). After 10 days the clinical symptoms have improved and the pain has subsided. Four months postoperatively the patient has appeared with an acute abscess along with facial swelling at the surgery site. The obtained panoramic radiograph has showed the loss of integration of one implant. The infected area has been treated surgically and the implant has been removed along with the inflammatory tissue by means of granulation. The superior border of the lifted sinus has been intact with dense, solid tissue separating the remaining defect from the sinus cavity (fig. 3B, 3C, 3D). It has appeared that the infection did not yet covered the entire graft. Post operation panoramic radiograph has showed the radiopaque dome at the most superior border of the lifted sinus. After treating the infection the acute symptoms have disappeared within 48 hours, and the patient's healing has gone uneventfully afterwards. The total healing time prior to the implant placement has been 7 months for this patient. After the healing period the defect has demonstrated a bone fill and has greatly reduced in size. The CT (fig. 4) scan has showed a radiolucent area in the center of the grafted area with a cloud-shaped radiopacity at the most superior border to the sinus cavity. New implants have been inserted and the gap has been filled with additional DBBM (Bio-oss). No further complication has been evident. The implants have been loaded four months after the placement and are still in function 5 years after the operation.

Deprotienized bovine bone (Bio-oss, Geistlich) and fully synthetic ceramic graft material (cerasorb, Curasans, Kleinostheim, Germany) within 100 to 400 μm particle size have been used in all the cases.

Postoperative complications

Sinus graft infection

In the postoperative period twenty two patients have experienced varying degrees of sinusitis symptoms from thickening the sinus mucosa to a purulent infection. One or more clinical symptoms of sinus graft infection they experienced between the first and fourth weeks after the sinus elevation were the following: an abscess, a severe pain, a recurrent facial swelling, a fistulous tract extending into the oral cavity, a loss of graft particles through the fistula or through the borders of the flap ("popcorn sign"). A postoperative CT scan has been performed for all the patients to evaluate the involvement of the sinus lumen. Thirteen patients have showed the sinus involvement according to the performed CT scans. Six patients have showed thickening of the sinus membrane and two patients have showed a complete pacification of the sinus cavity. Thirteen patients have developed an acute infection in the operated right maxillary sinus. After the treatment by antibiotics (Augmentin 875 twice a day) the site has been incised and drained under the local anaesthesia.

The last patient experienced a severe pain 1 to 2 weeks after the surgery which has disappeared later. No additional clinical symptoms occurred in this patient for 5 weeks, then the patient has had a high temperature and a recurrent facial swelling without an intraoral fistula, and this time a surgical intervention has been considered necessary. A combined treatment regime for sinus graft infection has been performed – both the surgical intervention to treat the infected graft material and the systematic pharmacologic treatment for the infection. All sinus graft infections have been treated locally with the same surgical approach. The full-thickness flap from the performed sinus floor elevation procedure has been re-elevated to expose the bone graft. Any loose grayish-looking graft particles floating on the purulent exudates and any loose membrane pieces have been removed and the site has been irrigated with a sterile saline, until a more confined, intact, stable, immature, healthy looking graft material has been visible. It has appeared that the infection did not involve the entire graft. A subjective decision is to determine which graft zone is not subjected to the infection. A locally applied antibiotic has been used empirically to treat the remainder of the sinus graft and reduce the risk of the persistent infection. 100 to 200 mg of doxycycline powder with saline has been placed in the bone graft for two minutes and then has been washed out with a sterile saline. To ensure the formation of a blood clot the defected place has been gently curetted to establish bleeding of the area resulting in a five-wall defect within the sinus graft and preserving the elevated sinus. The flap has been closed and sutured for a primary closure. There has been no the detectable communication between the defect and the sinus cavity in the patients including the two patients who have had a concomitant sinusitis. All the patients have received a systemic medication to prevent the infection spreading throughout the remaining graft and the sinus or other adjacent vital anatomic structures. A systemic antibiotic (Augmentin 875 mg, twice a day) and an anti-inflammatory medication (50 mg diclofenac potassium three times a day) have been administered for 1 week following the surgery. A nasal decongestant spray has been used three times a day for four days by the patients with concomitant sinusitis. The total healing time prior to the implant placement has been

extended to allow a new bone formation in the 5–wall defect area. Any remaining bone deficiencies have been grafted after the time of the implant placement. In 5 procedures the graft infection has occurred despite the absence of clinically detectable dehiscence and the graft has had to be partially or totally removed. Nevertheless, in 3 patients it has been still possible to complete the prosthetic rehabilitation by modifying the dimension, position and/or number of the originally placed implants, while only in 2 patients, due to the total loss of grafted bone, the implant placement has been impossible.

Wound dehiscence

The dehiscence of the surgical wound has occurred in 3 patients treated with sinus grafting along with guided horizontal bone regeneration. In 3 patients the exposed bone graft has been treated only with cautious curettage, antibiotic therapy, chlorohexidine gel and spontaneous healing by secondary intention. No clinical signs of infection have been found in 2 patients and the patients have been rehabilitated with the implants according to the pre-operative plan. The implants have undergone a normal integration and it has been possible to complete the prosthetic rehabilitation successfully. In one patient the infection has occurred despite this treatment and the graft has had to be partially removed until a spontaneous healing has been completed.

Peri-implant infection

The follow-up examination has revealed that 54 implants in 23 patients have developed local peri-implant infections. Local irrigation of the peri-implant sulcus with chlorhexidine diglucanate 0.2 % twice a day for two weeks has been initiated, and then the implants have been subjected to the open flap surgery. The peri-implant infection has been successfully treated. In 5 patients 8 implants have been surgically removed 12 months later because of increasing pain in the peri-implant region. The patients have reported a slight improvement of the state.

Atypical facial pain

One patient (a female of 39 years old) has experienced an unexplained facial pain in the right maxilla after the sinus grafting and delayed insertion of 3 implants. The pain has started a few weeks after the implant placement. No clear cause for the pain could be defined even after consulting an ear, nose and throat (ENT) specialist and a neurologist. The diagnosis has been "atypical facial pain". The implants have been removed later. The patient has reported a subsidence of the pain after a short period of time.

Discussion

Maxillary sinus floor elevation and grafting with biomaterial via a lateral approach is a safe and predictable procedure, which also allows implant placement in severely resorbed posterior maxillae. Multiple modifications of the original sinus lifting technique [12] have been proposed, which comprise a variety of biomaterials [46] and techniques [47, 48]. All the approaches have demonstrated a high predictability, regardless of the grafting material employed on condition that they are applied following an evidence-based approach [13, 14, 49]. If the residual bone volume is more than 5 mm in height the primary stability of the implants can usually be achieved [50] and it has also been our experience if there has been less than 5 mm of available residual bone. A two-step procedure has been recommended. The possibility of placing all the implants in one-stage is advantageous for the patient as it reduces the number of the procedures and the time needed to complete the prosthetics. Regardless of the surgery procedures still some problems can exist, ranging from discomfort to other complications in the sinus cavity [22, 39, 42, 45, 51, 52].

The most commonly reported intraoperative complication of sinus lifting is a membrane perforation [22-25, 27]. It has been reported to occur in 7-35% of sinus floor elevation procedures [6, 22, 25, 26]. In the present study the rate of membrane perforation has been 4.5%. The reported complication rates vary considerably. They start with 12% in the study of 965 sinus floor elevations reviewed retrospectively. The common rates of a meta-analysis are 18.4 %. Two other studies have described values of 6 perforations in 30 operations (20%) and 51 out of 216 cases (23.6%). The highest value in the literature is 36 out of 81 (44%) [22]. Our complication rate is the lowest of the reported rates. Schneiderian membrane on the whole contributes to an adequate graft healing, probably due to its high reparative potential [53]. This factor is essential to maintain the sinus cavity isolated from grafting material and implants. The 45 sinuses with membrane perforation have not shown any significant complications during the healing period or at the time of implant placement. On the contrary, other authors [24] have suggested that a sinus membrane perforation larger than 2 mm could be associated with reduced bone formation and a successful management of the implant compared to the sinus without a membrane perforation. To explain this fact it can be hypothesized that the displacement of a biomaterial through the sinus membrane can lead to transient or chronic sinusitis in 10% to 20 % of sinus elevation cases [51] and, thus, question the implant survival. Dislocated bone particles may also initiate a local inflammation and subsequent severe resorption of the bone graft [24]. Aimetti et al. [54] have observed that the presence of free moving alien bodies may lead to the initial phlogosis of the mucosa with edema and progressive obstruction of the nasosinus osteum leading to the reduced ventilation and mucociliary clearance. Several authors have recommended the usage of a resorbable collagen membrane for the sinus membrane repair [24], expecting it to seal the perforated membrane. Vlassis and Fugazzotto have introduced a classification for the perforated sinus membrane based on the location and difficulty to repair. A recent study has found out that the survival rates of implants placed under reconstructed membranes correlate inversely with the size of the perforation [55]. On the contrary, Schwartz-Arad et al. [22] have found no correlation between postoperative complications of the membrane perforations and the implant survival. In our study, however, the size of the perforation correlates with the implant failure. Although the high success rate of implant survival in our study complies with the studies, the present study smaller defects up to 5

mm have been covered with collagen membrane, and larger defects, more than 5 mm, have been additionally sutured to close the dehiscence, albeit with higher implant failures. In order to avoid the perforation, the surgeon should incorporate various precautions into the treatment plan and, thus, reduce the risk. The presence of the antral septa increases the risk of perforation during the procedure. It has been proposed that the regenerative result of the bone-grafting procedure is inferior to sinus membrane perforations and that simultaneous implant placement should be conducted following the repair of severe perforations [25]. According to the results of the present study, the membrane perforation should not be considered as an absolute contraindication to the simultaneous implant placement. However, lower implant survival values may appear in the cases of severe perforations.

The present study has showed no significant correlation between the occurrence of complications and the type of filling material used in the maxillary sinus lifting. The new bone formation has taken place within 6 months after the sinus lifting procedure. The radiographic evaluation of the lifted areas has showed no discrepancies in the amount of the regenerated bone between the sinus where only xenografts have been used and those where a 1:1 mixture of autogenous bone and xenograft particles has been used. The sinus graft infection is a major but infrequent complication; a meta-analysis has revealed that infections occur in up to 4.7 % of sinus graft procedures [42]. The treatment modalities of sinus graft infections reported in the literature include drainage through the bony window and the systematic administration of antibiotics, an endoscopic exploration of the sinus and surgical exploration and rinsing [39]. The signs and symptoms of the sinus graft infections are described in the clinical cases of this paper. Doud Galli et al. [56] have stated that the obstruction of the sinus by mucosal edentulous and particulate graft material may result in sinusitis. They presented the cases of chronic sinusitis following a sinus lifting surgery. Timmenga et al. [57] have evaluated the influence of sinus lifting on the development of maxillary sinus pathology by means of endoscopy. Only 4.5 % of the patients have developed sinusitis. It has been concluded that the occurrence of postoperative chronic sinusitis appears to be limited to the patients with a predisposition for this condition and these factors need to be considered before performing the sinus lifting. Carmelli et al. [40] have stated that the appearance of an irregular (more than 5 mm) circumferential or complete mucosal thickening is associated with an increased risk of the sinus outflow obstruction and therefore an ENT consultation is recommended. Five patients have undergone an endoscopic inspection via the nasal cavity, which has indicated a maxillary sinus osteum obstruction that has been cleared with endoscopy, the drainage has been provided and a full recovery has been obtained. Urban and colleagues [43] have described a treatment regime for infected grafted sinuses with no defective communications between the infected graft and the sinus cavity. They have presented the successful usage of surgical and pharmacological regimes to treat this complication that does not necessitate a complete removal of the graft. The patients with a communication between the infected graft and the sinus cavity or those who have developed the infection have been treated aggressively by a complete graft removal and/or endoscope sinus surgery. Our cohort patients have experienced the moderate sinus graft infections which have been controlled by a local approach supported by the antibiotic administration. Early evaluation of the symptoms is critical to prevent a spread of the infection and its progression to the sinus cavity and additional vital structures which, in turn, may lead to a complete graft removal. A report of a new bone formation without a graft material during the sinus elevation demonstrates a similar phenomenon [58], as well as in cases of the spontaneous bone regeneration after a postoperative sinus graft infection [44]. This study also presents a phenomenon, where a dense solid bone has been in the superior spot of the grafted area, in spite of an inflammatory complication that necessitates a surgical treatment. This dome has provided a 3 to 4 wall defect inside the grafted sinus, which has been repaired with regenerated bone and permitted the implant insertion without the need of additional sinus lifting. It is noteworthy that there are alternative treatments for the cases of the acute sinus infection. These include the removal of the infected grafted materials as well as regrafting or placing a membrane over the window to prevent soft tissue ingrowths. The incidence of peri-implantitis of different degrees, which has been identified in 18% of the placed implants in our study correlates with the results of the recently reported studies. The Lindhe & Meyle [59] consensus report shows that peri-implant infections of all types of implant therapy are a very common lesion. They report that peri-implant mucositis has occurred in 80% of the subjects and in 50% of the implant sites. Peri-implantitis has been identified in 28-56% of the subjects and in 12-43% of the implant sites. Peri-implant infections are usually linked with a poor oral hygiene, a history of periodontitis [60] and cigarette smoking. Other risk factors such as diabetes, alcohol consumption and genetics are defined to a less extent. Dental implants migrated to paranasal sinuses have been reported over the last 15 years, a total of 62 implants migrated to paranasal sinuses have been described in the last few years. There are two phases of migration characteristic of implants located in the sinus cavity: (a) the displacement of dental implants during their placement, (b) the migration of dental implants after their Osseo integration. The displacement of dental implants during their placement is easily understandable. It can be related to the poor bone quality or quantity, the surgical inexperience of the operator, the presence of an untreated perforation, an excessive tapping on the implant or the application of an excessive force [38]. The migration of the implant from its initial position to the maxillary sinus may occur two weeks or two months later, or after several years of its adequate functioning. The implant migration may cause the sinus disorder as in the cases described by Regev and associates [30], or the patient may remain asymptomatic like in the present cases. The reasons for the implant migration are still unknown. It can be an inadequate implant anchorage and,

therefore, a lack of primary stability as well as an inadequate preparation or placement of the implant or weakness of the bone as a result of osteoporosis or osteopenia. However, the mechanism of an implant migration to the maxillary sinus several years after its loading is easier to understand and this has been the case of the patient presented in our study whose implant migrated after 8 years of functioning. Various mechanisms have been proposed to explain the migration of an implant to the maxillary sinus, and these fall under 3 main headings: 1) changes in intrasinusal and nasal pressures; 2) an autoimmune reaction to the implant, causing the peri-implant bone destruction and endangering an Osseo integration; 3) the resorption produced by an incorrect distribution of occlusal force as proposed by Regev and coworkers [30]. Moreno et.al [61] has showed that the incidence of implant migration to the sinus cavity is higher for the cylindrical implants as compared to conical ones as well as for the narrower implants and when the implants were placed in smokers. In one case of our study a cylindrical implant migrated to the sinus cavity several years after its loading. The implant displacement or migration to the maxillary sinus is an increasingly serious complication influenced by multiple implants, patients and surgeons related factors. Understanding that helps to identify these factors minimizes the risk of developing this undesirable complication.

Conclusion

A sinus floor elevation is a predictable procedure with low morbidity and an expected implant survival rate well above 90% for midterm and long-term periods. Complications may occur during and after the sinus surgery. The implant placement in atrophic sites commonly requires the site development and, therefore, advanced surgical skill and experience to reduce the risk of complications. The presence of complications, which can occur despite the taken precautions, emphasizes the importance of thorough clinical and radiograph evaluation before performing the sinus lifting procedure. It is also recommended to expand the routine dental CT scans to include the maxillary sinus ostium to ensure that the nasoostium is patent. Early recognition of the signs and symptoms of the sinus graft infection is crucial to eliminate the infection and prevent its progression to the sinus cavity and additional vital structures. The intraoperative sinus membrane perforation does not represent a significant risk factor for the implant survival.

The sinus infection has occurred in 4.5% of patients which complies with the modern literature.

We need to educate our dentists concerning the risks associated with the atrophic maxillary posterior area and recommend an advanced training and cooperation as well as encourage the referrals and teamwork. These should be the ways to prevent the complications.

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