Federico Hernández-Alfaro
Marta Marín Torradeflot
Carlos Marti

Prevalence and management of Schneiderian membrane perforations during sinus-lift procedures

Authors' affiliations:
Federico Hernández-Alfaro, Department of Oral and Maxillofacial Surgery, Teknon Medical Center, Hospital General de Catalunya, Universitat Internacional de Catalunya, Barcelona, Spain
Marta Marín Torradeflot, Universitat Internacional de Catalunya, Barcelona, Spain
Carlos Marti, Teknon Medical Center, Universitat Internacional de Catalunya, Barcelona, Spain

Correspondence to:
Federico Hernández-Alfaro
C/Vilana
12, D-185
Barcelona 08022
Spain
Tel.: + 34 933933185
Fax: + 34 933933085
e-mail: director@institutomaxilofacial.com

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Abstract: This clinical study was undertaken to evaluate the prevalence of surgical complications of the sinus graft procedure and to set a protocol to repair sinus membrane perforations intraoperatively using a variety of techniques and materials. From January 2000 to May 2005, 338 patients were studied, on whom 474 sinus floor augmentation procedures were performed, and a total of 1166 dental implants were simultaneously placed. A total of 104 perforations of the sinus membrane were observed (19 were bilateral). In group number 1, sinus membrane perforations of <5 mm were observed in 56 sinus augmentation procedures (53.85%), 44 were treated using a resorbable collagen membrane and 12 were sutured with a resorbable material. In group number 2, 28 sinus membranes had a perforation size between 5 and 10 mm (26.92%) and were treated using lamellar bone combined with a resorbable membrane. Group number 3 consisted of 20 sinus membrane perforations>10 mm (19.23%), 10 were covered with lamellar bone combined with a buccal fat pad flap, six were treated with a mandibular block graft and four perforations were treated with only a lamellar bone sheet. Two-hundred and seventy-eight implants were placed under repaired membrane perforations and 247 implants survived. Interestingly enough, all the 25 implants that failed to integrate were placed under perforated and reconstructed membranes during the sinus lift procedure. Based on the results of this study, the survival rates of implants placed under reconstructed membranes correlate inversely with the size of the perforations.

The use of dental implants for oral rehabilitation has become a clinical routine (Nkenke et al. 2002; Stricker et al. 2003). Several studies have reported successful and predictable results in patients with normal bone volume and density, which provide adequate stabilization for implants of standard diameter and length (Khoury 1999; Stricker et al. 2003; Levin et al. 2004; Proussaefs et al. 2004). After loss of teeth in the posterior maxilla, the alveolar ridge decreases by bone atrophy and osseointegration of implants in patients with pneumatized maxillary sinuses are difficult to achieve (Chanavaz 1990; Ulm et al. 1995; Khoury 1999; Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b; Aimetti et al. 2001; Cho et al. 2001; Nkenke et al. 2002; Stricker et al. 2003; Sorní et al. 2005). Grafting the floor of the maxillary sinus is a method of attaining sufficient bone height for posterior maxillary implant placement and has proven to be a highly successful and predictable technique to overcome this problem (Ulm et al. 1995; Khoury 1999;

Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b; Cho et al. 2001; Cordioli et al. 2001; Stricker et al. 2003; Schwartz-Arad et al. 2004; Sorní et al. 2005), with an implant survival rate of over 90% for 3–5 years (Levin et al. 2004; Shlomi et al. 2004; Schwartz-Arad et al. 2004). The so-called 'sinus lift' procedure with bone grafting was reported by Tatum in 1975 (Chanavaz 1990; Betts & Miloro 1994), and published for the first time by Boyne and James in 1980 (Chanavaz 1990; Betts & Miloro 1994; Bergh van den et al. 2000a, 2000b; Aimetti et al. 2001; Stricker et al. 2003).

While the sinus elevation procedure is considered by some to be a relatively invasive procedure, a comparatively low incidence of surgical and postsurgical complications of the procedure has been reported (Cho et al. 2001; Schwartz-Arad et al. 2004). The most common surgical complication is the perforation of the Schneiderian membrane (Bergh van den et al. 2000a, 2000b; Cho et al. 2001; Levin et al. 2004; Proussaefs et al. 2004; Schwartz-Arad al. 2004; Shlomi et al. 2004; Sorní et al. 2005). It occurs in 7–10% to 35% of sinus floor elevation procedures (Khoury 1999; Nkenke et al. 2002; Stricker et al. 2003; Schwartz-Arad et al. 2004; Shlomi et al. 2004). Membrane perforations, according to the literature, are strongly associated with the appearance of postoperative complications and consist mostly of acute or chronic sinus infection, bacterial invasion, swelling, bleeding, wound dehiscence, loss of the graft material and a disruption of normal sinus physiologic function (Chanavaz 1990; Bergh van den et al. 2000a, 2000b; Aimetti et al. 2001; Cho et al. 2001; Cordioli et al. 2001; Nkenke et al. 2002; Levin et al. 2004; Proussaefs et al. 2004; Schwartz-Arad et al. 2004; Shlomi et al. 2004). However, no association has been found between membrane perforations or postoperative complications and implant survival (Cho et al. 2001; Nkenke et al. 2002; Fugazzotto & Vlassis 2003; Schwartz-Arad et al. 2004; Shlomi et al. 2004), although Khoury (1999) and Proussaefs et al. (2004) assumed that there is a correlation between implant failure and sinus membrane perforation.

Anatomical as well as technical factors have been implicated in membrane perforations (Ulm et al. 1995; Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b; Shlomi et al. 2004). Conditions such as sinus floor convolutions, sinus septum (Underwood septa) (Chanavaz 1990; Betts & Miloro 1994; Ulm et al. 1995; Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b; Schwartz-Arad et al. 2004; Shlomi et al. 2004), transient mucosa swelling, osteotomy design (Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b) and narrow sinus can complicate membrane elevation and increase the risk of perforation during the procedure (Bergh van den et al. 2000a, 2000b; Cho et al. 2001; Shlomi et al. 2004).

Several attempts have been made to classify membrane perforations. Vlassis and Fugazzotto proposed five classes based on the location and difficulty to repair (Vlassis & Fugazzotto 1999; Fugazzotto & Vlassis 2003; Shlomi et al. 2004; Sorní et al. 2005). Preferred management of membrane perforations is not clearly defined in the literature (Shlomi et al. 2004). Various surgical techniques to overcome these perforations include suturing (Khoury 1999; Vlassis & Fugazzotto 1999; Schwartz-Arad et al. 2004) and use of a fibrin adhesive (Chanavaz 1990; Khoury 1999; Bergh van den et al. 2000a, 2000b; Stricker et al. 2003; Schwartz-Arad et al. 2004). Small perforations usually do not need treatment because the membrane folds on itself during the elevation (Betts & Miloro 1994; Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b; Fugazzotto & Vlassis 2003; Shlomi et al. 2004). However, large perforations are usually managed using a bioabsorbable membrane (Betts & Miloro 1994; Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b; Cho et al. 2001; Cordioli et al. 2001; Fugazzotto & Vlassis 2003; Stricker et al. 2003; Proussaefs et al. 2004; Schwartz-Arad et al. 2004; Shlomi et al. 2004), by placing a large lamellar bone sheet (Betts & Miloro 1994; Vlassis & Fugazzotto 1999), using a block graft inserted of a cancellous graft (Shlomi et al. 2004) or by abandonment of the procedure (Chanavaz 1990; Khoury 1999; Bergh van den et al. 2000a, 2000b; Schwartz-Arad et al. 2004; Shlomi et al. 2004).

The purpose of the present study was to evaluate retrospectively the prevalence of surgical complications of the sinus graft procedure proposing a protocol to repair sinus membrane perforations intraoperatively using a variety of techniques and materials.

Material and methods

Patient selection

From January 2000 to May 2005 (an interval of 53 months), 474 sinus floor elevations were performed by the same surgeon (F. H. A.), at the Oral and Maxillofacial Surgery Institute, Teknon Medical Center, in Barcelona (Spain). Three-hundred and thirty-eight patients, representing 474 sinus floor augmentation procedures, were included in the study.

Patients who showed any uncontrolled systemic disease, ongoing chemo- or radiotherapy or a history of maxillary sinus diseases were excluded. All patients were informed of the requirements for participation in the study and signed an appropriate consent form.

Before treatment, all patients were clinically and radiographically examined [by panoramic radiography and computed tomography (CT) scanning in selected cases] for available bone volume, bone quality, anatomy and any existing sinus pathology.

A total of 1166 dental implants were simultaneously placed: 944 of them 3I Osseotite (3i, Implant Innovations Inc., Palm Beach Gardens, FL, USA), and the remaining 222 Astra (Astra-Tech, Malmo, Sweden).

Surgical technique

All the procedures were performed under light sedation and local anesthesia. Prophylactic oral antibiotics were used routinely (Amoxicilin 500–1000 mg), beginning 8 h before the procedure and continued for 7 days.

The sinus augmentation procedure followed the technique described by Tatum and coworkers (Chanavaz 1990; Betts & Miloro 1994). A horizontal antero-posterior incision was made slightly palatal to the alveolar crest and supplemented by buccal-releasing incisions at the anterior and posterior ends of the horizontal incision. A full-thickness mucoperiosteal flap was raised and the lateral wall of the sinus was exposed. A rectangular osteotomy was made with a round bur mounted on a high-speed handpiece or using a piezoelectric device with copious sterile saline

irrigation. The superior part of the osteotomy was left intact to allow infracture of the lateral sinus wall and the bony window was rotated medially and superiorly, shifting into a horizontal position.

Care was taken not to perforate the sinus membrane. The sinus mucosa was separated from the bony surface of the sinus floor with a series of curved elevators. The sinus membrane was carefully and completely reflected from the maxillary sinus floor and the medial wall to create enough space for the bone graft. Schneiderian membrane perforations were not considered a reason to abort the planned augmentation procedure. When a membrane perforation was discovered, the membrane surrounding the perforation was delicately dissected with a blunt instrument, in an attempt to relieve the pressure, at the perforated area. Depending on the extent of the perforation, various treatment options were performed using different techniques and materials. In cases of perforations smaller than 5 mm, direct suturing of the membrane with 6/0 Vicryl (Ethicon, Norderstedt, Germany) or patching with a collagen membrane (Bio-Gide, Geistlich Biomaterials, Wolhusen, Switzerland) was carried out. In cases where sinus membrane perforations were between 5 and 10 mm, again, a resorbable collagen membrane was used, and the lamellar bone from the sinus window was placed under it in order to reinforce the reconstruction and before insertion of the graft material. Finally, larger perforations (perforation size>10 mm) were treated in one of three ways: (1) covered with lamellar bone of the lateral sinus window (Fig. 1a–e), (2) covered with a pedicled buccal fat pad flap (Fig. 2a–d) or (3) by placement of a bone block graft harvested from the symphysis of the mandible or the retromolar area (Fig. 3a–d). (Table 1).

Once the resulting space had been examined and injuries to the membrane were repaired, the implants sites were prepared. Preparation of the fixture sites was undertaken using surgical guides based on wax-up models and according to the standard clinical procedures for the implant system. All implants placed at the sinus lift procedures were considered to be clinically stable.

At this stage, the graft was placed. The posterior part of the cavity was grafted first, followed by the anterior portion and finally the central area. Filling material consisted of inorganic bovine bone mineral (Bio-Oss; Geistlich) mixed with autologous bone collected from implant drilling, in an approximate proportion of 80 : 20 to 70 : 30 of Bio-Oss/Autogenous bone. This grafting protocol was used in all patients, except for those where a mandibular bone block was used.

The amount of grafting material used at each site varied according to the extent of maxillary bone resorption and sinus anatomy. Care was taken not to obstruct the middle nasal meatus to allow free sinus drainage.

After graft placement and packing, the mucoperiosteal flap was repositioned and sutured with monofilament sutures.

Postoperative care

Patients were advised not to blow their noses and to sneeze opening the mouth for 1 week after surgery. Patients were also instructed not to wear their dentures for 2 weeks postoperatively. Antibiotics (Amoxicilin 500 mg three times/day) were prescribed for 7 days and analgesics as required in each case. Finally, sutures were removed after 7–10 days following surgery.

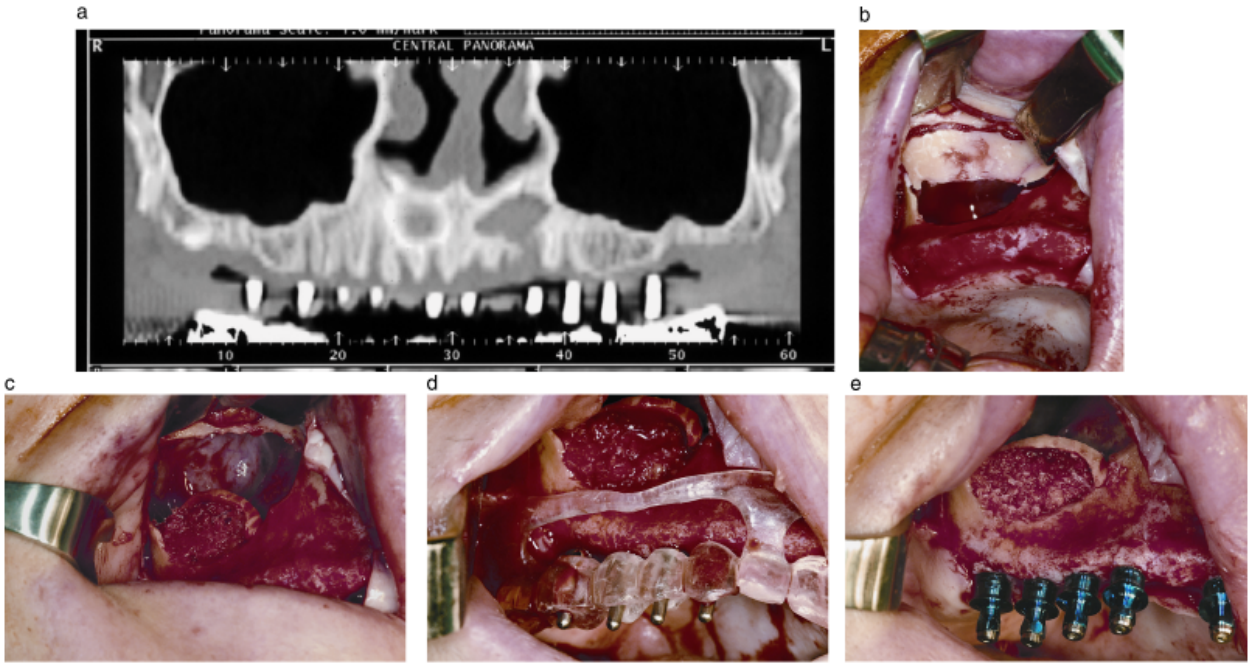

Fig. 1. Sinus membrane perforations >10 mm were treated with only a lamellar bone sheet adapted to isolate the graft from the sinus. (a) Dental computed tomographic scans were performed to measure the bone available and the presence of antral septa in the posterior maxilla in each patient. (b) Perforation of the sinus membrane is observed. (c) A lamellar bone sheet adapted superiorly and the filling material consisted of inorganic bovine bone mineral (Bio-Oss) mixed with autologous bone collected from implant drilling. (d) Preparation of the fixture sites was undertaken using surgical guides based on wax-up models. (e) Implants were placed into the augmented sinus.

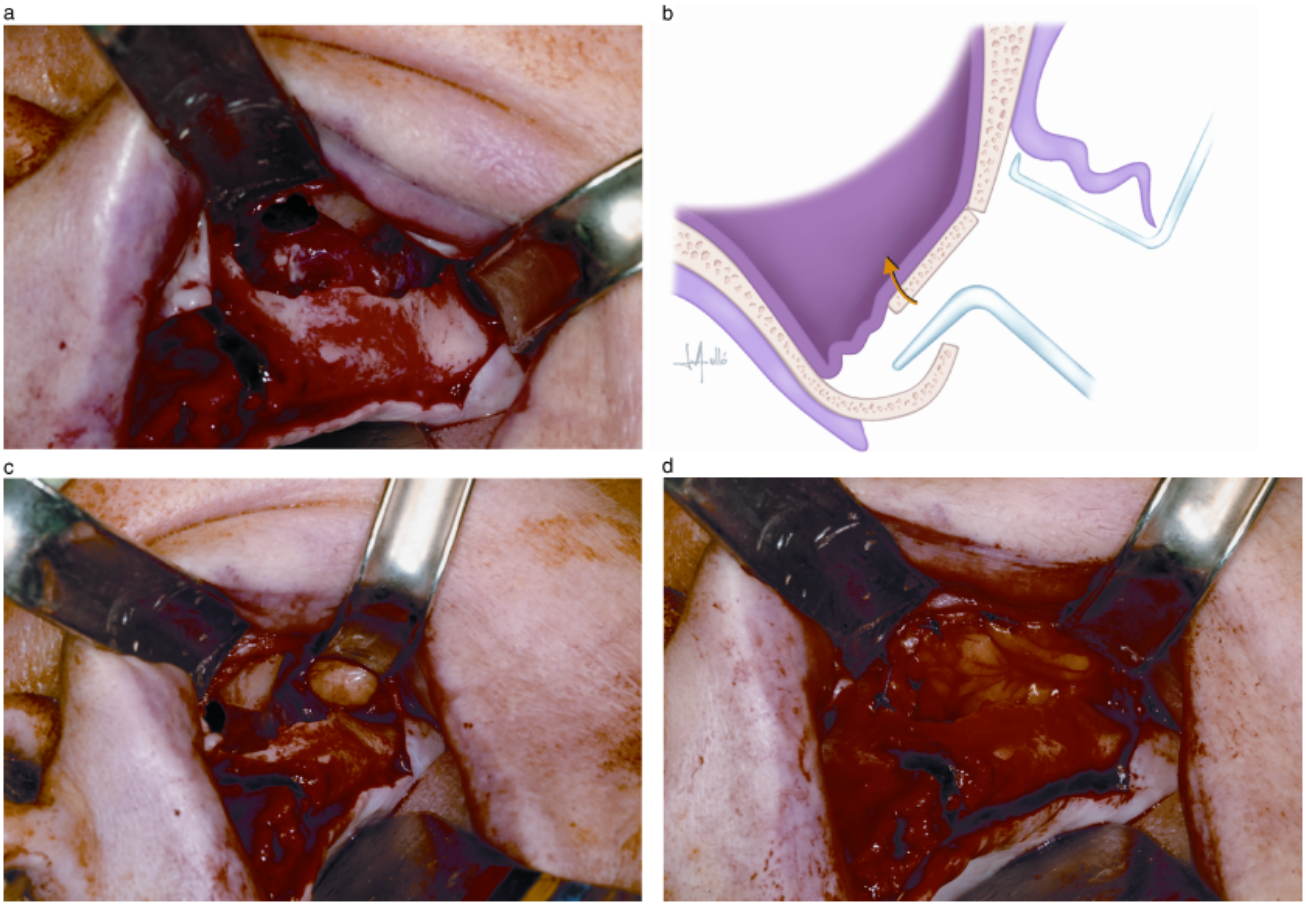

Fig. 2. Sinus membrane perforations >10 mm were covered with lamellar bone of the lateral sinus window combined with a buccal fat pad flap. (a) Perforation of the sinus membrane is observed. (b) Schematic drawing of the lateral sinus wall and the bony window rotated medially and superiorly, shifting into a horizontal position. (c) The bony lid is rotated toward the maxillary sinus and a buccal fat pad is placed against the perforated site. (d) The buccal fat pad is placed in the perforated site to repair the sinus membrane.

Records included: age and sex, membrane perforations, the size and method for membrane repair when needed, the number of placed implants and finally the number of functioning implants after prosthetic loading of at least 6 months.

Statistics

A proportion test was used for comparison of variables using Statgraphics program®. *P*-values ≤ 0.05 were considered to be significant. Three groups were defined: perforations of <5 mm, perforations between 5 and 10 mm and perforations>10 mm.

Using a binomial distribution, the survival rate of the implants was compared with all three groups. This test was used to obtain three comparisons: group number 1 with group number 2; group number 2 with group number 3 and group number 1 with group number 3.

Results

Four-hundred and seventy-four sinus lift procedures were performed in 338 patients, 150 men and 188 women, with a mean age of 48 years (range 27–69 years). Initial bone heights at the implant sites ranged between 4 and 9 mm (mean 7.2 mm).

Simultaneous implantation of 1166 implants was carried out. A total of 104 perforations of the sinus membrane were observed and 19 of them were bilateral. Perforations of the Schneiderian membrane were the main intra-operative complication [85 patients (25.15%)].

In group number 1, visible perforations of the sinus membrane of <5 mm were observed in 56 sinus augmentation procedures (53.85% of the perforations), 44 were treated using a resorbable collagen membrane and 12 were sutured directly with a resorbable material (Vicryl 6/0). In this situation, 140 implants were placed and 136 survived, which represents an implant survival rate of a 97.14%. In group number 2.28 sinus membranes had a perforation size between 5 and 10 mm (26.92% of the perforations) and were treated using lamellar bone of the sinus window combined with a resorbable collagen membrane at the side of the perforation, with simultaneous implantation of 74 implants (68 survived, yielding an implant survival rate of 91.89%). Group number 3 consisted of 20 sinus membrane perforations>10 mm (19.23% of the perforations); 10 were covered with lamellar bone of the lateral sinus window combined with a buccal fat pad flap, six were treated with a block graft harvested from the mandible (four block grafts harvested from the symphysis of the mandible and two harvested from the retromolar area and four perforations were treated with only a lamellar bone sheet adapted

to isolate the graft from the sinus). A total of 58 endosseous implants were inserted simultaneously; 43 of them survived (15 of 58 implants failed, having an implant survival rate of 74.14%) (Tables 2–3).

Statistical analysis (normal approximation to the binomial distribution) showed no significant implant survival rate at sinus membrane perforations of <5 mm compared with perforations between 5 and 10 mm ($P=0.08$). A significantly higher implant survival rate was seen in perforations between 5 and 10 mm than in perforations higher than 10 mm ($P=0.005$). The implant survival rate was significantly greater in perforations of <5 mm compared with the perforations >10 mm ($P=0.0000005$) (Table 4).

Two-hundred and seventy-two implants were placed under repaired membrane perforations; 247 implants survived and 25 implants failed (90.81% survival rate) (Table 5).

Implants with symptoms of pain or sensitivity to percussion as well as clinical signs of infection were considered to be failures and removed. According to the failure criteria established in this study, the cumulative success rate was 90.81%.

No complications occurred at donor sites. Temporary numbness in the mental region was recorded in two patients in which bone blocks were harvested from the symphyseal region.

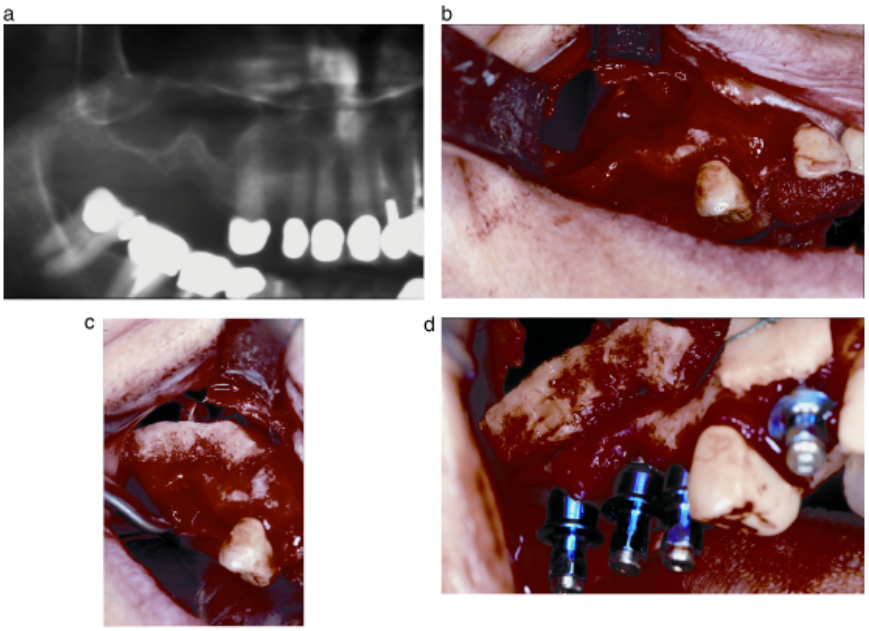

Fig. 3. Sinus membrane perforations >10 mm were treated with a block graft harvested from the mandible. (a) Pre-operative panoramic radiograph showing the presence of antral septa in the posterior right maxilla. (b) Perforation of the sinus membrane is observed. (c) A mandibular bone block is placed against the perforated site to repair the sinus membrane. (d) Stabilization of the bone block graft with three implants, which are used to achieve initial stability of the bone graft and implants.

***Table 1*. Treatment options in cases of sinus membrane perforations, depending on the extent**

Extent of perforation (mm)	Surgical treatment of sinus membrane perforations
<5	Suturing Resorbable collagen membrane
5–10	Lamellar bone + resorbable collagen membrane
>10	Lamellar bone Lamellar bone + buccal fat pad Bone block graft

Discussion

The current study demonstrated that the implant survival rate is correlated inversely with the size of the sinus membrane perforation.

Grafting of the maxillary sinus is a method for reaching sufficient bone height for posterior maxillary implant placement and has proven to be a highly successful method and to give predictable results (Chanavaz 1990; Bergh van den et al. 2000a, 2000b; Aimetti et al. 2001; Nkenke et al. 2002; Shlomi et al. 2004; Sorní et al. 2005). Sinus floor elevation procedures are routinely performed, although the function of the maxillary sinus is not clearly understood. Some of its functions might be adding resonance to the voice and some degrees of olfactory function, warming and humidifying inspired air, as well as reducing the weight

***Table 2*. Percentage of successful implants placed simultaneously in sinus lift, depending on the dimension of the perforation**

Extent of perforation (mm)	No. of perforations	Surgical treatment of sinus membrane perforations	No implants placed	No implants survived	No implants failed	Implant survival rate
<5	56 (Group No. 1)	12 suturing 44 resorbable collagen membrane	140	136	4	97.14%
5–10	28 (Group no. 2)	28 lamellar bone + resorbable collagen membrane	74	68	6	91.89%
>10	20 (Group no. 3)	Four Lamellar bone 10 Lamellar bone + buccal fat pad Six Bone block graft	58	43	15	74.14%

Table 3. **Comparson of the survival rate of the implants with all three groups**

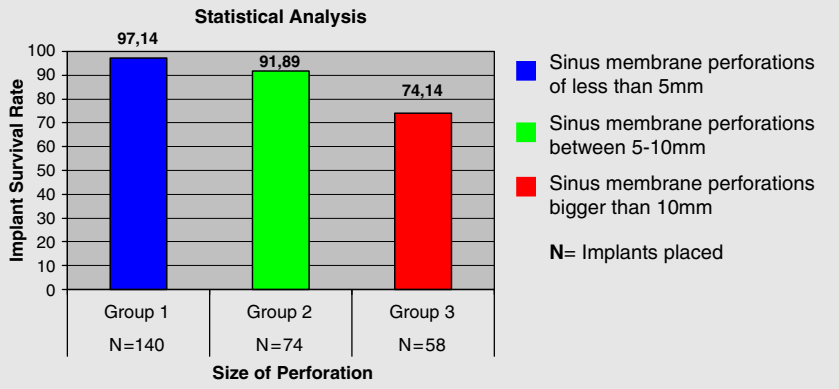

Table 4. **A proportion test was used to obtain the *P*-value**

	2	3
1	0.08	0.0000005
2		0.005

Comparing group number 1 with group number 2, the *P*-value was 0.08; comparing group number 2 with number 3, the *P*-value was 0.005 and comparing group number 1 with group number 3, the *P*-value was 0.0000005.

Table 5. **Percentage of successful implants placed simultaneously in sinus lift, when there is a perforation**

No. of patients	No. of sinus lift	No. of unilateral perforations	No. of bilateral perforations	No. of implants placed	No. of implants failed	No. of implants survived	Implant survival rate
338	474	85	19	272	25	247	90.81%

of the skull (Bergh van den et al. 2000a, 2000b; Nkenke et al. 2002).

The most commonly reported intraoperative complication of sinus augmentation is membrane perforation (Vlassis & Fugazzotto 1999; Cho et al. 2001; Levin et al. 2004; Proussaefs et al. 2004; Schwartz-Arad et al. 2004; Shlomi et al. 2004; Sorní et al. 2005). It has been reported to occur in 7–35% of sinus floor elevation procedures (Khoury 1999; Nkenke et al. 2002; Stricker et al. 2003; Schwartz-Arad et al. 2004; Shlomi et al. 2004). In the present study, the rate of membrane perforation has been 25.15%.

Interestingly enough, in this study, all the 25 implants that failed to integrate were placed under perforated and reconstructed membranes during the sinus lift procedure. It may be reasonable to assume that there is a correlation between implant failure and sinus membrane perforation (Khoury 1999). In 104 cases, sinus lift surgery was complicated by perforation of the sinus membrane, which was treated using different techniques and materials intended to act as a barrier between the sinus cavity and the site of graft placement. The results of this study point toward the idea that the extent of sinus membrane perforation can result in reduced bone formation and a compromised implant survival rate. To explain this fact, it can be hypothesized that displacement of a biomaterial through the sinus membrane can lead to transient or chronic sinusitis from 10% to 20% of sinus elevation cases, prompting the need for further treatment (Nkenke et al. 2002), and impairing the prognosis of the placed implants. Dislocated bone particles may also initiate local inflammation and subsequent severe resorption of the bone graft (Nkenke et al. 2002; Proussaefs et al. 2004). Aimetti et al. (2001) observed that the presence of foreign bodies, which are free to move inside the sinus antrum, appears to create the conditions for initial phlogosis of the mucosa, with edema and progressive obstruction of the nasosinus ostium leading to reduced ventilation and mucociliary clearance. In addition, during graft placement, the surgeon is unable to observe whether or not the membrane repair is adequate to resist pressure during graft packing (Proussaefs et al. 2004). Spread of the grafting material can be prevented by using block grafts (Nkenke et al. 2002). In our series, six large (>10 mm) perforations were treated using bone blocks and simultaneously placing the implants.

Johansson et al. (1999) suggested an interesting classification of implant failures, dividing failures into biologic, mechanical (technical), iatrogenic and inadequate patient adaption.

Several clinicians have recommended the use of a resorbable collagen membrane for repairing the perforated sinus membrane (Proussaefs et al. 2004). Proussaefs et al. (2004) reported repair of sinus perforations, with a collagen membrane, assuming that it forms a pouch around the sinus graft material and seals the lateral access window. In that study, they evaluated the effect of sinus membrane perforations on successful implants in grafted maxillary sinuses and reported a higher cumulative implant success rate in non-perforated sites (100%) than in perforated sites (69.56%). These figures compare unfavorably with our cases where the cumulative success rate was 90.81%.

Vlassis and Fugazzotto introduced a classification for the perforated sinus membrane based on location and difficulty to repair (Vlassis & Fugazzotto 1999; Fugazzotto & Vlassis 2003; Sorní et al. 2005). According to their classification, class I perforation is a perforation that occurs at any point along the most apical wall of the prepared sinus window. Class II perforations occur along the lateral or crestal aspects of the prepared sinus window, and are further subdivided according to their position. Class III perforations occur at any location within the body of the prepared sinus window. Our

classification is based on the size of the perforations and is associated with a treatment protocol.

As suggested by the results of the present study, minor membrane perforations may not play a significant role in the clinical outcome. However, it appears that the size of the membrane perforations relates to the prognosis of the implants placed. Schwartz-Arad et al. (2004) found no relation between membrane perforations or postoperative complications and implant survival. In our study, however, the size of the perforation correlates with implant failure.

Previous reports suggested that larger perforations represent an absolute contraindication to the continuation of surgery (Aimetti et al. 2001). In this study, sinus perforations>10 mm were treated with the above-mentioned protocol, albeit with higher implant failures.

The presence of anatomic variations as well as technical factors in the region of the sinus floor can cause complications during such procedures. In order to avoid perforation, the angles of the rectangular osteotomy should be rounded and softened, so as to minimize the risk of pinching the membrane when rotating the lateral wall of the osteotomy medially and superiorly (Vlassis & Fugazzotto 1999; Bergh van den et al. 2000a, 2000b). The osteotomy design should also be altered when variations in sinus anatomy exist. Hence, if the perforation risk is understood to be higher in this area, the surgeon should incorporate various precautions into the treatment plan and subsequently reduce the risk. When the sinus antrum is narrow, it will not be possible to rotate the window inwards and upwards turning into an horizontal position (Cho et al. 2001). In these situations, the complete ostectomy technique (removal of the lateral bony window) should be used (Cho et al. 2001). The presence of the antral septa also determines the shape of the osteotomy and increases the risk of perforation during the procedure. According to the literature, especially in the younger adult, the incidence of antral septa (Underwood's septa) varies between 16% and 58% (Betts & Miloro 1994; Ulm et al. 1995; Bergh van den et al. 2000a, 2000b). In this situation, the osteotomy technique consists of dividing the sinus into smaller accessory sinuses (Betts & Miloro 1994; Bergh van den et al. 2000a, 2000b).

The question of placing implants simultaneously or delayed in conjunction with a sinus floor augmentation procedure is controversial. If the residual bone volume is more than 5 mm in height, primary stability of the implants can usually be achieved (Peleg et al. 1999; Mangano et al. 2003) and it has also been our experience. However, if there is <5 mm of available residual bone, it has been considered to be insufficient to maintain the implants mechanically, and a two-step procedure has been recommended (Peleg et al. 1999). The possibility of placing all the implants in a one-stage procedure is perhaps more technically demanding than the two-stage method, but is advantageous for the patient in that it reduces the number of procedures and the time needed to complete implant-supported prostheses (Smedberg et al. 2001). It has been proposed that the regenerative result of the bone-grafting procedure is inferior following sinus membrane perforations and that simultaneous implant placement should not be conducted following repair of severe perforations (Shlomi et al. 2004). According to the results of the present study, membrane perforation should not be considered an absolute contraindication for simultaneous implant placement. However, lower implant survival figures may appear in cases of severe perforations.

Various grafting materials have been used during sinus augmentation procedures, including autogenous bone, freeze-dried bone allografts, xenografts, hydroxyapatite, tricalcium phosphate, a combination of these materials (Johansson et al. 1999; Guarnieri & Bovi 2002; Hallman et al. 2002; Valentini & Abensur 2003; Proussaefs et al. 2004; Shlomi et al. 2004) and bone morphogenetic protein (Bergh van den et al. 2000a, 2000b). The quantity and quality of the bone graft available from the mandible seems to be sufficient and may avoid the need to harvest the bone from an extraoral site to permit sinus grafting and simultaneous implant placement (Khoury 1999). In our series, the combination of anorganic bovine matrix with variable amounts of bone has proved to be an adequate grafting material.

Conclusion

Perforation of the Schneiderian membrane is the most prevalent intra-operative complication associated with the sinus elevation procedure. Sinus membrane perforations may be adequately reconstructed and covered, and therefore are not an absolute contraindication to the continuation of surgery, provided that they do not allow the passage of graft material inside the maxillary sinus.

The overall survival rate of implants placed under reconstructed membranes was 90.81. Based on the results of this study, the survival rates of these implants correlate inversely with the size of the perforations.

Autogenous bone mixed with inorganic bovine bone mineral (Bio-Oss) constitutes a viable alternative as an augmentation material for this type of procedure.

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要旨
本臨床研究は、上顎洞移植術の合併症の発症率を評価し、上顎洞粘膜の穿孔を様々なテクニックと材料を用いて術中に修復するためのプロトコールを設定した。2000 年 1 月から 2005 年 5 月までに受診した 338 名の患者において、474 の上顎洞底増生術が行われ、合計 1166 本のインプラントが 1 回法で同時に埋入された。104 箇所の上顎洞粘膜の穿孔が観察された（19 箇所は両側。）グループ 1 では 5mm 未満の上顎洞粘膜の穿孔が 56 例の上顎洞増生術で観察されたが（53.85%）、うち 44 箇所は吸収性コラーゲン・メンブレンを用いて治療し、12 箇所は吸収性材料で縫合した。グループ 2 では 5～10mm サイズの上顎洞粘膜の穿孔が 28 箇所でみとめられ（26.92%）、層板骨と吸収性メンブレンの併用で治療した。グループ 3 では 10mm 以上の上顎洞粘膜穿孔が 20 箇所あり（19.23%）、10 箇所は層板骨と頬脂肪パッドのフラップを併用して被覆し、6 箇所は下顎骨ブロック移植で治療し、4 箇所の穿孔は層板骨シートのみで治療した。修復した粘膜穿孔下に 278 本のインプラントを埋入し、247 本のインプラントが生着した。興味深いことに、骨性結合しなかった 25 本のインプラントは全て上顎洞挙上術中に穿孔し、再建した粘膜下に埋入したものであった。本研究の結果では、再建した粘膜下に埋入したインプラントの存続率は穿孔のサイズと逆比例していた。

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