

Complication Rate in 200 Consecutive Sinus Lift Procedures: Guidelines for Prevention and Treatment

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Purpose: Maxillary sinus grafting is a predictable and reliable procedure that has been routinely performed for more than 30 years. The complication rate is low, but some cases may require additional surgery, and the outcome of oral rehabilitation may be affected. The purpose of the present study was to evaluate the early and late complications after sinus lift procedures performed in the authors' center, with special attention to risk factors and their connection to the principles of prevention and treatment.

Materials and Methods: A retrospective analysis of 127 patients was performed. During an 8-year period, patients underwent preprosthetic surgery with implants and a maxillary sinus lift procedure because of maxillary atrophy. In total, 202 sinus lift procedures were performed and 364 implants were placed (117 simultaneously and 247 delayed). Clinical data, local or systemic disease, risk factors, type of surgery, intraoperative and postoperative complications, and the evolution of the implant zone were recorded.

Results: The most common intraoperative complication was damage to the Schneiderian membrane (25.7%), which did not show any connection to postoperative complications. Thirty patients (14.9%) developed postoperative complications, including wound infection, abscess, or dehiscence with drainage (9 cases), maxillary sinusitis of the operated area (6 cases), partial exposure of the simultaneous onlay graft (6 cases), and loss of the graft (2 cases).

Conclusion: Sinus lift surgery is a proven and reliable technique because of the low observed rate of postoperative complications and the success rate of implants placed into the grafted area. To minimize risk, care must be taken with all technical details and risk factors that can lead to fatality.

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The technique of lifting the floor of the maxillary sinus (sinus lift procedure [SLP]) to allow the insertion of implants was initially presented by Tatum in 1976.¹ Breine and Brånemark² conducted the first clinical trials by applying a particulate tibia bone graft apically over the implant on the maxillary alveolar ridge and reported 25% osseointegration of the implant. The first publication describing the SLP technique was by Boyne and James³ in 1980, with an osteotomy being

performed in the anterior wall of the maxilla to form a window in the bone. Subsequent developments of the technique include that by Kent and Block⁴ who used a modified Caldwell-Luc procedure to perform an inverted-U osteotomy in the anterolateral wall of the maxillary sinus and further infraction of the plate of the maxillary window. Subsequently, others, including Jensen et al,⁵ described 2-stage processes with SLP and implant placement being performed in

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separate operations. Loukota et al⁶ described a single-stage procedure of immediate implants, and Summers⁷ performed a less invasive, closed method of elevating the sinus floor using appropriate osteotomes. All these techniques, designed to increase the availability of bone in posterior sectors of the maxilla, have proved their worth and effectiveness over the years.

The maxillary sinus graft procedure is predictable and reliable, as are the implants placed into the graft. The placement may be simultaneous with the SLP or delayed 4 to 6 months depending on the preoperative residual bone. These implants have a proved high survival rate (up to 95.5% at 5 yr).⁸ Moreover, the technique is safe and has a low complication rate. Nonetheless, like any surgical procedure, it is not without risks. Complications can cause problems, which involve additional surgery, hospitalization, and lengthy recovery time, with the corresponding impact on the patient's quality of life and even fatality. Complications also may compromise the outcome and viability of the grafts and, hence, that of the implants and therefore of the oral reconstruction.

The purpose of the present study was to evaluate early and late complications after SLPs performed in the authors' center, with special attention to risk factors and their connection to prevention and treatment methods.

Material and Methods

A retrospective analysis was carried out on patients who had undergone preprosthetic surgery with implants that, because of maxillary atrophy, included a bone graft after SLP, performed at the Instituto Neofacial (Badajoz, Spain) by the senior author during an 8-year period from March 1999 to October 2007.

The protocol was designed according to the principles of the Declaration of Helsinki and the study was reviewed and approved by the local ethical committee.

The clinical data collected were the case history and physical examination, the existence of any systemic disease or other risk factors such as smoking, and the pathologic status of the maxillary sinus as determined from imaging studies (orthopantomography and computed tomographic Dentascan) examined by the senior author. Data on intraoperative and postoperative complications and the evolution of the implants placed in the grafted zone also were recorded.

All patients who underwent SLP had less than 10 mm of preoperative residual bone. The exclusion criteria were any major disease contraindicative of surgery, some uncontrolled pathology, a history of head and neck radiotherapy, chemotherapy, use and abuse of drugs, and uncontrolled periodontal disease. Smokers were informed of the increased risks of surgery and were advised to stop smoking.

The technique used was a modified Caldwell-Luc procedure. A window was cut into the bone of the anterolateral wall of the maxillary sinus, with dissection and subsequent lifting of the Schneiderian membrane accompanied by the remnant anterolateral maxillary wall, which formed the roof of the future SLP. An osteotomy was performed similar to that described by Kent and Block⁴ in 1989, but with a single crestal incision extended laterally in the vestibule to free the flap. For immediate implant placement, the crestal incision was shifted more toward the palate.

The operations were performed under general anesthesia or intravenous (IV) sedation. Treatment was initiated with the antibiotics amoxicillin plus clavulanic acid and the anti-inflammatory dexamethasone (8 mg) was included in the anesthetic induction. In patients under general anesthesia, this IV treatment was continued for 24 hours postoperatively until discharge. After their discharge and in patients under IV sedation, treatment continued at home with the same antibiotics taken orally for 8 days in addition to oral nonsteroidal anti-inflammatory drugs and analgesics.

In total, 127 patients were treated at the authors' center with implant placement in the atrophic maxilla after sinus lift bone grafting. Of these 127 patients, 77 were women and 50 were men (age range, 19 to 77 yr; average age, 49 yr). The SLP was unilateral in 52 patients (23 on the left side and 29 on the right side) and bilateral in 75. Thus, 202 procedures were performed.

Seventeen women and 13 men were under treatment for some systemic disease at the time of surgery (30 patients compared with the other 97 patients who were free from systemic disease). There were 83 SLPs performed in smokers (54 patients), of which 56 (36 patients) were in women and 27 (18 patients) were in men (Table 1).

In total, 364 implants were placed into the treated regions (external hex tapered RBM-coated Restore, Lifecore Biomedical, LLC, Chaska, MN; external hex tapered Osseotite, Biomet 3i, LLC, Palm Beach Gardens, FL). Of these, 117 were inserted simultaneously with the SLP and the remaining 247 were deferred. Of the 202 SLPs performed, 147 used "isolated" grafts using a mixture of Geistlich Bio-Oss spongiosa small granules (0.25 to 1 mm; Geistlich Pharma AG, Wolhusen, Switzerland) and particulate grafting material obtained from cancellous tibia or iliac crest (6 cases) or from bone recovered by filter (141 cases). These 147 isolated SLP grafts received 249 implants. The remaining 55 SLPs received bone block grafts: 49 with onlay grafts to increase the alveolar crest width (8 with a graft obtained from the mandibular retromolar area or the chin and 41 with a corticocancellous block from the inner wall of the iliac crest) and 6 with inlay grafts inserted into the floor of the maxillary sinus. These 55 SLP block grafts received 115 implants

Table 1. DISTRIBUTION OF PATIENTS AND SLPs SORTED BY SMOKERS, NONSMOKERS, AND SYSTEMIC DISEASES

| | Men | | Women | |
|-----------------------------|----------|------|----------|------|
| | Patients | SLPs | Patients | SLPs |
| Nonsmokers | 32 | 54 | 41 | 65 |
| Smokers | 18 | 27 | 36 | 56 |
| Without systemic disease | 37 | 61 | 60 | 91 |
| Systemic disease | 13 | 20 | 17 | 30 |
| Anemia | — | — | 1 | 1 |
| Asthma | 1 | 1 | — | — |
| Celiac disease | — | — | 1 | 1 |
| Cholelithiasis | 1 | 1 | — | — |
| Diabetes mellitus | 1 | 2 | 1 | 2 |
| Rheumatic fever | — | — | 1 | 2 |
| Hypercholesterolemia | 3 | 4 | — | — |
| Hypothyroidism | — | — | 2 | 4 |
| Arterial hypertension* | 6 | 10 | 7 | 12 |
| Old MI | 1 | 2 | — | — |
| Psoriasis | — | — | 1 | 2 |
| Treatment with Fosamax† | — | — | 1 | 2 |
| Unspecified thyroid disease | — | — | 2 | 4 |

Abbreviations: MI, myocardial infarction; SLPs, sinus lift procedures.

* One male patient had hypertension and chronic obstructive pulmonary disease and another also had hypothyroidism. One female patient had hypertension and hypothyroidism.

† Alendronate sodium (Merck, Whitehouse Station, NJ).

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(93 in cases associated with onlay grafts and 22 in cases with inlay grafts; Table 2).

Of the total number of implants, 203 formed part of a comprehensive maxillary reconstruction, 34 were for reconstruction of the molar region, 10 for treatment of a premolar edentulous sector, 98 in a premolar-molar combination reconstruction, and 19 in reconstructions of a posterior edentulous sector (premolar with or without the molar) with anterior

Table 2. DISTRIBUTION OF TYPES OF PROCEDURES AND IMPLANTS PLACED

| | Total | Single | SLP + Bone | Onlay | Inlay |
|----------|-------|--------|-------------|-------|-------|
| | | SLP | Block Graft | | |
| SLP | 202 | 147 | 55 | 49 | 6 |
| Implants | 364 | 249 | 115 | 93 | 22 |

Abbreviation: SLP, sinus lift procedure.

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extension (canine with or without the incisor). Because of the type of prosthodontic treatment, 229 of the total 364 implants were splinted to implants inserted outside the SLP region, and the other 135 were inserted into the SLP region and were exclusively responsible for the prosthetic reconstruction.

The follow-up period was 36 to 90 months (average, 57 months) from the time of surgery.

Results

INTRAOPERATIVE COMPLICATIONS

The most common intraoperative complication was damage of varying degrees to the Schneiderian membrane during the opening of the bone window or its dissection. In the authors' practice, this occurred in 52 (25.7%) of the 202 SLPs; the most frequent form of damage, occurring in 30 cases, was small 1- to 3-mm tears in the membrane (14.9% of cases). In 12 cases (5.9%), there were punctiform lesions of the membrane; included in this group were minor weakening lesions of the membrane caused by the bur; in another 10 cases (4.9%), larger lesions, with tears larger than 3 mm, were seen.

POSTOPERATIVE COMPLICATIONS

Of the total study population (127 patients), 25 (19.7%) had some form of postoperative complication. The most frequent complication was wound infection, which occurred in 9 patients (7.1%), followed by postoperative sinusitis in 5 patients (3.9%), including 1 patient with bilateral SLP in whom there appeared sinusitis on one side and wound infection on the other. There followed, in rate of occurrence, the following complications: exposure of the bone graft onlay in 4 patients (3.1%) and exposure and ultimate loss of the graft in 2 patients (1.6%), including 1 patient with bilateral SLP in whom there appeared exposure of the graft on the 2 sides with final loss of the graft on 1 side.

Of the 202 SLPs, 172 (85.1%) evolved without incident. The postoperative complications in the other 30 (14.9%) were wound infection, abscess, or dehiscence with drainage (9 cases), maxillary sinusitis of the operated area (6 cases), partial exposure of the simultaneous onlay graft (6 cases), loss of the graft (2 cases), and certain minor complications with no repercussion on the healing process and final recovery of the patient after the appropriate treatment (Table 3).

Prior Status of Maxillary Sinus

The status of the sinus mucosa before SLP was normal in 148 of the 202 procedures (73.3%). Of the 9 cases consistent with mucocele, there were 2 cases in which the wound became infected after surgery

Table 3. COMPLICATIONS IN SLPs

| | Patients | % | SLPs | % |
|----------------------|----------|------|------|------|
| None | 102 | 80.3 | 172 | 85.1 |
| Infection or abscess | 9 | 7.1 | 9 | 4.5 |
| Sinusitis | 5 | 3.9 | 6 | 3.0 |
| Exposed graft | 4 | 3.1 | 4 | 2.0 |
| Lost graft | 2 | 1.6 | 2 | 1.0 |
| Edema | 2 | 1.6 | 3 | 1.5 |
| Seroma | 3 | 2.4 | 3 | 1.5 |
| Bleeding | 1 | 0.8 | 2 | 1.0 |
| Membrane exposure | 1 | 0.8 | 1 | 0.5 |

Abbreviation: SLPs, sinus lift procedures.

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(22.2%). Of the 12 cases with a history of sinusitis, 8 (66.7%) had no complications, whereas 4 (33.3%) presented some complication after surgery. Of the 148 cases of maxillary sinuses with normal mucosa, 128 (86.5%) presented no postoperative complication, whereas the remaining 20 cases (13.6%) included wound infection (5 cases), postoperative sinusitis (4 cases), seroma (3 cases), edema (3 cases), bleeding (2 cases), exposure of the graft (2 cases), and exposure of the membrane (1 case; [Table 4](#)).

Type of SLP

The 202 SLPs performed corresponded to 2 basic groups: "isolated SLP" (147 cases, 72.8%), with insertion of particulate bone graft mixture (from cancellous iliac crest or from bone recovered with a filter) and "block graft SLP" (55 cases, 22.2%), which, in addition to the particulate graft in the zone being reconstructed, included the insertion of a bone block graft to augment the height or width. In the isolated SLP group, 127 (86.4%) had no complication compared

with 20 (13.6%) who developed some type of complication. In the block graft SLP group, 45 (81.8%) had no complication compared with 10 (18.2%) who developed some type of complication ([Table 5](#)).

Systemic Disease

No relation was observed between the complications and the existence of systemic disease. Of the 2 diabetic patients, 1 developed a postoperative infection, although the patient recovered satisfactorily after treatment. The series included very few patients with systemic diseases in general, and diabetes mellitus in particular, making it impossible to establish any statistically significant correlations.

Smoking

Of the subpopulation who were smokers (54 patients), 11 (20.4%) developed some form of complication after SLP compared with a complication rate of 19.2% in the nonsmoking population (14 of 73 patients). The total complication rate for the study population of 127 patients was 19.7%. Of the different types of complications observed, only sinusitis was more frequent in smokers (4 in smokers, 1 in a nonsmoker). In contrast, of the 9 cases of infection, 8 were in nonsmokers. Exposure of the graft occurred in 5 patients, for a total of 6 SLPs, 4 of which (2 in smokers, 2 in nonsmokers) healed after treatment and local dressing, whereas in 2 patients who were smokers, the complication evolved to the point of the loss of the onlay graft. The other complications were distributed without any significant differences between smokers and nonsmokers ([Table 6](#)).

By Type of SLP

For the isolated SLPs, a slightly higher complication rate was observed in smokers (17.0% [9 of 53 SLPs] vs 11.7% [11 of 94 SLPs] in nonsmokers). For the block

Table 4. POSTSURGICAL COMPLICATIONS RELATED TO PRIOR STATUS OF SINUS MUCOSA

| Postsurgical Complication | Normal | Enlarged | History of Sinusitis | Mucocele | Oroantral Fistula |
|---------------------------|-------------|------------|----------------------|-----------|-------------------|
| None | 128 (86.5%) | 29 (90.6%) | 8 (66.7%) | 7 (77.8%) | 0 (0%) |
| Complications | 20 (13.5%) | 3 (9.4%) | 4 (33.4%) | 2 (22.2%) | 1 (100%) |
| Infection or abscess | 5 | 2 | | 2 | |
| Sinusitis | 4 | | 2 | | |
| Exposed graft | 2 | | 1 | | 1 |
| Lost graft | | 1 | 1 | | |
| Membrane exposure | 1 | | | | |
| Edema | 3 | | | | |
| Seroma | 3 | | | | |
| Bleeding | 2 | | | | |
| Total | 148 | 32 | 12 | 9 | 1 |

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Table 5. POSTSURGICAL COMPLICATIONS RELATED TO TYPE OF BONE GRAFT

| Postsurgical Complication | Particulate Graft | Inlay | Onlay |
|---------------------------|-------------------|-----------|-------------|
| Total | 147 | 6 | 49 |
| Without complications | 127 (86.4%) | 5 (83.3%) | 40 (81.63%) |
| Complications | 20 (13.61%) | 1 (16.7%) | 9 (18.37%) |
| Infection or abscess | 6 | | 3 |
| Sinusitis | 6 | | |
| Exposed graft | | | 4 |
| Lost graft | | | 2 |
| Membrane exposure | 1 | | |
| Edema | 3 | | |
| Seroma | 3 | | |
| Bleeding | 1 | 1 | |

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graft SLPs, the postoperative complication rates were 16.1% (5 of 30 SLPs) in smokers and 20.0% (5 of 25 SLPs) in nonsmokers. Minor postoperative complications (edema, seroma, and membrane exposure) were seen only in isolated SLPs, with no difference between smokers and nonsmokers. In contrast, cases of sinusitis were more frequent in smokers than in nonsmokers (1 in a nonsmoker and 5 in isolated SLPs of smokers).

COMPLICATIONS IN IMPLANTS

Cases of implant complications occurred in 16 patients (12.6%), corresponding to 17 (8.4%) of SLPs

Table 6. POSTSURGICAL COMPLICATIONS RELATED TO SMOKING

| | Smokers (54 Patients) | Nonsmokers (73 Patients) | Total (127 Patients) |
|---------------------|--------------------------|-----------------------------|-------------------------|
| Sinusitis | 4 | 1 | 5 |
| Wound infection | 1 | 8 | 9 |
| Exposed onlay graft | 2 | 2 | 4 |
| Lost onlay graft | 2 | 0 | 2 |
| Seroma | 1 | 2 | 3 |
| Edema | 1 | 2 | 3 |
| Bleeding | 1 | 1 | 2 |
| Membrane exposure | 0 | 1 | 1 |
| | 12 | 17 | 29 |

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and 21 (5.8%) of the total number of implants. The most frequent complication was loss of the implant (9 cases, 42.9% of complications), followed by peri-implantitis (3 cases, 14.3%) and early marginal bone loss (3 cases, 14.3%). In 2 (9.5%) implants there occurred peri-implant mucositis, which was treated successfully, as were another 2 (9.5%) implants that presented early and initial mobility (Table 7).

Smoking

With respect to the relation between the implant complications and smoking as a risk factor, these complications appeared in 16 patients (12.6% of overall implant complication rate). Of these 16 patients, 9 were smokers and 7 were nonsmokers. Of the total 127 patients, 54 were smokers and 73 were nonsmokers. The complication rate involving implants was higher in smokers than in nonsmokers: 9 of 54 patients (16.7%) who were smokers had complications in some implant compared with 7 of 73 patients (9.6%) who were nonsmokers. Similarly, when considering the total number of implants, the incidence of complications was higher in smokers than in nonsmokers: the complication rate for implants in smokers was 8.4% (13 of 154 implants corresponding to smokers) versus 3.8% (8 of 210 implants) in nonsmokers. The implant complications were greater in smokers in number and in quantity. The most frequent complications were loss of the implant, with an incidence of 3.3% in smokers compared with 1.9% in nonsmokers, followed by peri-implantitis, marginal bone loss, and implant mobility, each with incidences of 1.3% in smokers and 0.5% in nonsmokers (Table 8).

Table 7. IMPLANT COMPLICATIONS

| | Patients (n = 127) | | SLPs (n = 202) | | Implants (n = 364) | |
|----------------------------|-----------------------|------|-------------------|------|-----------------------|------|
| | n | % | n | % | n | % |
| No complications | 111 | 87.4 | 185 | 91.6 | 343 | 94.2 |
| Complications | 16 | 12.6 | 17 | 8.4 | 21 | 5.8 |
| Lost | 8 | 6.3 | 8 | 4.0 | 9 | 2.5 |
| Peri-implantitis | 2 | 1.6 | 2 | 1.0 | 3 | 0.8 |
| Marginal bone loss | 2 | 1.6 | 2 | 1.0 | 3 | 0.8 |
| Mucositis | 2 | 1.6 | 2 | 1.0 | 2 | 0.6 |
| Mobility | 1 | 0.8 | 1 | 0.5 | 2 | 0.6 |
| Fracture | 1 | 0.8 | 1 | 0.5 | 1 | 0.3 |
| Local periapical infection | 1 | 0.8 | 1 | 0.5 | 1 | 0.3 |

Abbreviation: SLPs, sinus lift procedures.

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Table 8. IMPLANT COMPLICATIONS RELATED TO SMOKING

| | Smokers | | Nonsmokers | |
|----------------------------|---------|------------|------------|------------|
| | Count | Percentage | Count | Percentage |
| No complications | 141 | 91.6% | 202 | 96.2% |
| Complications | 13 | 8.4% | 8 | 3.8% |
| Lost | 5 | 3.3% | 4 | 2.0% |
| Peri-implantitis | 2 | 1.3% | 1 | 0.5% |
| Marginal bone loss | 2 | 1.3% | 1 | 0.5% |
| Mucositis | 1 | 0.7% | 1 | 0.5% |
| Mobility | 2 | 1.3% | 0 | — |
| Fracture | 0 | — | 1 | 0.5% |
| Local periapical infection | 1 | 0.7% | 0 | — |

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By Type of SLP

The greater overall complication rate of smokers was maintained when the 2 types of SLP (isolated and block graft) were considered separately. For the isolated SLP group, the complication rates were 5.4% in smokers and 3.9% in nonsmokers. For the block graft SLP group, the respective rates were 13.1% and 3.7%. There were too few cases of each complication to establish the statistical significance of the differences in the data. Except for implant losses after isolated SLP, in which the complication rates were similar in smokers and nonsmokers, the general tendency was to observe more complications in smokers, especially in the block graft SLP group.

Time of Placement

With respect to the type of treatment carried out, in 67 SLPs there was immediate placement of 117 implants, and in the other 135 SLPs there was delayed placement of 247 implants. Of the 117 immediate implants, there were 4 complications (3.5%), and of the 247 delayed implants, there were 17 complications (6.9%). In addition to the higher complication rate in the delayed implants, there were more implant losses: 2 immediate implants were lost (1.7%) and 7 delayed implants were lost (2.8%). There was marginal bone loss in 1 immediate implant (0.9%) and in 2 delayed implants (0.8%). There was a process of periapical local infection in 1 immediate implant. All other cases of implant complications (peri-implantitis in 3 cases, mobility in 2 cases, mucositis in 2 cases, and fracture in 1 case) occurred only in the delayed implant group (Table 9).

By Type of SLP

This greater overall number and rate of complications in the delayed implant group was maintained

Table 9. IMPLANT COMPLICATIONS RELATED TO TIMING OF SURGERY

| | Immediate | | Delayed | |
|----------------------------|-----------|------------|---------|------------|
| | Count | Percentage | Count | Percentage |
| No complications | 113 | 96.6% | 230 | 93.1% |
| Complications | 4 | 3.5% | 17 | 6.9% |
| Lost | 2 | 1.7% | 7 | 2.8% |
| Peri-implantitis | 0 | — | 3 | 1.2% |
| Marginal bone loss | 1 | 0.9% | 2 | 0.8% |
| Mucositis | 0 | — | 2 | 0.8% |
| Mobility | 0 | — | 2 | 0.8% |
| Fracture | 0 | — | 1 | 0.4% |
| Local periapical infection | 1 | 0.9% | 0 | — |

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when the 2 types of SLP (isolated and block graft) were considered separately. The only exception was a single case of marginal bone loss in an immediate implant with block graft SLP, which, because of the very small number of implants of this type, led to a complication rate higher than that of the corresponding delayed implant group. In summary, isolated SLP with immediate implant placement appears to be the surgical option with the lowest risk of complications.

Discussion

The aim of the present study was to analyze the prevalence and types of complications that were encountered in a sample of patients with alveolar atrophy of the posterolateral maxilla who underwent SLP to augment the availability of bone. The patients presented severe maxillary atrophy (Classes IV and V of Cawood and Howell).⁹ In the following sections, the authors consider the viability of the technique in light of the complications that were encountered in connection with the known risk factors. The goal is to anticipate and treat these complications and to improve the survival of implants placed in the grafted zone.

PERFORATION OF SCHNEIDERIAN MEMBRANE

Intraoperatively, tearing or perforation of the Schneiderian membrane is the most common complication, in the present series and in the literature reviewed by the authors. The reported incidence in the literature ranges from 7 to 56% of cases.^{10,11} The incidence in the present study was somewhere in the middle of this range (25.7%) of the SLPs performed. Various methods have been proposed to deal with these complications, from leaving them untreated to suturing the Schneiderian membrane, sealing with reabsorbable membranes, and using glues obtained from autologous fibrin gel.^{4,10,12} In general, small perforations may regenerate spontaneously. In their

practice, to avoid the risk of contamination and sinus disease, the authors protect the sinus membrane prophylactically with strips of biological reabsorbable membranes. This serves the further purpose of avoiding the risk of small, submillimetric perforations or zones of weakened membrane produced during the osteotomy. It also obviates the risk of complications arising from small perforations or tears at the time of inserting and packing the graft, especially when cancellous particulate graft is used and the sinus membrane is particularly thin. If a perforation is observed, a larger quantity of reabsorbable membrane is applied to this "lining" to ensure greater stability and a continuous seal.

During the dissection maneuvers, more extensive tears may occur, depending on the thinness of the sinus membrane and the difficulty of its dissection caused by corners of the sinus, sharp septal edges of the sinus floor, and even the edge of the infrafractured plate, in addition to any possible traumas from suction maneuvers during dissection. In any case, if they do arise, all these traumas are dealt with by covering the tear or mucosal defect with reabsorbable membrane. Perforation of the sinus membrane may represent an avenue for the entry of bacteria, with the resulting contamination and infection of the sinus graft. Prousaefs et al¹³ found that perforations larger than 2 cm were associated with decreased bone formation and implant viability compared with intact zones. In the present study, however, even when the defects were extensive, neither loss of graft nor greater prevalence of associated sinus infection was observed, in accord with other results described in the literature.^{10,14}

POSTOPERATIVE INFECTION

Postoperative infection in the region of the wound was in the form of inflammation or suppuration and was treated with antibiotics and washouts with local drainage. Despite the proximity and potential intraoperative risks, such as perforation of the Schneiderian membrane, sinus complications are rare. The incidence of sinus complications in the literature series reviewed by the authors was lower than 1%.^{15,16} In the present series, it was somewhat higher (3.9%). It is often resolved with systemic antibiotics, local measures, vasoconstrictors, and aerosol sprays. Some cases may call for nasoendoscopic exploration. In addition to exploration of the nostrils and sinus cavities, this allows one to observe the status of the sinus membrane and whether the graft is exposed. As a therapeutic method, it also allows washouts, drainage, and local application of antibiotics or antiseptics. When nasoendoscopic exploration is necessary, it has been found that the origin of the sinusitis appears to be in the ostium, with its decreased capacity for

ventilation and drainage. Once freed, the infection is resolved without further difficulty.¹⁰ Kent and Block⁴ routinely administered nasal decongestants to patients as a prophylaxis, thus obviating the risk of obstruction of the ostium and blockage of the sinus ventilation. Although no relation has been found between sinus complications and the tears and perforations of the sinus mucosa produced during surgery, an increased incidence of complications has been observed when the history before surgery includes factors that favor sinusitis.^{15,17} In the present series, the SLPs in which there was intraoperative rupture of the Schneiderian membrane had no postoperative sinus complications. Of the 5 cases of sinusitis, 2 had a clinical history that included sinusitis. In the remaining cases, the sinus mucosa was normal, and there was no history of sinus ailments.

Treatment of the 5 cases of sinusitis complication included an antibiotic cycle based on the association of amoxicillin plus clavulanic acid, using fluticasone as a nasal anti-inflammatory, and aerosol therapy consisting of gentamicin, mesna, fluocinolone, and budesonide 0.25 mg/mL, with sessions every 12 hours for 1 week, followed by another week with daily sessions. In the present series, only 1 case of sinusitis showed no improvement in response to this treatment. The failure to achieve full ventilation of the maxillary sinus required nasoendoscopic exploration with washouts and sinus drainage. This exploration showed unaltered status of the sinus cavity and the graft, but it showed obstruction of the maxillary sinus ostium. No curettage of the sinus mucosa was needed.

SMOKING

Smoking has been definitively established as a risk factor in the evolution, outcome, and complications of periodontal and implant surgery. This negative influence of smoking has been attributed to decreased tissue oxygenation capacity, alterations in microcirculation, effects on fibroblasts and connective tissue, and effects on chemotaxis and adherence in leukocyte phagocytosis.^{10,18-20} The frequency of postoperative infections is greater after onlay bone grafts than with isolated SLP^{10,18} and is greater still when the 2 techniques are used in combination. In such cases, a relation has been observed between smoking and the frequency of infections.¹⁰ In their series, Levin et al¹⁸ found a higher complication rate after onlay graft surgery in smokers than in nonsmokers; but, unlike other series, they found no significant increase in infectious complications after SLP in smokers and former smokers compared with nonsmokers.

With respect to complications associated with the bone block graft itself, however, these were indeed more frequent in smokers, in agreement with studies reported in the literature (Table 9).

Smoking also is a risk factor for implant survival. It increases the likelihood of loss of the implants placed into the grafted area by a factor of 3.5 compared with nonsmokers. Other risk factors for implant viability are the location of the implant (the premolar region being 60% safer than the molar) and the type of surgery (2-stage procedures being 90% safer than single-stage procedures).²¹ Nonetheless, there are no data indicative of any higher risk of implants placed into a grafted zone of the maxilla than into the untreated maxilla. In the present series, the percentage of implants lost was slightly larger in smokers (3.25%) than in nonsmokers (1.90%), but the frequency of complications was higher in smokers. Even so, the survival rate was higher than 95% in these 2 population groups.

GRAFTING MATERIAL

The material used for the graft in the SLP does not affect the number of complications, the viability and ossification of the graft, or implant survival.⁸ Barone et al¹⁰ found that the formation of new bone grafted into the zone takes place within 6 months after the SLP and observed no radiologic differences in the amount of regenerated bone between SLPs treated solely with autologous bone and those treated with a mixture of particulate autologous and bovine bone. Wanschitz et al²² determined the evolution of bone grafts placed after SLP. They found a constant loss of nearly 14%, independently of the volume grafted. With respect to the viability of the graft, studies comparing alloplastic material (hydroxyapatite), bovine bone, and autologous bone showed the lowest degree of reabsorption of the bone graft corresponded to hydroxyapatite. This was followed by autologous bone, with heterologous material presenting the greatest degree of loss.²³ In the present study, all SLPs were grafted with a mixture of bovine spongiosa granules and autologous bone recovered from the osteotomies or taken from the cancellous iliac crest.

USE OF MEMBRANES

There is still discussion as to whether isolation of the graft is necessary. Tawil et al²⁴ studied Bio-Oss-grafted SLPs covered with a reabsorbable membrane in 1 group and without the cover in another group. They found a larger percentage of implant failures in the group without the membrane cover, but only when the implant placement was simultaneous with the SLP and the amount of bone remaining was small (<5 mm). For implants with delayed placement, a larger amount of contact of bone with the implant has been observed.^{25,26} However, results on the viability of implants according to whether they are immediate or delayed vary according to the study.^{24,27} In the present series, implant failures (lost implants and

those that led to complications) were more frequent when the placement was delayed than when it was simultaneous with the SLP (delayed implants, 6.88% complications, 2.83% implant loss; immediate implants, 3.46% complications, 1.71% implant loss).

COMPLICATIONS IN IMPLANTS

Most series in the literature have reported survival rates of implants placed into the grafted zone after SLP that surpass 85% with no difference from the survival rate found in implants placed directly into the bone of the posterior maxillary region without SLP. In the present series, the overall survival rate of the implants during the follow-up period was 97.2% (98.3% in the immediate implant group and 97.0% in the delayed implant group). The osteoconductive properties of the grafting material allow it to act as a skeleton on which the growth of new capillaries, perivascular tissue, and osteogenic cells can take place. For this process to occur, the zone receiving the graft must have at least 3 walls of receptor bone to stimulate the formation of new bone.²⁸ In a meta-analysis of the survival of implants placed in the posterior maxillary region with SLP, McDermott et al²¹ found that, although there were indeed differences in survival rates depending on the grafting material used, all rates exceeded 87%, and they concluded that this survival may depend more on the healing time required by the different materials than on the material itself. In an experimental study in animals using synthetic materials, no significant differences in survival between implants placed in maxillary regions treated with an SLP and those in untreated regions of the maxilla were found.²⁹ However, McDermott et al noted that 1 risk factor was the location of the implants in the molar region, with the premolar region being 60% safer than the molar. These differences in implants on an already treated maxilla may be due to the naturally greater load borne by the teeth of the molar region than to any influence of the height and quality of the residual bone before treatment.^{8,21}

With respect to osseointegration, Herzberg et al⁸ found no relation between the residual bone before SLP and the marginal bone loss in implants. However, there was greater marginal bone loss in delayed implants compared with those placed simultaneously with the SLP, although this relation was not found to be statistically significant until it was restricted to cases in which there was less than 4 mm of residual maxillary bone.⁸ According to those investigators, sufficient primary stability for implants placed simultaneously with SLP is ensured if there is more than 4 mm of residual bone. For other investigators,³⁰ primary stability of the implant is achieved when at least 25 to 35% of the total height filled with graft

corresponds to residual bone. Nonetheless, there have been studies that have found no relation between implant survival and preoperative residual bone.³¹ Posterior maxilla implants simultaneous with SLP with residual bone of 1 to 5 mm are predictable if there is mastery of the technique, the graft is properly packed into the bone, and the choice of cases is appropriate. It remains to be determined in which cases the implant will have primary stability when there is little residual bone (<4 or 5 mm) despite the SLP. The Sinus Consensus Conference of 1996 considered the amount of residual bone to be a potentially important factor in achieving and maintaining the implant's osseointegration.³² This may be an important factor to take into account and could be the cause of the differences in complication and survival rates found in the present series. These were greater in the delayed implant group in which the residual bone was less than in the immediate implant group (implant losses, 2.8% and 1.7%; complications, 6.9% and 3.5%; in the delayed and immediate implant groups, respectively).

It is recognized that delayed implants are necessary when the amount of residual bone available for the SLP is no more than 4 mm.³³ Indeed, this was the criterion followed in the present series. The rationale is the need to attain the sufficient degree of primary stability for osseointegration and of support for functional load during the graft's ossification. The data of Herzberg et al⁸ suggest that the residual bone is a useful guide before surgery, but that the implant's primary stability is of greater importance than the amount of residual bone or the grafting material used, and that as long as the implants achieve primary stability, there is no reason for their placement not to be immediate.

Sinus lift surgery is a proven and reliable technique because of the low rate of postoperative complications observed and the success rate of implants placed into the grafted area. Nonetheless, as with any surgical procedure, it is not exempt from risk. To minimize the risk, the surgery must be carried out by professionals experienced in the technique, with each case appropriately planned, care taken with all the technical details of the procedure, and the risk factors that can lead to increased fatality properly taken into account. With respect to this last point, one must consider smoking in particular and the time of placement of the implants relative to the SLP. Although there were too few cases in the present series to establish other aspects as risk factors, it is also interesting to consider those situations or pathologic states that may have some sort of repercussion on the capacity for recovery from surgery. These include certain types of systemic disease and a status or history of sinus disease. Awareness of these risk factors makes it possible to foresee the appearance of potential complications and therefore make their early diagnosis more likely so that

prompt treatment can be initiated. The result will be to decrease the morbidity of the technique in the number of complications and, when they do occur, in their severity.

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