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Maxillary sinus floor elevation surgery

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Chapter 2

Maxillary Bone Grafting for Insertion of Endosseous Implants: Results after 12-124 Months

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Abstract

Insertion of endosseous implants in the atrophic maxilla is often complicated because of lack of supporting bone. Elevation of the floor of the maxillary sinus with autogenous bone graft has been proven to be a reliable treatment modality, at least in the short term. The long-term clinical and radiographic outcome with regard to the grafts, the implants and satisfaction of the patients with their implant-supported overdenture was studied in 99 patients. The sinus floor was elevated with bone grafts derived from the iliac crest (83 subjects, 162 sinuses, 353 implants), the mandibular symphysis (14, 18, 37), or the maxillary tuberosity (2, 2, 2). Before implant installation the width and height of the alveolar crest were increased in a first stage procedure in 74 patients, while in the other 25 patients elevation and implant installation could be performed simultaneously (width and height of the alveolar crest >5 mm). Perforation of the sinus membrane occurred in 47 cases, which did not predispose to the development of sinusitis. Loss of bone particles and sequestration were observed in one (diabetic) patient only, in whom a dehiscence of the oral mucosa occurred. A second elevation procedure was successful in this patient. Symptoms of transient sinusitis were observed in 3 patients. These symptoms were successfully treated with decongestants and antibiotics. 2 other patients developed a purulent sinusitis which resolved after a nasal antrostomy. In all cases, the bone volume was sufficient for implant insertion. 32 of 392 inserted Brånemark implants (8.2%) were lost during the follow-up. After the healing period of the bone grafts, no sinus pathology was observed. The patients received implant-supported overdentures (72 patients) or fixed bridges (27 patients). Overall, the patients were very satisfied with the prosthetic construction. We conclude that bone grafting of the floor of the maxillary sinus floor with autogenous bone for the insertion of implants is a reliable treatment modality with good long-term results.

Introduction

Implant supported fixed and removable prostheses provide a proper treatment modality with reliable success, especially for the rehabilitation of an edentulous mandible (Adell et al. 1981; Engquist et al. 1988; Jemt et al. 1996; Batenburg et al. 1998). Prosthetic rehabilitation of the edentulous maxilla using endosteal implants often is limited by insufficient quality and quantity of available bone. Several grafting procedures have been described to create sufficient volume of bone for placement of implants in atrophic maxillae, including total or segmental bone onlays, Le Fort I osteotomy with interpositional bone grafts, and grafting of the maxillary sinus with autogenous bone or bone substitutes (Keller 1994; Cawood et al. 1994; van Steenberghe et al. 1997).

Bone onlays and Le Fort I osteotomies with interpositional grafts are the treatments of choice in cases with horizontal maxillary deficiency or with a wide interarch distance, but both procedures are contraindicated in patients with a normal or reduced interarch distance. By contrast, coronal displacement of the maxillary sinus floor by elevation of the inferior bone tissue increases the volume of bone for placement of implants without reducing the interarch distance. It is usually achieved by a modified Caldwell-Luc procedure in which the lateral wall of the maxillary sinus is fractured upward and the sinus membrane is raised (Boyne and James 1980; Tatum 1986). This procedure is particularly applicable for normal or reduced interarch distance, and it can be easily combined with procedures to enlarge the width of the alveolar crest. Several recent clinical studies and reports have attempted to evaluate the maxillary sinus elevation procedure using a variety of bone grafting materials such as autogenous bone grafts from the iliac crest and the oral cavity, as well as bone substitutes (Chanavaz, 1990; Hirsch and Ericson 1991; Tidwell et al. 1992; Williamson, 1996; Hürzeler et al. 1996; Wheeler et al. 1996; Lundgren et al. 1997; Block and Kent 1997; Watzek et al. 1998; Blomqvist et al. 1998; Kaptein et al. 1998a; Van den Bergh et al. 1998). In most retrospective studies, a variety of grafting materials and/or techniques have been used within the same study, without clearly specifying the criteria used for a particular grafting material in a particular patient. This makes retrospective analysis in those studies rather troublesome as to which extent a problem that occurs can be related to a particular grafting technique and/or grafting material.

The aim of this study was to evaluate the long-term clinical and radiographic outcomes as well as patient satisfaction after sinus floor elevation surgery with autogenous bone grafts.

Materials and Methods

Patients

Between 1988 and 1997, elevation of the maxillary sinus floor with autogenous bone grafts, often in combination with enlargement of the width of superior alveolar crest, was performed in 105 patients. Surgery and prosthodontics were performed within the same clinic. 6 patients had to be excluded from the study because they deceased (2 patients) or had moved abroad (4 patients) without leaving a change of address. The other 99 patients (58 women, 41 men; mean age 48 ± 12 years, range 17-73 years at time of surgery) all agreed to participate in the study. The mean follow-up after implantation was 58 ± 27 months (range 12 to 124

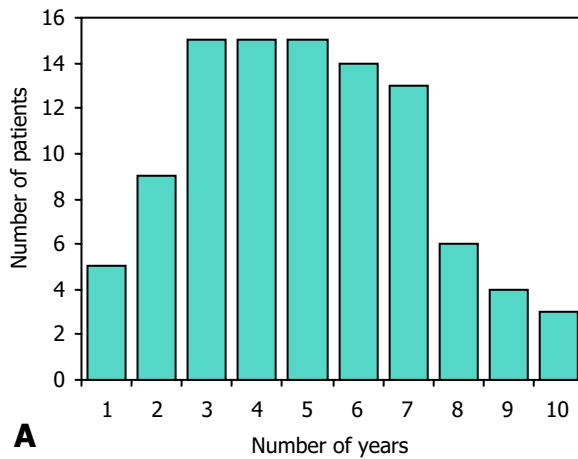
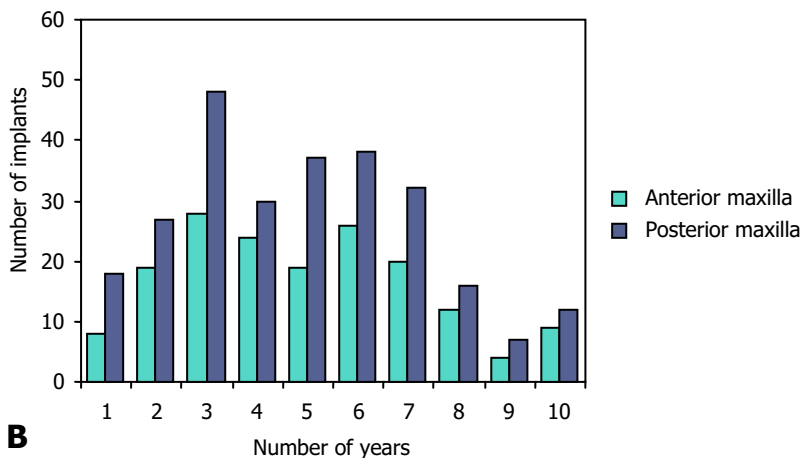


Figure 1

Frequency distribution of the patients (A) and implants (B) as a function of time.



months, median 60 months, Figure 1). The maxilla was edentulous in 75 patients, and partially dentulous in 24 patients. In the mandible the edentulous patients wore implant-supported overdentures (n=21) or full dentures (n=53). 25 patients were partially dentulous in the mandible.

Planning of treatment

Orthopantomograms, lateral cephalograms, and postero-anterior oblique radiographs were made to assess the height of the maxillary alveolar bone, the dimensions of the maxillary sinus, and the antero-posterior relationship of the maxilla to the mandible. The radiographs were also screened for sinus pathology. For every sinus to be included in this study, the alveolar height was measured on the orthopantomogram. The mean vertical height of the alveolar bone between the most caudal part of the maxillary sinus and the oral cavity was on average 3 ± 2 mm, range 1-7 mm.

A diagnostic set up of each prosthesis was made and converted to a surgical template. Based on this it was decided whether an implant-supported overdenture or a fixed bridge had to be made for the edentulous patients. Deciding factors included aesthetics (support for lips and cheeks), estimated position of implants, intermaxillary relationship, parafunctions (for example bruxism) and the space available for the superstructure. A minimum of 6 implants with a length of at least 10 mm was installed in the edentulous maxilla. The implants were preferably equally distributed across both sides of the maxilla and connected with a superstructure. Prosthodontic considerations for additional insertion of implants in the anterior region included the need to position the implants as near as possible to the planned maxillary dental arch, sufficient intermaxillary space for the mesostructure and the overstructure, especially considering the distance to the occlusal plane, and the width of the prosthesis in the anterior region. In case the interarch distance was insufficient for prosthetic construction with an optimal aesthetic and phonetic result, 2 superstructures were planned supported by 3 implants, inserted in the region between the canine and first molar. Partially dentulous patients were all supplied with implant-supported fixed bridges.

Surgery

When iliac crest bone grafts were used, the patients were treated under general anesthesia; in all other cases surgery was performed under local anesthesia. Large autogenous cancellous bone grafts (n=83) were harvested from the superior anterior medial part of the iliac crest. When smaller amounts of bone were sufficient

for grafting, they were taken from the mandibular symphyseal area (n=14) or the maxillary tuberosity (n=2).

A two-stage procedure (first stage, bone grafting; second stage, placement of implants) was performed when the height of the maxillary bone and/or the width of the alveolar crest were less than 5 mm (74 patients, 137 sinuses, 306 implants). Otherwise, a one stage procedure (bone grafting and placement of implants) in the same session was performed (25 patients, 45 sinuses, 86 implants).

Sinus floor elevation surgery with iliac crest bone grafts

After harvesting the bone grafts, the maxillary surgical sites were infiltrated with a local anaesthetic containing epinephrine as a vasoconstrictor. The palatal mucosa was incised, just below and parallel to the top of the alveolar crest. After vertical releasing incisions had been made in the buccal mucosa, a mucoperiosteal flap was raised to expose the alveolar process and lateral wall of the maxilla. If necessary, the mobility of the reflected flap was enlarged by cutting the periosteum at the base of the buccal flap. The lateral wall of the maxillary sinus was fenestrated with a round bur at high speed and adequately cooled with sterile saline. Care was taken to preserve the mucosal lining. Subsequently, the sinus membrane was raised and the mobilized part of the lateral sinus wall, together with the raised sinus membrane, was rotated medially and upwards. Perforations of the sinus membrane were not treated as these defects were closed off by folding of the lifted membrane. No membranes were used to cover the lateral wall defect after the bone graft was placed. After grafting, the height of the maxillary bone had to be at least 13 mm.

In case of a one-stage procedure, the holes for the implants were drilled in the desired positions. Septa encountered in the sinus floor were removed to facilitate placement of the bone graft, which was then shaped to fit exactly into the maxillary sinus. A thin monocortical block of iliac bone was placed in the sinus with the cortical layer upwards and often another thin bone block was placed perpendicularly to increase stability. Great care was taken to secure initial stability of the grafts. The remaining space between the iliac bone block and the alveolar crest was filled with particulate cancellous bone. To enable insertion of an implant the graft was stabilized with a small clamp. Titanium implants (Brånemark®, Nobel Biocare, Göteborg, Sweden) were inserted through the alveolar bone into the grafts, using the surgical template. Up to 3 implants were placed in each bone graft. Both the implants and the grafts were additionally stabilized by anchoring of

the implants in the cortical bone block. Finally the wound was closed with horizontal mattress sutures.

Before harvesting bone grafts, the patients received broad-spectrum antibiotics, starting one hour preoperatively (intravenously) and continued orally for seven days after surgery. Postoperatively the patients received a 0.2% chlorhexidine mouth rinse (1 minute, 5 times daily) for 2 weeks. One month postoperatively, the edentulous patients were allowed to wear dentures if possible, after relining them in the operated areas and relining them with a soft liner. In the partially edentulous cases, in general no temporary prosthesis was made.

In case of the two-stage procedure the width of the alveolar crest also was reconstructed in 64 patients. After the sinus lift procedure, the width was increased by placing monocortico-cancellous bone blocks buccally of the cortex of the alveolar defect, with the cancellous side of the bone graft in contact with the jaw bone. The graft was fixed with titanium screws to the alveolar bone. Cancellous bone particles were used to fill the small gaps between the bone graft and the alveolar crest. The mean width of the alveolar crest after grafting was 7 mm (range 6.5 to 8). The antibiotics and oral hygiene regimen were the same as those used for the one-stage procedure. After a healing period of at least 3 months the implants were inserted using a surgical template. In 59 patients the bone volume was sufficient at the time of implantation, but in 5 patients (7 implants) the bone width was not enough. In these cases, the implants could be inserted with sufficient primary stability, although some threads of the implants were exposed. These threads were covered with bone and a GTAM® membrane (W.L. Gore and Associates, Inc, Arizona, USA).

6 months after insertion the implants were uncovered, the oral mucosa was thinned where applicable and the abutments connected.

Sinus floor elevation surgery with intra-oral grafts

In case of mandibular symphyseal or maxillary tuberosity bone grafts, the sinus-floor-elevation procedure was similar to the procedure for iliac crest grafts. Mandibular symphyseal bone grafts provided less cancellous bone, and in the case of maxillary tuberosity bone grafts less cortical bone was available.

Implants in the anterior maxilla

In addition to the insertion of implants in the grafted maxillary sinuses, 160 Brånemark implants were inserted in the anterior region in pre-existing maxillary bone. For proper positioning of these implants, the same surgical template was

used. In 7 patients (10 implants) in which the one stage procedure was used, some threads of the surface of the implant were exposed. The exposed surfaces were covered with bone and a GTAM® membrane (W.L. Gore and Associates, Inc, Arizona, USA).

Prosthodontics

The patients were rehabilitated with implant-supported overdentures (n=72), full bridge (n=3) or partial bridge (n=24).

Experimental setup

All patients were on a recall schedule at least once a year. Complications during surgery and postoperative healing (inflammation, wound dehiscence, sequestration, loss of bone particles and sinusitis) and loss of implants were obtained from the patients records. In addition to this standard recall schedule, all patients were recalled for a clinical and radiographic examination between September 1997 and March 1998. During this recall visit the mesostructures were removed and all implants were individually checked if they were mobile. The clinical examination included assessment of peri-implant soft tissue, bleeding index (Mombelli et al. 1987; Mombelli and Lang 1992), gingiva index (Silness and Løe 1964) and the probing depth (Merrit-B, Hu-Friedy, USA). Sensory changes of the skin were examined by stroking the upper lip and cheek with a cotton pellet and by pinching the lower lip in a pair of tweezers. Also plaque index (Mombelli et al. 1987; Mombelli and Lang 1992) and presence of calculus was registered.

Radiological evaluation to detect marginal peri-implant bone loss was carried out by 2 observers using orthopantomograms and intra-oral dental radiographs taken immediately after the prosthetic procedure and at yearly intervals. Peri-implant bone loss was rated on a 4-point scale: 0 = no apparent bone loss; 1 = reduction of the bone level not exceeding one third of the length of the implant; 2 = reduction of the bone level exceeding one third but not one half of the length of the implant; and 3 = reduction of the bone level exceeding one half of the length of the implant.

Sinusitis was suspected to be present if the patient complained about pain or tenderness in the region of the maxillary sinus, nasal obstruction and mucopurulent rhinorrhea. The clinical diagnosis of sinusitis had to be confirmed by rhinoscopy (i.e. hyperaemic inflamed nasal mucosa with mucopurulent secretion) and inspection of the oropharynx to detect post nasal drip. In addition, Waters' radio-

graphs were taken and compared with presurgical X-rays to detect the presence of new sinus pathology.

Implant failure was defined according to the following criteria: implant mobility; persistent pain, infection, presence of peri-implant radiolucency; significant, ongoing cervical or apical implant-related bone loss (exceeding one third of the length of the implant); or the implant could not be used for the prosthetic rehabilitation.

Patient satisfaction was assessed by using a validated questionnaire (Vervoorn et al. 1988). The questionnaire focused on satisfaction with function of the prosthetic construction (overdenture and fixed bridge) and with aesthetics. 8 items were presented with a five-point rating scale on which the patient indicated to what extent he or she was (dis)satisfied (1 = very satisfied, 2 = satisfied, 3 = neither satisfied nor dissatisfied, 4 = dissatisfied, 5 very dissatisfied). The patient's overall treatment satisfaction was expressed on a 10-point rating scale (1 = very bad to 10 = excellent).

Statistics

The 95% confidence interval (CI) of differences between 'survival-rates' were calculated; a difference was considered statistically significant on a 5% level when this confidence interval did not contain 0.

Results

Surgical complications

Although the sinus membrane was perforated during surgery in 47 cases (26%), healing was uneventful, and loss of bone particles through the nose was not observed. Symptoms of transient sinusitis were observed in 3 patients, which resolved with decongestants and antibiotics used for a period of 2 weeks. These patients had a history of sinus maxillary clearance related problems (symptoms of chronic maxillary sinusitis) preoperatively, and in one of them the sinus membrane had been perforated. Development of purulent sinusitis was observed in 2 patients without predisposition for sinusitis. In one of them, the sinus membrane had been perforated accidentally during surgery. In both patients the purulent sinusitis healed uneventfully after nasal antrostomy of the middle meatus.

2 patients developed a fistula near the GTAM® membrane. Both membranes were removed. At the abutment connection a dehiscence of 2 treads of the im-

plant was noted in 1 of these patients. In all other patients the implants were covered with bone-like-tissue.

In 4 patients, a wound dehiscence occurred near a screw used to fix the bone graft for the widening of the alveolar crest. Healing was uneventful after removal of that screw. Incision breakdown occurred in the first week after bone grafting in 7 patients. In 6 of them the dehiscence closed spontaneously after 2 weeks, while in the other (diabetic) patient loss of bone particles and sequesters was observed. The bone sequesters were removed and the wound was closed with the buccal fat pad. Wound healing was uneventful, but the volume of the remaining bone was insufficient for insertion of implants. In this case a second elevation procedure was performed, where after 8 implants could be inserted successfully.

No major complications were observed at the donor sites. 1 patient had a wound haematoma and 2 patients had a seroma that had to be evacuated surgically. In all other cases postoperative healing was uneventful, although the majority of the patients suffered from pain, discomfort, and disturbances in gait. In most patients, the latter problems subsided within 4 weeks postoperatively, but 6 patients experienced hip-related discomfort up to 3 months post-surgery. In the intra-oral bone harvesting areas, no damage to teeth or roots was observed. Transient hypoesthesia of the labial gingiva of the donor site (mandibular symphyseal bone graft) was observed in 1 patient.

Healing results

A total of 392 Brånemark implants (13 mm: n=79; 15 mm: n=304; 18 mm: n=9) were placed in 182 grafted floors of maxillary sinuses, viz. 353 implants in iliac crest grafts (162 sinuses), 37 implants in symphyseal bone grafts (18 sinuses), and two implants in a bone graft taken from the maxillary tuberosity (2 sinuses). Up to the time of the last recall visit, 32 out of 392 implants (survival rate 91.8%) had to be removed in 18 patients: 7 one-stage implants (survival rate 91.9%) and 25 two-stage implants (survival rate 91.8%). There were no significant differences in survival rate between implants inserted as a one-stage or a two-stage procedure ($p>0.05$). 18 implants in 13 patients were lost during the first 6 months. 9 implants were lost 6-30 months after loading and 5 implants (1 patient) were mobile at the time of the study, 2 of these 5 implants showing pus in the implant sulcus. The latter patient experienced also a slight hyposensibility of the left side of the upper lip. In the group of 75 edentulous patients (149 sinuses, 326 implants), 30 implants were lost (survival rate 90.8%), while in the group of 24 partially edentulous patients (33 sinuses, 66 implants), 2 implants were lost (survival rate 97.0%, $p<0.05$).

30 of the 32 lost implants had been inserted in iliac crest bone grafts (survival rate 92.5%), and the other 2 in symphyseal bone grafts (survival rate 94.6%). There was no significant difference in survival rates with regard to whether bone graft was harvested from the iliac crest or from the mandibular symphysis ($p>0.005$).

23 of the 32 lost implants had to be replaced with new implants. In 2 patients, in whom in total 8 implants had been lost, there was not enough bone for insertion of implants necessitating a second elevation procedure (iliac crest: 1 patient and symphysis: 1 patient). There was no need to replace the remaining lost implants ($n=9$), as proper prosthodontic rehabilitation could be undertaken without replacement.

Of the 160 implants inserted in non-grafted sites of the anterior maxilla, 12 implants failed (survival rate 92.5%). 7 implants were lost during the healing phase (up to 6 months), 3 implants after loading for 6-30 months and 2 implants could not be used for prosthetic construction, because the position was not optimal.

The parameters for evaluating peri-implant tissue health showed favorable results (Table 1). Only 2 patients with overdentures needed correction of the peri-implant mucosal hyperplasia during the follow-up.

Table 1 *Mean values and standard deviations (SD) of plaque-index, gingiva-index, bleeding-index, calculus index and probing depth.*

Plaque-index (score 0-3)	0.7 ± 0.8
Gingiva-index (score 0-3)	0.4 ± 0.8
Bleeding-index (score 0-3)	0.8 ± 0.9
Calculus-index (score 0-1)	0.3 ± 0.4
Probing depth in mm	4.2 ± 1.5

Radiology, at time of evaluation indicated no loss of marginal bone around 463 implants and slight bone loss of the marginal alveolar crest not exceeding 1/3 of the implant length around 41 implants of which 28 in the posterior region. Bone loss between 1/3 and 1/2 of the implant length was seen around 4 implants, all in the posterior region. In 1 patient, the bone loss progressed after the first year post-implantation. In that patient the iliac crest bone graft resorption resulted in the loss of 5 implants in the posterior region (bone loss exceeding 1/2 of the implant). Latter 5 implants were mobile at time of investigation. No further bone loss was observed in all other cases after one year post-implantation. According to the fail-

ure criteria applied in the present study, the success rate was 90.8% (36/392 implants) in the posterior region and 92.5% (12/160 implants) in the anterior region.

The mean score on the questionnaire concerning denture satisfaction was 2.05 ± 0.9 . The mean satisfaction score with regard to the total treatment was 7.6 ± 1.2 .

Discussion

The procedure described to increase the bone volume in the atrophic maxillae of edentulous and partially dentulous patients with autogenous bone grafts has proven to result in prosthodontic success in a group of patients with insufficient volume of bone in the posterior maxilla for reliable placement of implants. The overall success rate of implants in this retrospective study was 90.8% for implants placed in the posterior region and 92.5% for implants additionally inserted in the anterior region.

In this study a significant difference in implant survival rate between the partially dentulous (97.0%) and edentulous maxilla (90.8%) was observed, which is in agreement with the study of Esposito et al. (1998a). A possible explanation is that partially edentulous patients have less resorbed jaws (speaking in favor of sufficient bone volume and bone quality). In addition, in contrast to partially dentulous patients, edentulous patients were allowed to wear their upper dentures (relieved in the operated areas) during the healing phase. Moreover, in partially dentulous patients, occlusal forces on the prosthetic construction are merely transferred to the natural dentition. Since the overload is directly proportional to the bone-implant contact, early loss of the implants can occur when wearing prostheses during the healing phase which may be related to loss of implants. In the edentulous patients there is thus an increased risk of implant failure due to biomechanical imbalance and poor bone quality. Most likely, late failures have a multifactorial background, such as overload and bacterial infection (Esposito et al. 1998b). In most articles, the results of implant survival in the partial dentulous and edentulous maxilla were not analyzed separately, but there are some indications that the survival rate is higher in case of partially dentulous patients (Mazor et al. 1999).

The question of timing, i.e. whether to insert implants simultaneously with the elevation procedure or as a delayed procedure, remains unresolved. In this study no significant difference in implant survival of the simultaneous and delayed inserted implants was noted. Proponents of delayed placement favor creation of a

solid foundation prior to implant placement. This may improve site selection and also takes advantage of bone healing biology (Moy et al. 1993; Blomqvist et al. 1998). Proponents of simultaneous placement favor one-stage surgery as being less invasive, more cost-effective, and more time-efficient. From a biologic point of view, a two-stage surgery is preferable, because time will be allowed for revascularization and incorporation of the grafted bone before the implants are inserted. If the residual bone height beneath the maxillary sinus is at least 5 mm, the results of a one-stage procedure (simultaneous grafting and insertion of implants) appear to be equivalent to those of a two-stage procedure, since initial stability of the implants can be achieved by both approaches. Thus, the most important issues to be addressed are initial stability and optimal positioning of the implants. If insufficient bone remains to provide proper implant stability and positioning, delayed implant placement is the treatment of choice (Block and Kent 1997).

Perforation of the sinus membrane was the most common complication during the sinus floor elevation procedure. The occurrence of perforations was not related to increased loss of implants. This is in accordance with the literature (Jensen et al. 1994; Timmenga et al. 1997). An advantage of the cortical bone plate on the top of the graft just below the sinus membrane is that this bone plate will prevent shedding of bone particles into the maxillary sinus in case a perforation was not closed off by folding of the membrane (Raghoobar et al. 1997). Shedding of bone might lead to local inflammation and subsequently increase resorption of the bone graft. A second advantage of a bone graft with a cortical bone plate is that the bone graft is fixed when the implants are inserted simultaneously, which provides optimal stability for both the bone grafts and implants. A third advantage is that the bone particles can be firmly packed into the created space. Incision breakdown is rare but may occur because of ischemia from a lack of blood supply coursing across the crestal tissue, especially if the incision was placed too far palatally to the alveolar crest (Block and Kent 1997).

In our study, 5 patients (5%) developed signs of sinusitis, while other authors have reported transient sinusitis to occur in 10-26% of their patients (Tidwell et al. 1992; Block and Kent 1997; Kaptein et al. 1998a). The sinus mucosa will usually regenerate across the immobilized bone graft during normal healing. It has been reported that large sinus membrane perforations should be repaired with collagen (Block and Kent, 1998) or fibrin adhesive (Sullivan et al. 1997). Suturing is very difficult and sometimes causes even greater perforations. In 1 of the 2 patients who developed purulent sinusitis, a perforation of the sinus membrane of 5 mm had occurred during the elevation procedure. Inflammation of this sinus possibly

might have been related to shedding of bone. In the patient without a perforation of the sinus membrane, development of purulent sinusitis was probably due to the combination of hematoma and a temporarily disturbed sinus clearance.

Various space maintainers have been proposed, but from both a clinical and biological point of view filling the bony defect with autogenous bone is preferred to filling of the defect with allogeneous materials like hydroxyapatite, demineralised freeze dried bone or a combination of both. There is still lack of sound scientific data supporting the use of these heterogeneous bone-filling materials. Autogenous bone grafts possess excellent space maintaining properties because they support membranes and act as an osteoconductive scaffold during osteoblast bone formation (Buser et al. 1992). This together with the high concentration of osteocompetent cells within these grafts explain why we prefer autogenous bone grafts for elevation of the maxillary sinus floor. Support for this view comes from a histomorphometric study on bone formation within grafted sites (Moy et al. 1993). These authors showed that the yield of bone after grafting with cortical chin bone was 59.4%, while the yield after grafting with either hydroxyapatite graft alone, hydroxyapatite mixed with cortical bone, and hydroxyapatite mixed with demineralised bone was 20.3%, 44.4%, and 4.6%, respectively. These results indicate that the amount of bone formed within the sinus is the highest for autogenous bone grafts.

The use of mandibular bone grafts for the elevation of the floor of the maxillary sinus is growing (Hirsch and Ericsson 1991). Resorption of these bone grafts after transplantation is less when compared with iliac crest, tibial, or rib grafts. Other advantages of intra-orally harvested bone grafts are the use of local anesthesia instead of general anesthesia, a relatively short operating time, no need for postoperative hospitalization, less morbidity at the donor sites, and lower costs (Hirsch and Ericsson 1991; Jensen et al. 1994; Raghoobar et al. 1996; Williamson et al. 1996). A disadvantage is that the intra-oral donor sites offer smaller volumes of bone than the iliac crest. In general, rather large amounts of bone are needed to establish adequate elevation of the maxillary sinus floor, particularly in bilateral edentulous patients or in combination with a reconstruction of the width of the alveolar crest. We had to use iliac crest grafts in most of our cases, because of the volume of bone required to be grafted. There was no difference in implant survival when comparing iliac crest bone with chin bone. The easy availability of chin grafts should be considered as an advantage. However, as reported the morbidity of harvesting bone from the anterior superior medial aspect of the iliac crest is low

(Kalk et al. 1996; Williamson et al. 1996). No serious complications were encountered in the present study as well.

Overall, the patients were satisfied with their prosthetic construction. The patient's satisfaction index in the present study with regard to the total treatment (Kaptein et al. 1998b) appears to be comparable to the index of their study although a different scale is used.

From this study we conclude that sinus floor elevation surgery with autogenous bone grafts is a reliable procedure if properly planned and performed. It has been shown to result in good overall denture satisfaction of patients. The procedure is not without complications and the surgeon must be able to manage problems that arise perioperatively as well as those that develop in the early and late postoperative phases.

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