Augmentation of the Sinus Floor with Mandibular Bone Block and Simultaneous Implantation: A 6-Year Clinical Investigation

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Between 1991 and 1995, 216 sinus-lift procedures were accomplished as part of a clinical study. The study involved placing 467 implants in the atrophic posterior maxillae of 142 female and 74 male patients. The initial bone height at the implant site was between 1 and 5 mm. The implants were supported subantrally with bone block grafts harvested from the retromolar or symphysis areas of the mandible. Perforations of the maxillary sinus membrane were observed in 51 patients; these were repaired with fibrin adhesive. The spaces remaining above the bone graft were filled with various materials. A total of 28 implants failed. All the remaining implants were deemed successfully osseointegrated, based on radiographic and clinical (including periodontal health) criteria. No patients experienced maxillary sinus complications. Clinically and radiographically, the best bone regeneration was observed in those patients in whom the surgically created space was completely grafted with autogenous bone that included a high percentage of resorption-resistant cortical bone. In those patients having bone grafts harvested from the mandibular symphysis, none of their facial profiles were adversely affected; however, some patients experienced neurosensory deficits involving the mandibular anterior incisors and adjacent alveolar mucosa. Occasionally, these symptoms persisted for up to 1 year following the procedure.
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Key words: atrophic maxilla, autogenous bone augmentation, bony lid, mandibular bone block, sinus floor elevation

Oral rehabilitation with osseointegrated implants is very successful and predictable in patients with normal bone volume and density, which provide adequate stabilization of implants of standard diameter and length.[1] Osseointegration of implants is difficult to achieve in patients with pneumatized maxillary sinuses because of the lack of primary stabilization of the implants in the atrophic maxillary posterior alveolar ridges.[2] The sinus lift is a procedure, which, if carried out properly, permits endosteal implants to be placed in the severely resorbed posterior maxilla. This procedure can be accomplished in 1 or 2 stages.[3–7]

If the residual alveolar bone is greater than 5 to 6 mm in height, sinus lift and implant placement procedures are usually accomplished simultaneously, assuming that initial stability of the implants is obtained. The resulting space is filled with autogenous bone, allogeneic bone, alloplastic bone substitute, or a combination of alloplastic bone substitute and grafted bone.[8–10]

The 2-stage approach involves first grafting the surgically created compartment between the superiorly repositioned sinus membrane and the bony sinus floor with autogenous bone from the mandible or iliac crest or with allogeneic material.[11–14] Once the graft has matured, a second procedure is then performed to place the implants. This

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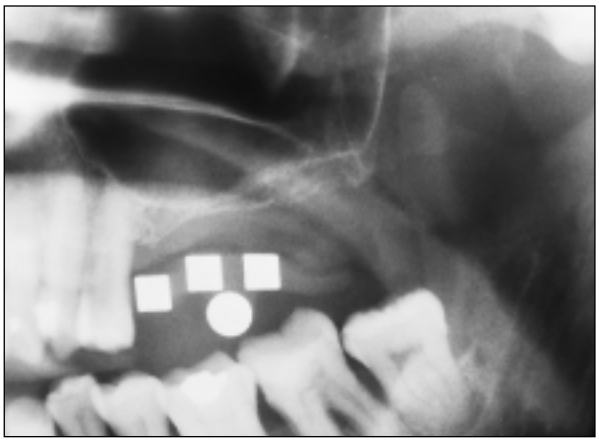

Fig 1 Preoperative panoramic radiograph with surgical guides shows a remaining bone height of 1 to 3 mm in the posterior left maxilla.

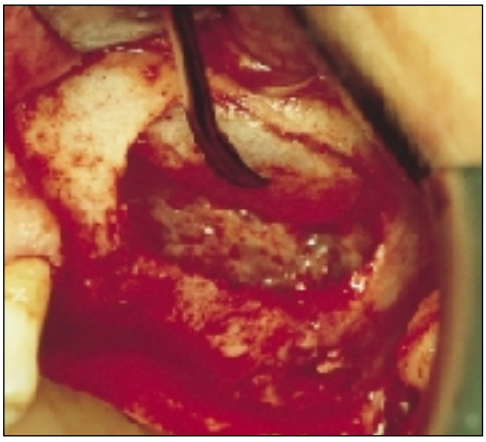

Fig 2 The bony lid is rotated toward the maxillary sinus without injuring the maxillary sinus membrane. The remaining bone height is about 2 mm.

technique is usually employed in situations where the residual bone in the maxillary posterior region is less than 5 mm in height; otherwise initial implant stability in the host bone cannot be assured.[8]

As an alternative to the 2-stage technique, if the residual bone is less than 5 mm in height, implants can be stabilized by grafting a block of bone transantrally.[15–18] This block of bone can be harvested from the iliac crest[6,13,18,19] or the mandible.[15–17] The use of the mandible as a donor site for an autogenous block graft is less invasive, saves surgical and anesthetic time, and can be accomplished in the dental operatory or outpatient setting.[16] The objective of this clinical study was to evaluate the validity of this 1-stage procedure.

Materials and Methods

Between 1991 and 1995, 216 sinus-lift procedures were performed as part of a clinical study. Altogether, 467 implants were placed in the atrophic posterior maxillary regions of 142 female and 74 male patients. The patients' ages ranged from 22 to 69 years. Initial bone heights at the implant sites, as measured on orthopantomograms, were between 1 and 5 mm (Fig 1). The preoperative radiographs also included a lateral skull film to evaluate the bone quantity in the mandibular symphysis and the position of the roots of the mandibular anterior teeth. The implants were fixed subantrally by a block graft harvested from the retromolar or symphysis of the mandible.

Surgical Technique. The majority of procedures were accomplished with light sedation and local anesthesia. Prophylactic oral antibiotics were used routinely, beginning 8 hours prior to the procedure and continuing for 7 days. Amoxicillin (2 g per day in 4 divided doses) was the preferred regimen.

An incision was made 5 mm to the palatal side of the alveolar crest, and a laterally based mucoperiosteal flap was reflected to expose a liberal surgical site extending from the canine fossa to the zygomaxillary ridge. The window technique for gaining access to the maxillary sinus was preferred. The bony lid (12 × 18 mm) was prepared approximately 2 to 3 mm above the junction of the alveolar process and the lateral maxillary sinus wall using a small round diamond bur. This margin can usually be identified because of the difference in color (the alveolar process looks redder). Great care should be taken to avoid traumatizing or perforating the sinus membrane. A sinus elevator was used to rotate the bony lid, which is attached to the sinus membrane, superiorly (Fig 2).

The sinus membrane was carefully and completely reflected from the maxillary sinus floor and the medial wall to create sufficient space for the bone block graft. Once the resulting space had been examined and injuries to the membrane and/or pathologic changes were ruled out, the implant sites were prepared. Using a surgical guide based on a diagnostic wax-up, a 2-mm pilot drill was used to indicate the position and angulation of each implant. An adequately sized bone block graft for the number of implants to be placed was then taken from the mandible.

A fine-grit diamond disk (Microsaw, Friadent, Mannheim, Germany) was used to harvest the graft from the retromolar or symphysis region of

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the mandible.[20,21] When bone is removed from the symphysis, it is essential to ensure that sufficient space remains between the osteotomy and the root apices of the mandibular anterior teeth and the inferior border of the symphysis (3 mm minimum). After the graft was removed from the symphysis, the bony defect at the donor site was filled with collagen and porous hydroxyapatite granules (Algipore) and covered with a Gore-Tex membrane (WL Gore & Associates, Flagstaff, AZ). The wound was closed primarily with a layered closure.

The bone graft was then placed into the newly created space such that the cancellous side of the graft was in contact with the sinus floor. The elevator was used to support the bone graft in this position, so that the pilot drill could be used to mark the bone graft through the previously drilled sites in the alveolar process. The bone graft was then removed, and the pilot drill hole in the graft was accomplished extraorally. The bone graft was transferred subantrally and supported with a long, 2-mm-diameter pin through the first drill hole and the elevator, while the pilot drill holes were made for other implants. The bone graft was stabilized at each implant site with the 2-mm pins. The pins were then removed one at a time as the implant sites were prepared to the appropriate diameter and the corresponding implants were placed. During this period, the graft was held in place by the other pins and the elevator. The implants were placed approximately 1 mm below the alveolar crest, and a wide cover screw was used to compress the bone graft onto the alveolar ridge (Figs 3a to 3c).

Perforations in the maxillary sinus membrane were sealed with fibrin adhesive (Beriplast HS, Centeon Pharma, Dortmund, Germany) or sutured with 5-0 Vicryl (Ethicon, Norderstedt, Germany). The remaining spaces between the block graft and the superiorly positioned maxillary sinus membrane were managed as follows:

1. No filling of the space; the mucoperiosteal flap was simply repositioned and sutured (10 patients).
2. No filling of the space, but the fenestrated lateral wall of the maxillary sinus was covered with a Gore-Tex membrane (10 patients).
3. The remaining space was filled with collagen block (10 patients).
4. The remaining space was filled with cancellous bone from the maxilla (11 patients).
5. The remaining space was filled with a mixture consisting of equal parts of autogenous mandibular bone graft and hydroxyapatite-Algipore (12 patients).
6. The remaining space was filled with the same mixture mentioned above (5.) but also stabilized with fibrin adhesive (30 patients).
7. The remaining space was filled with the same mixture mentioned above (5.), but also covered with a Gore-Tex membrane (31 patients).
8. The remaining space was filled with autogenous bone only, but this included a high percentage of cortical bone from the mandible (39 patients).
9. The remaining space was filled as described above (8.) and covered with Gore-Tex membrane (32 patients).
10. The remaining space was filled as described above (8.) and stabilized with fibrin adhesive (31 patients).

In the first 100 patients, the residual spaces were filled with material selected according to a random protocol (10 patients in each group). As the study proceeded, it was apparent that certain techniques provided superior results, and therefore the random protocol was abandoned. Therefore, the distribution of patients was not equal. In 69 patients, bone grafts were harvested from the retromolar area of the mandible, and in 147 patients they were taken from the symphysis of the mandible.

Postoperative Management. Ten to 14 days were allowed to elapse between the procedure and placement of the denture. The denture was maintained with a soft liner for the entire healing period. The abutment operation was performed after 9 months. Healing abutments were attached for 3 to 4 weeks prior to impression taking. A provisional prosthesis was used for the next 2 years. Following the 2-year period, a definitive porcelain restoration was placed.

The results were evaluated by repeated clinical and radiographic examinations according to protocol; clinical postoperative examinations were made after 1, 2, and 4 weeks and then every 2 months; following completion of the interim prosthodontic restoration, patients were examined every 3 months. After the definitive prosthesis was fabricated, the patients were seen twice a year for evaluation and hygiene maintenance. When complications occurred, additional treatment was scheduled. All examinations included assessment of the peri-implant status, dental hygiene, Periotest, microbiology, and functional relationships.

Orthopantomograms, radiographs of the paranasal sinuses, and, in patients where bone had been harvested from the symphysis, additional lateral skull films were taken preopera-

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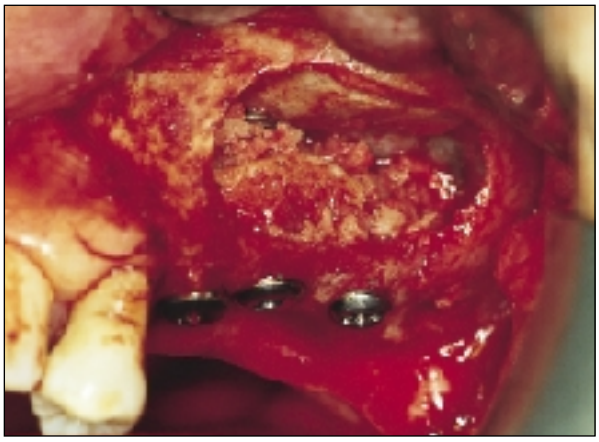

Fig 3a Stabilization of the bone block graft with 3 Frialit-2 implants. Wide cover screws are used to achieve initial stability of the bone graft/implant structure on the alveolar ridge.

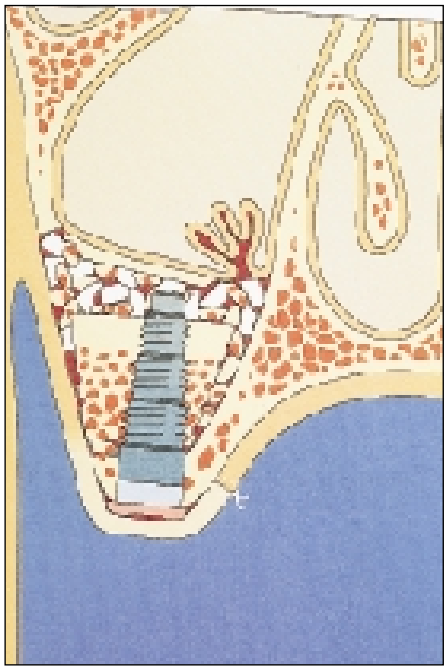

Fig 3b *(Right)* Schematic representation of the stabilization of the bone graft on thin alveolar bone with implants and wide cover screws.

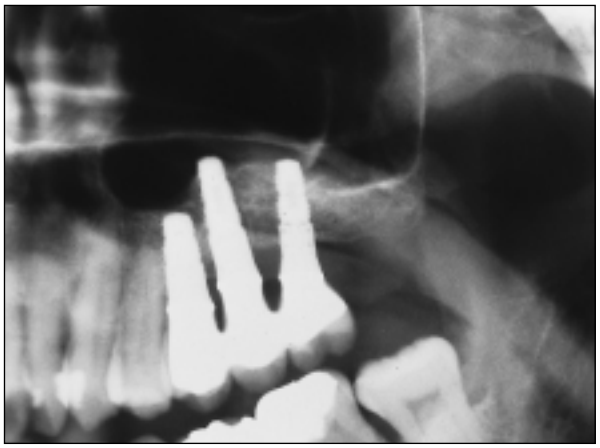

Fig 3c Radiographic situation 6 years postoperatively.

tively, postoperatively, after 9 months, and then annually. In addition, tomographic films were taken of 49 patients.

Results

During the 6-year follow-up period, 216 sinus-lift procedures were carried out, with simultaneous implantation of a total of 467 implants using bone block grafts harvested from the mandible. The patients were examined regularly. The implants, with a length varying from 10 to 15 mm, were: 62 IMZ apical screws (Friadent), 24 standard Brånemark (Nobel Biocare, Göteborg, Sweden), 39 Brånemark Mark II, and 342 Frialit-2 (Friadent) screw implants. The minimum examination period was 24 months and the maximum was 6 years; the average period was 49 months. Visible perforations of the sinus membrane of less than 3 mm were observed in 51 patients (23.6%) and treated using fibrin adhesive or sutured with 5-0 Vicryl. No visible perforations of the maxillary sinus membrane were observed in the remaining 165 patients. During a period of 6 years, only 1 wide perforation of the maxillary sinus membrane was observed. In this patient, the procedure was abandoned and the incision was closed without grafting or implant placement.

Judged by the criteria of Albrektsson et al,[22] 28 implants failed (6%). Nineteen were lost between 1 and 6 months after the restoration had been completed (4.1%), and the other 9 implants were classified as failures because of marginal bone loss of more than 3 mm (1.9%). One hundred fifty-two patients (70.4%) received fixed prostheses, and the remaining patients received implant-supported overdentures, where the implants were fixed primarily by a bar. Implant failure did not demonstrate any correlation to the various treatment choices outlined above. However, in 14 of the implant failures, perforation of the Schneiderian

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membrane during the initial surgery was documented. In all patients where implants were lost, a new implant was placed 8 to 12 weeks after removal. In these patients, the bone height of the augmented sinus floor was adequate to place an implant 2 mm shorter than the failed implant.

All of the other 439 implants underwent osseointegration and did not exhibit clinical or radiographic evidence of peri-implant compromise. No patient suffered acute complications of the maxillary sinus, except for intermittent epistaxis during the first week following the procedure. No patient experienced subjective complaints or showed signs of sinusitis or frequent upper respiratory tract infections (colds).

Part of this study included exposing the operative site on the lateral maxillary sinus wall while uncovering the implants for abutment connection to evaluate bone regeneration macroscopically (Table 1). It was clinically obvious that, in those patients in whom the residual spaces had not been grafted, either with or without a Gore-Tex membrane, no bone regeneration had taken place in the residual spaces[23] above the bone graft (Figs 4a and 4b). Moderate bone regeneration was observed in those patients in whom the residual spaces had been filled with collagen or cancellous bone had been harvested from the maxillary tuberosity region. Among those patients in whom the residual spaces had been grafted with a mixture of autogenous bone and hydroxyapatite, improved results were achieved in those in whom fibrin adhesive or Gore-Tex membrane had been used for additional support. The best macroscopic and radiographic results were achieved in those patients in whom the residual spaces had been grafted with autogenous bone with a high percentage of resorption-resistant mandibular cortical bone (Figs 5a and 5b), regardless of whether additional support had been provided with a membrane or fibrin adhesive.

Radiographic examinations (orthopantomographs, maxillary sinus radiographs, periapical radiograms, and, when necessary, tomographic films) indicated no signs of pathologic changes in the maxillary sinus region in any of the patients. Furthermore, no definite loss of bone height or horizontal or vertical bone breakdown of the graft or the adjacent alveolar crest around the implants was seen.

The implants placed during sinus-lift procedures had a high percussion sound and showed no signs of loosening. After an appropriate period, the Periotest (Siemens, Bensheim, Germany) values deviated toward the negative (Figs 6a and 6b). The different periodontal parameters and local gingival status of the implants were satisfactory, with findings similar to those implants placed in local bone without augmentation. These results are described in detail elsewhere.[24]

Table 1 Differences in Macroscopic Bone Regeneration, Depending on Operative Technique

Filling of the remaining space	Bone regeneration (macroscopic)
No filling	–
No filling, Gore-Tex	–
Collagen	+
Maxillary bone graft	+
HA + autogenous bone	++
HA + bone + fibrin glue	+++
HA + bone + Gore-Tex	+++
Mandibular bone graft	++++
Mandibular bone graft + Gore-Tex	++++
Mandibular bone graft + fibrin glue	++++

No complications arose in retromolar bone donor sites. In patients in whom bone grafts were harvested from the symphysis, none of the patients' facial profiles were adversely affected. However, apart from the pain experienced during the first postoperative week, neurosensory disturbance of the mandibular anterior teeth and the adjacent alveolar soft tissue occurred; in some patients, this persisted for up to 1 year following the procedure.

Discussion

To date, the authors' experience with this modified sinus-lift technique can be considered positive. Although no complications occurred during the operations, the follow-up period of 6 years is insufficient time to make a definitive statement.

The quality and quantity of the bone graft available from the mandible seems to be sufficient and may alleviate the need to harvest bone from an extraoral site, such as the iliac crest. This not only eliminates the need for a second surgical site, with its inherent mobidity, but it decreases surgical, anesthetic, and recovery time.[25] In some instances, an adequate quantity of bone was harvested from the mandibular symphysis to permit bilateral sinus grafting and the simultaneous placement of up to 6 implants.

The possibility of placing all the implants in a 1-stage procedure is perhaps more technically demanding than the 2-stage method, but is advantageous to the patient in that it reduces the number of proce-

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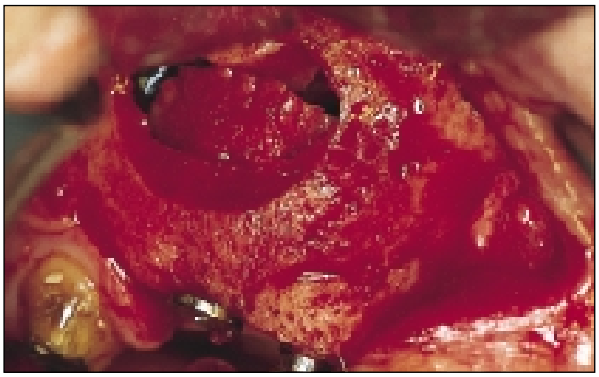

Fig 4a Transantral stabilization of an IMZ apical screw implant using the bone block. The residual space was not filled.

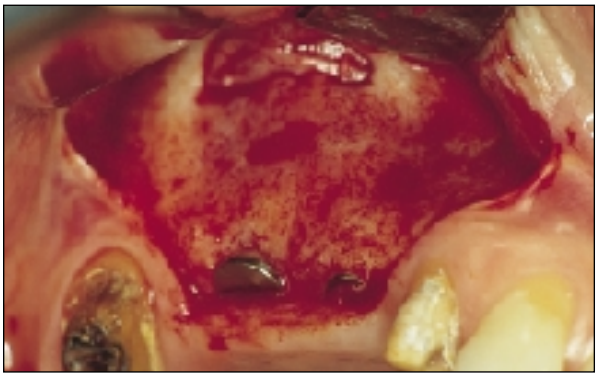

Fig 4b Clinical situation 9 months after surgery. The bone has regenerated next to the bone graft, but not in the empty space above it.

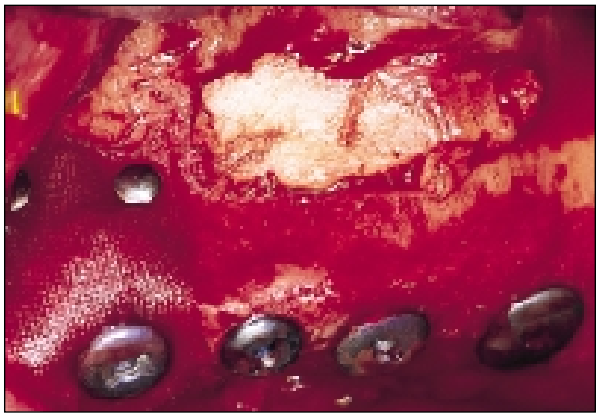

Fig 5a The residual space above the bone graft was filled with bone fragments and the window was closed with a bone block from the mandible.

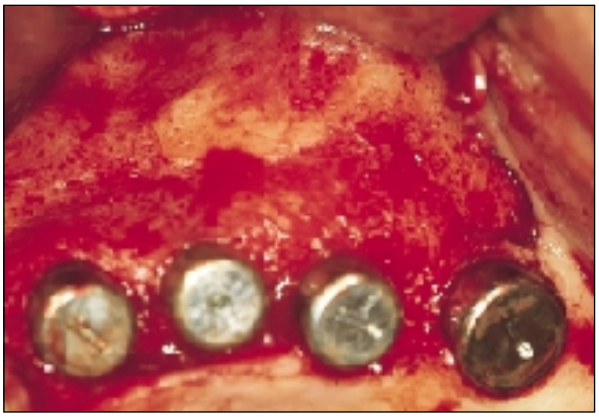

Fig 5b Clinical situation 9 months after the operation indicates good bone regeneration macroscopically.

dures and the time needed to complete implant-supported prostheses.[15,17,18] Because the success of such an operation depends on the complete stability of both the implants and the grafts, in patients in whom the height of the residual local bone was minimal, initial implant stability was achieved by using wide cover screws to compress the bone graft with the implants against the sinus floor bone.[17]

In the present study, abutment connection was accomplished 9 months postoperatively and the prosthodontic treatment, 10 months postoperatively. Usually, maxillary implants in nongrafted sites are loaded after 4 to 6 months. The additional healing time was considered advantageous to enable both incorporation of the graft and osseointegration of the implants.[18] Periotest values tended to become more negative toward the second postoperative year. Only minimal changes were noticed thereafter. This may be the result of virtual completion of bone remodeling of the grafted and newly formed bone. This phenomenon was occasionally demonstrated on the radiographs, where the grafted area was becoming much more dense than the nonaugmented anterior site up to 2 years after loading. This density was similar to that of the mandible. For this reason, most of the patients and especially those with extensive restorations were provided with long-term temporary resin restorations. Once the 2-year postoperative period had elapsed, the porcelain superstructure was fabricated.

In this study, and as pointed out by several authors,[1,17,18] most implant failures became evident during the first year after loading. Of the 19 implants that failed to integrate, 14 had documented

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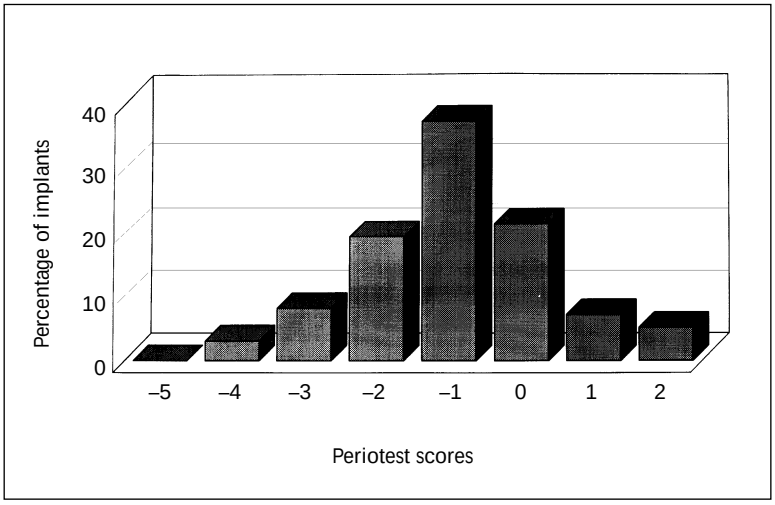

Fig 6a Periotest values after completion of the prosthodontic restoration (n = 467).

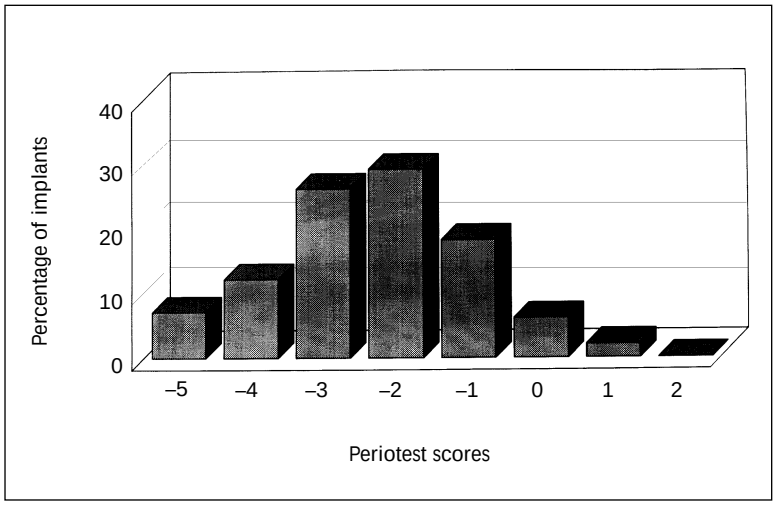

Fig 6b Periotest values 2 years after loading (n = 448). After this period, no significant changes were seen.

evidence of perforation of the Schneiderian membrane during the sinus-lift procedure. It may be reasonable to assume that there is a correlation between implant failure and sinus membrane perforation.

All implants were stabilized with a mandibular bone block. The remaining space between the bone block and the superiorly repositioned sinus membrane was treated with different methods. In this study, it was found that macroscopically, a mixture of alloplastic material such as hydroxyapatite and autogenous bone chips can achieve osseointegration if it is stabilized by fibrin glue or covered by a nonresorbable membrane. However, in 5 patients, the Gore-Tex membrane had to be removed earlier because of infection or exposure. Bone harvested from the maxillary tuberosity alone and grafted to the sinus floor seemed to resorb very quickly under the pressure of the sinus mucosa. Particulated mandibular bone grafts appeared to give the best results macroscopically in this area.[26]

Conclusion

The results achieved thus far, especially in patients in whom implants were subjected to functional loading for up to 5 years, encourage the continuation of this type of augmentative technique. Thus, a patient can be provided with a fixed restoration, even if only minimal bone is available, without having to resort to removing bone from the iliac crest. Autogenous bone with a high percentage of resorption-resistant cortical bone and no additional measures has proven to be a good augmentation material for this type of operation.[15,17,26,27]

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