Bone grafting to the maxillary sinuses, nasal floor and anterior maxilla in the atrophic edentulous maxilla
A two-stage technique


Abstract. This study presents the results from 20 consecutive patients treated with an autogenous bone graft from the iliac crest. In ten patients the graft was placed in the maxillary sinuses and the floor of the nose (inlay group). Ten patients, in addition to the inlay graft, had a corticocancellous bone block secured with mini-screws to the anterior maxillary ridge (inlay/onlay group). Endosteal implants (Brånemark®) were placed six months after surgery. A total of 136 implants were placed, of which eight failed to integrate during the six-month healing period. A further 15 implants were lost during the follow-up period. For the inlay group the average follow-up period was 22 months and for the inlay/onlay group 19 months. Donor site morbidity was significantly less when iliac bone was harvested with a trephine (inlay group) than in patients treated with our routine procedure for bone harvesting (inlay/onlay group). Surgical technique, donor site morbidity, implant survival and patient acceptance are presented.

Key words: bone grafting; autogenous bone; iliac crest; maxilla; implants.

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The reconstruction of the severely resorbed edentulous maxilla with iliac crest bone grafts to accommodate endosteal implants has been the subject of many studies. The full-arch onlay technique1,14, bone grafting to the maxillary sinus floor6,8,9 and grafting to the nasal cavity7,9 are examples of techniques described in some of the recent publications.

In some patients with severe maxillary atrophy (Class V and VI2) a reversed intermaxillary relation or an increased vertical distance3 between the jaws may be the result. In other patients the final state of resorption results in a thin remaining alveolar ridge, while some patients lose all vertical height of the alveolar process. Since reconstruction with bone grafts and implants should aim to restore the facial morphology, the final state of resorption should influence the surgical technique selected, so that optimal results can be achieved, both functionally and aesthetically.

This study presents the results from 20 consecutively treated patients: the first ten patients were treated with an inlay bone graft in the maxillary sinus and the nasal floor (inlay group), and the second ten with an inlay graft in combination with an onlay bone graft to the anterior maxilla (inlay/onlay group).

Material and methods
The inlay group included four women and six men with an average age of 57 years (range 46-70). The patients had been totally edentulous in the maxilla for an average of 29 years (range 2-40). A preoperative clinical examination and radiograms, including a panoramic radiograph, lateral tomograms and a cephalometric film revealed severe alveolar atrophy (Class V-VI according to CA-
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Fig. 1. Residual bone height with min. width of 4 mm in preoperative situation evaluated from lateral tomograms. Planned implant positions were indicated with lead spheres before the radiological investigation. Black bars: inlay/onlay group of patients. White bars: inlay group of patients.

Fig. 2. a) Bone cores harvested from iliac crest. b) Possible sites for bone harvesting indicated along iliac crest.
osteal flap was raised labially at the recipient site through a midcrestal incision and divided along the midline. The nasal mucosa was then carefully elevated in the anterior part of the nasal floor and the nasal aperture was widened with a large round bur to allow the bone cylinders to be more easily placed. The lateral wall of the maxillary sinus was exposed and a bone window was created. The preparation of the sinus area was completed in a manner similar to that described earlier by Kent & Block. The bone window, approx. 15 mm wide and 20 mm high, was outlined with a round bur. The uppermost part was scored and left intact so that a greenstick fracture would allow for infraction of the lateral wall, thus creating a trapdoor. Care was taken not to lacerate the sinus membrane through the inferior cuts. The sinus membrane was carefully elevated through the osseous cut using a blunt elevator and the lateral bone window was pushed in to create a ceiling. In this way, the recipient site was separated from the upper portion of the maxillary sinus. The procedure was performed bilaterally. If the sinus membrane was perforated, it was dissected more excessively in the posterior part of the sinus, allowing the membrane to fold over the perforation. The bone cylinders were placed vertically against the anterior wall of the maxillary sinus (Fig. 3). The flap was then closed with a resorbable suture. Penicillin was administered for one week and a soft diet was recommended for the first two postoperative weeks. The patients were not allowed to wear a denture during the first six postoperative weeks.

In the inlay/onlay patients, a labially directed circumvestibular incision was used to expose the lateral wall of the maxillary sinus and nasal aperture, as well as the anterior maxillary alveolar process. The bone cylinders were placed vertically against the anterior wall of the maxillary sinus and in the anterior part of the nasal floor. The corticocancellous bone block was adjusted and placed on the alveolar process and rigidly fixed with 2 mm wide titanium mini-screws. The mini-screws were placed on the palatal aspect so as not to interfere with the planned implant positions (Fig. 4a, b). In order to stretch the flap over the graft and to avoid tension on the incision, a horizontal incision was made in the labial flap and the flap was stretched and closed with peristomal sutures. The mucosal layer was then closed with a running suture. The patients were not allowed to wear a denture during the first eight postoperative weeks.

Six months after the bone grafting, implants were inserted under local anesthesia.

Fig. 3. Bone cores placed vertically in maxillary sinus against anterior wall with lateral cortical part of core facing upwards.

Fig. 4. a) Onlay corticocancellous bone graft placed on alveolar process in anterior maxilla. Corticocancellous bone graft (black arrows). Palatal positioned titanium mini-screws for rigid fixation of graft (white arrows). b) Postoperative lateral view of graft placed vertically on maxillary alveolar process.
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Fig. 5. a) Seven implants (Bränemark®) placed in graft after six months of healing. Arrow indicates where mini-screws were placed. b) Exposure of implants six months after placements. Arrow indicates bone overgrowth on cover screw.

and conscious sedation. The grafted area was inspected and the implants (Bränemark®) were placed (Fig. 5a) with the aid of a surgical stent.

After another healing period of six months the implants were uncovered (Fig. 5b) and all patients received a fixed bridge.

Results

All patients were discharged from the hospital within four days. In the inlay group only five out of ten patients experienced any symptoms at all from the donor site and none of the patients experienced any disturbances in their gait. For the patients in the inlay/onlay group the pain, discomfort, and disturbances in gait from the hip subsided over the three postoperative weeks in the majority of the patients. Two patients experienced prolonged discomfort from the hip during the two-month healing period. Thus, in the inlay group where the bone was harvested with a trephine and without exposure of the iliac crest, the morbidity from the donor site was much less than that in the inlay/onlay group.

In the inlay group a total of 66 implants were inserted (Table 1a). The Bränemark® implants were self-tapping, of the Mark II type. Five implants failed to integrate and were removed at abutment surgery. Another six implants were lost during the 22-month (range 12–32) follow-up period from the time of implant surgery. One patient lost all six implants (Table 1a). In the inlay/onlay group a total of 70 implants were inserted (Table 1b). The Bränemark® implants were self-tapping, of the Mark II type. Three implants failed to integrate and were removed at the time of abutment surgery. Another nine implants were lost during the 19-month (range 12–32) follow-up period, from the time of implant surgery. One patient

Fig. 6. a) Computerized tomography of maxilla immediately after bone grafting from iliac crest. b) Computerized tomography of same area as a) six months later, demonstrating good graft cooperation in host bone, but also loss of bone volume as compared to a).
lost all seven implants (Table 1b). Asked if they would consider recommending the treatment to a family member, 19 patients said yes; asked if they would consider repeating the treatment if necessary, all but four replied affirmatively.

Discussion

The most common postoperative complications when bone is harvested from the ilium are postsurgical pain and gait disturbance. Previous reports concerning donor site morbidity have demonstrated pain and gait disturbance for a significant number of patients throughout the first postoperative month, and persistent gait disturbance for a few patients lasting as long as several months. In the inlay group of patients, where through-by-through bone cylinders were harvested with a trephine with no previous reflection of muscles and periosteum from the iliac crest, the morbidity was significantly lower than in the inlay/onlay group. All the inlay patients were able to walk within a few hours after the operation and none of them reported any disturbances in their gait. Only five of the patients reported any donor site morbidity (pain and discomfort) and all patients were free of symptoms within four weeks.

As seen in Figs. 6a and 6b, there was a loss of width of the bone cores placed in the maxillary sinus over a six-month healing period, but also good incorporation of the graft and healing of the lateral sinus wall defect. A varying rate of graft resorption was found in each individual patient during the six-month healing time. Optimal implant stability was not always achieved in patients with a considerable graft resorption, resulting in a decreased volume of the bone graft. A decreased remaining volume of the graft also resulted in short implants (Table 1). The success rate of maxillary implants is dependent on implant length. It is not yet clearly understood whether the degree of the individual pattern of resorption is a result of donor bone quality, vascularization, or local occlusal trauma to the graft.

Of the 20 implants inserted in the nasal grafts in the inlay group of patients, two were lost in the same patient who also lost four implants in the antral graft site. At the time of implant surgery in this patient, optimal initial implant stability was not achieved due to low density and loss of volume of the graft.

The overall success rate in the inlay group of patients was 83% implant survival, 90% success for implants placed in nasal graft and 80% success for the implants placed in the maxillary sinus graft. For the inlay/onlay group the success rate was lower (80%) for the 40 implants placed into the onlay bone graft, where 20 of the implants also involved the nasal inlay grafts, compared to the 87% success rate for the 30 implants placed into the antral graft.

Occlusal trauma from anterior mandibular teeth is probably the main reason for the advanced resorption located in the anterior maxilla as seen in the inlay/onlay patients. In these patients where the mandibular teeth could reach the soft tissue covering the onlay graft, a splint was fabricated (Fig. 7). The patient was advised to wear the splint 24 hours/day continually during the first two postoperative weeks, and thereafter, for the following two months, only when asleep until the new denture was ready. It is advisable to replace missing mandibular posterior teeth with a removable partial denture during the graft healing period, in order to avoid

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**Table 1a. Implant length and positions (inlay group)**

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* One implant failed to integrate. ** Two implants failed to integrate.

Left (L), right (R), incisor (1), canine (2), premolar (3), and molar (4) positions.

**Table 1b. Implant length and positions (inlay/onlay group)**

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* One implant failed to integrate. ** Two implants failed to integrate.

Left (L), right (R), incisor (1), canine (2), premolar (3), and molar (4) positions.

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Fig. 7. Splint with posterior bite blocks to prevent occlusal trauma to anterior graft site during initial healing period.
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Fig. 8. a) Corticocancellous bone graft (black arrow) and nasal inlay (white arrow) at first surgery. b) Graft after healing period of six months. Moderate bone resorption. c) Corticocancellous bone graft at first surgery. d) Graft after healing period of six months. Substantial bone resorption.

a possible overload of the anterior maxillary onlay graft.

Nyström et al. have demonstrated that in case of one-stage full arch onlay grafting, the majority of graft resorption takes place during the first six months and is minimal after 12 months of healing. Visual inspection of the graft after the initial resorption has taken place, allows the implants to be placed at an optimal depth with less risk of exposure than if the implants and grafts are placed simultaneously. The initial resorption was found to be rather variable and is thus difficult to predict. Cortical thickness of donor bone and donor bone density are factors which might possibly influence the resorption pattern (Figs. 8a, b, c, d). In many of the patients in this study, the height of the residual alveolar bone was low, which precludes initial stability for implants placed simultaneously (Fig. 1).

Graft resorption during the initial six months varied between patients, which supports the notion of delayed insertion of implants. In some patients the resorption was so extensive that initial stability of the endosteal implants could not be achieved, or short implants had to be used. Oversized corticocancellous grafts, with a thick resorption-resistant cortex should, therefore, be harvested in order to maintain enough graft volume after the initial resorption phase to
allow for long implants with good initial stability.

References


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