Implant Treatment Without Bone Grafting in Severely Resorbed Edentulous Maxillae

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Purpose: This article describes the surgical technique for implant treatment in severely resorbed edentulous maxillae without any alveolar reconstruction before or combined with implant placement.

Patients and Material: Fifteen patients with severely resorbed edentulous maxillae were treated with osseointegrated implants and fixed dental prostheses. All patients were initially considered to be treated with bone grafting because of a lack of sufficient bone volume for conventional treatment. Preoperative radiographic examinations showed that the height of the alveolar crest was on average 7.4 mm at the 4-mm-width level (Classes V to VI).

Results: By fenestration of the maxillary sinus and uncovering the nasal floor, the maxillary bone could be visualized and used maximally for installation of implants. By angulation of the implants and permitting two to five uncovered fixture threads on the palatal aspect, implants of optimal length could be installed. Eighty-six implants were placed (four to six implants in every patient). One implant was lost during the observation time (range, 36 to 54 months; mean, 45 months). All patients had stable fixed prostheses at the end of the observation time.

Conclusion: This cost-effective surgical technique may be considered as an alternative to more resource-demanding techniques such as bone grafting in patients with severely resorbed edentulous maxillae. However, further prospective comparative studies are necessary for full evaluation.

Since the development of osseointegrated dental implants, the standard procedure has been to install them vertically positioned and totally covered by bone. In patients with a bone volume in the maxillary alveolar crest of less than 10 mm in the vertical aspect and 4 mm in the horizontal aspect (Classes V to VI according to Cawood and Howell†), the prognosis for conventional treatment with osseointegrated implants has been considered dubious or poor. Therefore, Breine and Bränemark2 considered bone grafting to be necessary in such cases in combination with implants. They described an onlay technique with autogenous bone to augment the bone volume for osseointegrated implant placement. Keller et al3 described a technique for horizontal osteotomy of the maxillary alveolar process and an interpositional bone graft. Sailelk showed a similar method in which a Le Fort 1 osteotomy was used to allow iliac bone grafts to the maxillary sinuses and the anterior nasal floor and installation of implants during the same procedure. Adell et al5 reported 73.8% implant anchorage function after use of an iliac bone graft as an onlay in a single-stage technique. Loukota et al6 described a technique for inserting endosseous implants in the atrophic maxilla in a single-stage procedure by grafting autogenous bone to the floor of the maxillary sinus. Kondell et al7 have described maxillary reconstruction with autogenous rib grafts in combination with implants in a single-stage technique. Also, the use of an allogeneic bone graft as an onlay has been described, but in a two-stage procedure.8 However, the predictability of the grafting procedures may be doubtful compared with nongrafting procedures because of higher complication rates intraoperatively.
and postoperatively for these procedures. Furthermore, none of the previous reports presented the criteria for case selection. Therefore, there is still a lack of clear clinical criteria for determining the threshold level at which resorption is so severe that bone grafting is necessary for successful installation of implants.

The anatomy of the bone within the margins of the nasal cavity, the maxillary sinuses, and the alveolar crest margin allows alternative mesial-distal angulation of implants. The height at the 4-mm width of an alveolar crest is the measure to describe the available bone volume for total coverage of the implant. However, the height at 4 mm width is often not enough for implant installation in severely resorbed maxillae. Therefore, mesio-distal angulation of the implant provides better primary stability than conventional straight vertical positioning because it permits use of a longer implant (Fig 1), even though this will leave implants with uncovered coronal threads on the palatal side of the alveolar crest (Fig 2). Thus, a surgical technique was developed to exploit the maximum amount of available bone and allow the installation of longer implants than indicated from computed tomography (CT) parasagittal reconstructions. By also fenestrating the maxillary sinuses to explore the anterior-medial wall, lifting the nasal mucosa, and mesio-distal angulation of the implant with several uncovered threads marginally on the palatal aspect, this technique allows installation of implants of optimal length with good primary stability. The aim of this article is to describe the application of this surgical technique as an alternative to bone grafting for implant treatment in severely resorbed edentulous maxillae.

**Materials and Methods**

The study involved 15 maxillary edentulous patients in whom radiographic examination showed the bone volume to be inadequate for conventional treatment and implantation in combination with primarily bone grafting was indicated. This group was taken from consecutive patients referred for maxillary implant treatment. The patients, four men and 11 women, with a mean age of 59 years (range, 44 to 75 years), were without any known systemic disorders.

The inclusion criteria for treatment with this surgical technique was that the patients had an average maxillary bone dimension not more than 10 mm in the vertical aspect at the 4-mm horizontal wedge thickness (Classes V to VI according to Cawood and Howell).  

**RADIOGRAPHIC TECHNIQUE**

All patients underwent a panoramic radiographic examination before the CT scan. The panoramic examination were performed in a Planmeca orthopantomograph (Planmeca OY, Helsinki, Finland) with Kodak Tmax L-film (Kodak, Rochester, NY) and Kodak Lanex medium screens. The tube potential was 68 kV and the tube current was 9 mA. The CT examination was done in a Siemens Somatom Plus with a 256-matrix and standard software options (Siemens AG, Erlangen, Germany). The slice thickness was set to 1 mm. The tube potential was 120 kV, and the tube current was 165 mA. Axial cross sections were obtained consecutively with 1-mm intervals parallel to the nasal floor. The examination started 1 cm above the nasal floor and ended at the most inferior part of the alveolar crest. Parasagittal reconstructions were then reformatted perpendicular to the alveolar crest (Fig 3) and used to estimate the bucco-palatal width. The distance to the nasal floor and bottom of the maxillary sinuses was determined at the 4-mm width level of the alveolar crest (Fig 3). A cephalogram was used to indicate the inclination of the implants in the lateral view. Conventional Kodak intraoral radiographs were used to estimate the bone edge on all implants when treatment was completed with a fixed prosthesis. New intraoral radiographs were taken 1 and 3 years later. New CT images were taken 1 year...
after implant installation to again see where the implants were placed and to evaluate any bone resorption.

SURGICAL TECHNIQUE

Treatment planning and the surgical procedures were performed according to the Brånemark System (Nobel Biocare AB, Gothenburg, Sweden) technique. All patients were treated under local anesthesia (approximately 10 mL 2% lidocaine with epinephrine 12.5 μg/mL; Xylocain-Adrenalin, Astra, Södertälje, Sweden). No antibiotics were given preoperatively or postoperatively. After raising a mucoperiosteal flap, the anterolateral wall of the maxilla and the inferior part of the piriform aperture were exposed. A round bur was then used to fenestrate the lateral wall of the maxillary sinus and the mucosal lining was carefully elevated and the anterior wall of the maxillary sinus was explored with a probe (Fig 4). The mucosal base of the nasal cavity was also elevated to allow exploration of the cortical bone of the nasal floor. The positioning of the implants was determined with the guide bur. Brånemark System (diameter, 3.75 mm) implants (7-mm standard implants, but without pretapping, or 10- to 18-mm self-tapping implants) were then installed. One posterior implant on each side was installed angulated and tangentially according to the anatomy of the anterior-medial wall and bottom of the sinus (Fig 5). The second implant on each side of the piriform aperture was inserted into the sinus-nasal wall more axially. Finally, one or two implants were placed with an angulated direction into the nasal spine or penetrating the cortical bone of the nasal cavity without penetrating the nasal mucosa (Fig 5).

Eighty-six implants were installed (four to six implants in every patient). Seventy-six of the implants (88%) were installed with two to five uncovered threads on the palatal side (Fig 6). No membrane for bone augmentation or regeneration was used in any of the patients. After the nasal and sinus mucosa was replaced, the stability of the implants was checked and the procedure completed according to the routine method. All implants were considered to have good primary stability. The patients were not allowed to wear a removable prosthesis for 2 weeks. In all
cases, the healing period was at least 6 months before abutment connection.

**PROSTHETIC TECHNIQUE**

All patients were rehabilitated with fixed prostheses according to the original protocol for the Bränemark System. Dr. Kühns impression plaster (Ernst Hinrichs GmbH, Goslar-Jerstedt, Germany) was used for the impression. The superstructures were fabricated with a metal framework made of cobalt-chromium (Co-Cr) in six patients, silver-palladium (Ag-Pd) in six patients, and titanium in three patients.

The superstructures of the Co-Cr group were designed with the metallic parts facing the alveolar crest and part of the lingual surface, and the other parts were made of acrylic resin material. The Ag-Pd and the titanium group prostheses were designed with a bar, and the rest of the prosthesis (including the parts facing the oral mucosa) was made of acrylic resin material. For fabrication of the Co-Cr framework, a two-stage technique was used, with the framework first finished and then secondly the gold cylinders were united to the framework by casting. The Ag-Pd frameworks were fabricated according to the original protocol by Bränemark et al. Of the titanium superstructures, one was fabricated with a Procera (Nobel Biocare AB, Gothenburg, Sweden) framework, and two were fabricated with a cast titanium framework (Titanbron i Åhus AB, Åhus, Sweden). As attachment cylinders, gold cylinders (Nobel Biocare AB), Procera (Nobel Biocare AB) titanium components, or premachined titanium cylinders (Titanbron i Åhus AB) were used. In all the titanium cases, the different parts were united by laser welding.

**Results**

Sixty-eight self-tapping (diameter, 3.75 mm) and 18 standard (diameter, 3.75 mm) implants were installed in 15 patients (11 patients with six implants, three patients with five implants, and one patient with four implants). Table 1 shows the bone height at the 4-mm width, which in the frontal regions (central and lateral incisors) ranged from 4.0 to 10.0 mm (mean, 7.0 mm), and in the lateral regions (canine and first premolars) ranged from 3.0 to 14.0 mm (mean, 7.8 mm). Table 1...
also shows the total bone height and the length of the implants inserted in each region; on average, 10 mm in the frontal regions and 13 mm in the lateral regions. The observation time was 36 to 54 months (mean, 45 months) after installation of the implants (Table 2). One 15-mm implant was lost, giving a success rate of 99%. The lost implant had been distally aligned with the anterior-medial wall of the maxillary sinus. It did not osseointegrate and was removed at the abutment operation 6 months after installation. All of the other implants were stable throughout the observation time.

In 13 of the 15 patients, 76 standard abutments (68 with 3-mm length, 8 with 4-mm length) were used. In two patients, 10 abutments were of the EsthetiCone type (Nobel Biocare AB). In one of these cases, abutments of the angulated type (Nobel Biocare AB) were used due to the extremely divergent directions of the implants.

Impressions for the suprastructures were made without any complications in all cases. All patients could be rehabilitated with fixed prostheses, which consisted of 12 teeth. There were no complications related to the superstructures. All prostheses were stable and hygienic, and no abnormal tissue reactions were observed. The aesthetic outcome was considered to be satisfactory for all patients. Initially, four patients complained of phonetic problems after insertion of the prostheses, but at the 1-year follow-up, these were no longer perceived as socially limiting. In one case, transient hypersalivation occurred after insertion of the prosthesis.

On the CT images taken 1 year after treatment, it was confirmed that all implants were installed within the available bone. No major bone resorption (≥1 mm) was observed on the radiographs 1 and 3 years after implant installation.

### Discussion

In spite of the results of the primary clinical and radiological examinations showing inadequate available bone for conventional implant treatment, we successfully installed implants in all 15 patients. They all had well-functioning, fixed prostheses without any symptoms during the entire observation period, which was between 3 and 4.5 years.

Several techniques have been described for implant treatment of the severely resorbed edentulous maxilla. However, the criteria for selection of cases suitable for treatment with the various techniques have not been addressed, and therefore comparative evaluation is difficult. Most of the bone grafting procedures are resource-demanding treatments with higher costs, longer treatment time, higher morbidity.
and lower success rates than implant treatment without bone grafting. Therefore, it is important to investigate the exact threshold level at which implant treatment still may be possible without bone grafting.

In the Bränemark System, the shortest, not self-tapping implant is 7 mm. Ten-millimeter and longer, self-tapping implants are available. In the maxilla, the use of self-tapping implants is preferable because the bone quality does not usually allow tapping. Furthermore, implants shorter than 10 mm cannot be installed with sufficient primarily stability.

In this study, we used the most reliable and commonly accepted radiologic technique, CT scanning with specified criteria, for estimating the bone volume in the edentulous maxilla. However, parasagittal reconstruction does not take into consideration the possibility of placing the implants in an angulated position by directing them in a mesial-distal or a bucco-palatal direction. An angulated position will extend from one parasagittal reconstruction into another, and therefore this represents a larger amount of available bone. The axial scans may possibly give an idea of this volume. Three dimensional CT may be another possibility to better get a view of the bone volume. The now more common spiral CT technique, together with much better software functions, has resulted in a shorter examination time, which makes this technique cheaper compared with the conventional CT.

In all patients, the implants penetrated the cortical bone of the nasal floor or maxillary sinus. The implants then have good primary stability. The penetration of the cortex did not have any negative clinical consequence as long as the implants did not penetrate the mucosa. This is in accordance with the results of an experimental study by Bränemark et al. To get good primary stability of the implant, the deficiency of the thin marginal crest less than 4 mm wide was enhanced with palatal positioning of the implant. This left threads uncovered on the palatal side; in the present study, most of the implants (88%) were installed with two to five exposed threads. This did not seem to lead to any mucosal problems or marginal bone resorption. This has also been shown by Lekholm et al., who proposed that bone augmentation techniques indicated only by exposed fixture threads should be used judiciously because of the increased cost and infection risk.

In this study, four to six implants were installed in every patient. This seems to be enough for good function. Bränemark et al. have, in a recent study, concluded that "the present tendency of some clinicians to install as many implants as possible in full edentulism should be seriously questioned." In this study, the angulated position of the implants caused a most divergent insert direction of the prosthetic constructions, which made impression taking and installation of the fixed prostheses more demanding for the prosthodontist. To control bending stress on the implants, an even distribution of the forces is necessary. Therefore, a passive fit without any tension between the superstructure and the abutments is of decisive importance. In all patients, a good clinical fit was achieved between the abutments and the fixed prosthesis. Also the length of the prostheses (12 teeth) was acceptable for allowing good function.

This surgical technique, with maximal use of the remaining maxillary bone, angulation of the implants, and permitting of uncovered fixture threads, may allow implant treatment in patients with severely resorbed edentulous maxillae in whom bone grafting procedures would otherwise be indicated. However, further prospective comparative studies are necessary for full evaluation.

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