Placement of Posterior Mandibular and Maxillary Implants in Patients with Severe Bone Deficiency: A Clinical Report of Procedure

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The purpose of this investigation was to modify the method for implant placement in the posterior parts of the arches for fixed implant-supported prostheses using minimally invasive surgery. Eighty-six implants were placed posterior to the mental foramina in patients with severely resorbed mandibles, and 75 implants were placed in the posterior severely resorbed maxilla. Bone grafting from the mandible to the maxillary sinus was performed in 9 patients with severely atrophic maxillae. In all patients, optimal use of the anatomic features of the arch was achieved by tilting the implants. Patients were followed up for 12 to 123 months after prosthesis connection (mean 18 months). Three maxillary implants were lost at the time of abutment connection: 1 in the pterygoid plate, 1 close to the posterior sinus wall, and 1 placed in the palatal cortex. One implant was mobile approximately 1 year later, apparently because of an ill-fitting prosthesis. In the mandible, no implants were lost. The method described for the treatment of edentulous arches represents an alternative therapy to several others currently in use. This minimally invasive surgical procedure should be applicable in an outpatient clinic for treatment of severely resorbed posterior portions of the arches with implant-supported prostheses. (INT J ORAL MAXILLOFAC IMPLANTS 2000;15:722–730)

Key words: *bite force, bone graft, dental cantilever bridge, dental prosthesis, endosseous dental implantation, endosseous dental implants, maxillary sinus, mandibular nerve, partially edentulous jaw*

Bite force registrations of patients with their natural dentition show greater forces further back in the dentition.[1] Edentulous patients treated with fixed prostheses supported by osseointegrated implants have shown improved masticatory function and increased bite force in comparison with their performance when using overdentures.[2] Chewing capacity, however, is contingent on the distribution of implants in the arch.[3] Placement of implants in the posterior arches generally increases chewing efficiency and decreases the problems of long cantilevers as compared with anterior implant placement. The anatomic features of the premolar and molar region in severely resorbed partially edentulous arches are an important factor when planning patient rehabilitation by appropriate distribution of the implants.

In partially edentulous premolar or molar regions of the mandible, reconstruction demands unique solutions. Transposition of the mandibular nerve is one possibility. Following nerve transposition, long and stable implants could be applied in the molar region.[4] However, problems with permanent paresthesia of the mental nerve have been reported.[4–7] Another technique involves placement of short implants above the mandibular canal.[7,8] These implants are anchored only in the superior cortex, which reduces the optimal load-bearing capacity. Moreover, short implants have failed more frequently than longer ones.[9] Krekmanov and Rangert[3] described the placement of implants in premolar and molar mandibular areas using the lingual cortical plate and mylohyoid line for stable

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Table 1 Distribution of Tilted Implants Relative to Location in Arches

Implant location	No. placed	No. lost
Mandibular region		
Partially edentulous arches		
Unilateral	41	0
Bilateral	30	0
Completely edentulous arches	15	0
Maxillary region		
Pterygoid plate	14	1 + 1*
Posterior sinus wall	10	1
Palatal concavity	19	1
Anterior sinus wall	11	0
Bone-grafted sinus	21	0

*One implant was lost 1 year after prosthesis connection. No early postoperative signs of inflammation were present.

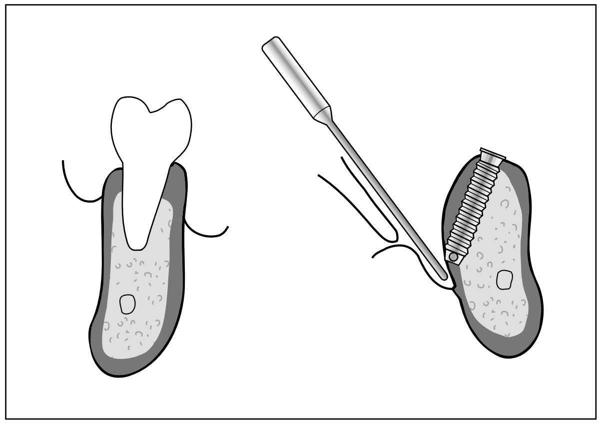


Fig 1 Schematic drawing of bicortical implant anchorage in the molar region of the mandible.

bicortical implant anchorage. These implants were placed medial to the mandibular nerve.

In the partially edentulous, severely resorbed maxilla, placement of tilted implants parallel to the posterior sinus wall is frequently done (unpublished observations).[10] Anchorage of the implant in the pterygoid process has also been described.[3,10,11] A technique has been reported for implants placed tangential to the palatal curvature in the area of the first or second molar.[3,12] These implants were placed in the direction of the palatal sulcus, ie, the bone impression of the great palatal bundle. Bone grafting from the lateral side of the mandible, in combination with sinus lift augmentation, has been reported in cases of extremely resorbed maxillae.[13,14]

The aim of this investigation was to evaluate the surgical and prosthodontic effects of rehabilitation of premolar and molar areas in partially edentulous, severely resorbed arches.

MATERIALS AND METHODS

Mandible

Twenty-four consecutive patients (15 males and 9 females) with a mean age of 43.4 years (range 37 to 61) underwent minimally invasive surgery. Seventeen patients were operated on unilaterally, 5 bilaterally, and in 2 the bilateral technique was utilized in totally edentulous mandibles for equal distribution of implants in the arch. The overall number of implants was 86 (Table 1).

Two or 3 implants were placed posterior to the mental foramina in all patients. Two of the most posterior implants were placed with a slight buccal tilt. These implants passed from the top of the alveolar crest toward the mylohyoid line, where the tip of the implant was anchored (Figs 1 to 3). The third implant was typically placed posterior to the mental foramina and parallel to the lingual surface of the mandible (Figs 2 to 4). In 11 sites, where the first premolar was missing, 1 implant was placed into the created space. This implant was tilted in a posterior or buccal direction to avoid damage to the mental loop.[3,10]

Maxilla

Twenty-two patients (10 males and 12 females) with a mean age of 47.6 years (range 33 to 71) underwent minimally invasive surgery. These patients received 75 implants. Forty-two implants were placed in 13 patients (14 sites) with severely resorbed posterior maxillae. The most posterior implant in these patients was placed, depending on the bone available, into the pterygoid plate (9 implants) and into the tuberosity close to and parallel with the posterior sinus wall (6 implants). Eight additional implants were placed close to and parallel with the anterior sinus wall (Fig 5).[3,10] Nineteen implants were placed into the palatal curvature in the molar region (Figs 5 to 7).

In 9 patients (10 sides) with severe alveolar crest atrophy, bone grafting from the lateral side of the mandible to the sinus was performed under local anesthesia. Twenty-one implants were placed into the grafted maxillary sinus combined with different tilted implants, as described above (5 implants were placed in the pterygoid plate, 4 implants were placed in the posterior sinus wall, and 3 implants were placed in the anterior sinus wall) (Table 1).[3,10]

Surgical Procedures

For all patients, a local anesthetic agent containing 3.6 mL of epinephrine with adrenaline (xylocaine,

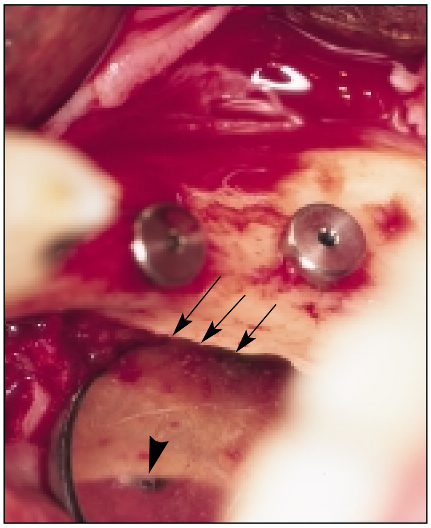
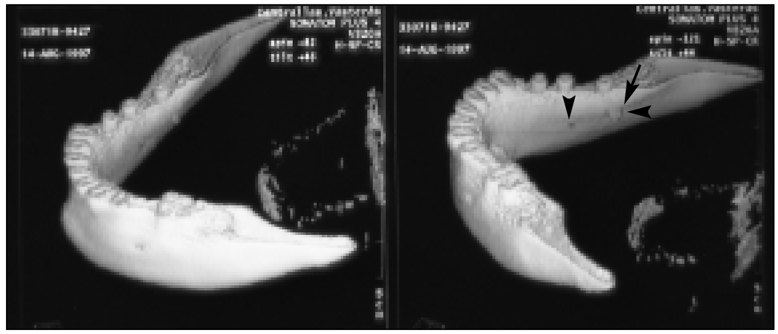


Fig 2 *(Left)* Intraoperative view of implant placed into the lingual cortex of the mandible and into the mylohyoid line *(arrows).* Note that the tip of the implant *(arrowhead in mirror)* perforates the lingual cortex. All 3 implants, despite different tilting angles, have perforated through the top of the alveolar crest.

Fig 3 *(Below)* Computed tomographic reconstruction of the posterior mandible. Note placement of the implants in the molar region with their tips *(arrowheads)* through the lingual cortex. Arrows = mylohyoid line.



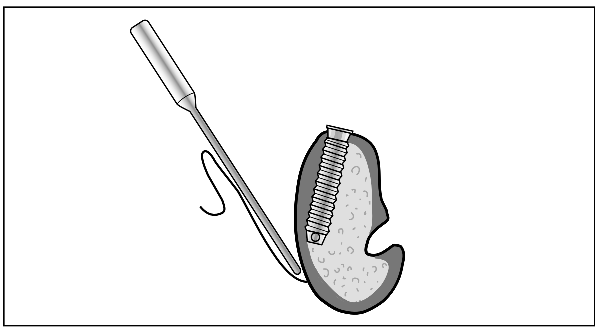


Fig 4 Schematic drawing of implant anchorage in the premolar region of the mandible.

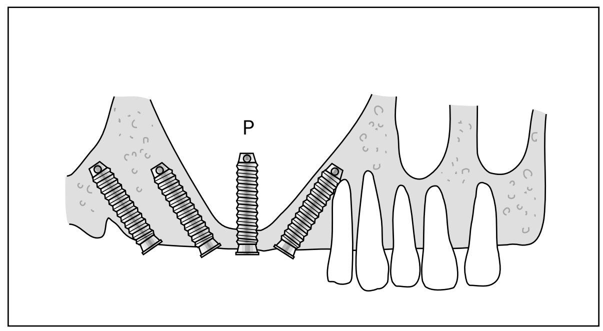


Fig 5 Schematic drawing of implant placement in the molar region of the maxilla. Note that the tip of the most anterior implant is placed a few millimeters medially to the premolar apex. Note the placement of one implant into the palatal curvature (P).

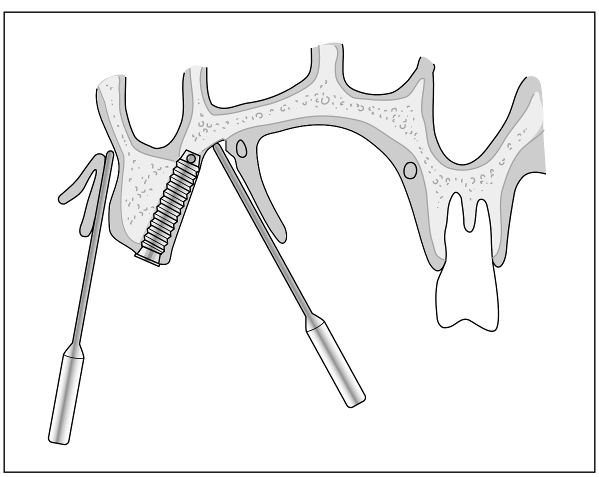


Fig 6 Schematic drawing of bicortical anchorage of implant placed into the palatal curvature.

Fig 7 Intraoperative view of implants placed into the palatal sulcus. Note that the tip of the implant *(arrowhead)* perforates the palatal cortex. All implants, despite different tilting angles, have perforated through the top of the alveolar crest. Arrow = palatal artery.

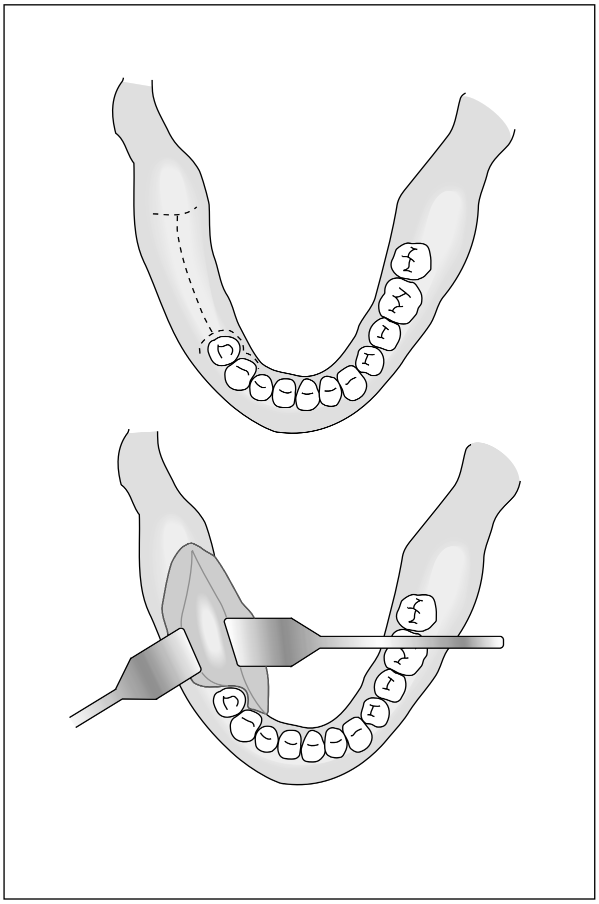


Fig 8a Schematic illustration of incisions and flaps in the mandibular arch.

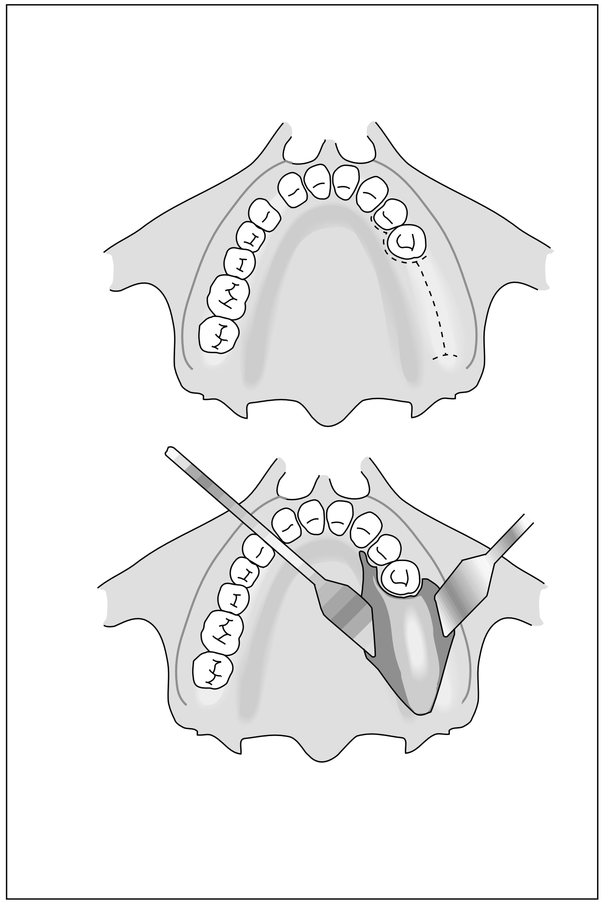


Fig 8b Schematic illustration of incisions and flaps in the maxillary arch.

adrenalin 2%) was injected on the side of the arch in which surgery was carried out.

Mandible. An incision was made along the alveolar ridge crest in the edentulous area of the mandible and completed by lateral release incisions. Further, subperiosteal dissection was carried out on the lingual and vestibular surfaces of the mandible (Fig 8a). The mental foramina were then localized. On the lingual side, the mylohyoid line was exposed and the mylohyoid muscle was elevated. An instrument was placed below the mylohyoid line for soft tissue protection during the drilling procedure (Fig 1). The depth of the mental canal in relation to the lingual mandibular surface was calculated for implant placement in the second premolar region. The implant was placed into the mandibular lingual cortex. Two additional implants were placed from the alveolar ridge crest into the mylohyoid line. In the event of a previously removed first premolar, the most anterior implant was placed into the first premolar position along the lingual cortical plate of the mandible.[3,10]

Maxilla (No Grafting). An incision was made along the alveolar ridge crest in the edentulous area of the maxilla. This incision was completed with vertical release incisions bilaterally. In addition, subperiosteal dissection on the palatal and vestibular surfaces was performed (Fig 8b). Subsequently, the lateral sinus wall close to the anterior and posterior sinus borders was perforated. By means of a straight probe, the inclinations of the anterior and posterior sinus walls were noted. Implants were placed close to and parallel with these walls (Fig 5). For patients with significantly soft or insufficient tuberosity, an implant was placed into the pterygoid plate. Patients whose tuberosity consisted only of a thin cortex received palatal tilted implants. In these latter patients, a palatal flap was elevated until the superior border of the impression (sulcus) of the great palatal bundle was reached. The implant was placed from the alveolar ridge crest close to and tangential with the palatal surface. This implant passed through the palatal cortical palate and sulcus formation, which assured that cortical anchorage was achieved (Figs 6 and 7).[3,10]

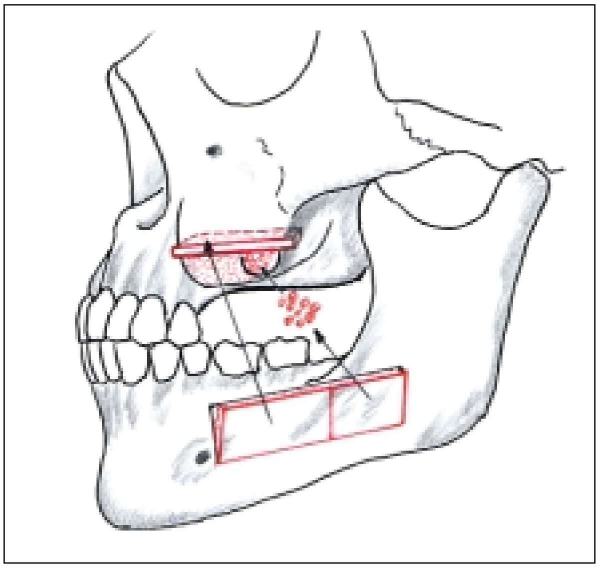


Fig 9 Schematic illustration of sinus grafting with bone from the lateral side of the mandible.

Maxilla (with Grafting from the Lateral Mandible). In the maxilla, a horizontal incision was made at the base of the vestibular sulcus from the incisor to the third molar region. Bilateral incisions to release tension were made upwards from the horizontal incision. Subperiosteal dissection was done from the maxillary tuberosity to the piriform aperture. A horizontal osteotomy was done with a side-cutting bur approximately 13 to 15 mm above and parallel to the alveolar ridge. Anteriorly, the osteotomy was started in the thick bone of the anterior sinus/nasal wall and extended posterior into the middle of the zygomatic-alveolar crest (Fig 9). A parallel osteotomy 3 to 4 mm below to the first (horizontal) osteotomy was then accomplished and the intermediate bone removed. The sinus mucosa was elevated.

To prepare the donor site, a horizontal incision was made in the mandibular vestibular sulcus from the third molar area to the mental foramen; incisions were also made to release the tension on each side. A subperiosteal dissection was performed inferiorly toward the mandibular base and the mental foramen was identified. With a small side-cutting bur, a horizontal osteotomy was accomplished above and parallel to the oblique line, up to a few millimeters from the mental foramina. Another parallel osteotomy was then made 10 to 12 mm below the previous osteotomy. These osteotomies could be extended posteriorly 10 to 15 mm behind the third molar region. Vertical osteotomies, one on each side, connected the horizontal osteotomies. All of these osteotomies were done through the cortex until minimal bleeding indicated penetration through the cortical plate. The graft was elevated and divided into 2 pieces. One piece was trimmed to fit into the slot created in the maxillary sinus. Bone chips were made of the remainder of the harvested bone from the lateral side of the mandible (Fig 9).

The graft plate was horizontally forced into the slot in the lateral sinus wall. To increase stability, the graft was gently tapped into the medial sinus wall. Bone chips were then packed into the space between the original sinus floor and the horizontally placed graft.[13,14]

Implant Procedures. The size of the spiral drill used in the maxilla was 3.0 mm in diameter, except for the palatally tilted implants. In the mandible, a 3.3-mm spiral drill was used, where, as in the maxilla, only standard Brånemark System (Nobel Biocare, Göteborg, Sweden) implants were used, while in the mandible, Mark II implants were applied (Nobel Biocare). The implants were placed in grafted maxillae approximately 3 months after the grafting procedure. The abutment operation followed 3 months after implant placement in the mandible and 4 to 5 months after implant placement in the maxilla. In one patient with a completely edentulous grafted maxilla, a definitive prosthesis was fixed on 6 implants 12 days after implant placement. In another patient with a non-grafted severely resorbed edentulous maxilla and an edentulous mandible, tilted implants were placed (8 implants in the maxilla and 6 in the mandible), and fixed prostheses were placed 12 days later (Figs 10 and 11). During abutment connection surgery in all patients, implant stability was checked by the surgeon; it was checked again later by the prosthodontist. Panoramic radiographic examination was conducted immediately after the abutment connection. The prosthetic treatment was started in all but 2 patients 3 weeks after abutment connection. These 2 patients received prostheses within 2 weeks after implant placement.

To avoid infection, all patients were given 1.5 g phenoxymethyl penicillin twice daily for 5 days. The patients rinsed their mouth with chlorhexidine (Corsodyl, SmithKline Beecham Consumer Healthcare, Philadelphia, PA) twice daily for 1 week after surgery to improve routine oral hygiene. Regular follow-up examinations were carried out at 1 and 4 weeks and then at 3, 4, 6, and 12 months; subsequent follow-up appointments took place annually.

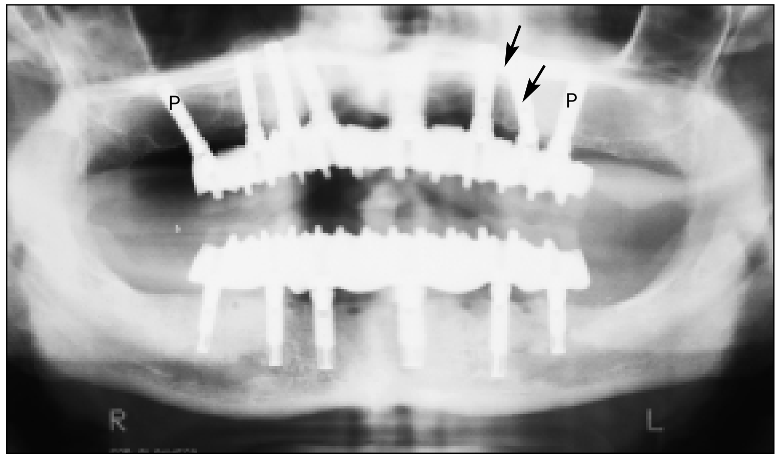


Fig 10 Panoramic radiograph of a patient with immediate prosthesis connection after placement of implants in both arches. Note tilting of the implants along the anterior sinus wall *(arrows)* and the palatally tilted implants (P).

RESULTS

Mandible

Of the 86 tilted implants placed, 1 could not be used. It had been placed into the third molar region in the left mandible and interfered with the buccal mucosa. All the other implants were asymptomatic through second-stage surgery for abutment connection. Suture dehiscence was observed in 1 patient postoperatively; in this situation, the cover screws were visible. The patient was instructed to maintain careful oral hygiene and thoroughly brush the exposed metal. Paresthesia of the mental nerve was observed on 3 sides during the first few weeks after the implant operation. No incidence of nerve disturbance was noted at the time of abutment connection. Healing abutments were used in all cases. Later, these healing abutments were replaced by the prosthodontist with the required abutments.

Non-Grafted Maxilla

Of the 14 implants placed into the pterygoid plate, 1 was mobile at the time of abutment connection. During implant placement, this implant slid along the pterygoid surface without penetrating the drilled canal. This made the entire canal oval-shaped and jeopardized primary stability in the soft tuberosity, even when this implant was correctly reinserted. Another implant (of 19), palatally tilted and placed into the first molar region, was also mobile at the time of abutment connection. One of 10 implants placed close to the posterior sinus wall was also found to be mobile during abutment connection. All of these implants were removed. Another implant placed in the pterygoid plate was lost 1 year after prosthesis placement. The fixed prosthesis misfit the 7-implant base, which could have been the reason for early bone resorption

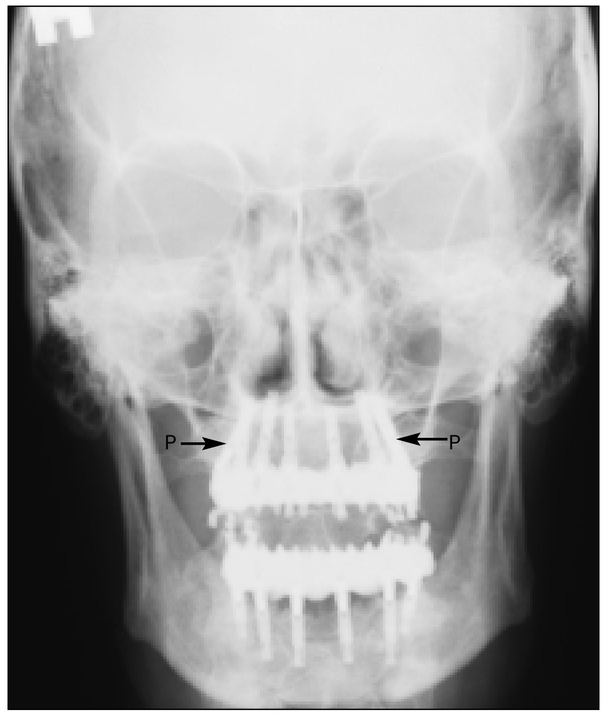


Fig 11 Posteroanterior radiograph of the same patient. Note that the implants that appear to be in the sinus (P) are tilted similarly to the maxillary molar palatal root.

around the implant. The patient reported tension and pain in the region at the time of fixed prosthesis connection and tightening.

Grafted Maxillae

Ten grafts were performed in 9 patients, and a total of 21 implants were placed into these grafts. Recipient site healing was uneventful in all patients. In 2 patients, suture dehiscence was seen at the donor site, with food impaction and the report of pain. Local treatment resulted in secondary healing. Standard 10- to 15-mm-long implants were used in these grafted maxillary sites. Firm implant stability was achieved in all of these patients. The mean observation period after prosthesis connection was 18 months (range 12 to 123 months). During the 1- to 10-year follow-up, neither significant radiographic changes of the bone close to the implants nor subjective impairment of masticatory function were noted.

DISCUSSION

The chewing ability of edentulous patients in which rehabilitation involves endosseous implants depends on proper implant distribution in the arch.[3,10] Where a normal maxillomandibular relationship exists, masticatory function takes place mainly in the premolar and molar regions. Control of prosthetic load distribution on the implants is essential for the establishment of appropriate functioning on a long-term basis for any type of prosthesis supported by endosseous implants. To achieve acceptable rehabilitation of chewing capacity, it is also important to provide adequate support for the prosthesis in the premolar and molar areas. Firm anchorage of the prosthesis in the posterior part of the maxilla or mandible will help normalize the chewing efficiency in the partially edentulous patient. While patients with severely atrophied completely edentulous arches may improve their chewing ability with a prosthesis fixed on anterior implants in combination with long cantilevers,[15] this method is less successful in patients with partially edentulous arches.[10]

Mandible

Frequently used implant placement methods in the mandible involve mandibular nerve transposition[4] and placement of short implants superior to the mandibular canal.[7,8] Mandibular nerve transposition can result in paresthesia of the area supplied by the mental nerve.[4] Damage of the mandibular nerve is also possible when short implants are placed superior to the canal. The use of short implants in the premolar and molar regions, where masticatory loading is significant, can offer insufficient support for the prosthesis. The 5-mm-wide Brånemark System implants may solve the problem in patients with a wide alveolar ridge crest in edentulous molar areas, assuming there is sufficient space above the mandibular canal. However, these implants may be supported by only a single cortex.[16] The mandibular nerve transposition technique, however, permits implant placement more posterior than implants placed above the mandibular canal.

Maxilla

Bone grafting from the iliac crest to the maxilla has been suggested.[12,17] This procedure usually requires hospitalization of the patient and may be associated with serious complications. The tilted implant approach solved a number of problems in these patients.[10] It was shown that fixed prostheses supported by tilted implants can be an excellent solution for patients in whom parallel placement of implants will not acceptably improve chewing capacity.

Ivanoff[16] recently showed that the stability of bicortically anchored implants is superior to the stability of an implant that is supported by only one cortex, as is the condition of an implant placed above the mandibular canal. However, optimal stability would be achieved by placing the implant along any cortical plate. Thus, the implant that is placed close to the anterior and posterior sinus walls, tangential to the palatal concavity in the maxilla, or close to the lingual cortex in the posterior mandible can be expected to provide acceptable support for fixed prostheses in areas of maximal occlusal loading.

Pterygoid Process

Softness of the tuberosity usually requires that the surgeon use spiral drills of a smaller diameter (3.0 mm). In this way, the stability of implants placed into the host site by condensing the bone during surgery could be improved.[16] Blunted standard implants were used because they could easily follow the canal in soft bone without displacement in an undesirable direction. In the cortical pterygoid plate, this small canal should ensure excellent implant stability. However, there is the risk that the implant can miss the entrance into the pterygoid plate canal and slide upward. This failure to enter the pterygoid plate canal occurred in one of the patients described in this material.

Sinus Walls

Placement of an implant close to and parallel with the inclined sinus wall is not difficult to perform under intrasinusal control as described above. Additional tilting of these anterior implants in the palatal direction would avoid collision of the implant with the roots of the first premolar or canine, since their roots are situated close to the buccal surface.

Palatally Tilted Maxillary Implants

Canal preparation and implant placement are similar for palatally tilted maxillary implants, posterior mandibular implants, and implants in the pterygoid region. Firm control under the entire drilling and implant placement process is necessary to prevent sliding of the drill or implant from the firm bone. The implant bed for palatally tilted implants consists of holes in the cortex on top of the alveolar ridge crest, penetrating the opposite side in the palate. Between these 2 holes, there is a semi-canal that consists of a firm cortex along the palatal side. This semi-canal is partially open toward the maxillary sinus. In case of pterygoid implants, the space between the firm holes, drilled in the cortex on top of the alveolar ridge crest and the pterygoid process, consists of soft trabecular bone. A similar situation exists in the posterior areas of the mandible, where the implant bed consists of holes in the cortex on top of the alveolar ridge crest and the opposite side, penetrating the mylohyoid line. Trabecular bone fills the space between these holes. On the lingual side, this implant is often placed very close to the lingual cortex of the mandible (Figs 1, 4, and 6).

Bone grafting of the maxillary sinus is a method commonly used in patients with severely resorbed posterior segments of the maxilla.[12,14,17] Despite the trend toward immediate loading of dental implants by definitive prosthesis connection,[18] more attention should be given to the possibilities of implant placement using the anatomic features of the arches, without the use of bone grafting procedures. Two of the patients in the present series received definitive fixed prostheses within 12 days after implant placement. In one of the patients, grafting of the maxillary sinuses with the donor site on the lateral sides of the mandible was performed 3 months before implant placement. In another patient, tilted implants were placed in both arches, as shown in Figs 10 and 11.

A method for expansion of the prosthetic base of the arches by the placement of tilted implants employing the anatomic features of the arch has been described previously.[3,10] Subsequently, clinical reconstruction of the occlusion prosthetically was achieved using this procedure. It was shown that tilted implants offered excellent support for prostheses and thus enhanced the possibility for simpler rehabilitation of patients with severely resorbed arches. Desirable tilting of implants in the premolar and molar regions may provide better load distribution on the implants.[15]

SUMMARY

The method described for the treatment of edentulous arches represents an alternative therapy to several others currently in use. The method of tilted implants offers the following advantages:

1. It provides further extension of the treatment possibilities for patients with severely resorbed posterior arch segments.
2. It is possible to use longer implants in areas of extreme masticatory loading because of the implant tilting.
3. The technique is simple.

The technique to apply will depend largely on the anatomy and the need for functional and esthetic rehabilitation. Angulated abutments, used in combination with tilted implants, can compensate for the angle of implant inclination against the occlusal plane. Otherwise, standard abutments or esthetic cones could be applied. However, posterior tilted implants usually result in less accessibility for the restorative dentist. Other than this inconvenience, there have been no specific problems with this procedure in this patient population. As far as maintenance is concerned, the patients initially seemed to have some problems with cleaning in all cases of posteriorly placed implants, which is similar to cleaning problems related to natural molars.

Reports of high survival rates of implants in completely edentulous arches are well documented.[19] In the present material, 3 maxillary implants were lost at second-stage surgery. Furthermore, the radiologic findings up to 123 months after prosthesis connection do not appear to differ from those seen at the time of abutment connection.

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