Anteriorly Tilted Implants in Maxillary Tuberosity: Avoiding the Maxillary Sinus

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Placing implants in the posterior maxilla is always a challenging situation, due to the fact that this region has compromised bone with decreased quantity and quality. Various alternatives have been proposed to solve these situations in posterior maxilla. Anteriorly tilted implants is an effective alternative or complementary technique to others mentioned in the literature. This article describes a clinical protocol for the use of anteriorly tilted implants in the maxillary tuberosity to extend fixed implant-connected prostheses further distally, and to reduce the length of cantilevers without performing bone grafting or sinus lifting.

Treatment of the posterior maxilla with implants is always a challenging situation. Compromised bone, with less quantity and poor quality is often present in this region, which can complicate implant placement and may compromise the prognosis of the clinical results. The presence of the maxillary sinus (which tends to enlarge over time) and limited vertical space are two other obstacles encountered when placing implants in this region. Loss of alveolar bone secondary to periodontal disease, tooth loss, or periapical disease further reduces the amount of available bone for implant placement.

Moreover, even though the first and second molars are the most commonly missing teeth[1] and are often the teeth lost initially in the development of a partially edentulous maxilla[2], the often insufficient residual bone volume makes implant placement posterior to the first premolar difficult.[3]

Although not indispensable, molars are important for masticatory reasons and may successfully be replaced with fixed prostheses supported by osseointegrated implants.[4]

Different therapeutic options have been described for the rehabilitation of the posterior maxilla when there is not enough bone availability (less than 7 mm) under the maxillary sinus.

The least intrusive solution is the use of short dental implants, but is not advisable in sites with poor bone quality.[5] There are some studies[6] suggesting good success rates for 7 mm implants in posterior jaws, but longer follow-ups are needed, and at present they are not a predictable technique in sites with less than 6mm of height availability. Biomechanically, short implants are also associated with increased mechanical problems.[7,8]

Distal cantilevers are another non-invasive option for the positioning of teeth in the absence of a fixed support. However, survival rates for implant-supported prostheses with long distal extensions (more than 15mm) are generally lower than for prostheses with short cantilevers, achieving even better results without cantilevers.[9,10] Cantilever length has been related to marginal bone loss

around implants and mechanical failure of the components[11], including screw loosening, mechanical fracture of implants or prosthetic components.

Bone compacting by the use of osteotomes is another treatment approach[1] but has limitations in the possible amount of bone volume to be gained. The maximum height gain is between 2 and 4.6 mm, depending on the previous residual bone height.[12]

Sinus lift grafting is another procedure that is well supported in the literature[13], but patient acceptance is relatively low due to the risk of increased site morbidity, the graft choice dilemma, postoperative discomfort, extended healing periods and costs.

Several authors have documented the clinical efficacy of tilting distal implants, placing them parallel to the anterior sinus wall and positioning the implant platform in a more posterior position[3,14,15]. The tilted implants can be anchored in the bone pyramid anterior to the maxillary sinus, where no anatomic vital structures, such as arteries or nerves, are present. Implantation following this approach makes it possible to extend the prosthetic support posteriorly, thus reducing cantilever arms. The favorable clinical outcomes in retrospective and prospective analyses of this technique imply that tilting does not negatively affect the outcome of implant therapy; rather, it appears that tilting allows for better prosthetic support due to larger inter-implant distances. Finite element analysis data regarding rehabilitation of the posterior maxilla reveals that tilting distal implants, rigidly splinted with a fixed denture, does not increase stress in the peri-implant bone and frameworks.[16]

One attractive approach when treating the posterior maxilla is to use anteriorly tilted implants into the tuberosity and the areas of the pterygoid process to overcome the sinus antrum obstacle.[15,17-19] In the literature, tilting of implants for engaging the pterygoid plate in the posterior maxilla is reported, indicating that this is a predictable procedure for establishing end support for a maxillary prosthetic restoration.[17,20-22]

The use of tilted implants moves implant support posteriorly and permits a longer distance between implants, allowing for the elimination of cantilevers in the prosthesis, which results in a better load distribution situation and provides satisfactory molar support for a fixed prosthesis. Angled implants also permit the use of significantly longer implants, which increases the degree of implant-to-bone contact area and also the implant primary stability. Another advantage is the placement of implants in residual bone, avoiding more complex techniques, such as sinus lifting and other grafting procedures.

The anatomy of the maxillary tuberosity[23,24] has its posterior boundary in the pyramidal process of the palatal bone. This process intervenes between the posterior-inferior surface of the maxilla and the anterior-inferior surface of the pterygoid laminae of the sphenoid bone. The medial portion of the process contains the lesser palatine canal and foramen, and immediately adjacent to the anterior edge is the greater palatine canal and foramen, which thus lie lingual and lateral to the tuberosity. The bone in this area is very cancellous, and when there is tooth loss secondary to periodontal disease, the bone is reabsorbed in a palatal direction, thus narrowing the tuberosity. The cortical bone is very thin and irregular, and it sometimes merges into the cancellous bone, which has an open and irregular distribution of the lamellae.

The clinical results[15] indicate that implant tilting does not induce any biological disadvantage. On the contrary, it seems to be both clinically and biologically advantageous, and a tilted implant as a member of a prosthesis configuration can be well justified from a biomechanical point of view.

The tilted implant must be placed in combination with at least one more implant in cases of partial edentulism and in combination with at least two more implants with cross-arch stabilization in cases of total edentulism.

The purpose of this article is to describe a clinical protocol for the use of anteriorly tilted implants in the maxillary tuberosity to extend fixed implant-connected prostheses further distally, and to reduce the length of cantilevers without performing bone grafting or sinus lifting.

Clinical Case

A 44 years-old male presented with the absence of the first and second upper premolars, as well as the second and third right upper molars. The first right upper molar had extensive subgingival destruction of its crown with no possibilities of restoration. Only 5-6 mm of bone were available under maxillary sinus, and after careful evaluation and diagnosis of the case, all the treatment alternatives previously described were proposed to the patient (Fig. 1).

Placing implants in the maxillary tuberosity requires the accurate diagnosis of the dimensions, morphology, and character of bone at the proposed site. This must be thoroughly evaluated in three dimensions, complementing the information of periapical radiographs with a computed tomography (CBCT).

Among the treatment options, the patient chose to rehabilitate his upper right zone with two implants (one of them mesially angled) and a four-unit PFM fixed partial denture.

One hour prior to surgery antibiotic prophylaxis with 2 g Amoxicillin, and Ibuprofen 600mg was administered. Local anesthetic (lidocaine 2% 1:100000 with epinephrine) was infiltrated in the posterior lateral side of the tuberosity and beyond the pyramidal process with a 45-degree angle at a depth of 1 to 2 cm, as well as at the level of the posterior and anteriorpalatal foramina.

First, the first maxillary right molar was extracted; a midcrestal incision was made from the pterygomaxillary notch

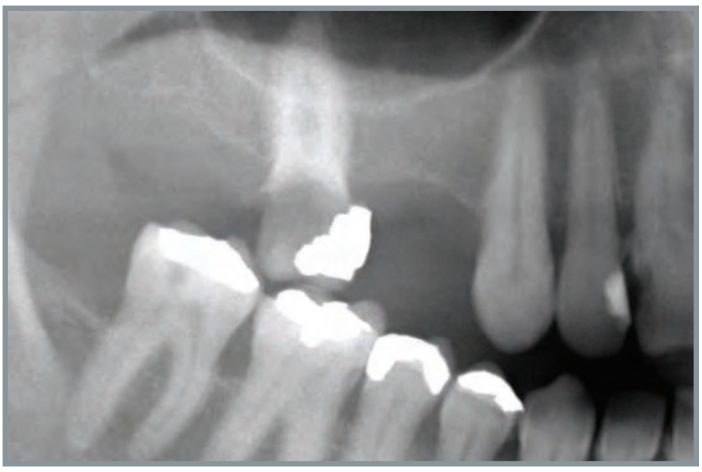

Figure 1 — Preoperatory radiograph. Note 5-6 mm of bone available under maxillary sinus. Enough bone availability in maxillary tuberosity.

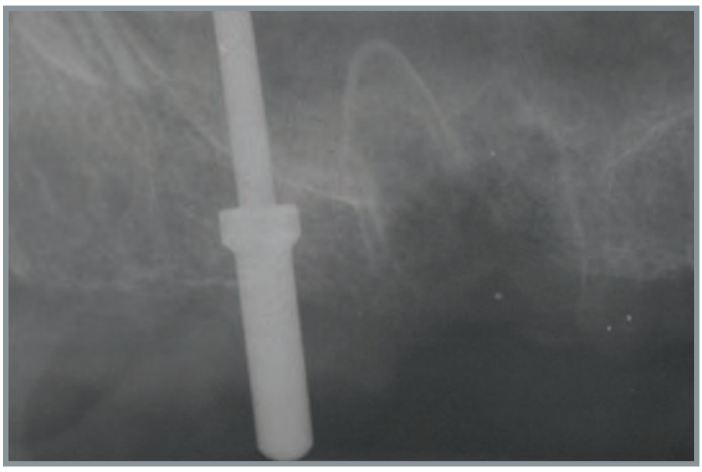

Figure 2 — Periapical intraoperative radiograph. The initial drill is not angled enough to avoid maxillary sinus.

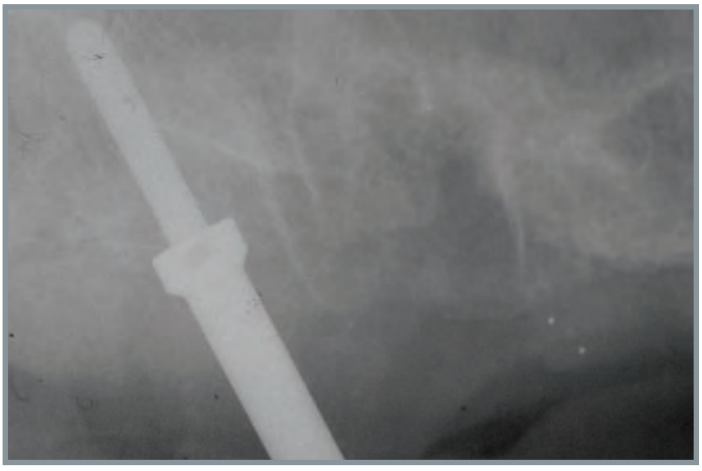

Figure 3 — Periapical intraoperative radiograph. The axis obtained with the initial drill is corrected.

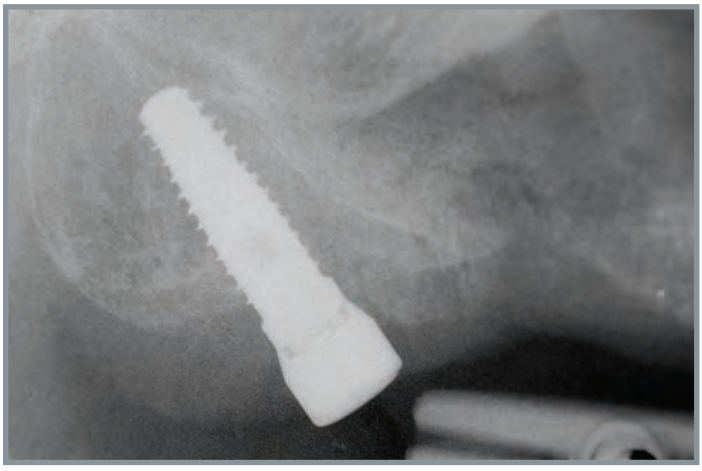

Figure 4 — Periapical intraoperative radiograph. Implant placed in maxillary tuberosity.

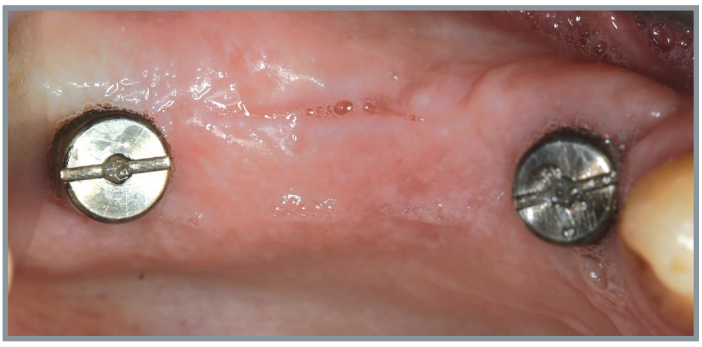

Figure 5 — Occlusal view after 3 months.

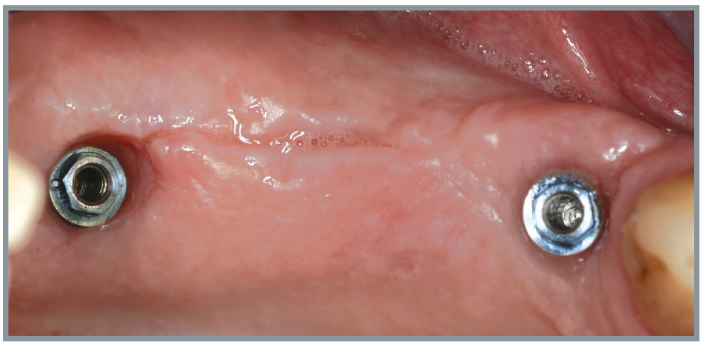

Figure 6 — Implants. Occlusal view.

to the premolar area. Small releasing vertical (buccal and palatal) incisions were also made at both ends of the crestal incision. Then the buccal and palatal flaps were carefully raised.

Implant sites were prepared in the place of upper first right premolar and mesially tilted in the maxillary right second molar. The mesial implant was placed before the distal one. The correct inclination of this tilted implant was evaluated intra-operatively with a periapical radiograph after the preparation of the first 5 mm depth with the initial drill (Fig. 2), correcting the angle if necessary until this first drill had the correct angulation (Fig. 3). Angulation is the most difficult aspect of the technique described, because an attempt is made to minimize the angulation as much as possible, but at the same time maintaining the drill within

Figure 7 — Pre-welded cast titanium framework. Occlusal view.

Figure 8 — Pre-welded cast titanium framework. Palatal view.

Figure 9 — Pre-welded cast titanium framework. Buccal view. Note the screwdrivers showing the axis of the implants.

Figure 10 — Pre-welded cast titanium framework. Buccal view.

Figure 11 — Pre-welded cast titanium framework. Apical view.

Figure 12 — Clinical fit test of the pre-welded cast titanium framework. Occlusal view.

the bone and avoiding the maxillary sinus, simulating the correct inclination of a natural third molar.

Bone infra-preparation is essential when implants are placed in compromised areas such as the tuberosity. The implant site must be as narrow as possible to allow implant insertion but prevent micromovements thereafter; otherwise, the implant has a decreased chance to integrate. To achieve stabilization, minimal and precise manipulation with the fewest possible entries is required. The tilted implant site in the tuberosity was slightly underprepared in full length to ensure high implant stability. The depth of the drilled site was measured with an appropriate depth gauge, and the integrity of the sinus membrane was verified. Countersinking was avoided in order to engage as much of the crestal bone as possible and to avoid damaging the cortical bone. Tapping was also avoided to allow the implant to achieve good initial stability. Two rough-surfaced acid-etched self-tapping tapered implants (Osseotite NT; Biomet 3i, Palm Beach Gardens, FL, USA) were placed with good primary stability after placement. Both of them were 4 mm wide, with the mesial having a 10 mm length, and the distal angled implant with a length of 13 mm (Fig. 4).

Flaps were then adapted and sutured around healing abutments. No provisional prosthesis was delivered. After 3 months osseointegration was achieved and the prosthetic phase began (Fig. 5). The mesial angulation of the distal implant will have a better passive fit than the distal one, so careful impressions of the implant platforms

Figure 13 — Clinical fit test of the pre-welded cast titanium framework. Buccal view.

Figure 14 — Titanium PFM implant prostheses. Buccal view.

Figure 15 — Titanium PFM implant prostheses. Occlusal view.

Figure 16 — Titanium PFM implant prostheses. Palatal view.

Figure 17 — Titanium PFM implant prostheses. Apical view.

Figure 18 — Titanium PFM implant prostheses. Clinical occlusal view.

Figure 19 — Titanium PFM implant prostheses. Clinical buccal view.

were taken (Fig. 6). Due to the decreased inter-occlusal space available in the second molar area, a screw-retained restoration was planned. In order to use machined abutments (avoiding casting burn-out abutments) and easily achieving a passive fit in this case, a titanium framework was casted and laser-welded to machined abutments[26,27] (Figs. 7-13) and then covered with ceramic (Figs. 14-17). Finally, a screw-retained four-unit titanium PFM fixed partial denture was delivered and placed on the implants (Figs. 18-21).

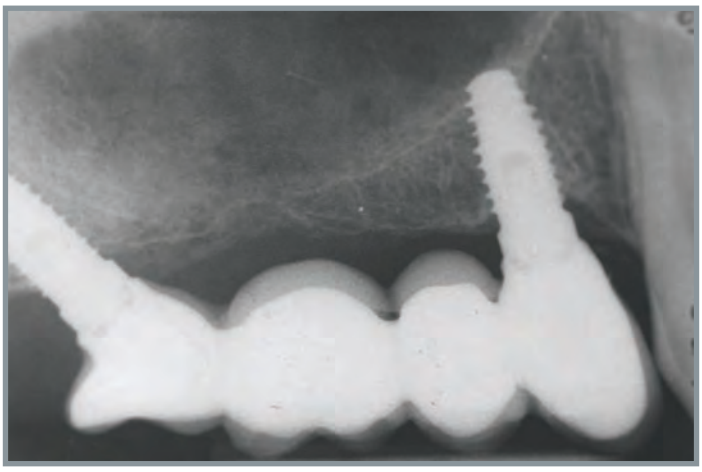

Figure 20 — Three-year control. Periapical radiograph.

Figure 21 — Three-year control. Clinical buccal view.

Conclusions

1. The results in the literature indicate that tilted implants are an effective alternative to the maxillary sinus bone grafting procedure. The method of tilting implants described represents an alternative or complementary technique to others mentioned in the literature.
2. More patients can be successfully treated with dental implants without more complex techniques, placing implants in the pre-existing bone. Anteriorly tilted dental implants placed in the maxillary tuberosity can avoid the compromised bone of the sinus antrum. Additional clinical advantages of this approach are the possibility of avoiding cantilever arms, and creating larger interimplant distances than the posteriorly tilted implants technique.
3. The treatment principle is to make the maximum use of the available bone, which simplifies treatment procedures, reduces surgical invasion and shortens treatment time compared to sinus lift procedures.
4. Surgical planning must be precise. The occlusal scheme must be carefully designed and executed, and the prosthetic phase must be previously planned to easily achieve passive fit, solving the different angulation of the implants.
5. The site preparation technique must adapt to the bone in the tuberosity: low-speed drilling technique and infra-preparation of the site for the implant must be performed, in order to respect the cancellous bone in this area, and to achieve good primary stability. ■

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