A Modified Surgical Protocol for Placing Implants in the Maxillary Tuberosity: Clinical Results at 36 Months After Loading With Fixed Partial Dentures

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The purpose of this study was to investigate the impact of a modified surgical protocol and the survival of implants placed in the posterior maxilla. Forty-two implants were placed in the maxillary posterior area of 29 partially edentulous patients (17 men, 12 women; mean age 50 years; range 38 to 62 years) according to the modified surgical protocol. Twenty-nine of these implants had been placed into the maxillary tuberosity. All implants were checked radiologically every 12 months with a customized film holder. The restorations were fixed partial prostheses. Only 1 of the 42 implants was lost at stage 2 surgery. Results suggest that considerable benefits may be obtained by modifying a standard surgical protocol to maximize the results for a particular anatomic site.

Key words: fixed partial prosthesis, maxillary tuberosity, modified surgical protocol, standardized radiographic follow-up

The maxillary arch has always been considered a challenging area for implant placement. The success rate for maxillary treatment has been reported to be lower when compared to that for mandibular treatment. Specific results of implants in the posterior maxilla reported by Adell et al had a success rate of 81%. Jaffin and Berman studied 44 patients with implants placed in the posterior maxilla and reported a failure rate of 44% for type IV bone quality. Bahat retrospectively studied 45 partially edentulous patients treated with implants that had been placed in the maxillary tuberosity and loaded with partial fixed dentures for an average of 21.4 months. The success rate reported was 93%. Balshi et al recently reported a failure rate of 13.7%; most failures occurred with implants longer than 13 mm. All published results were based on implants placed according to the standard Brånemark surgical protocol.

The particular quality of maxillary bone (thin cortical bone and large marrow spaces) and the presence of the maxillary sinus tend to complicate the use of implants in the maxilla (Fig 1). Furthermore, surgical access to the tuberosity is rather limited. Surgical techniques, such as sinus lifting, are not always practical because many patients are not willing to accept extended healing periods and the increased risk of complications. In general, patients tend to opt for prosthetic...
solutions more comfortable than removable partial dentures and more functional than cantilevered prostheses.

Based on these considerations, a modified surgical protocol for treatment of the posterior maxilla is proposed and described in the present study. The clinical advantages of this protocol are discussed.

**Materials and Methods**

The present study reports the specific results of 42 implants placed in 29 patients (17 men, 12 women; mean age 50 years; range 38 to 62 years) and loaded with fixed partial dentures for a mean period of 40 months (range 36 to 48 months). Of the 29 patients, 19 received a single implant in the tuberosity (Fig 2a), 7 received two implants (Fig 2b), and 3 received three implants (Fig 2c). Of the 42 implants, 29 were placed into the tuberosity; the other 13 were placed in the posterior maxillary area (Table 1). Forty-one implants were screw type (Implant Innovations, West Palm Beach, FL) and one was a cylindrical implant (Implant Innovations). The cylindrical implant was used because of the limited surgical access with the instrumentation used for placement of screw-type implants. The distribution of implants can be seen in Tables 2 and 3. The evaluation of types III and IV bone quality was done with preoperative radiographs, and it was confirmed at the time of surgery, according to the classification of Lekholm and Zarb. All implants were placed using the standard implant mount (3.0 mm).

**Anatomic Considerations.** The posterior border of the maxillary tuberosity is defined by the pyramidal process of the palatal bone, located between the posterior-inferior surface of the maxillary bone and the anterior-inferior surface of the pterygoid laminae of the sphenoid bone. 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 bone resorption that follows periodontal disease is directed toward the palatal side. Therefore, the position of the implant tends to be more palatal. Particular attention must be paid to the distance between the implant site and the opposing dentition; at least 35 mm must be available at the maximum opening for placement of the screw-type implant. Reduced space may cause excessive inclination, and it may limit surgical access with the risk of compromising primary stabilization. In this case, it is better to select a cylindrical implant, which requires reduced interocclusal distance for placement.

**Surgical Technique.** Local anesthetic (lidocaine with epinephrine 1:100,000) was infiltrated in the posterior lateral side of the tuberosity and beyond the pyramidal process with a 45-degree angulation at a depth of 1 to 2 cm (retrotuberal anesthesia). Anesthetic was also infiltrated at the level of the posterior and anterior palatal foramina. A crestal incision was made from the pterygomaxillary notch to the premolar area, using a No. 15 blade where a releasing vertical incision was also made. Then the buccal and palatal flaps were carefully raised.
The site was prepared with care to minimize drilling maneuvers. Drilling (Figs 3a and 3b) began with a 2.0-mm round drill at 1,500 rpm through the cortical bone. Next, a 2.0-mm twist drill at 500 rpm was used to the depth of the superior cortical plate. The depth of the drilled site was measured with an appropriate depth gauge, and the integrity of the sinus membrane was verified. If damage to the sinus membrane was revealed, a new more distal site was selected, and the described sequence was repeated. All subsequent drilling was done with internal irrigation drills. A pilot drill was then used to shape the hole entrance. After using a 2.5-mm shaping drill, a 3.0-mm trispade cylinder bur at 200 rpm was used until the predefined depth was reached. If the quality of bone (type III) allowed, a 3.3-mm triflute bur was used. Single-stroke drilling was always employed to avoid overextending the site in poor quality bone.

To avoid damaging thin cortical bone, countersinking was not used. Tapping was also avoided because of the particular quality of bone present. All implants were placed with standard implant mounts (3 mm). A self-tapping implant was first placed at 15 rpm. When even minimal instability was seen, the implant was removed and replaced immediately with a 4.0-mm-diameter implant without any further drilling. This technique was applied eight times in the study (Table 2). The cover screw was then positioned, and the flap was sutured with resorbable suture.

Prosthesis Considerations. After healing from surgical implant uncovering, all implants were restored with a reinforced acrylic resin provisional restoration for a minimum period of 6 months. The implants presented different situations regarding the opposing dentition: 7 were opposed by natural teeth; 4 were opposed by fixed partial dentures that had gold occlusal surfaces; 8 were opposed by fixed partial dentures that had ceramic occlusal surfaces; and 10 were opposed by removable partial dentures. No significant differences associated with the type of opposing dentition were noted. No direct contact was permitted between the distal implant and the opposing arch. In one patient, a mandibular third molar was specifically removed for this purpose (Figs 4a and 4b).

Results
During the healing phase, no implants were lost. Second-stage surgery was performed after 6 to 8 months, and a healing abutment was connected to the implant. If the thickness of the soft tissues exceeded 3 mm, surgical reduction was performed.

After 2 weeks, an abutment was placed, but not before each implant had been tested for stability and sensitivity using a countertorque force of 10 Ncm, as described by Sullivan,18 delivered by an electronically controlled device. At this time, one of the patients with three implants in the posterior maxillary area showed slight mobility and pain during testing of the buccal side of a 4.0-mm-diameter, 10-mm-long implant. This particular implant was removed immediately without replacement, and the connection was made to the other remaining implants (the
palatal side and the inside tuberosity implant). This was the only implant lost in the entire study.

The baseline for future radiographic comparisons was the day of the placement of the final restoration. Every 12 months, periapical radiographs were obtained and checked for marginal bone loss. A custom-made film holder was prepared for each patient (Figs 5a and 5b) to maintain a constant position for the long-term follow-up (Figs 6a and 6b). In the first year, the patients were examined every 3 months for occlusal control and hygiene. A minimum 36-month follow-up was carried out for all patients.

Except for the 4.0-mm-diameter, 10-mm-long implant removed before abutment connection, no other implant was lost, resulting in a cumulative survival rate of 97.6%. Longitudinal radiographic 36-month follow-up showed changes in marginal bone height for the osseointegrated implants, largely within the criteria proposed by Albrektsson et al.

Discussion
The clinical and radiologic results of this study are very encouraging and invite further testing of the proposed protocol.

**Modified Surgical Protocol.** The proposed variations in the standard Brånemark protocol are aimed at minimizing surgical trauma to the bone in an already difficult treatment area. In particular, the choice of internally irrigated drills to cool the bone was made because external irrigation is rather difficult to use in the posterior region of the mouth, and it is poorly tolerated by patients with an exaggerated gag reflex. Reduced speed of instrument rotation and the reduction of drilling time are necessary to reduce the amount of heat generated. Moreover, the one-stroke drilling technique is important because the quality of the bone does not tolerate excessive drill reentries. Too much drilling can cause an excessive enlargement of the implant site, thus compromising the primary stability. All 4.0-mm-diameter implants used were replacements for 3.75-mm-diameter implants, which showed insufficient stability immediately after placement. The specific drilling sequence and recommended speed are crucial not only for the reduction of frictional heat, but also for maintaining the integral shape of the drilled site. When placing implants, the standard (3-mm) implant mount is preferred to further reduce leverage.

**Biomechanical Factors.** The occlusal forces developed in the molar region are very high (300 to 400 N). To effectively counter these forces and to also achieve optimum primary stabilization, the longest possible implants were used. Special efforts were made to engage the upper cortical plate with the apex of the implant (bicortical support). No single short implants (10 mm) were placed in any other patients. In patients in whom bicortical support was not achievable, more than one implant was placed.
From a biomechanical point of view, implants in the maxillary tuberosity should not be restored with distal cantilevers to avoid their inherent risks. Moreover, inclination of the implants was reduced as much as possible. Most of the implants in the study had an angulation of less than 30 degrees with respect to the occlusal plane. This minimizes potentially injurious horizontal forces. The importance of the inclination factor is illustrated in Fig 7, which shows that with an angulation of 45 degrees, 50% of the load is transmitted horizontally.

Prosthodontic design may also play a role in the final success. All of the distal implants considered in the study were purposely left out of occlusion to reduce the amount of force on these implants.

Conclusions
Modification of the classic Brånemark surgical protocol seems to be effective in reducing the high failure rates (usually during stage 2 surgery) for implants placed in the maxillary tuberosity. Fundamentals of the proposed method are:

1. A modified surgical protocol should be followed to adapt the technique to the particular anatomic site.
2. Maximum primary stability is attained through the use of long implants and bicortical support.
3. A strict prosthodontic protocol, including the use of a provisional restoration for at least 6 months, should be followed.

In the present study, the use of implants in the tuberosity to support a fixed partial denture was demonstrated to be a reliable, predictable alternative to distal cantilever prostheses or sinus-lifting procedures. Only one of 42 implants loaded for a minimum of 36 months was lost at stage 2 surgery. Further study is required on a wider range of patients to verify the significance of the proposed protocol. Preliminary results from this study seem to suggest that considerable benefits can be obtained by adapting a specific standard surgical protocol to the quality of the bone types found in the area to be treated.

Acknowledgments
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### Table 1: Distribution of Implants in Different Anatomic Sites

<table>
<thead>
<tr>
<th>No. of implants per patient</th>
<th>Maxillary posterior area</th>
<th>Maxillary tuberosity area</th>
<th>Total</th>
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<tbody>
<tr>
<td>One implant</td>
<td>0</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Two implants</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Three implants</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>29</td>
<td>42</td>
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### Table 2: Distribution of Implant Design and Length

<table>
<thead>
<tr>
<th>Length (mm)</th>
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<th>13 mm</th>
<th>15 mm</th>
<th>18 mm</th>
<th>20 mm</th>
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<tr>
<td>Self-tapping</td>
<td>3</td>
<td>8</td>
<td>13</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Standard 4.0 mm</td>
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<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cylindrical</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>10</td>
<td>16</td>
<td>8</td>
<td>2</td>
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### Table 3: Distribution of Patients Based on Number of Implants and Bone Quality

<table>
<thead>
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<th>Type 3</th>
<th>Type 4</th>
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</thead>
<tbody>
<tr>
<td>Patients</td>
<td>Implants</td>
<td>Patients</td>
</tr>
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<td>11</td>
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<tr>
<td>Two implants</td>
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<td>6</td>
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<tr>
<td>Three implants</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>26</td>
</tr>
</tbody>
</table>
Fig. 1 Section of tuberosity area: cancellous bone with its open and irregular distribution of the lamellae.

Fig. 2a Periapical radiograph of patient with only one implant in the maxillary tuberosity at the time of abutment connection.

Fig. 2b Panoramic radiograph of patient with two implants in the posterior maxillary area. One of the implants was placed
into the tuberosity at healing abutment connection.

**Fig. 2c** Periapical radiograph of patient with three implants in the posterior maxillary area. One of the implants was placed into the tuberosity at the time of the intermediate substructure connection.
Fig. 3a Sequence of the drills

and burs used in the surgery protocol.
Fig. 3b Drills and burs used (from left): 2-mm round drill; 2.0-mm twist drill; pilot drill; 2.5-mm shaping drill; 3.0-mm trispade drill; and 3.3-mm triflute bur.

Fig. 4a Preoperative panoramic radiograph. The mandibular third molar is still in place.
Fig. 4b Panoramic radiograph of the same patient in Fig 4a after treatment. The mandibular third molar has been removed.

Figs. 5a and 5b (Left) Film plastic holder customized with autopolymerizing resin. (Right) The same film holder positioned in the mouth.
Periapical radiographs from one patient. *(Left)* Twelve months after loading with fixed partial denture. *(Right)* Thirty-six months after loading with fixed partial denture.

Fig. 7 Load distribution (Newtons) between vertical and horizontal forces according to different inclinations of implants (Vf = vertical force, Hf = horizontal force).