Bone Level Changes in Patients With Transmandibular Implants

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Purpose: In this article, the mandibular bone height in edentulous patients previously treated with a transmandibular implant was evaluated after the dentures were modified according to the latest prosthetic protocol.

Patients and Methods: The bone height of 36 patients was measured on three radiographs; the first at the time of insertion of the implant, the second just before using the latest prosthetic protocol, and the third 1 year later.

Results: A slight bone increase at the lateral posts and at the cortical screws mesial to these posts was measured. No significant bone increase was found above the lateral cortical screw.

Conclusion: The bone increase that is found in this study was not of the extent indicated in earlier reports.

Edentulous jaws show resorption of bone that continues for many years. The mandible, for instance, has an average bone loss of 0.2 mm per year for 10 to 25 years after extraction. Implants seem to reduce the amount of bone loss. In several studies on patients treated with fixed bridges attached to four to six Brånemark implants, bone resorption of an average of 1.0 mm during the first year and 0.1 mm during the following years was reported. With respect to the transmandibular implant, however, bone increase has been reported. In a recent study, an increase in bone height varying from 77% to 225% distal of the lateral posts of the implant was reported in more than 90% of the patients. This increase was thought to be the result of a bending moment developed posterior to the baseplate during function. The rigid box frame structure of the implant should direct the chewing forces through the superstructure and transosseous posts to the inferior border of the mandible, creating a caudally directed tracional force in the symphyseal area of the mandible. This force, combined with the cranially directed forces in the mandibular angle region, produced by the masseter, medial pterygoid, and temporalis muscles, should result in a bending moment along the lateral extensions of the baseplate, leading to bone apposition in the superior part of the mandible.

To achieve this bone increase a special prosthetic protocol has to be followed. This protocol involves a triple bar with cantilever extension on both sides, full coverage of the retromolar pad by the mandibular denture, relieving of the denture-bearing area distal to the lateral transosseous posts, a limitation of the number of (pre)molars, and a linguallized occlusion concept.

In the Department of Oral and Maxillofacial Surgery in cooperation with the Department of Oral Function and Prosthetic Dentistry, we started treatment of edentulous patients with transmandibular implants in 1987. In the beginning we followed the prosthetic protocol usual performed for overdentures supported by implants. This meant that the denture-bearing area was not relieved posterior to the transosseous posts. To investigate whether it was possible to obtain similar results of bone growth in our patients, we decided to fully adjust the dentures of this group of patients according to the new prosthetic protocol and to evaluate the changes in bone level.
Patients and Methods

Seventy-six patients were treated with a transmandibular implant between 1987 and 1993. Of these, 30 patients were included in another research protocol and therefore excluded from this study. Another 10 patients were lost to follow-up because of the following reasons: deceased (n = 3), removal of the implant because of complications (n = 4), or moving to another part of the country (n = 3). Thirty-six patients remained, with an age varying from 34 to 82 years (average, 60 years), consisting of 4 men and 32 women. The postoperative follow-up at the time of the adjustment (period I) varied from 1 to 6 years, with a mean of 2.3 years. The second evaluation was 12 months later (period II).

All patients had received dentures with cantilever extensions, full coverage of the retromolar pad, limitation of the number of (pre)molars, and a lingualized occlusion concept. However, a special relieving gap between the denture base and the oral mucosa, was not made at that time. In September 1993, we adjusted the mandibular denture according to the new protocol. During the following year the patients were seen twice for checkups. If contact had developed between the denture-bearing area posterior to the lateral posts and the oral mucosa, it was not made at that time. In September 1993, we adjusted the mandibular denture according to the new protocol. During the following year the patients were seen twice for checkups. If contact had developed between the denture-bearing area posterior to the lateral posts and the oral mucosa during the period between checkups, a new space of at least 1 mm between the denture base and the mucosa was created. This gap was visualized using impression material (Fit Checker, GC Dental Products Corporation, Tokyo, Japan).

The bone condition was documented by panoramic radiographs, made directly after the implant insertion (T0), at the time of the adjustment of the denture (T1), and a year later (T2). A digital millimeter calliper (Mitutoyo digimatic callipers) was used for the measurements on the radiographs. The shortest distance between the cranial and caudal borders of the mandible were measured through the center of the fixation screws at R4, R2, L2, L4, and distally to the lateral posts R3 and L3 (Fig 1). If no distinct cortical bone outline was visible on the caudal border, the cranial border of the baseplate was used as the caudal measuring point. All measurements were performed twice on two separate occasions. The duplicate measurement error was found to be 0.3 mm. In five patients, it was not possible to measure the bone height at all positions in all three radiographs because of missing posts or cortical screws. These posts and screws were removed because of complications during the research period.

Calculation of the enlargement factor was done for right and left sides of all radiographs separately. The enlargement factor was \( T \) divided by \( 1.25 \times S \) with \( T \) representing the measured distance between the highest and lowest thread surrounded by bone at posts R3 and L3; \( S \) representing the number of threads surrounded by bone — 1; 1.25 mm in this formula was the actual distance of a thread. The actual height of the bone at the same place would then be the measured bone height divided by the enlargement factor.

The differences between the measurements on the radiographs taken at times T0, T1, and T2 were calculated, representing the changes in bone heights in period I \( (T_1 - T_0) \), period II \( (T_2 - T_1) \) and both periods \( (T_2 - T_0) \). For the statistical analyses, the measurements of the right and the left sides were taken together and analyzed using \( t \)-tests.

Results

Table 1 shows the mean heights of the mandibles at the right and left posts (location R3/L3) measured on the radiographs at \( T_0 \) and corrected for the enlarge-

<table>
<thead>
<tr>
<th>Location</th>
<th>R4/L4</th>
<th>SD</th>
<th>R3/L3</th>
<th>SD</th>
<th>R2/L2</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period I</td>
<td>( (T_1 - T_0) )</td>
<td>0.06</td>
<td>0.44</td>
<td>0.04</td>
<td>0.57</td>
<td>0.18</td>
</tr>
<tr>
<td>Period II</td>
<td>( (T_2 - T_1) )</td>
<td>0.17</td>
<td>0.47</td>
<td>0.23*</td>
<td>0.55</td>
<td>0.19</td>
</tr>
<tr>
<td>Period I + II</td>
<td>( (T_2 - T_0) )</td>
<td>0.28</td>
<td>0.77</td>
<td>0.34</td>
<td>0.91</td>
<td>0.42†</td>
</tr>
</tbody>
</table>

* Significant bone increase; \( P < .05 \).
† Significant bone increase; \( P < .01 \).
ment. The mean height of the entire group was 8.2 mm, with a standard deviation of 2.4 mm.

The mean values of the bone height changes and the standard deviations during periods I, II, and I + II are presented in Table 2. In all locations the values were positive. No significant differences between locations were found in period I. In period II, a significant difference (P < .05) was found at the lateral post (locations R3/L3). Over both periods (I + II), a significant difference (P < .01) was measured at the medial cortical screws (locations R2/L2).

The patients were divided in two groups: one group with mandibular bone heights lower than 8 mm, and the second with mandibular bone heights higher than 8 mm, both measured at the lateral posts. The values of the bone height changes are presented in Tables 3 and 4. Significant bone level changes were found in the group with bone height lower than 8 mm at the same locations as in Table 2.

**Discussion**

Measurement of differences in bone heights on radiographs has its limitations. The position of the mandible cannot be reproduced reliably at different times. Furthermore, variations in voltage and amperage, as well as in the developing process of the film, can occur. This can lead to a high error of measurement within each radiograph. However, other x-ray imaging techniques, for instance, the long cone technique, are difficult to perform in severely resorbed mandibles because of the hindrance of the tongue muscles and the genial tubercle. To correct for the differences in enlargement caused by the limitations in positioning of the mandible in "plane of focus" of the x-ray machine, the enlargement factors were calculated separately for the right and the left side of each radiograph, and all heights were corrected for these enlargements.

The heights of the mandibles, measured at the start of the study (Table 1), indicate that it was a group of patients with extremely resorbed mandibles. Fifty-five percent of the patients have a mandible lower than 8 mm in height at the lateral posts, as measured on the radiograph. In this respect, these patients were comparable to the group of patients treated in previous studies.

In this study, an increase in bone height varying from 0.04 and 0.42 mm average was measured over the first period (Table 2). This is in contrast with other studies, in which losses of 1 mm in the first year after implantation and 0.1 the following years have been reported by some authors. The reason for our results may be that in the other studies more patients with high ridges may have been included.

The increases were only significant at the lateral posts in period II and at the medial cortical screws in period I + II. From the data presented in Tables 3 and 4, it can be concluded that significant changes were especially present in the extremely resorbed mandibles (bone height less than 8 mm). Our results do not confirm the theory that significant bone increase will occur above the lateral cortical screw. Another factor that might explain the increase in bone could be the elevation of the perioosteum by the threads of posts and cortical screws during the surgical procedure. This would, however, give a bone change mainly in the period directly after the operation and not at a later time, as we found, and mainly in the area between the posts. The actual bone increase that was found was in the magnitude of tenths of millimeters. One clear positive measurement of 1.7 mm that was found in our study at the lateral cortex screw in the first period was attributed to a healed fracture near the lateral post, sustained and treated shortly after placement of the implant. Previous studies, however, reported on several millimeters of bone increase. To which mechanisms one can attribute this phenomenon is still to be investigated. It can be concluded, however, that in our cases no spectacular bone increase was found after treatment of patients with a transmandibular implant using a special prosthetic protocol to enhance bone formation.

**Table 3. Changes in Bone Height for the Group With a Mandible Lower Than 8 mm (N = 20)**

<table>
<thead>
<tr>
<th>Location</th>
<th>R4/L4</th>
<th>R3/L3</th>
<th>R2/L2</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period I</td>
<td>(T1-T0)</td>
<td>0.23</td>
<td>0.48</td>
<td>0.13</td>
</tr>
<tr>
<td>Period II</td>
<td>(T2-T1)</td>
<td>0.30</td>
<td>0.53</td>
<td>0.40</td>
</tr>
<tr>
<td>Period I + II</td>
<td>(T2-T0)</td>
<td>0.57</td>
<td>0.97</td>
<td>0.47</td>
</tr>
</tbody>
</table>

* Significant bone increase; P < .05.

**Table 4. Changes in Bone Height for the Group With a Mandible of More Than 8 mm (N = 16)**

<table>
<thead>
<tr>
<th>Location</th>
<th>R4/L4</th>
<th>R3/L3</th>
<th>R2/L2</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period I</td>
<td>(T1-T0)</td>
<td>-0.06</td>
<td>0.38</td>
<td>-0.05</td>
</tr>
<tr>
<td>Period II</td>
<td>(T2-T1)</td>
<td>0.06</td>
<td>0.40</td>
<td>0.04</td>
</tr>
<tr>
<td>Period I + II</td>
<td>(T2-T0)</td>
<td>-0.04</td>
<td>0.23</td>
<td>0.14</td>
</tr>
</tbody>
</table>

**References**


