The Effect of Inter-Implant Distance on the Height of Inter-Implant Bone Crest*


Background: The biologic width around implants has been well documented in the literature. Once an implant is uncovered, vertical bone loss of 1.5 to 2 mm is evidenced apical to the newly established implant-abutment interface. The purpose of this study was to evaluate the lateral dimension of the bone loss at the implant-abutment interface and to determine if this lateral dimension has an effect on the height of the crest of bone between adjacent implants separated by different distances.

Methods: Radiographic measurements were taken in 36 patients who had 2 adjacent implants present. Lateral bone loss was measured from the crest of bone to the implant surface. In addition, the crestal bone loss was also measured from a line drawn between the tops of the adjacent implants. The data were divided into 2 groups, based on the inter-implant distance at the implant shoulder.

Results: The results demonstrated that the lateral bone loss was 1.34 mm from the mesial implant shoulder and 1.40 mm from the distal implant shoulder between the adjacent implants. In addition, the crestal bone loss for implants with a greater than 3 mm distance between them was 0.45 mm, while the implants that had a distance of 3 mm or less between them had a crestal bone loss of 1.04 mm.

Conclusions: This study demonstrates that there is a lateral component to the bone loss around implants in addition to the more commonly discussed vertical component. The clinical significance of this phenomenon is that the increased crestal bone loss would result in an increase in the distance between the base of the contact point of the adjacent crowns and the crest of bone. This could determine whether the papilla was present or absent between 2 implants as has previously been reported between 2 teeth. Selective utilization of implants with a smaller diameter at the implant-abutment interface may be beneficial when multiple implants are to be placed in the esthetic zone so that a minimum of 3 mm of bone can be retained between them at the implant-abutment level. J Periodontol 2000;71:546-549.

KEY WORDS
Dental implants; dental implantation; bone loss; alveolar bone; papilla.

The existence of the biologic width around teeth has been documented in the literature. It was a study by Gargiulo et al.1 in 1961 that gave us a dimensional understanding of this physiologic attachment apparatus. The average distance from the base of the sulcus to the crest of the bone was found to be 2.04 mm. The epithelial attachment averaged 0.97 mm and the connective tissue attachment averaged 1.07 mm in length. Another cadaver study by Vacek et al.2 in 1994 confirmed the consistency of these dimensions while showing the connective tissue attachment to average 0.77 mm and the epithelial attachment to average 1.14 mm.

The presence of a biologic width around implants has also been investigated. Multiple research groups have verified that a biologic width also exists around implants.3-8 This is true for implants of all shapes after uncovering (stage 2) surgery. For 1-piece non-submerged implants4,7,8 or 2-stage implants used with a single-stage non-submerged protocol, the biologic width will form at the time of implant placement. This phenomenon is not related to loading and it will occur whether the implant is unloaded or loaded.7

The biologic rationale is that the bone exposed to the oral cavity will always cover itself with periosteum and connective tissue. Additionally, connective tissue will always cover itself with epithelium. If a chronic irritant, such as bacteria, reaches the implant-abutment interface through screw-access channels,9-12 or if the abutment is removed after initial healing,5 the bone will resorb to create a distance from this chronically exposed or irritated area. Tarnow et al.13 have previously histologically documented a similar bone response to subgingival crown preparations that violate the attachment apparatus on human teeth.
Two-stage implants are usually placed at or near the crest of bone. Once they are uncovered, an implant-abutment interface is established and the bone resorbs about 1.5 to 2.0 mm apically. This vertical bone loss has been well researched. The purpose of this paper was to evaluate the lateral bone loss at the implant-abutment connection and to see if this lateral dimension has an effect on the height of the crest of bone between 2 implants separated by different distances.

MATERIALS AND METHODS
Thirty-six patients were utilized for this radiographic study. These patients were part of a longitudinal study conducted at the New York University Department of Implant Dentistry on machined titanium implants. Radiographic measurements were taken at a minimum of 1 and a maximum of 3 years after implant exposure. Only areas with 2 adjacent implants were utilized for this study. All radiographs were taken with a parallel technique utilizing a customized XCP bite block as a positioning index for consistency and reproducibility of the radiographic images. The radiographs were computer scanned, imaged, and magnified for measurement. Figure 1 illustrates the measurements taken for this study.

The lateral distances from the crest of the inter-implant bone to the implants were recorded (A and B in Fig. 1). In addition, the radiographs were divided into 2 groups: those where the inter-implant distance (D in Fig. 1) was 3 mm or less, and those where the inter-implant distance was greater than 3 mm.

RESULTS
The lateral distance from the implant to the crest of the ridge was 1.34 mm (SD = 0.36 mm) for A and 1.40 mm (SD = 0.60) for B. The crestal bone loss (C) for implants with a 3 mm or less distance between them (as measured by D) was 1.04 mm, while the crestal bone loss (C) for implants that were more than 3.0 mm apart was 0.45 mm. These data are presented in Table 1.

DISCUSSION
These findings demonstrate two important facts. The first is that there is a lateral component to the bone loss after abutment connection of a 2-stage implant. The second is that this lateral component of bone loss can result in greater inter-implant crestal bone loss if the two implants are not spaced more than 3 mm apart (measurement D). The lateral dimension of the defect is readily observed in Figures 2 and 3.

Table 1.
Recorded Data for Lateral and Crestal Bone Loss (see Figure 1)

<table>
<thead>
<tr>
<th>Lateral A (n = 36)</th>
<th>Lateral B (n = 36)</th>
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<tbody>
<tr>
<td>Mean 1.34</td>
<td>1.40</td>
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<tr>
<td>SD (±) 0.36</td>
<td>0.60</td>
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<tr>
<th>Crestal D ≤3 mm (n = 25)</th>
<th>Crestal C &gt;3 mm (n = 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.04</td>
<td>0.45</td>
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In 1978 Waerhaug\textsuperscript{14} demonstrated that there was a 1.78 mm distance between plaque on teeth and the surrounding bone. In addition, in 1984 Tal\textsuperscript{15} examined the presence or absence of intrabony defects when roots were at different distances apart. It is interesting to note that the minimum distance between roots for 2 separate angular defects to be present on adjacent teeth was 3.1 mm. In other words, the lateral aspect of each angular defect appears to be at least 1.55 mm on each root. This distance correlates with the present finding of 1.34 mm and 1.40 mm of bone loss (Fig. 1A and B, respectively) in the lateral direction from an implant to the crest of bone.

Separating the data into 2 groups, with the inter-implant distance of the first group being 3 mm or less and that of the second group being greater than 3 mm, was based on the hypothesis that 2 adjoining implants with 3 mm or less of separation should have increased inter-implant bone loss as a result of the horizontal distance that bone will be lost on each side of the inter-implant crest. The scatter graph shown in Figure 4 demonstrates the clear trend of increased crestal bone loss as the inter-implant distance decreases.

\textbf{CONCLUSIONS}

This paper demonstrates that there is a lateral component to the bone loss around implants once the biologic width has formed.

The clinical significance of this phenomenon is that the increased crestal bone loss results in an increase in the distance between the base of the contact point of the adjacent crowns and the crest of bone. This could determine whether the papilla will be present or absent between 2 implants, as has been reported by Tarnow et al.,\textsuperscript{16} between 2 teeth. In that study, a small difference of 1 mm was clinically significant. When the distance from the contact point to the crest was 5 mm, the papilla was almost always present. When this distance increased to 6 mm, the papilla completely filled the embrasure space in only 55\% of the observed cases.

It is commonly observed that it is more difficult to maintain or create a papilla between 2 adjacent implants than it is to maintain or create the papilla between an implant and a natural tooth. This may indicate that the selective utilization of implants with a smaller diameter at the implant-abutment interface may be beneficial when multiple implants are to be placed in the esthetic zone so that a minimum of 3 mm of bone can be retained between them at the implant-abutment level. It may also indicate that wide-bodied implants adjacent to one another may be of limited use in the esthetic zone, since they would diminish the inter-implant distance and potentially lead to increased crestal resorption. Measurements are presently underway to evaluate whether the papillae are affected by this crestal resorption between adjacent implants.

\textbf{REFERENCES}


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