Estimation of the Safe Distance Between the Implant and an Adjacent Tilted Implant Using Trigonometry

Farideh Geramipanah, DDS, MS
Leyla Sadighpour, DDS, MS*

INTRODUCTION

The tilted implant was developed to overcome the problems associated with inserting an implant in a posterior resorbed mandible or posterior maxilla with limited bone height. Overall cumulative 3-year success rates of over 90% have been reported for axial and tilted implants. The cantilever length may be reduced by posterior tilting of a distal implant on each side, resulting in better load distribution. Tilting may also allow for increased implant length and improved anchorage, thus better primary stability.

The recently developed All-on-4 system (Nobel Biocare, Gothenburg, Sweden) provides edentulous patients with a fixed prosthesis utilizing an optimum number of 4 implants which are immediately loaded by the interim prosthesis. In this protocol 2 distal implants are tilted posteriorly about 30° or 45° relative to the vertical plane followed by 2 implants placed in more anterior positions. Correct angulation and optimum position of implant placement is assisted by the All-on-4 surgical guide which is placed into a 5- to 10-mm deep osteotomy site made at the midline of the edentulous arch (Figure 1). Since the anterior implants are placed vertically, they must be placed as far apart from posterior implants to avoid interference between the apices. When a computerized tomography (CT) or cone-beam CT is not planned, the safe distance between the 2 implants could be addressed by the following technique, which presents a simple solution to estimate the safe interimplant distance or fixture length of an anterior and posterior implant, to avoid conflict between the apices.

TECHNIQUE

(1) Draw a triangle by connecting lines A, D, and P between the outer surfaces of the 2 implants (Figure 2), where A, D, and P represent the anterior implant length, distance between the implant necks, and the posterior implant length, respectively.

(2) Apply the sine rule, which defines the relationship between A, D, and P as follows:

\[ \frac{\sin \alpha}{A} = \frac{\sin \beta}{D} = \frac{\sin 90^\circ}{P} \]

where \( \beta \) is the angulation of the tilted implant (30° or 45° in most instances for an All-on-4 system).

(3) Solve the above equation for any unknown variables. For instance, with a length of 18 mm for the tilted implant and an angulation of 30°, the second implant in a distance of 9 mm should just touch the...
posterior implant in the apical part, according to:

\[
\frac{\sin 30}{D} = \frac{\sin 90}{P} = \frac{1}{18}
\]

\[D = 0.5 \times 18 = 9\text{mm}\]

If the implant site is planned in advance, the length of the anterior implant that should be observed can be determined by solving equation (1) with \(A\) as an unknown variable and \(P\), \(\alpha\), and \(\beta\) as known variables. Therefore, the anterior implant should be placed in a distance no closer than 9 mm plus a minimum safe zone distance of 1 mm or must be shorter than 15 mm to miss the posterior implant apex. Some frequent values are calculated and summarized in the Table.

![Figure 1](image1.png)

**Figure 1.** Simulation of All-on-4 surgical guide in place. Each scored section forms a rectangle 10 mm in height and 7 mm in width. Therefore, the diameter of the rectangles indicates the angulation of 35° (\(\tan^{-1} 0.7\)). The direction defined in black indicates 45°. Grading the upper edge enhances accuracy in placing tilted implant.

![Figure 2](image2.png)

**Figure 2.** The sides of the triangle are the distance between and the lengths of the 2 implants. Beta is the angulation of the tilted implant.

<table>
<thead>
<tr>
<th>Angulation</th>
<th>Length of Tilted Implant, mm</th>
<th>Critical Distance, mm*</th>
<th>Critical Length of Vertical Implant, mm†</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
<td>18</td>
<td>9.0</td>
<td>15.6</td>
</tr>
<tr>
<td>35°</td>
<td>18</td>
<td>10.3</td>
<td>14.7</td>
</tr>
<tr>
<td>45°</td>
<td>18</td>
<td>12.7</td>
<td>12.7</td>
</tr>
</tbody>
</table>

*Minimum of 1 mm of safe zone should be added to avoid interference of apices.
†The vertical implant must be shorter than the quoted values if the measured interimplant distance could not be observed.

**Summary**

A trigonometry ratio was developed to estimate a 2-dimensional safe distance between a tilted implant and an adjacent vertical implant. The distance or length between the fixtures can be determined by multiplying the known length of each implant by a constant derived from the sin of the insertion angle.

**Abbreviations**

CT: Computerized tomography

**References**