Classification of Maxillary Central Incisors—Implications for Immediate Implant in the Esthetic Zone

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Purpose: This is the first study to analyze the positions and angulations of the central maxillary incisors with reference to the alveolus, providing data for clinicians to achieve good esthetic results for immediate implant placement in the esthetic zone.

Materials and Methods: A total of 300 cone beam images were selected randomly. Five aspects were measured: the thickness of the palatal and buccal bone at their mid-root and apical level and the apical bone height. A classification was established according to the positions and angulations of the tooth.

Results: The data from 170 cone beam images were included in the present study. The mean thickness of the buccal bone at the mid-root level was 0.9 ± 0.4 mm and at the apical level was 2.04 ± 1.01 mm. The mean thickness of the palatal bone at the mid-root level was 3.76 ± 1.37 mm and at the apical level was 8.51 ± 2.54 mm. The mean apical bone height was 9.53 ± 2.76 mm. The proportion of incisors positioned more buccally (type B) was 78.8%, 19.4%, and 1.8% positioned midway (type M) and more palatally (type P), respectively. Regarding the angulation, 49.9% were classified as type 2 (toward buccal), 34.7% as type 3 (toward buccal, with the long axis anterior to the A point), and 15.4% were categorized as type 1 (toward palatal or parallel to the alveolus).

Conclusions: We recommend that clinicians appreciate the socket in 3 dimensions to achieve a good outcome. According to the difficulty of achieving good results, the cases were categorized as levels I to III and recommendations were given.

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Throughout the past 40 years, dental implantation has gradually changed our thoughts about the line between saving a tooth and extraction, as well as tooth replacement therapy. With rapid advances in grafting materials and refinements in the surgical and prosthetic protocols, the restoration of a single tooth gap by a dental implant has become the reference standard. Traditional guidelines have suggested a 2- to 3-month healing period after dental extraction to allow sufficient bone infilling and remodeling before dental implant placement, after which, a 3- to 6-month healing period should be allowed before the
implant is exposed and loaded with a fixed prosthesis. However, the negative effect of tooth extraction on the volumetric hard and soft tissue changes in the buccolingual and vertical dimensions has been reported extensively in published studies. Using diagnostic casts, radiographs, and direct measurements to evaluate the magnitude of bone resorption, it has been reported that during the first 4 months after extraction, the mean bone reduction was 5 to 7 mm buccolingually and 2 to 4.5 mm vertically. Because such bone resorption will strongly affect the implant placement and, thus, the esthetics outcome, clinicians started to insert the implant directly into the extraction socket immediately after extraction, under the assumption that this would reduce the bone resorption. The first case report of this technique was published in 1976. Since then, numerous studies have been published regarding the refinement of this technique. Additional clinical research has shown that the outcomes of immediate implant placement, delayed implant placement, and implant placement in healed socket sites were all comparable.

The multiple advantages of immediate implant placement are well known, especially in the esthetic zone, such as the maxillary central incisors. These advantages include a reduction in the number of surgeries, a reduction of the total treatment time, the preservation of alveolar bone, the maintenance of a good soft tissue profile, and the reduction of the patients’ psychological trauma owing to the loss of a front tooth. However, such therapy is not without drawbacks. The greatest problem for clinicians is the unpredictability of the long-term soft tissue stability. The problem of soft tissue recession is usually exacerbated in patients with relatively thin buccal bone and thin gingival biotypes. Because the gingival biotype cannot be changed, the critical aspect of achieving esthetic success depends on the ideal 3-dimensional implant position and the maintenance of adequate buccal bone thickness over the implant buccal surface. Immediate implant therapy has been reported to be very technically demanding and requires an understanding of all these aspects and more. Failure to do so will result in an adverse outcome, defeating the initial objectives of the therapy itself. Immediate implantation is never easy, especially when the demand for long-term stable esthetic results is high; thus, case selection is of the utmost importance.

The criteria for implant success have been changing, and interest in the esthetic outcome is becoming a major concern. Implant dentistry has gradually evolved from a bone-driven surgical protocol to a restorative and biologically driven protocol. The present study is the first to analyze the positions and angulations of the central maxillary incisors with reference to the alveolar bone. Our results will provide data for clinicians to achieve the best long-term esthetic results. The thicknesses of the bone at the buccal and palatal side were evaluated, as was the bone height at the apical tooth region. A new classification is introduced to categorize the different tooth positions and angulations, providing a reference to help avoid compromising the buccal bone thickness and to prevent fenestration and perforation during implant placement. Different types of teeth were also ranked according to their difficulties for achieving good long-term results, and general recommendations for their management were given.

Materials and Methods

A series of 300 cone beam (CB) images of the maxilla taken from April 2006 to August 2006 were randomly selected from the computer record at the Dental Implant and Maxillofacial Centre in Hong Kong. All CB images were taken with the same machine (I-CAT cone beam volumetric tomography and panoramic dental imaging system; Imaging Science International, Hatfield, PA). The head positions were standardized by aligning the patient’s head with horizontal and vertical reference lines, constructed using a beam of light. The patient’s head was positioned such that the horizontal reference beam was at the level of the patient’s eyes and the vertical reference beam was passing through the patient’s facial midline. Once the ideal head position had been located, the patient’s head was fixed with a head frame. The CB images were viewed and measured by the software provided. Each image was examined to identify a fully formed, intact, and healthy permanent central upper right incisor (tooth 11) for analysis. If the central upper right incisor was missing, the upper left central incisor was selected for analysis. The CB imaging data were excluded if any radiographically detectable enamel or dentine defect, caries, apical pathologic features, periodontal alveolar bone loss, restoration of any kind, or fracture was present or when both central incisors were missing.

Landmarks were identified and marked in the computer before the measurements were done. The sagittal section of the chosen incisor was viewed at the center of its mesial-distal dimension. As shown in Figure 1, both the palatal line (line 1) and the buccal line (line 2) were marked by a line best-fit to the palatal alveolar surface and the buccal alveolar surface, respectively. The alveolar line (line 3) was marked by bisecting the palatal and buccal lines. This indicated the angulation of the alveolar process in the sagittal plane. The angulation of the tooth root was indicated by its long axis (line 4), and this axis was marked by the midpoint of a line drawn from the buccal enamel-dentine junction to its palatal counterpart, the apex of the root. The present study involved measure-
ment of the residual bone thickness and angulations of the extraction sockets. The long axis of the tooth root, instead of the long axis of the whole tooth, was used, because the range of the crown-root angle is 25.5° for maxillary central incisors. From these reference lines, 4 measurements were performed, using the built-in measuring function of the computer software. The measurements are shown in Figure 2.

A line was drawn from the mid-point of the long axis of the root perpendicularly from the palatal bone toward the buccal bone surface. The thickness of the buccal bone at the mid-root level (measurement I) was measured from a point at the buccal root surface to the buccal bone surface along this line. The palatal bone thickness at the mid-root level (measurement II) was measured from a point at the palatal root surface toward the palatal bone along this same line. The thickness of labial bone at the apical level (measurement III) was defined as a line perpendicular to the long axis of the root, from the apex of the root toward the buccal bone surface. The thickness of the palatal bone at the apical level (measurement IV) was defined as the distance of the line perpendicular to the long axis of the root from the apex of the root toward the palatal bone surface. The apical bone height (measurement V) was

FIGURE 1. Landmarks for measurement.

FIGURE 2. Measurements of bone thickness at different aspects (measurements I to V).
measured along the long axis of the root from the root apex toward the superior bone surface.

From the CB measurements, the positions and angulations of the tooth roots were classified with reference to the alveolar process. By comparing the buccal and palatal bone thickness at the mid-root level, their positions with reference to the mid-alveolar line were defined and classified as follows (Fig 3): type B (closer to the buccal alveolar surface); type M (midway between the buccal and palatal alveolar surface); and type P (closer to the palatal alveolar surface). Comparing the angulations of the alveolar process with the long axis of the roots, the angulations were classified as follows (Fig 3): type 1 (root apex angulated toward the palatal side or parallel to the alveolus); type 2 (root apex angulated toward the buccal side with the long axis passing posterior to point A); and type 3 (root apex angulated toward the buccal side with the long axis passing anterior to point A).

All measurements and classifications were performed by 2 investigators. Reliability tests were also performed to check the consistency and accuracy using the Statistical Package for Social Sciences, version 11.0, software (SPSS, Chicago, IL). Studies of this type are exempt from approval by the local institutional review board.

Results

The CB imaging data from a series of 300 randomly selected patients were accessed initially. The images were all examined to identify useful data according to the defined inclusion and exclusion criteria. The CB imaging data from 170 patients were included in the final analysis. Of the excluded 130 patients, 109 had a defective incisor (eg, caries, infections, restorations, periodontal bone loss, or fracture) and 21 had both central incisors missing. The mean patient age was 47
years (range 13 to 85). Of the 170 patients, 76 (45%) were males and 94 were females (55%).

The mean thickness of the buccal bone at the mid-root level (measurement I) was 0.9 mm (range 0.1 to 1.99), and the mean thickness of the palatal bone at the mid-root level (measurement II) was 3.76 ± 1.37 mm (range 0.5 to 10.1). The mean thickness of the buccal bone at the apical level (measurement III) was 2.04 ± 1.01 mm (range 0.1 to 7.72), and the mean thickness of the palatal bone at the apical level (measurement IV) was 8.51 ± 2.54 mm (range 2.56 to 22.41). The mean apical bone height (measurement V) was 9.53 ± 2.76 mm (range 2.15 to 17.2). These measurements are listed in Table 1.

Additional analysis of the measurements revealed that 57% of the patients had a buccal bone thickness at the mid-root level of less than 1 mm (Table 2), and 62.4% of patients had a palatal bone thickness at the mid-root level of less than 4 mm—up to 86.5% of patients had a thickness of less than 5 mm (Table 3). Similarly, the buccal bone at the apical level was much thinner than its palatal counterpart. The buccal bone thickness at the apical level was less than 5 mm in 98.8% of the patients, and more than one half of the patients (51.8%) had a thickness of less than 2 mm (Table 4). In contrast, 96.5% of patients had a palatal bone thickness at the apical level of 5 mm or more, and more than one half of the patients (55.9%) had a thickness of 8 mm or more (Table 5). Regarding the apical bone height, measured from the apex of the root to the nasal floor, almost one half of the patients (47.6%) had at least 10 mm of bone height; 97.6% had 4 mm or more of bone height and 71.2% of patients had 8 mm or more of bone height (Table 6).

A classification of the positions and angulations of the central incisors with reference to the alveolar bone was established. Most of the central incisors (78.8%) were positioned more buccally within the alveolar bone (type B), 19.4% were positioned in midway (type M), and 1.8% were positioned more palatally (type P; Table 7). Regarding the incisor angulations, almost one half (49.9%) of the central incisors were classified as type 2, 34.7% were classified as type 3, and 15.4% (26 cases) were categorized as type 1. An analysis that combined both the position and the angulation type showed that most were type B2 (38.2%). The incidence of type B3 (34.7%) was only slightly less than that of type B2, followed by type M2 (11.7%). No type P2, P3, or M3 was found in our patient series. The rest of the types were few and are listed in Table 7.

A reliability test was done to determine the accuracy of the measurements and classifications between the 2 investigators. The correlation coefficients for the different measurements are listed in Table 8 and reflected the good consistency between the 2 investigators.

### Table 1. MEASUREMENT RESULTS

<table>
<thead>
<tr>
<th>Measurement (mm)</th>
<th>Thickness at Mid-Root Level</th>
<th>Thickness at Apical Level</th>
<th>Apical Bone Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buccal Bone (Measurement I)</td>
<td>Palatal Bone (Measurement II)</td>
<td>Buccal Bone (Measurement III)</td>
</tr>
<tr>
<td>Mean</td>
<td>0.90</td>
<td>3.76</td>
<td>2.04</td>
</tr>
<tr>
<td>Median</td>
<td>0.89</td>
<td>3.69</td>
<td>1.96</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.40</td>
<td>1.37</td>
<td>1.01</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.99</td>
<td>10.10</td>
<td>7.72</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.10</td>
<td>0.50</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Data in parentheses are percentages.


### Table 2. THICKNESS OF BUCCAL BONE AT MID-ROOT LEVEL (MEASUREMENT I)

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Patients (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.5</td>
<td>23 (13.5)</td>
</tr>
<tr>
<td>&lt;1.0</td>
<td>97 (57)</td>
</tr>
<tr>
<td>&lt;1.5</td>
<td>158 (92.9)</td>
</tr>
<tr>
<td>&lt;2.0</td>
<td>170 (100)</td>
</tr>
</tbody>
</table>

Data in parentheses are percentages.


### Table 3. THICKNESS OF PALATAL BONE AT MID-ROOT LEVEL (MEASUREMENT II)

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Patients (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>8 (4.7)</td>
</tr>
<tr>
<td>&lt;3</td>
<td>40 (23.5)</td>
</tr>
<tr>
<td>&lt;4</td>
<td>106 (62.4)</td>
</tr>
<tr>
<td>&lt;5</td>
<td>147 (86.5)</td>
</tr>
<tr>
<td>&lt;6</td>
<td>159 (93.5)</td>
</tr>
</tbody>
</table>

Data in parentheses are percentages.

Discussion

The present study aimed to provide data to aid the treatment planning of immediate implant in the esthetic zone using a CB imaging technique. With rapid advances in surgical and imaging techniques, the demand for accuracy in 3-dimensional and volumetric measurements is ever increasing. CB imaging has become the standard for implant planning, especially in the highly esthetically demanding areas. Numerous studies have been published to support the routine use of CB imaging in implant dentistry, including the advantages of convenience, accuracy, and relatively low radiation dosage.24-27 Increasingly, more clinicians have been incorporating this into daily practice.

Only the roots of the maxillary central incisors were evaluated in the present study, instead of the whole tooth. Neither were the crown-to-root relationships measured. This was because it was reported by Bryant et al23 that only a mean of 1.74° is present between the long axis of the root and the crown of normal central maxillary incisors. With priority given to a restorative driven concept, if implants could be placed into the extraction sockets exactly at the same angulations as the roots inside the alveolar bone, it would provide an ideal 3-dimensional position for the prosthetic crown and only a simple straight stock abutment would be needed. Thus, it is important to evaluate the root position 3 dimensionally before placement.

Although it might be worthwhile information, we purposely did not include the measurements of the buccal and palatal bone thickness at the crestal region, because of the uncontrollable high percentage of error owing to its relative thinness. Although magnification is possible in the computer, the resolution will be too low for measurement. Moreover, a beam hardening effect is always present over the edge, making measuring the bone thickness at the crestal level worthless.

As previously mentioned, the main drawback of immediate implant placement into the extraction sockets has been the lack of predictability of the long-term soft tissue profile, especially on the buccal aspect. Thus, the position of implant placement is critical and is a limiting variable. Although it was previously believed that the bone remodeling and soft tissue recession over an extraction socket would be arrested by inserting a dental implant into the socket, recent studies have failed to support this.28-30 It has been confirmed that, irrespective of the placement of a dental implant, bone resorption after extraction will still occur, leading to a loss of bone volume.28-30 It has also been reported that the buccal bone resorbs more than the lingual or palatal bone after extraction, because it is composed of bundle bone alone. In contrast, lingual or palatal bone is composed of cortical bone, at least at the outermost surface; thus, the resistance to resorption is better.31 The mid-buccal recession of an immediate implant placed into a fresh extraction socket has been reported to be 0.55 to 0.75 mm at 1 year of follow-up.32,33 However, long-term data are still not available to determine whether additional resorption occurs. Kohal et al34 have shown that pressure of the inserted implant on the bony wall can result in microfractures, leading to crestal bone loss. Therefore, the ideal placement of an immediate implant should be aimed toward obtaining maximum bone-to-implant contact to achieve good primary stability and promote greater osseointegration.35,36 However, the key to long-term good esthetic

<table>
<thead>
<tr>
<th>Table 4. THICKNESS OF BUCCAL BONE AT APICAL LEVEL (MEASUREMENT III)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (mm)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>&lt;1</td>
</tr>
<tr>
<td>&lt;2</td>
</tr>
<tr>
<td>&lt;3</td>
</tr>
<tr>
<td>&lt;4</td>
</tr>
<tr>
<td>&lt;5</td>
</tr>
</tbody>
</table>

Data in parentheses are percentages.


<table>
<thead>
<tr>
<th>Table 5. THICKNESS OF PALATAL BONE AT APICAL LEVEL (MEASUREMENT IV)</th>
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<tbody>
<tr>
<td>Thickness (mm)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>≥5</td>
</tr>
<tr>
<td>≥6</td>
</tr>
<tr>
<td>≥7</td>
</tr>
<tr>
<td>≥8</td>
</tr>
<tr>
<td>≥9</td>
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<tr>
<td>≥10</td>
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</table>

Data in parentheses are percentages.


<table>
<thead>
<tr>
<th>Table 6. APICAL BONE HEIGHT (MEASUREMENT V)</th>
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<tbody>
<tr>
<td>Thickness (mm)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>≥4</td>
</tr>
<tr>
<td>≥6</td>
</tr>
<tr>
<td>≥8</td>
</tr>
<tr>
<td>≥10</td>
</tr>
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</table>

Data in parentheses are percentages.

TABLE 7. CLASSIFICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>B</th>
<th>M</th>
<th>P</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.9 (10)</td>
<td>7.7 (13)</td>
<td>1.8 (3)</td>
<td>15.4 (26)</td>
</tr>
<tr>
<td>2</td>
<td>38.2 (65)</td>
<td>11.7 (20)</td>
<td>0 (0)</td>
<td>49.9 (85)</td>
</tr>
<tr>
<td>3</td>
<td>34.7 (59)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>34.7 (59)</td>
</tr>
<tr>
<td>Total</td>
<td>78.8 (134)</td>
<td>19.4 (33)</td>
<td>1.8 (3)</td>
<td>100 (170)</td>
</tr>
</tbody>
</table>

Data are presented as parentheses, with numbers in parentheses.


level I to level III (Fig 4).

LEVEL I

Level I (M1, P1) indicates that the implant could be placed with the same angulation as the extraction socket, without compromising the primary stability and long-term esthetic outcome because of the common features of a relatively thicker buccal bone. Because no modification of the drilling angle would be required, a straight stock abutment could be used. These types are the most straightforward for both surgery and its restoration of all the levels. However, only 9.5% of patients had extraction sockets categorized as this level (Fig 4).

Type M1 should be ideal for immediate implant cases. This type of tooth lies in the middle of the alveolar bone and root apex, angulated away from the buccal wall. When placing an implant into the extraction socket, enough bone will be present to support the implant, thereby achieving good primary stability and enough bone-to-implant contact for good osseointegration. Also, the implant angulation will be perfect for the superstructure. Moreover, enough buccal bone is present to support the overlying gingoiva, thus minimizing mid-buccal recession and shrinkage of the papillae. However, only 7.7% of type M1 were reported (Table 7).

Although type P1 is not as perfect as type M1, these types are still good, because they will have enough buccal bone to support the overlying soft tissue. Relatively less bone will be present at the palatal side; however, the palatal soft tissue is very thick and the palatal bone can resist resorption much better. The recession of palatal tissue will be less significant, if any occurs, and the esthetic demand is usually not high on the palatal side. Similar to those with type M1, those with type P1 were in the minority, with only 3 patients (1.8%) classified as having type P1 (Table 7).

LEVEL II

Level II (B1, B2, M2, M3, P2, P3) is more technically demanding. The angulation of the implant should be

Table 8. INTERINVESTIGATOR RELIABILITY TEST

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Correlation Coefficients</th>
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</thead>
<tbody>
<tr>
<td>Measurement I</td>
<td>0.955</td>
</tr>
<tr>
<td>Measurement II</td>
<td>0.805</td>
</tr>
<tr>
<td>Measurement III</td>
<td>0.830</td>
</tr>
<tr>
<td>Measurement IV</td>
<td>0.876</td>
</tr>
<tr>
<td>Measurement V</td>
<td>0.898</td>
</tr>
<tr>
<td>Classifications</td>
<td>0.922</td>
</tr>
</tbody>
</table>

changed to avoid thinning of the buccal bone to maintain a long-term stable esthetic outcome, because it has the common disadvantage of a relatively thin buccal plate. The angle of the implant should be placed more palatally to avoid compressing or drilling the buccal bone, minimizing the chance of perforations and fenestrations. Because a discrepancy exists between the implant angle to the original tooth, an angled abutment should be chosen to obtain good esthetics. More than one half of the cases (55.8%) were categorized as level II (Table 7).

Regarding the positions of the maxillary central incisors, most were type B (78.8%); thus, most of the teeth lie more buccally. Type B1 (5.9%) is not ideal for immediate implantation, because it is close to the buccal wall, indicating relatively thinner buccal bone. However, type B1 is not the most challenging of this level because it does not angulate toward the natural depression of the buccal alveolus. The chance of additional thinning of the buccal wall or fenestration will be reduced.

The least favorable types of maxillary central incisors for immediate implant are those positioned near the buccal wall with the apex pointing toward the buccal side (types B2 and B3; type B3 was categorized as difficult [level III] and was included in the next section). A type B2 tooth would naturally produce a thin buccal plate at both the crestal and the apical region. For immediate implant placement, good primary stability is mandatory, especially for those scheduled to have immediate placement of a provisional crown. When achieving good primary stability, pressure is almost always present on the buccal bone, either at the apical region or at both the apical and the crestal regions. Because this type has a thin buccal plate, any pressure exerted on it will significantly increase the risk of bone resorption, leading to the loss of soft tissue in the long term. However, a major proportion of patients will have these types (type B2, 38.2%). This explains the “physiologic” bone and soft tissue loss on the buccal side in some immediate implant cases. Although it can be difficult to achieve good primary stability, clinicians will still need to avoid overcompression of the buccal plate in such cases. This explains why these cases are so technique-sensitive.

Our data suggest that the buccal bone of maxillary incisors were, on average, thin. The mean thickness of the buccal bone at the mid-root level (measurement I) was only 0.9 mm, and the buccal bone at the apical level (measurement III) was 2.04 mm. More than one half of the patients (57%) have a buccal bone thickness at the mid-root level of less than 1 mm (Table 2), and 51.8% of patients had a buccal bone thickness at the apical level of less than 2 mm (Table 4). It is critical not to drill over the buccal area—even the side of the implant drill should not be cutting on the buccal plate during osteotomy, especially for type B, because it is expected to be thinner than other types. Otherwise, the risk of perforation or thinning down the already thin buccal plate will be high. Table 9 provides a reference for the apical radius of commonly used implant brands for immediate implant in the esthetic zone, which ranges from 1.35 to 1.75 mm. More than one half of the patients had a buccal bone thickness of less than 2 mm at the apical region, indicating that placing implant drills exactly along the axis of extraction sockets will result in a high risk of perforation, especially when placing the implant deeper toward the apical bone to achieve primary stability.

The mean thickness of the palatal bone at the apical level (measurement IV) is much greater than its buccal counterpart. We found an average of 8.51 mm of palatal bone at this region, with a maximal thickness of 22.41 mm (compared with an average of 2.04 ± 1.01 mm). More than one half (55.9%) of the patients had a thickness of 8 mm or more and 96.5% of patients had a thickness of 5 mm or more (Table 5). In contrast, the thickness of the palatal bone at the mid-root level (measurement II) had a mean of only 3.76 mm, and 76.5% of patients have a bone thickness of less than 3 mm. This probably resulted from the contour of the palatal vault. Thus, the more apically placed, the thicker the palatal bone. However, this is not the same for the buccal aspect owing to the natural depression at point A and, sometimes, the extreme root angulations, such as a type 3 tooth. Thus, the implant should be placed more palatally in the extraction socket, because more bone will be present in that area to achieve good implant stability and to avoid thinning of the buccal wall. However, the implant should also be placed more palatally at the apical area, pivoting around the mid-root level.

### Table 9. Apical Dimensions of Commonly Used Immediate Implants in Esthetic Zone

<table>
<thead>
<tr>
<th>Implant Brand</th>
<th>Apical Diameter (mm)</th>
<th>Radius (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankylos (A type), Densply</td>
<td>3.5</td>
<td>1.75</td>
</tr>
<tr>
<td>Friadent</td>
<td>3.5</td>
<td>1.75</td>
</tr>
<tr>
<td>OsseoSpeed (4.5), Astra Tech Dental</td>
<td>3.5</td>
<td>1.75</td>
</tr>
<tr>
<td>Tapered Internal (3.8 mm), BioHorizons</td>
<td>2.8</td>
<td>1.40</td>
</tr>
<tr>
<td>ITI (Bone Level), Straumann</td>
<td>3.5</td>
<td>1.75</td>
</tr>
<tr>
<td>Replace Tapered Groovy (RP), Nobel Biocare</td>
<td>2.7</td>
<td>1.35</td>
</tr>
<tr>
<td>Tapered Screw-Vent (3.7 mmD), Zimmer Dental</td>
<td>3.1</td>
<td>1.55</td>
</tr>
</tbody>
</table>

This is because the palatal bone is relatively thicker at the apical area than at the mid-root region. Clinicians must also be careful not to angulate the apex of the implant too palatally, otherwise, the coronal part of the implant will be tilted too buccally. This can lead to overcompression, or even perforation, on the buccal crestal wall, making the coronal platform point outward buccally and compromising the esthetic outcome. A recent study confirmed that the buccal-lingual position of the implant shoulder is a very important factor determining the degree of buccal marginal tissue recession.\textsuperscript{37} It was reported that an implant with a shoulder positioned at, or buccally, to a line drawn between the cervical margin of the adjacent teeth resulted in 3 times more recession than an implant with a shoulder positioned lingually or palatally to this line.\textsuperscript{37} If an ideal angulation for good apical stability without exerting excessive pressure on the buccal wall and without placing the shoulder buccal to this line cannot be achieved, clinicians can always consider choosing an implant with a smaller coronal diameter.

Regarding the apical bone height (measurement V), it was recorded that 97.6% of patients had a bone height of 4 mm or more, and 90% of patients had a bone height of 6 mm or more (Table 6). The general recommendation for the placement of immediate implant in an extraction socket in the apical dimension is to engage the implant 3 to 5 mm beyond the apex of the socket to achieve good primary stability.\textsuperscript{38,39} The results of the present study have shown adequate bone is present at the apical area. Even when the primary stability is not optimal, the implant could be placed deeper to achieve this, because usually more than enough bone is present at this region (almost one half of the patients had 10 mm or more of apical bone height). However, a suitable implant length should carefully be chosen, because the apical-coronal position of the implant shoulder is also an important factor in determining the long-term soft tissue profile and the esthetic outcome.\textsuperscript{21,40,41} The length of the implant should be optimal, deep enough to provide good apical stability, without perforation, and the shoulder positioned with, or slightly apical to, the buccal marginal bone crest (around 3 to 4 mm from the buccal gingival margin\textsuperscript{38,42,43} or 3 mm apical to the cementoenamel junctions of the periodontally sound adjacent tooth\textsuperscript{41}).

Unlike type B2, types M2, M3, P2, and P3 have similar characteristics, including a relatively thicker buccal plate. However, the root apexes will point toward the buccal side. If the implant were placed exactly into the extraction socket with the same angulation, the risk of perforation would be very high. The general recommendation for all level II cases is that the implants should be inserted with a modified angulation with reference to the extraction socket, and in this case, more palatally.

\textbf{LEVEL III}

The type B3 tooth is the most challenging case with respect to achieving good long-term esthetic outcomes because it not only will have a very thin buccal plate, but also the long axis of the tooth apex will be angulated very buccally, passing anterior to the natural contour of the maxillary alveolar bone (Fig 5A). This type is mostly seen in patients with maxillary alveolar hyperplasia and angle Class II division 2 occlusion. Because a large difference exists between the angulations of the alveolar bone and the tooth, the implant position will be compromised, regardless of whether a bone-driven or restorative-driven protocol is used (Figs 5A,B). Sometimes, traditional guidelines can be followed for such cases by extracting the

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{example.jpg}
\end{figure}
tooth, with or without simultaneous grafting, and inserting the implant several months later. As such, although the advantages of immediate implantation would not be achieved, the long-term soft tissue stability will be more predictable.

If enough bone is present at the palatal and apical aspects, an attempt could be made by placing the implant both palatally and apically to avoid touching the buccal plate. However, even if primary stability can be achieved, the difference will still be large between the angle of the implant and prosthetic crown. An angled abutment will always be needed.

One should be familiar with the implant system one is using, whether an angulated temporary abutment is available, and, if so, the different angles available if planning an immediate provisional crown. The final restoration should also be considered before the implant is inserted. Most often, for an abutment with a relatively big angle, a step of metal will be present on the buccal aspect. It can sometimes show through the buccal gingiva, compromising the esthetic outcome. Placing the implant further apically can be done to solve this problem. Customized abutments or a ceramic abutment can also be used according to the position and angulation of the implant. However, the implant position will most often be controlled by the bone available for such cases. Thus, type B3 is very technically demanding for immediate implant, because it is both a bone-driven and a prosthetic-driven procedure.

If the demand for a good esthetic outcome and immediate provisional restoration is very high, a socket transformation procedure can be done by grafting the buccal wall in the first stage, followed by extraction of the problematic tooth and a normal immediate implantation protocol several months later. Thus, a type B3 (level III) socket could be transformed iatrogenically to an easier type, such as type B2 (level II) or, even, type M2 (level II), keeping the advantages of immediate implant. However, more evidence is needed to justify the long-term success of this treatment concept.

In conclusion, the bone availability in all dimensions should be considered to achieve a good implant esthetic. The angulation and position of the original tooth should be well appreciated 3-dimensionally during the planning stage. This is best performed by measurement of a CB image. A suitable implant type and the length and diameter at the apical, mid-body, and coronal level should be customized to the original socket as much as possible. Tapered-screw implants are suggested, because they can fit to the extraction socket better, and primary stability can be achieved easily. After an atraumatic extraction, all granulation tissue should be removed. A flapless approach is recommended to minimize the breakdown of the blood supply from the periosteum to the buccal plate during the flap raising. For level I cases, inserting the implant with the same angulation of the socket using a standard drilling protocol will be straightforward. For level II cases, the implant angulation should be changed to a more palatal aspect at the apical region, pivoting around the mid-palatal area. It is recommended to first use a round bur to create a step at the palatal aspect of the apical area of the socket before using a straight drill to ensure that the hardness of the cortical bone and natural contour of the socket does not misguide the operator to drill parallel toward the apical long axis (Fig 6). The implant should be inserted with good primary stability, without exerting pressure on the buccal wall. To ensure the absence of pressure on the buccal bone, the operator can leave a gap between the implant surface and the buccal bone, as long as the primary stability is not compromised. The gap can be treated with grafting materials and/or a barrier membrane to achieve maximum osseointegration and good soft tissue healing, depending on the gap size. The implant shoulder should be optimally placed in terms of the depth and buccal-palatal dimension. A provisional crown should be considered whenever possible for soft tissue support, favoring the long-term esthetic outcome, by selecting an appropriate abutment. For level III cases, extra precautions should be given to the prosthetic piece owing to its extreme angulations. One should be familiar with the different types of abutments available, as well as their dimensions and shapes. The implant can be placed deeper apically to avoid buccal showing of the metal margin of an angulated abut-

**FIGURE 6.** Drilling with a round bur toward palatal aspect.

ment. A traditional protocol can sometimes be followed to achieve a more predictable long-term result by grafting or preserving the alveolar ridge before implant placement. However, if the esthetic requirement is very high, a socket transformation procedure should be considered.

It is never easy to achieve long-term stable esthetic results with immediate implantation. However, it is not impossible, provided that a good case selection protocol is in place and surgery is performed by experienced operators.

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