The Basal Bone and Alveolar Process in the Maxillary Anterior Region in Humans: A Cone Beam Computed Tomographic Study

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The aim of this study was to describe the basal bone and alveolar process in the maxillary anterior region by assessing patient CBCT scans. Parasagittal reconstructions were made to quantify basal bone and alveolar process dimensions and inclination of teeth in the maxillary anterior region. The CBCT scans of 87 patients and 522 tooth sites were included in this study. The results showed that the surface areas of the basal bone, alveolar process, and palatal triangle varied from 22.1 to 54.1 mm², 87.8 to 144.0 mm², and 37.1 to 66.0 mm², respectively. The basal bone in the canine region had a significantly smaller cross-sectional area than in the incisor region. The alveolar process in the canine region was markedly larger than those of the central and lateral incisor regions. The mean overall thickness of the alveolar facial bone at 3, 5, and 7 mm above the CEJ were 0.6 ± 0.5 mm, 0.9 ± 0.5 mm, and 0.7 ± 0.6 mm, respectively. Additionally, the findings demonstrated that the cross-sectional area of the alveolar process and palatal triangle were greater among men than women. The study identified significant anatomical differences among various tooth regions in the anterior maxilla. The results also demonstrated that the tooth type, but not the tooth inclination or apex location, correlates with the size of the alveolar process. Int J Periodontics Restorative Dent 2020;40:907–914. doi: 10.11607/prd.4571

Immediate implant placement has become a frequent procedure in daily practice due to its reduced treatment time, low morbidity, and the potential for an immediate provisional prosthesis installation.1–6,8 However, this procedure is also considered complex, demands a minimum amount of available bone, and requires careful case selection to achieve clinical success.6–8 The requirements for immediate implant placement in the proper 3D position include the presence of (1) an intact facial bone wall; (2) appropriate facial bone width; and (3) minimum bone volume apical and palatal to the extraction socket.6,8,9 Primary stability of implants inserted immediately into a fresh extraction socket is obtained by mechanical engagement to the remaining bone, and therefore knowledge of the anatomical characteristics of the alveolar process and basal bone are critical for clinical decision-making.

The basal bone and the alveolar process anatomy in the maxillary anterior region have been described by a limited number of studies.10–12 The alveolar process may be defined as the bone that surrounds the root of a fully erupted tooth and is developed during tooth eruption.11–14 Basal bone in the anterior maxilla may be defined as the bone tissue that is contiguous with the alveolar process beyond the api-
cal position of roots and is superiorly limited by the floor of the nasal cavity or of the maxillary sinus. During the embryologic formation of the face, the basal bone at the lateral and central incisor regions is formed by the fusion of the medial nasal prominences (intermaxillary segment), while the canine region is formed by the maxillary process.

Misawa et al evaluated the dimension of the alveolar process in the maxillary anterior region in 69 individuals. The authors observed that the largest cross-sectional area of the alveolar process was at the canine region, followed by the central and lateral incisor regions, respectively. Additional information about the dimensions of the entire maxillary bone have been reported, though no distinctions have been made from the alveolar process and basal bone. Zhang et al performed linear measurements of the alveolar process (height and width) on CBCT scans of 51 subjects. The results showed that the mean bone height was similar among the various anterior tooth regions. In addition, the lateral incisor region exhibited the thinnest alveolar process when compared with the central incisor and the canine regions.

Further information concerning the thickness of the facial bone wall in the maxillary esthetic zone in humans has been described in the literature. According to these reports, most of the anterior teeth have a thin facial bone wall. Januário et al observed that the labial alveolar bone thickness was ≤ 0.5 mm for nearly 50% of all anterior maxillary teeth. Braut et al also analyzed the facial bony wall thickness of anterior teeth at the crest level, and the results revealed that 62.9% of anterior teeth had a thickness < 1 mm, and in 25.7% of patients, the facial bony wall was not detectable. This limited information concerning the anatomical characteristics of the maxillary anterior region may compromise clinical decision-making and the implant treatment outcomes. Therefore, the aim of this study was to describe the basal bone and alveolar process in the maxillary anterior teeth in humans using CBCT imaging.

Materials and Methods

Study Design and Sample Selection

This is a descriptive study that evaluated CBCT scans from 100 patients who presented to the Dental Clinic of the Department of Dentistry of the State University of Maringá, Brazil, from January 2016 to May 2016 for the diagnosis of potential root fractures, presence of periodontal disease, or history of orthodontic treatment; and (7) an edentulous site or implant adjacent to the included tooth. All participants signed a written informed consent.

Image Acquisition

CBCT scans for all patients were obtained using an i-CAT unit (Imaging Sciences International). The images were acquired by means of the i-CAT software and processed by a computer. Acquisition was performed (field of view: 6 × 8 cm) for 20 seconds with the following i-CAT tomography acquisition protocol: 0.3-mm voxel size; 14-bit grayscale; 0.5-mm focal spot; amorphous silicon flat-panel image detector; and single 360-degree rotation for image acquisition.

For each dental group analyzed (central incisor, lateral incisor, and canine), parasagittal reconstructions were obtained at the center of the socket. All measurements were made by one experienced calibrated examiner (S.V.B.) with the aid of an image analysis software (Invivo 5.0, Anatomage; Fig 1). Intraobserver error was determined by measuring all parameters on 10 randomly selected CBCT scans. The variable was measured twice in a 24-hour interval. The interclass correlation coefficient obtained was 0.85.
Measurements

Basal bone
The following landmarks were identified on the parasagittal reconstructions: (1) apical limit of the basal bone (ALBB), identified as an imaginary line parallel to the axial (orbitomeatal) plane of the skull at the level of the maxillary sinus floor or at the level of the nasal fossa (Fig 2); and (2) coronal limit of the basal bone (CLBB), identified as an imaginary line parallel to the orbitomeatal plane, at the level of the apex of the tooth (Fig 2). The following assessments were taken:

- Basal bone cross-section area (mm²): determined by outlining the facial surface of the bone and by connecting the landmarks ALBB and CLBB with a straight line in the palatal limit (Fig 3). In the central incisor region, only the bone anterior to the incisive canal was included in the measurements.
- Basal bone height (mm): determined as the linear distance between ALBB and CLBB (Fig 3).
- Basal bone thickness (mm): determined by the length of a perpendicular line connecting the facial and palatal limits of the basal bone, at the level of the apex of the tooth.

Alveolar Process
The following landmarks were identified on the parasagittal reconstructions at the center of the tooth: (1) the apical limit of the alveolar process (CLBB; Fig 2); and (2) the coronal limit of the alveolar process (CLAP), identified as an imaginary line connecting the facial and palatal bone ridges (Fig 1). The following assessments were taken (Fig 3):

- Alveolar process cross-section area (mm²): determined by outlining the profile surface of the alveolar process hard tissue between the CLBB and CLAP landmarks.
- Alveolar process thickness (mm): determined by the length of a line parallel to the axial plane connecting the facial and palatal limits of the alveolar process, at 3, 5, and 7 mm above the palatal bone crest.
- Palatal triangle area (mm²): determined by outlining the profile surface of palatal bone tissue between landmarks CLBB and CLAP.
- Facial bone thickness (mm): determined by a line within the facial wall, parallel to the CLAP, at 3, 5, and 7 mm above the CEJ.
- Distance from the apex to the facial bone wall (mm): determined by the length of a
line parallel to the axial plane connecting the highest point of the apex to the facial wall.

- Tooth inclination (degrees): angle formed by the long axis of the tooth and the axial plane of the skull.

**Statistical Analysis**

Sample size calculation was conducted with G* power 3.1.9.3 software. The sample size required was computed for the parametric equivalent test as recommended by Lehmann and D’Abrera, with a power of 0.85, an alpha level of .05, an effect size of 0.40, and subsequent 15% adjustment for the non-parametric test. It was calculated that a minimum of 84 patients were necessary for this study.

Descriptive statistical analysis of all data was performed to calculate means and SDs for each variable and tooth region. Kolmogorov-Smirnov test with Lilliefors correction was used to verify the normal distribution of the data. After attesting non-normal distribution, Friedman test was used to compare differences between groups (central incisor, lateral incisor, and canine). Pearson correlation coefficient was calculated to evaluate the relation between the cross-sectional area of the alveolar process and (1) the cross-sectional area of the basal bone, (2) the root inclination, and (3) the distance from the apex to the facial bone wall. All analyses were performed by BioEstat 5.0 software (Sociedade Civil Mamirauá), with a 5% significance level and a 95% confidence level.

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**Fig 2** Schematic drawing of a parasagittal reconstruction describing the landmarks used for the measurements. The ALBB line represents the apical limit of the basal bone. The CLBB and CLAP lines represent the apical and coronal limits, respectively, of the alveolar process.

**Fig 3** Schematic drawing of a parasagittal reconstruction describing the parameters used to determine the dimensions of the basal bone and alveolar process. The black dotted line surrounds the outer contour (faciopalatal) of the basal bone, and the blue dotted line surrounds the alveolar process. H = distance between ALBB and CLBB. The gray lines parallel to the CLBB determine the distance between the facial and palatal limits of the alveolar process at 3, 5, and 7 mm above the palatal bone crest. The gray triangular figure between the CLBB and CLAP landmarks represents the palatal triangle. The red lines identify the facial bone thickness at 3, 5, and 7 mm above the CEJ. The green line illustrates the distance from the root apex to the facial bone wall.
Results

CBCT scans from 100 patients were evaluated. However, 13 patients and their respective CBCT scans were excluded from the study due to the presence of metal artifacts that jeopardized proper examination, diagnosis of periapical lesion/root fracture, or previous history of orthodontic treatment. A total of 87 patients (63 women and 24 men), aged between 18 and 46 years (mean: 27 years) and 522 tooth sites were included in the study.

The basal bone often exhibited a trapezoidal shape. The alveolar process displayed a rectangular shape in the incisor tooth regions, while it exhibited a triangular shape in the canine region. The roots of all teeth in various regions were mostly located in the facial half of the alveolar process. However, the sockets in the canine region were often located outside of the bone envelope. The root apices at all tooth sites were commonly situated in the anterior or central portion of the alveolar process.

Basal Bone

The overall cross-sectional area, thickness, and height of the basal bone at all tooth regions were 42.4 ± 27.1 mm², 6.1 ± 3.9 mm, and 5.6 ± 3.6 mm, respectively (See Appendix Table 1 in the online version of this article at quintpub.com/journals). The lateral incisor region exhibited the largest cross-sectional area (54.1 ± 20.9 mm²) while the canine region had the smallest area (22.1 ± 27.1 mm²). The lateral incisor region also exhibited the thickest basal bone, followed by the central incisor and canine regions. The basal bone height was similar between the central and lateral incisor regions, while it was significantly shorter at the canine region (Appendix Table 1). Among all participants, men presented with greater cross-sectional area of the basal bone in the lateral incisor region and thicker basal bone in the central and lateral incisor areas than women.

Alveolar Process

The overall cross-sectional area of the alveolar process in all tooth regions was 114.0 ± 36.6 mm² (Appendix Table 2). The largest alveolar process was observed in the canine region (144.0 ± 36.0 mm²), while the smallest was found in the lateral incisor region (87.8 ± 21.6 mm²); the corresponding value in the central incisor region was 113.0 ± 26.0 mm². The overall cross-sectional area of the palatal triangle was 49.1 ± 24.9 mm². The canine showed the largest area (66.0 ± 29.3 mm²), followed by the central (46.1 ± 20.5 mm²) and lateral incisors (37.1 ± 18.0 mm²). The overall thickness of the alveolar process at 3, 5, and 7 mm above the CEJ was 8.4 ± 1.4 mm, 9.4 ± 1.5 mm, and 9.5 ± 1.7 mm, respectively (Appendix Table 2). The thickest alveolar process at 3, 5, and 7 mm above the CEJ were observed at the canine region (9.1 ± 1.4 mm, 10.1 ± 1.4 mm, and 10.3 ± 1.6 mm, respectively).

The findings of the present study also demonstrated that the cross-sectional area of the alveolar process in the central incisor, lateral incisor, and canine regions was larger among men (123.3 ± 25.4 mm, 98.3 ± 19.5 mm, and 166.7 ± 39.7 mm², respectively) than women (108.3 ± 25.4 mm, 82.7 ± 20.2 mm, 136.9 ± 31.0 mm², respectively). Similarly, the thickness of the alveolar process and the cross-sectional area of the palatal triangle were greater in men than in women.

The mean overall thickness of the alveolar facial bone at 3, 5, and 7 mm above the CEJ was 0.6 ± 0.5 mm, 0.9 ± 0.5 mm, and 0.7 ± 0.6 mm, respectively (Appendix Table 3). The thickness of the facial bone at 3 mm above the CEJ varied between 0.6 and 0.5 mm, while at 5 and 7 mm above the CEJ, the corresponding ranges were 0.8 to 0.9 mm and 0.7 to 0.8 mm, respectively.

The overall mean distance from the apex to the facial bony plate was 1.9 ± 0.8 mm. In the canine and central and lateral incisor regions, the distances were 1.7 ± 0.7 mm, 1.9 ± 0.8 mm, and 1.9 ± 0.9 mm, respectively. There were no statistically significant differences between the groups (Appendix Table 3). The overall tooth inclination was 72.2 ± 9.0 degrees. The canine showed the greatest root inclination (78.2 ± 6.5 degrees), followed by the central incisor (71.0 ± 9.1 degrees) and the lateral incisor (67.5 ± 7.7 degrees; Appendix Table 3). There was no difference in root inclination, facial bone thickness, distance from the apex to the facial bone wall, or basal bone height among genders.

Pearson correlation between the cross-sectional area of the alveolar
process and that of the basal bone showed a low positive correlation for lateral incisors \( r = 0.25 \) and negative moderate correlation for canines \( r = -0.31 \); Appendix Table 4. There was no or very low correlation in all tooth regions between the cross-sectional area of the alveolar process and both the root inclination and distance from the apex to the facial bone wall.

**Discussion**

The present human study is the first to describe the basal bone and the alveolar process at the anterior region of the maxilla in the same patient using CBCT imaging. Previous studies have described basal bone in combination with the alveolar process.\(^{10,12}\) Beckmann et al\(^{10}\) evaluated the basal and alveolar process in cephalometric radiographs of 460 patients. The authors observed that the mean cross-sectional area of the central incisor region was 222.00 mm\(^2\) but failed to single out the dimension of the basal bone from the overall dimension of the maxillary bone. Likewise, Zhang et al\(^{12}\) performed linear measurements (height and width) in CBCT scans of 51 subjects, including the entire maxillary bone (from the floor of the nasal cavity to the alveolar crestal bone).

The cross-sectional area of the basal bone at the canine region was significantly smaller than the corresponding dimension at the incisor regions. Likewise, the height and thickness of the basal bone at the canine region were significantly smaller than at the incisor regions. The bone at the central and lateral incisor regions (premaxilla) is formed by the fusion of the medial nasal prominences (intermaxillary segment) that have evolved to form the lip philtrum, lips, and primitive palate. On the other hand, the bone at the canine and remaining tooth regions is formed by the maxillary process. Thus, the different developmental processes may explain the similar anatomy between the lateral and central incisors, as well as the marked difference between the incisor and canine regions.\(^{15}\)

In the present study, the quantitative data based on CBCT imaging showed that the mean cross-sectional area of the alveolar process in the central incisor, lateral incisor, and canine regions was 113 mm\(^2\), 88 mm\(^2\), and 144 mm\(^2\), respectively. These findings are consistent with the data reported by Misawa et al,\(^{11}\) who evaluated the dimension of the alveolar process by CBCT imaging. Their results showed that the area of the alveolar process at the central and lateral incisor regions were, respectively, 103.00 and 82 mm\(^2\). The corresponding value at the canine region was 128 mm\(^2\). The present findings support the concept that the alveolar process dimension is directly related to the size of the root,\(^{13}\) as the canine root is larger than the central incisor root, which in turn is larger than the lateral incisor root.\(^{11,23}\) However, the present study failed to find any correlation between the cross-sectional area of the alveolar process and the corresponding tooth inclination and apex location. Thus, the present findings are not in accordance with the concept that the size of the alveolar process is determined by the inclination and location of the dental roots.\(^{13}\) Other factors besides tooth-related characteristics, such as genetic factors, may also play a role in determining the alveolar process dimension.

The present study showed that the tooth roots were in intimate contact with the facial alveolar bone wall. Likewise, the recent study by Lau et al\(^{24}\) corroborates with the findings above and further analyzes the effect of root position in the alveolar process, observing that the majority (78.8%) of the incisors present the root positioned against the facial bone wall. Kan et al\(^{25}\) evaluated 100 CBCT scans and classified the relationship of the sagittal root positions of the maxillary anterior teeth to their respective osseous housings. The frequency of the distribution showed that Class I (root positioned against the facial bony wall) was by far the most predominant root position (86.5% of central incisors, 76% of lateral incisors, and 81% of canines).

In addition, the measurements of the present study showed that the overall thickness of the alveolar facial bone at 3 mm above the CEJ did not exceed 0.6 mm. This finding agrees with recent studies,\(^{4,17–20}\) which demonstrated that most anterior teeth exhibit a thin facial bone phenotype (< 1 mm). Januário et al\(^{17}\) evaluated the thickness of the facial bone in the anterior maxilla and reported that, of the examined teeth, most locations presented ≤ 1 mm thick and that close to 50% of all teeth and sites had a thickness...
of 0.5 mm. These observations are also in agreement with those of Dos Santos et al,20 who assessed 1,463 teeth and demonstrated that 70.1% of central incisors, 72.9% of lateral incisors, and 75.8% of canines showed a bone thickness between 0.1 and 1 mm.

The mean distance from the apex to the facial bone wall in different anterior regions was 1.9 ± 0.8 mm. This finding is similar to Kheur et al,19 who evaluated 150 CBCT scans in the maxillary central incisor region and had a corresponding value of 1.6 ± 0.9 mm. The authors also observed that the facial bone was thinner when the apex was closer to the facial wall. In a recent study, Nahás-Scocate et al26 assessed the amount of apical facial bone of 60 maxillary central incisors and the relationship with their inclination. The authors showed a significant positive correlation between the apical facial thickness and the inclination of the maxillary central incisors.26 In other words, the closer the root inclination to 90 degrees, the thinner the apical facial region. In the present study, canines showed the greatest root inclination, the smallest distance from the apex to the facial bone plate, and the greatest palatal bone availability.

The findings of the present investigation can have implications on planning the replacement of maxillary anterior teeth with dental implants. Immediate implants are typically inserted in the palatal triangle. Canines were found to have the largest palatal triangle; however, they were also frequently outside of the bone envelope and exhibited the smallest basal bone. Lateral incisors exhibited the largest basal bone and the smallest palatal bone. It is important to know that significant variability was found among the patients analyzed. Therefore, it is prudent for clinicians to preoperatively analyze the anatomy of each site using 3D imaging.

Conclusions

The present study indicated that there was a significant anatomical difference among various tooth regions in the anterior maxilla. In addition, the results demonstrated that the tooth type, but not the tooth inclination or apex location, correlates to the size of the alveolar process. Other factors besides tooth-related characteristics, such as genetic factors, maybe also play a role in determining the alveolar process dimension.

Acknowledgments

The study protocol was approved by the Institutional Review Board for Research Conducted with Human Beings at the State University of Maringá, Brazil (protocol no. 267.799). The authors declare no conflicts of interest.

References

### Appendix 1

#### Appendix Table 1 Mean ± SD Values of Parameters Characterizing the Dimensions of the Basal Bone

<table>
<thead>
<tr>
<th>Location</th>
<th>Central incisor (n = 174)</th>
<th>Lateral incisor (n = 174)</th>
<th>Canine (n = 174)</th>
<th>Overall (n = 522)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-section area, mm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>49.7 ± 21.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.1 ± 20.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.1 ± 27.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>42.4 ± 27.1</td>
</tr>
<tr>
<td>Thickness, mm</td>
<td>6.1 ± 2.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.9 ± 2.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.8 ± 5.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.1 ± 3.9</td>
</tr>
<tr>
<td>Height, mm</td>
<td>7.2 ± 2.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.9 ± 2.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.3 ± 2.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.6 ± 3.6</td>
</tr>
</tbody>
</table>

Different superscript letters indicate statistically significant differences among groups (P < .05, Friedman test).

#### Appendix Table 2 Mean ± SD Values of the Cross-Sectional Area and Alveolar Process Thickness

<table>
<thead>
<tr>
<th>Location</th>
<th>Central incisor (n = 174)</th>
<th>Lateral incisor (n = 174)</th>
<th>Canine (n = 174)</th>
<th>Overall (n = 522)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional area, mm&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
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<tr>
<td>Alveolar process</td>
<td>113.0 ± 26.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.8 ± 21.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>144.0 ± 36.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>114.0 ± 36.6</td>
</tr>
<tr>
<td>Palatal triangle</td>
<td>46.1 ± 20.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.1 ± 18.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>66.0 ± 29.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>49.1 ± 24.9</td>
</tr>
<tr>
<td>Thickness of the alveolar process, mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 mm</td>
<td>7.9 ± 1.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.9 ± 1.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.14 ± 1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.4 ± 1.4</td>
</tr>
<tr>
<td>5 mm</td>
<td>9.0 ± 1.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.2 ± 1.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.1 ± 1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.4 ± 1.5</td>
</tr>
<tr>
<td>7 mm</td>
<td>9.05 ± 1.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.2 ± 1.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.3 ± 1.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.5 ± 1.7</td>
</tr>
</tbody>
</table>

The alveolar process was thickness measured apical to the palatal bone crest. Different superscript letters indicate statistically significant differences among groups (P < .05, Friedman test).

#### Appendix Table 3 Mean ± SD Facial Bone Thickness, Tooth Inclination, and Distance from the Apex to the Facial Bone Plate

<table>
<thead>
<tr>
<th></th>
<th>Central incisor (n = 174)</th>
<th>Lateral incisor (n = 174)</th>
<th>Canine (n = 174)</th>
<th>Overall (n = 522)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial bone thickness, mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 mm</td>
<td>0.6 ± 0.5</td>
<td>0.6 ± 0.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.5 ± 0.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.6 ± 0.5</td>
</tr>
<tr>
<td>5 mm</td>
<td>0.8 ± 0.4</td>
<td>0.9 ± 0.6</td>
<td>0.9 ± 0.5</td>
<td>0.9 ± 0.5</td>
</tr>
<tr>
<td>7 mm</td>
<td>0.7 ± 0.5</td>
<td>0.7 ± 0.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.8 ± 0.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7 ± 0.6</td>
</tr>
<tr>
<td>Tooth inclination, degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>71.0 ± 9.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.5 ± 7.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>78.2 ± 6.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>72.2 ± 9.0</td>
</tr>
<tr>
<td>Distance from the apex to the facial bone wall, mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.9 ± 0.8</td>
<td>1.9 ± 0.9</td>
<td>1.7 ± 0.7</td>
<td>1.9 ± 0.8</td>
</tr>
</tbody>
</table>

Values are given in millimeters. The thickness was measured apical to the CEJ. Different superscript letters indicate statistically significant differences among groups (P < .05, Friedman test).
### Appendix Table 4 Pearson Correlation Coefficients Between the Cross-Sectional Area of the Alveolar Process and the Other Measured Parameters

<table>
<thead>
<tr>
<th>Tooth area</th>
<th>Basal bone cross-sectional area</th>
<th>Root inclination</th>
<th>Distance from the apex to the facial bone wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central incisor</td>
<td>0.12</td>
<td>−0.03</td>
<td>−0.01</td>
</tr>
<tr>
<td>Lateral incisor</td>
<td>0.25**</td>
<td>−0.04</td>
<td>0.16*</td>
</tr>
<tr>
<td>Canine</td>
<td>−0.31**</td>
<td>−0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*P < .05.

**P < .001.