Buccal Bone Plate Thickness of the Asian People

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Abstract

Distances from the apex to the buccal bone plate were measured on the computed tomography (CT) images of 1806 teeth from 66 patients, using an image analyzer program (Image-Pro Plus, Ver. 4.0, Media Cybernetics). In the mandible, the mean distance from the distal apex of the mandibular second molar to the buccal bone plate was the largest distance measured, at 8.51 mm, followed by distance from the mesial root to the buccal bone (7.34 mm). In the mandibular first molar, the mean distal and mesial bone thicknesses were 5.18 mm and 4.09 mm, respectively. However, when there were two distal roots, the distance of the disto-lingual root to the buccal plate was found to be 9.52 mm, which constitutes the greatest measured thickness. In the maxillary buccal roots, the distances from the mesio-buccal and disto-buccal root of the second molar to the buccal bone plate were the largest, at 4.63 mm and 3.61 mm, respectively. The average distances from the palatal apex of the maxillary first and second molars to the buccal bone plate were 10.69 mm and 10.17 mm, respectively, while, from the palatal bone plate, average distances of 3.15 mm and 3.08 mm were measured. Special considerations, such as bony lid approach, lingual approach, or intentional replantation may be required, especially when a patient has a surgical need in the second molars and the disto-lingual root of the mandibular first molar, or in the palatal root of the maxillary molars.

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The appropriate method by which the surgical field is accessed and secured is very important for accurate apical surgery. The manipulation of the surgical instruments and the securing of the surgical field are limited in many ways during apical surgery, which is performed in a cramped space, and in a situation which involves irreducible bleeding. From a clinical point of view, the thickness of the buccal bone plate is always a point of concern. Frankle et al. (1) investigated the distance between the mesial root and the buccal bone plate in the mandibular molars, and found the distances to be 4.18 mm and 7.35 mm in the first and second molars, respectively. If a large portion of the buccal bone plate must be sacrificed to reach the apex through the thick buccal bone plate, the overall healing process will be disturbed. Obtaining good surgical access through these thick buccal bone plates is extremely difficult, particularly when the buccal vestibular depth is shallow. Even if the apex can be reached with only a reasonable amount of effort and complication, but retrograde filling is not performed appropriately, the root canal isthmus may still remain open, leading to an eventual failure. To resolve these problems, the bony lid approach (2, 3) was introduced. In this technique, retrograde filling is performed after the buccal plate of the mandible has been separated into blocks, and then placed back into its original position after surgery. The same problems can also be encountered in the palatal root of the maxillary molars, which is remote from the buccal bone plate. When a feasible degree of accessibility is not anticipated, either a lingual approach or replantation was recommended, to secure appropriate retrograde filling (4, 5). In many instances, however, the lingual approach is extremely restricted, not simply because of the poor accessibility inherent in the approach, but also by the adjacent sensitive anatomical structures, most notably the greater palatine foramen or the lingual artery. Therefore, knowledge of the thickness of the buccal bone plate is of prime importance when planning apical surgery.

Computed tomography (CT) provides three-dimensional information about the anatomy of the jawbone and the root apex, before apical surgery. Sliced or reconstructed CT images reveal the detailed structure of the tooth, viewed from various directions (6–9).

The aim of this study was to evaluate the anatomical distance between the apices to the buccal bone plate in the Asian population, using the reconstructed CT images.

Materials and Methods

There were 66 patients (1806 teeth), who had undergone a CT examination at the Department of Conservative Dentistry at the Yonsei University Dental Hospital in Korea, enrolled in this study. The subjects included 33 men and 33 women, whose ages ranged from 14 to 80 years (average age: 37 yr for men and 35 for women). Those patients with prostheses, or those with vague CT images, were excluded.

CT DATA COLLECTION

CT images were obtained using a CT Hi-Speed Advantage (GE Medical System, Milwaukee, WI) at the Department of Oral and Maxillofacial Radiology of the Yonsei University Dental Hospital. The images were created by taking a series of 1 mm-thick cross-sectional slice images under a high-resolution bone algorithm, with a 9.6 cm diameter field of view (DFOV), at 200 mA and 120 kV, for 1 s. A gantry angulation of 0 was used, and the reconstruction matrix contained 512 ×512 pixels.

APEX CONFIRMATION, MEASURED ITEMS AND METHOD OF MEASUREMENT

To identify the apex on the1 mm cross-sectional axial CT images, the last root apex observed on each previous cross-section, but no longer observed in the next image, was

considered an apex. When two mesial root canals were involved, the center of the line connecting the two canals in the last CT image was used as an apex. These measurements were made using a digital sliding caliper (Mitutoyo Co., Tokyo, Japan), with up to 1/20-mm detail. To compensate for the magnification of the radiographic images, the measured values were converted, according to the measured values from the CT, to calculate the actual distances (Figs. 1 and 2).

Statistical Analysis

The nonparametric Kruskal-Wallis test (Chi-Square Approximation) was performed using SAS, version 6.12 software, to evaluate the statistical significance, according to gender, at 95% significance level.

Results

Maxilla

In the maxillary buccal roots, the distances from the mesio-buccal and disto-buccal roots of the second molar to the buccal bone plate were the largest, at 4.63 mm and 3.61 mm, respectively. The remaining maxillary teeth were measured to be less than 3 mm, and were within 2 mm away, particularly in the anterior teeth. When the palatal root was present, the distances between the buccal and palatal root of the first and second premolars were 4.15 mm and 3.94 mm, respectively. The average distances from the palatal apex to the buccal bone plate in the maxillary first and second molars were 10.69 mm and 10.17 mm, respectively. The average distances between the palatal apex and the palatal bone plate in the first and second molars were measured to be 3.15 mm and 3.08 mm, respectively (Table 1).

Mandible

In the mandibular second molar, the mean distance from the distal apex to the buccal bone plate was the largest measured, at 8.51 mm, followed by the mesial root (7.34 mm) and the fused root (7.19 mm). In the mandibular first molar, the mean distal and mesial bone thicknesses were measured to be 5.18 mm and 4.09 mm, respectively. However, when there were two distal roots, the buccal thickness of the disto-lingual root was 9.52 mm, which is the thickest. The mean distances between the second and first premolars and the buccal bone plate were 3.68 mm and 3.02 mm, respectively. The remaining anterior teeth displayed a range of distances from 2.07 mm to 2.48 mm (Table 2). Both the mandibular and maxillary buccal bones were thicker in men than in women, but no statistical significance was observed ($p > 0.05$).

Discussion

With the exception of a few special cases, apical surgery normally involves a labial or buccal approach. The thickness of the buccal bone plate is an important factor, in terms both of actually reaching the apex, and the securing of the surgical field, particularly in the case of molars. Even when the apex is easily and safely accessible, failure can result if the isthmus cannot be appropriately retro-filled.

There have been, as yet, only a few reports regarding the thickness of the buccal bone plate. Eberhardt et al. (10) examined CT images, and reported that the distance between the mesial apex and the buccal bone plate in the maxillary second molar was 4.45 mm, which was the thickest, while in the maxillary first premolar, it was measured to be 1.63 mm, which was the thinnest. Their results were similar to those obtained in this study, in which the average distance in the maxillary first premolar and maxillary second molar were measured to be 1.64 mm and 4.63 mm, respectively. Eberhardt et al. also reported that the distance between the apex to the palatal bone plate was 3.01 mm in the maxillary first molar, and 2.76 mm in the second. These values were also consis-

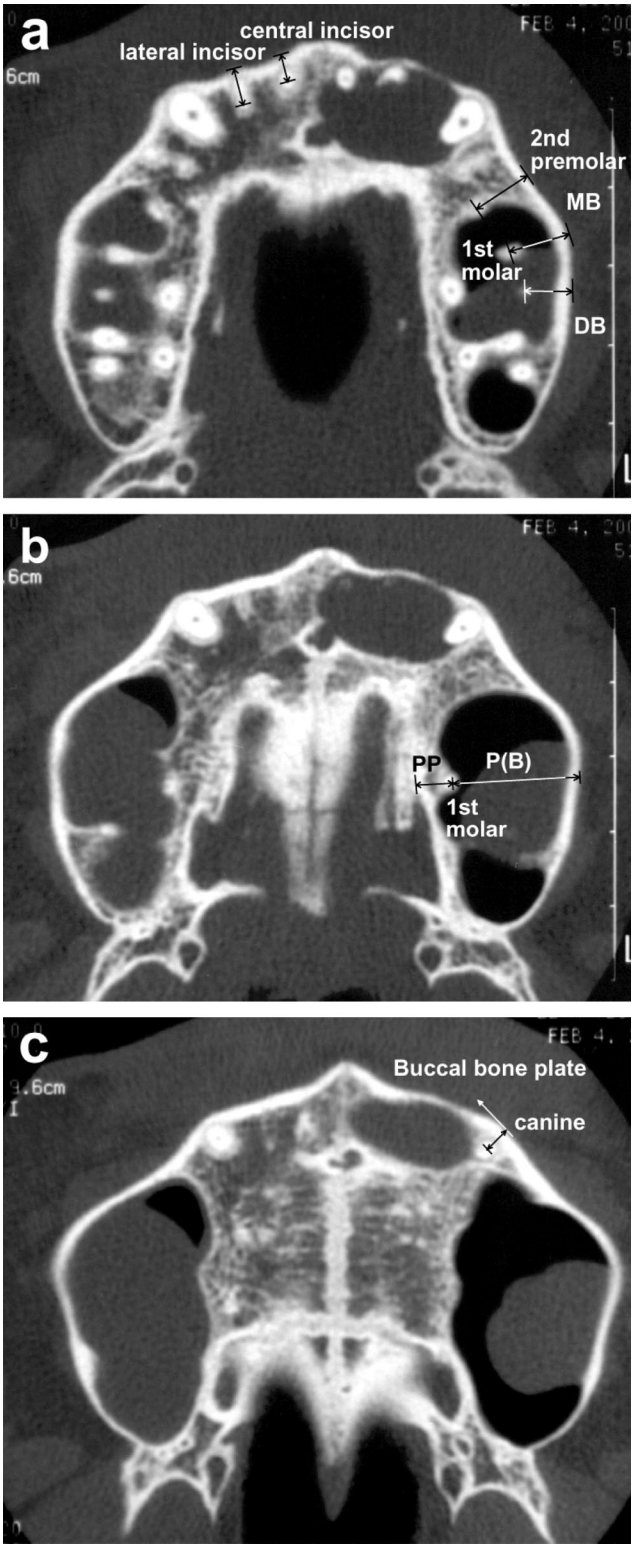

Figure 1. Maxillary Axial CT images for measurement. (a) Distance between the central incisor, lateral incisor, 2nd premolar apex and the buccal bone plate. MB: Distance between the first molor mesial apex and the buccal bone plate; DB: Distance between the first molar distal apex and the buccal bone plate. (b) P(B): Distance between the first molar palatal apex and the buccal bone plate; PP: Distance between the first molar palatal apex and the palatal bone plate. (c) Distance between the canine apex and the buccal bone plate.

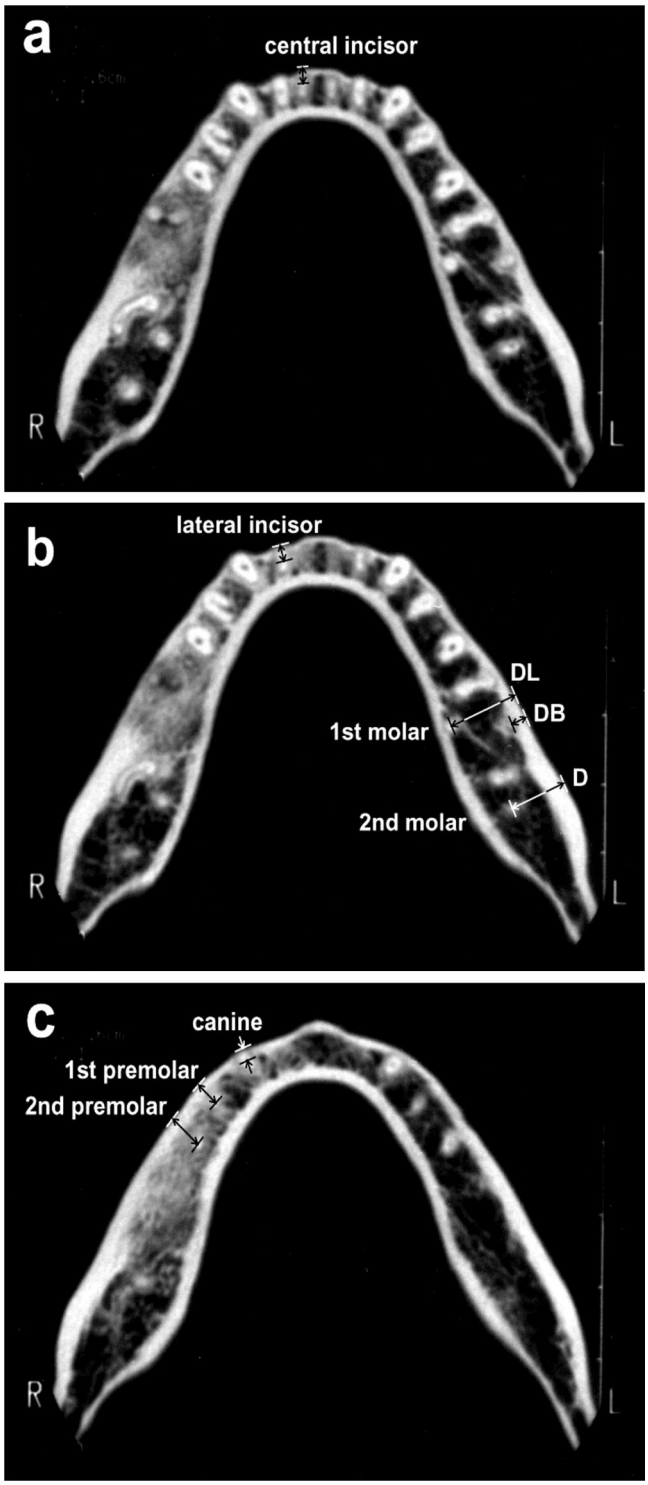

Figure 2. Mandibular Axial CT images for measurement. (a) Distance between the central incisor apex and the buccal bone plate. (b) Distance between the lateral incisor apex and the buccal bone plate; DB: Distance between the first molar distal apex and the buccal bone plate; DL: Distance between the first molar disto-lingual apex and the buccal bone plate; D: Distance between the second molar distal apex and the buccal bone plate. (d) Distance between the canine, first, 2nd premolar apex and the buccal bone plate.

tent with the results of this study, 3.15 mm and 3.08 mm. Frankle et al. (1) examined 33 cadaver mandible halves, and reported that the average distances from the mesial apex to the buccal bone plate in the mandibular first and second molars were 4.18 mm and 7.35 mm, respectively. Again, their values were consistent with the values obtained in this study, i.e. 4.09 mm and 7.34 mm. Therefore, it can be presumed that the measurements obtained from the CT images are comparable to those actually obtained from sectioned cadaver specimens. Within the range of these limited data, the thicknesses of buccal bone plates in Asian people do not seem to significantly differ from the thicknesses of buccal bone plates in other ethnic groups.

According to the results of this study, the thicknesses from the palatal root to the buccal bone plate in the maxillary first and second molars were 10.69 mm and 10.17 mm, respectively, which was comparable with the results of Rigolone's study, in which the mean root apex-buccal cortex distance was found to be 9.73 mm in the maxillary first molar (11). Considering that the usual length of a maxillary molar root is approximately 10 mm, any surgical approach here would entail a significant amount of bone removal. Therefore, approaching the surgery site via the palatal side appears to be the more feasible choice, unless, of course, anatomical problems appertain, most notably in the greater palatine foramen.

When two root apices existed, the palatal root of the maxillary first premolar was 4.15 mm away from the buccal bone plate, which was a bit more distant than the 3.94 mm measured for the second premolar, although they were not significantly different ($p > 0.05$). Considering that the present study revealed that 56% of the maxillary first premolar, and 26% of the second premolar, contained two root apices, care should always be taken to not miss the palatal root during apical surgery on the maxillary premolars.

More difficulties are anticipated when there is a disto-lingual root of the first molar, which measured, on average, 9.52 mm in buccal bone thickness. A routine buccal approach may not, in these cases, ensure appropriate retrograde filling, although some skillful operators would be able to access the root apex. Rather than forcefully creating a buccal bone cavity, it would be wise to utilize a bony lid approach in this situation (2, 3).

With regard to differences between men and women in this study, most of the maxillary and mandibular teeth showed thicker bone plates in men than in women, but this disparity was not found to be statistically significant ($p > 0.05$). Therefore, it seems unnecessary to recommend or establish different apical surgery protocols for men and women.

One of the problems encountered during the CT measurements was that the entire stretch of teeth apices could not be observed on a single axial plane, as the lengths of the teeth were all different. In this study, the last root apex observed on the previous cross section, but no longer observed in the next image, was designated the identified apex. However, in apical surgery, not all surgical access occurs parallel to the axial plane. This constitutes a limitation in this study protocol, with respect to the accurate reproduction of the actual surgical distances involved. Therefore, obtaining a 3-D image, which could adequately depict the actual distance from any surgical approach, would certainly help matters. The values measured on the CT images are not the actual values associated with the actual subject, but have been reduced in scale. A ratio of 0.81:1 was used to convert the measured values to the actual ones.

Recently, CT has become even more widely used in clinical endodontics. During the diagnosis and localization of Stafne's bone cavity, Katz et al. (12) suggested that dental CT was the most suitable noninvasive diagnostic and follow-up modality. Lee et al. visualized both the exact size and the location of the extracanal invasive resorption in the maxillary central incisors, using CT 3-D reformats and rapid prototyping tooth models (13). The possibility has also been evaluated, of using low-dose, low-cost computed tomography (low-dose cone-beam) dedicated to the jawbone, to obtain anatomic information for the planning

TABLE 1. Distance between the root apex to the outer surface of the buccal or palatal cortical plate in maxilla

Maxilla				1st premolar			2nd premolar			1st molar				2nd molar							
Root area	Central Incisor	Lat. incisor	Canine	R (2)		R (1)	R (2)		R (1)	M	D	P (B)	P (P)	R (3)				R (2)			PR
				B	P (B)		B	P (B)						M	D	P (B)	P (P)	M	P (B)	P (P)	
Male	2.02 ± 0.47	1.78 ± 0.40	1.62 ± 0.41	1.94 ± 0.51	4.56 ± 1.36	2.17 ± 0.72	2.36 ± 0.84	4.43 ± 1.71	3.32 ± 1.42	3.12 ± 1.17	2.92 ± 2.42	10.75 ± 2.42	3.17 ± 1.05	4.77 ± 1.34	3.70 ± 1.20	10.34 ± 1.87	3.19 ± 0.95	4.09 ± 1.20	8.99 ± 3.49	3.59 ± 1.01	6.37 ± 1.80
Female	2.09 ± 0.51	1.89 ± 0.54	1.66 ± 0.48	1.42 ± 0.49	3.74 ± 1.33	2.22 ± 0.63	1.62 ± 0.54	3.44 ± 1.50	3.43 ± 1.34	2.82 ± 0.98	2.54 ± 1.05	10.64 ± 2.66	3.14 ± 1.07	4.49 ± 1.32	3.52 ± 1.02	10.01 ± 2.84	2.98 ± 0.91	5.06 ± 1.38	9.38 ± 1.48	3.58 ± 1.10	4.33 ± 1.09
Total	2.05 ± 0.49	1.84 ± 0.47	1.64 ± 0.45	1.68 ± 0.50	4.15 ± 1.35	2.19 ± 0.68	1.99 ± 0.69	3.94 ± 1.61	3.38 ± 1.38	2.97 ± 1.09	2.73 ± 1.74	10.69 ± 2.54	3.15 ± 1.06	4.63 ± 1.33	3.61 ± 1.11	10.17 ± 2.35	3.08 ± 0.93	4.57 ± 1.29	9.19 ± 2.73	3.59 ± 1.06	5.35 ± 1.45

All data are expressed in average (mm) ± SD.

B: Buccal, M: Mesial, D: Distal.

R (1): One root, R (2): Two roots, R (3): Three roots, FR: Fused root, P (B): Distance between the palatal apex and the buccal bone plate, P (P): Distance between the palatal apex and the palatal bone plate.

TABLE 2. Distance between the root apex and the outer surface of the buccal cortical plate in mandible

Mandibule						1st molar					2nd molar		
Root area	Central incisor	Lateral incisor	Canine	1st premolar	2nd premolar	R (2)		R (3)			R (2)		FR
						M	D	MB	DB	DL	M	D	
Male	2.10 ± 0.52	2.27 ± 0.56	2.56 ± 0.70	3.17 ± 0.95	3.89 ± 1.39	3.93 ± 1.52	5.15 ± 1.47	4.43 ± 1.11	4.46 ± 1.42	9.66 ± 2.24	7.56 ± 1.23	8.40 ± 1.29	6.71 ± 1.82
Female	2.05 ± 0.52	2.34 ± 0.54	2.41 ± 0.73	2.86 ± 0.86	3.50 ± 1.05	4.25 ± 0.98	5.21 ± 1.90	3.94 ± 1.09	4.10 ± 1.81	9.38 ± 2.27	7.13 ± 2.06	8.62 ± 1.65	7.67 ± 2.87
Total	2.07 ± 0.52	2.31 ± 0.55	2.48 ± 0.72	3.02 ± 0.91	3.68 ± 1.22	4.09 ± 1.25	5.18 ± 1.68	4.19 ± 1.10	4.28 ± 1.62	9.52 ± 2.26	7.34 ± 1.65	8.51 ± 1.47	7.19 ± 2.35

All data are expressed in average (mm) ± SD.

M: Mesial, D: Distal, MB: Mesio-buccal, DB: Disto-buccal, DL: Disto-lingual.

R (2): Two roots, R (3): Three roots, FR: Fused root.

of 31 apicoectomies of the maxillary first molars (11). The authors suggested that CT played an important role in optimizing palatine root apicoectomy through vestibular access, both in terms of precision, and the prevention of complications. CT is also relatively low-cost, in terms of both biological and economic costs, which also possibly contributes to the increasingly widespread affirmation of the surgical procedure. Further development of this technique is necessary, to reduce the cost of the procedure, and the patient's radiation dosage.

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