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Original Article

Analysis of mandibular molar anatomy in Taiwanese individuals using cone beam computed tomography

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Mental foramen;
Mandibular posterior teeth

Abstract *Background/purpose:* Before periapical surgery in the mandibular posterior teeth is performed, the thicknesses of the buccal alveolar bone wall and buccolingual root might be a critical issue. This study aimed to assess the anatomical structure of the posterior region of the mandible in Taiwanese individuals using cone-beam computed tomography (CBCT).
Materials and methods: The CBCT images of 96 Taiwanese individuals (51 male and 45 female), which included 192 mandibular first molars and 192 mandibular second molars, were imported into medical imaging software to measure the buccal alveolar bone thickness and buccolingual root thickness at 3 mm above the root apex. Statistical analysis was conducted to examine the impact of tooth position, gender, and age on the anatomical position of mandibular molars.
Results: The buccal alveolar bone thickness at 3 mm above the root apex of the mandibular second molar demonstrates a significantly higher value when compared to that of the first molar. Nonetheless, concerning the buccolingual root thickness, no significant differences were observed between these two teeth. In addition, the buccal alveolar bone thickness and buccolingual root thickness at 3 mm above the root apex may not be influenced by gender and age.

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Conclusion: The anatomical structures of the posterior region of the mandible in Taiwanese individuals exhibited variations between the mandibular first and second molars. However, these differences were not influenced by gender or age.

Introduction

It is important that the endodontic surgeon be knowledgeable of the anatomic dimensions of the surgical site. An understanding of the root thickness of mandibular premolars and molars at the preferred level for root resection (3—3.6 mm),[1,2] bone thickness over these roots, and the proximity of each root apex to the mental foramen and inferior alveolar nerve will help the surgeon before and during the surgical procedure. Endodontic microsurgery (EMS) techniques have increased success rates over traditional approaches for mandibular posterior teeth. In broad terms, EMS refers to the surgical procedure involving the excision of the area located 3 mm above the root apex of a tooth.[3,4] This is achieved by making an incision through the buccal window of the mandible, facilitating direct resection of both the alveolar bone and the tooth root, situated 3 mm above the tooth's root apex.[5,6]

However, anatomically challenging scenarios can preclude EMS in certain cases. Microscopic surgery in the posterior mandibular region has several limitations owing to the relatively thick buccal cortical bone, lingual tilting of the roots, and small proximity between teeth and the inferior alveolar nerve.[6] These factors may cause unnecessary complications during surgery, including injury of the inferior alveolar nerve, which can result in facial paresthesia. The researchers have indicated that the microscopic apicoectomy in the posterior mandibular region comes with some risk.[7] The thickness of the alveolar bone is essential for surgeons who are planning bone removal for periapical surgery. It provides crucial anatomical information.[8,9] The success rate of periapical surgery in the posterior mandibular region is significantly lower when compared with other regions of the mandible[10] due to the region's unique anatomical structure. Thus, anatomical structure information is needed to perform periapical surgery.[11] The further posterior the teeth are positioned in the mandible, the greater the thickness of the buccal cortical bone in the facial direction is. Periapical surgery requires extensive bone removal, which can cause increased patient pain and compromised prognosis. When more volume of bone is removed during the procedure, the patient experiences more pain, and the affected area takes longer to heal. Previous studies have not investigated Asian populations, including the Taiwanese population, especially in gender and age differences.

Therefore, this study utilized dental cone-beam computed tomography (CBCT) to investigate the thickness of the buccolingual alveolar bone, the root thickness in the buccolingual direction, and the distance from the root apex to the inferior alveolar canal in the first and second mandibular molars. The findings of this research can guide clinicians to accurately locate lesions and determine how much bone should be removed. Furthermore, it can aid in assessing the complexity of apicoectomy, choosing the most suitable surgical approach, minimizing bone loss, and mitigating surgical trauma.

Materials and methods

Dental CBCT examinations

This retrospective study was conducted at the Dental Division of the China Medical University Hospital from August 2018 to March 2022. ProMax 3D Max (Planmeca, Helsinki, Finland) was used for CBCT imaging with the following scanning parameters: 200-μm voxel size, 96 kV, and 12 mA. This study analyzed data on 384 suitable teeth from 96 individuals (51 male and 45 female). This dataset included data on 192 mandibular first molars and 192 mandibular second molars. The inclusion criteria were as follows: (a) The measurement area had four fully formed molars, excluding the third molar, (b) the patient was older than 20 years old, and (c) the image resolution was 200 μm. The exclusion criteria were as follows: (a) The patient had severe periodontitis, (b) one or more root apexes in the measurement area had external absorption, (c) the measurement area had lesions, and (d) the patient had undergone root canal treatment. This study was approved by the Institutional Review Board of China Medical University Hospital (No. CMUH 111-REC3-205). We adhered to the relevant guidelines and regulations when conducting the study. The need to obtain informed consent was waived by CMUH 111-REC3-205 due to the study's retrospective nature.

Measurement of mandibular molar anatomy

The CBCT images were input into the medical imaging software Mimics 15.0 (Materialise, Leuven, Belgium, Germany). Multiplanar 2D reconstruction technology was used to determine a suitable section for measurement. Subsequently, the teeth were aligned in the axial plane, which is one of the orthogonal planes. Fig. 1(a) depicts how measurements for the distal root of the right mandibular first molar were taken. Measurements for the sagittal section of the tooth were obtained by aligning the orange tangent line shown in Fig. 1(b) with the distal root of the first molar. Aligning the orange tangent with the long axis of the distal root reveals the cross-section of the tooth, as shown in Fig. 1(c). Fig. 1(d) provides an enlarged view of Fig. 1(c),

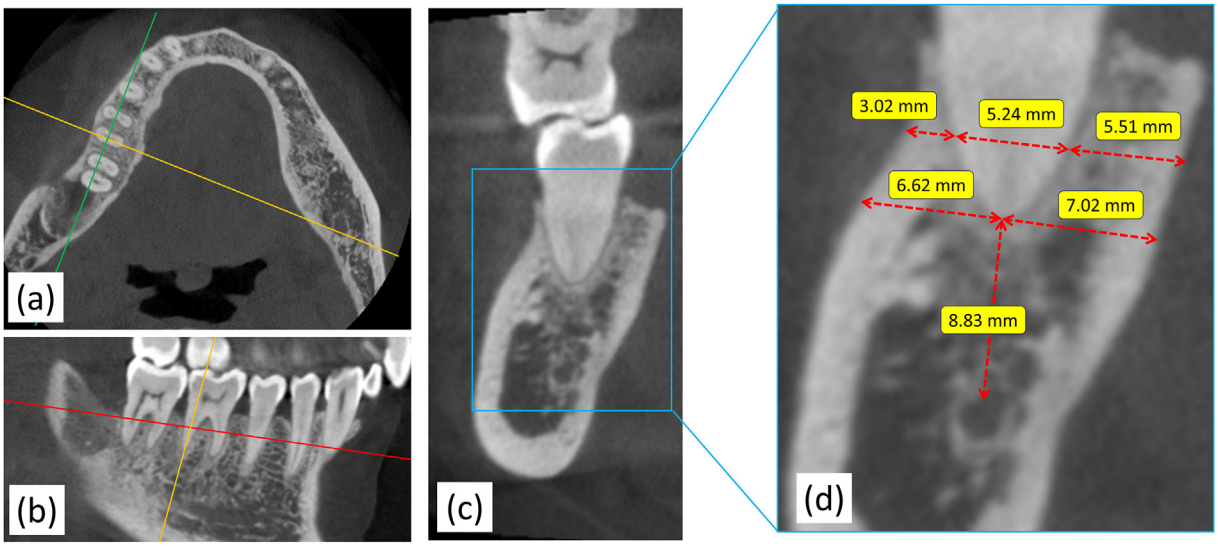

Figure 1 (a) Aligning the orange line with the root of the tooth on the axial view (b) aligning the orange line with the root of the tooth on the sagittal section (c) the cross-section of the tooth where the parameter was measured (d) enlargement of image C.

displaying the measured parameters of the root. The following parameters pertaining to the anatomy of the mandibular molar were measured in this study:

(1) Buccal alveolar bone thickness at 3 mm above the root apex: 3mmB
(2) Lingual alveolar bone thickness at 3 mm above the root apex: 3mmL
(3) Buccolingual root thickness at 3 mm above the root apex: 3 mm Root
(4) Buccal alveolar bone thickness at the root apex: Apex B
(5) Lingual alveolar bone thickness at the root apex: Apex L
(6) The straight-line distance from the root apex of the tooth to the mandibular canal: IC

The bone thickness of the buccal alveolar is measured as the distance from the outer edge of the buccal alveolar bone to the root surface, whereas the bone thickness of the lingual alveolar was measured as the distance from the outer edge of the lingual alveolar bone to the root surface.

Statistical analysis

Measurement accuracy was verified prior to parameter assessment. Intraclass correlation coefficients (ICCs) were calculated to evaluate the reliability of the measurements found by the intra- and inter-examiners. Ten randomly chosen CBCT image data sets were used to evaluate the level of interexaminer agreement. Two experienced examiners and two dental radiation technicians evaluated the agreement among observers regarding the measurement of cortical bone thickness. Interexaminer error was determined through measurements conducted by two examiners for each factor. The resulting ICCs for cortical bone thickness in CBCT ranged from 0.928 to 0.963. To assess intraexaminer error, a single examiner measured the six parameters twice, yielding ICC values between 0.957 and 0.985. These findings indicated that the method used in this study had negligible intraexaminer and interexaminer errors.

The Shapiro–Wilk test was employed to assess the normality of the data. For comparisons between different molar roots in various positions and three age groups, one-way analysis of variance (ANOVA) and Scheffé's method were conducted. Student's *t*-test was used to compare the left versus right sides of the mandible, and the first versus second molars. All statistical analyses were conducted using SPSS Version 19 (IBM, Armonk, NY, USA).

Results

Table 1 presents the parameters corresponding to the various tooth root positions. The buccal alveolar bone thickness at 3 mm above the root apex was the highest at the disto-buccal root of the second molar (14.1 mm) and lowest at the mesial root of the first molar (2.67 mm). The lingual alveolar bone thickness at 3 mm above the root apex was highest at the disto-lingual root of the first molar (8.8 mm) and lowest at the disto-lingual root of the second molar (0.92 mm). Similarly, the buccolingual root thickness at 3 mm above the root apex was highest at the mesial root of the first molar and lowest at the disto-lingual root of the second molar. For all measurement in molar positions, the alveolar bone thickness at the root apex was higher than the 3 mm above the root apex. The distance from the root apex to the mandibular canal was highest in the mesial root of the first molar (7.17 mm) and lowest in the distal root of the second molar (4.48 mm). Fig. 2 presents the buccal surface area required for complete resection during apicoectomy, including the buccolingual dimension of the root and the buccal bone thickness for each tooth. Specifically, 8.32 and 13.52 mm of the buccal surface were required for

Table 1 Alveolar bone, root thickness, and distance from the root to the mandibular canal of the first and second molars. 3mmB: buccal alveolar bone thickness at 3 mm above the root apex; 3mmL: lingual alveolar bone thickness at 3 mm above the root apex; 3 mm Root: buccolingual root thickness at 3 mm above the root apex; Apex B: buccal alveolar bone thickness at the root apex; Apex L: lingual alveolar bone thickness at the root apex; IC: shortest distance from the root apex to the inferior alveolar canal. N: sample size. Post hoc pairwise comparisons were conducted using Scheffe's method; the use of the same letter indicates no significant difference in the same column.

Tooth	Root number	Root position	3mmB	3mmL	3 mm Root	Apex B	Apex L	IC
Mandibular first molar	two roots (N = 143)	Mesial root	2.67 ± 1.53 ^{c}	5.47 ± 1.29 ^{b}	5.61 ± 0.93 ^{a}	4.24 ± 1.84 ^{c}	6.6 ± 1.46 ^{b}	7.17 ± 2.23 ^{bc}
		Distal root	4.21 ± 1.82 ^{b}	5.76 ± 1.23 ^{b}	4.76 ± 0.9 ^{b}	6.36 ± 1.87 ^{b}	6.69 ± 1.61 ^{b}	6.39 ± 2.17 ^{b}
	three roots (N = 45)	Mesial root	2.69 ± 1.21 ^{bc}	5.59 ± 1.3 ^{b}	5.72 ± 0.89 ^{a}	4.4 ± 1.61 ^{c}	6.57 ± 1.36 ^{b}	6.4 ± 2.82 ^{abc}
		Distal-buccal	3.69 ± 2.18 ^{bc}	8.8 ± 1.84 ^{a}	3.22 ± 0.62 ^{c}	5.53 ± 2.36 ^{bc}	9.24 ± 2.01 ^{a}	6.52 ± 2.41 ^{abc}
		Distal-lingual	10.88 ± 2.3 ^{a}	2.55 ± 1.11 ^{c}	2.36 ± 0.52 ^{d}	11.94 ± 2.87 ^{a}	3.39 ± 1.37 ^{c}	8.33 ± 2.55 ^{c}
Mandibular second molar	two roots (N = 180)	Mesial root	7.90 ± 2.58 ^{d}	3.56 ± 1.55 ^{c}	5.25 ± 1.17 ^{a}	10.13 ± 2.44 ^{d}	3.9 ± 1.84 ^{c}	5.25 ± 2.66 ^{ad}
		Distal root	8.86 ± 2.45 ^{e}	3.22 ± 1.53 ^{c}	4.66 ± 1.04 ^{b}	10.38 ± 2.35 ^{d}	3.38 ± 1.79 ^{c}	4.48 ± 2.33 ^{d}
	three roots (N = 2)	Mesial root	7.28 ± 5.03 ^{abcde}	3.1 ± 1.91 ^{bc}	5.48 ± 0.02 ^{abc}	9.44 ± 4.83 ^{abcd}	3.79 ± 2.31 ^{bc}	10.41 ± 0.78 ^{abcd}
		Distal-buccal	7.95 ± 4.37 ^{abcde}	6.09 ± 1.68 ^{abc}	2.93 ± 0.14 ^{abcd}	9.08 ± 3.69 ^{abcd}	6.59 ± 2.21 ^{abc}	8.26 ± 0.87 ^{abcd}
		Distal-lingual	14.1 ± 1.88 ^{ade}	0.92 ± 0.4 ^{c}	2.28 ± 0.08 ^{bcd}	14.81 ± 2.3 ^{ad}	1.01 ± 0.37	9.47 ± 2.69 ^{abcd}
		Unit: mm						
		P*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

* *one-way analysis of variance*

the mesial roots of the first molars and the distal roots of the second molars, respectively.

Differences by gender

Table 2 presents the data for males (n = 51) and females (n = 45). Student's *t*-test was used to analyze the differences between genders. Significant variations were observed only in (a) the lingual alveolar bone thickness at 3 mm above the root apex for all first molar roots, and in (b) the buccolingual root thickness at 3 mm above the root apex for the mesial root of the second molar. The mean buccal alveolar bone thickness at 3 mm above the root apex of the mesial root of the first molar was 2.77 ± 1.62 and 2.54 ± 1.4 mm for males and females, respectively. At the distal root of the second molar, the corresponding mean values were 8.84 ± 2.65 and 8.88 ± 2.22 mm for males and females, respectively. The mean value of the lingual alveolar bone thickness at 3 mm above the root apex of the mesial root of the first molar was 5.36 ± 1.38 and 5.6 ± 1.18 mm for males and females, respectively. At the distal root of the second molar, the corresponding mean values were 3.00 ± 1.32 and 3.47 ± 1.7 mm for males and females, respectively. The mean buccolingual root thickness at 3 mm above the root apex of the mesial root of the first molar was 5.72 ± 0.98 and 5.49 ± 0.86 mm for males and females, respectively. At the distal root of the second molar, the corresponding mean values were 4.92 ± 1.05 and 4.38 ± 0.95 mm for males and female, respectively. The mean buccal alveolar bone thickness at the root apex of the mesial root of the first molar was 4.46 ± 1.92 and 3.99 ± 1.7 mm for males and females, respectively. At the distal root of the second molar, the corresponding mean values were 10.58 ± 2.49 and 10.16 ± 2.17 mm for males and females, respectively. The mean lingual alveolar bone thickness at the root apex of the mesial root of the first molar was 6.5 ± 1.51 and 6.71 ± 1.39 mm for males and females, respectively.

Differences by age

Table 3 presents the Comparison of parameters between age groups. Due to the limited sample size of only 7 and 3 individuals, respectively, for molar with three roots in the age groups of 31–40 years and 41–70 years, statistical analysis was not performed due to the insufficient sample size. Therefore, Table 3 only presents the measurement results for the molar with two roots. In this study, all data were divided into three age groups: 20–30 years, 31–40 years, and 41–70 years. The sample selection criteria resulted in a lower number of samples in the older age group because the proportion of older individuals without prior treatment or pathological conditions at the targeted measurement sites was relatively small. Consequently, most images from older individuals were not suitable for analysis. Given these limitations in sample size, this study grouped all individuals between 41 and 70 years old together. Age-related statistical analysis was conducted using ANOVA, with a focus on dual-rooted teeth. However, owing to the small sample sizes, no ANOVA analysis was conducted for three-rooted teeth. The mean thickness of

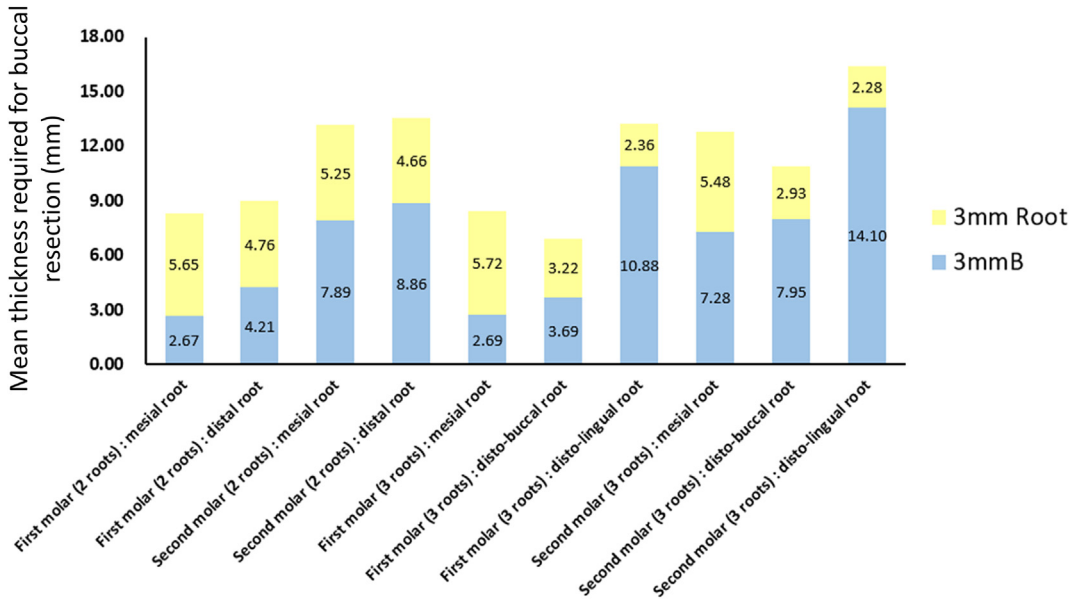

Figure 2 The mean thickness required for buccal resection. 3mmB: buccal alveolar bone thickness at 3 mm above the root apex; 3 mm Root: buccolingual root thickness at 3 mm above the root apex.

the buccal alveolar bone at 3 mm above the root apex of the mesial root of the first molar was 2.56 mm, 3.14 mm, and 2.63 mm for the 20—30, 31—40, and 41—70 age group, respectively. The mean lingual alveolar bone thickness at 3 mm above the root apex of the mesial root of the first molar was 5.54 mm, 5.49 mm, and 4.82 mm for the 20—30, 31—40, and 41—70 age groups, respectively. The mean straight-line distance between the root apex and the mandibular canal for the mesial root of the first molar was 6.8 mm, 7.74 mm, and 9.23 mm for the 20—30, 31—40, and 41—70 age group, respectively.

Discussion

In clinical research, the thickness of the alveolar bone in the posterior mandibular region, the distance from the root apex to the inferior alveolar nerve canal, and the distribution of mental foramen all provide essential preoperative information for dental practitioners conducting endodontic microsurgery. However, limited research has been conducted on alveolar bone thickness in Asian populations, particularly among the Taiwanese population. Thus, this study aimed to fill this research gap by measuring the thickness of the buccal and lingual alveolar bone in the posterior mandibular region of Taiwanese individuals with the aid of the imaging database of the Department of Dentistry at China Medical University Hospital. The linear distance from the root apex to the inferior alveolar nerve canal was also measured. The findings indicated decreasing linear distances from the root apex to the mandibular bone in the posterior tooth region among Taiwanese individuals. Females had a higher mean distance from the root apex to the inferior alveolar nerve canal in the first molar, whereas males had a higher mean distance in the second molar.

Periapical surgery is frequently conducted when conventional endodontic therapy is unfeasible. This procedure involves accessing the apical area of the tooth through a buccal incision to remove lesions surrounding the root apex. Performing this surgery in the posterior mandibular region is more challenging and has lower success rates than other tooth regions due to proximal anatomical complexities.[12,13] Therefore, a clear understanding of the anatomical structures in the posterior mandibular region is crucial for surgical access and effective treatment planning. CBCT is increasingly used as a 3D-imaging technique for evaluating tooth and bone morphology owing to its enhanced measurement precision.[14—21]

Iranian patients had the thinnest average buccal alveolar bone thickness at the level of resection,[22] followed by Egyptian patients[23] (Table 4), whereas Taiwanese patients had intermediate thickness values similar to those of patients in Turkey[24] (Table 4). Taiwanese patients had the greatest thickness of the second molar, closely resembling the values of South Korean patients, and Turkish and Iranian patients both had intermediate values.[5] South Koreans had exceptionally thick lingual alveolar bones at the level of resection, whereas Egyptian individuals had the thinnest measurements; Taiwanese individuals had lingual alveolar bones at the level of resection that were slightly larger than those of Egyptian patients (Table 4).

Populations from different countries did not significantly differ in terms of root thickness in the buccolingual direction at the level of resection. Among the first molars, individuals of Turkish descent had the thickest mesial root (Table 4), whereas individuals of Chinese—Mongolian descent had thicker distal roots (Table 4).[25] In the second molars, Turkish patients had slightly thicker mesial roots, whereas South Korean patients had slightly thicker distal roots.

This study measured the alveolar bone thickness, the distance between the root and inferior alveolar nerve canal, and mental foramen distribution in the posterior mandibular region of Taiwanese individuals. This valuable

Table 2 Comparison of characteristics between men and female. 3mmB: buccal alveolar bone thickness at 3 mm above the root apex; 3mmL: lingual alveolar bone thickness at 3 mm above the root apex; 3 mm Root: buccolingual root thickness at 3 mm above the root apex; Apex B: buccal alveolar bone thickness at the root apex; Apex L: lingual alveolar bone thickness at the root apex; IC: shortest distance from the root apex to the inferior alveolar canal. N: sample size. Comparisons were conducted using Student's *t*-test; the * indicates a significant difference between corresponding male and female groups.

Gender (sample number)	Tooth	Root number (sample number)	Root position	3mmB	3mmL	3 mm Root	Apex B	Apex L	IC
Male (N = 51)	Mandibular first molar	Two roots (N = 76)	Mesial root	2.77 ± 1.62	5.36 ± 1.38	5.72 ± 0.98	4.46 ± 1.92	6.5 ± 1.51	7.09 ± 2.08
			Distal root	4.31 ± 1.91	5.7 ± 1.20	4.84 ± 0.97	6.54 ± 1.99	6.62 ± 1.49	6.14 ± 2.16
		Three roots (N = 24)	Mesial root	2.71 ± 1.35	5.94 ± 1.10*	5.68 ± 0.95	4.24 ± 1.79	6.86 ± 1.13	6.72 ± 2.97
			Distal-buccal	3.57 ± 2.21	9.33 ± 1.30*	3.09 ± 0.58	5.2 ± 2.39	9.72 ± 1.50	6.74 ± 2.42
			Distal-lingual	10.82 ± 2.65	2.92 ± 1.06*	2.31 ± 0.48	11.7 ± 3.23	3.74 ± 1.25	8.52 ± 2.69
	Mandibular second molar	Two roots (N = 95)	Mesial root	7.61 ± 2.64	3.49 ± 1.41	5.53 ± 1.20*	10.14 ± 2.5	3.83 ± 1.58	5.44 ± 2.68
			Distal root	8.84 ± 2.65	3.00 ± 1.32	4.92 ± 1.05	10.58 ± 2.49	3.22 ± 1.54	4.74 ± 2.41
		Three roots (N = 2)	Mesial root	7.28 ± 5.03	3.1 ± 1.91	5.48 ± 0.02	9.44 ± 4.83	3.79 ± 2.31	10.41 ± 0.78
			Distal-buccal	7.95 ± 4.37	6.09 ± 1.68	2.93 ± 0.14	9.08 ± 3.69	6.59 ± 2.21	8.26 ± 0.87
			Distal-lingual	14.1 ± 1.88	0.92 ± 0.40	2.28 ± 0.08	14.81 ± 2.30	1.01 ± 0.37	9.47 ± 2.69
Female (N = 45)	Mandibular first molar	Two roots (N = 67)	Mesial root	2.54 ± 1.40	5.6 ± 1.18	5.49 ± 0.86	3.99 ± 1.70	6.71 ± 1.39	7.26 ± 2.38
			Distal root	4.1 ± 1.70	5.83 ± 1.27	4.67 ± 0.81	6.16 ± 1.69	6.76 ± 1.72	6.67 ± 2.14
		Three roots (N = 21)	Mesial root	2.64 ± 0.95	5.14 ± 1.35*	5.88 ± 0.84	4.55 ± 1.30	6.19 ± 1.45	6.3 ± 2.64
			Distal-buccal	3.66 ± 2.13	8.24 ± 2.09*	3.41 ± 0.63	5.74 ± 2.27	8.83 ± 2.35	6.53 ± 2.44
			Distal-lingual	10.91 ± 1.7	2.18 ± 1.02*	2.38 ± 0.55	12.17 ± 2.21	3.03 ± 1.37	8.08 ± 2.26
	Mandibular second molar	Two roots (N = 85)	Mesial root	8.19 ± 2.47	3.67 ± 1.67	4.92 ± 1.05*	10.07 ± 2.35	4.01 ± 2.09	4.99 ± 2.58
			Distal root	8.88 ± 2.22	3.47 ± 1.70	4.38 ± 0.95	10.16 ± 2.17	3.56 ± 2.03	4.20 ± 2.2
				Unit: mm					

Table 3 Comparison of parameters between age groups. 3mmB: buccal alveolar bone thickness at 3 mm above the root apex; 3mmL: lingual alveolar bone thickness at 3 mm above the root apex; 3 mm Root: buccolingual root thickness at 3 mm above the root apex; Apex B: buccal alveolar bone thickness at the root apex; Apex L: lingual alveolar bone thickness at the root apex; IC: shortest distance from the root apex to the inferior alveolar canal. N: sample size. Comparisons were performed using a one-way analysis of variance method; the * indicates a significant difference among the three age groups.

Age group (sample number)	Tooth	Root number (sample number)	Root position	3mmB	3mmL	3 mm Root	Apex B	Apex L	IC
20～30 years (N = 72)	Mandibular first molar	Two roots (N = 107)	Mesial root	2.56 ± 1.53	5.54 ± 1.29	5.65 ± 0.9	4.11 ± 1.76	6.66 ± 1.43	6.8 ± 2.13*
			Distal root	4.15 ± 1.82	5.79 ± 1.27	4.81 ± 0.9	6.22 ± 1.81	6.58 ± 1.58	5.99 ± 2.04*
	Mandibular second molar	Two roots (N = 138)	Mesial root	7.74 ± 2.27	3.44 ± 1.44	5.25 ± 1.15	9.89 ± 2.15*	3.71 ± 1.61*	4.87 ± 2.42*
			Distal root	8.75 ± 2.14	3.15 ± 1.43	4.68 ± 1.02	10.21 ± 2.1*	3.29 ± 1.65	4.12 ± 2.17*
31～40 years (N = 15)	Mandibular first molar	Two roots (N = 23)	Mesial root	3.14 ± 1.49	5.49 ± 1.01	5.52 ± 0.93	4.71 ± 2.07	6.62 ± 1.52	7.74 ± 2.09*
			Distal root	4.76 ± 1.88	5.84 ± 0.98	4.67 ± 0.88	7.12 ± 2.12	7.14 ± 1.56	6.83 ± 1.89*
	Mandibular second molar	Two roots (N = 28)	Mesial root	9.04 ± 3.54	3.72 ± 1.61	5.46 ± 1.20	11.7 ± 3.12*	4.28 ± 2.09*	6.48 ± 3.35*
			Distal root	9.97 ± 3.64	3.21 ± 1.62	4.8 ± 1.10	11.68 ± 3.12*	3.36 ± 2.19	5.66 ± 2.52*
41～70 years (N = 9)	Mandibular first molar	Two roots (N = 13)	Mesial root	2.63 ± 1.36	4.82 ± 1.57	5.49 ± 1.16	4.47 ± 1.88	6.00 ± 1.40	9.23 ± 1.91*
			Distal root	3.73 ± 1.43	5.35 ± 1.31	4.59 ± 0.93	6.21 ± 1.52	6.79 ± 1.74	8.83 ± 1.83*
	Mandibular second molar	Two roots (N = 15)	Mesial root	7.34 ± 2.69	4.40 ± 2.06	4.84 ± 1.11	9.53 ± 2.49*	4.99 ± 2.66 *	6.32 ± 2.21*
			Distal root	7.91 ± 1.83	3.94 ± 1.98	4.31 ± 1.04	9.66 ± 2.16*	4.17 ± 2.01	5.66 ± 2.24*
				Unit: mm					

Table 4 Analysis of mandibular molar anatomy across various populations; incorporates data from current and previous studies. Includes scanning machine type, resolution, and measurement approaches.

Country	Korea	Egypt		Turkish		Iran		China	Taiwan
author	Jeon et al.[5]	Sharaan et al.[22]		Uğur Aydın et al.[24]		Zahedi et al.[23]		Wang et al.[25]	This study
year	2021	2022		2019		2018		2019	2023
Resolution	0.2 mm	0.5 mm		0.3 mm		0.3 mm		0.2 mm	0.2 mm
Measurement method	In axial view	In coronal section		In axial view		In axial view		In axial view	In cross-section
		left side	right side	left side	right side	left side	right side		
First molar mesial root	2.8 ± 1.23	1.76 ± 0.56	1.88 ± 0.58	2.591 ± 1.59	1.909 ± 1.312	1.43 ± 1.28	1.66 ± 1.34	2.24 ± 0.97	2.66 ± 1.53
First molar distal root	3.84 ± 1.49	1.77 ± 0.48	1.78 ± 0.54	4.394 ± 2.128	3.663 ± 1.663	2.57 ± 1.62	2.76 ± 1.67	3.15 ± 1.28	4.21 ± 1.82
Second molar mesial root	6.75 ± 1.72	1.69 ± 0.74	2.07 ± 0.71	5.744 ± 1.788	5.232 ± 2.299	5.54 ± 2.12	5.16 ± 2.09	Not Available	7.90 ± 2.58
Second molar distal root	7.93 ± 1.68	1.74 ± 0.67	2.11 ± 0.66	6.857 ± 2.151	7.049 ± 1.758	6.31 ± 2.03	6.2 ± 1.73	Not Available	8.86 ± 2.45
	Unit: mm								

information can assist dental practitioners in assessing optimal surgical access routes and formulating effective treatment plans for periapical surgery procedures.

Taiwanese patients had the greatest distance between the root apex of the inferior alveolar nerve which is located in the mandibular canal, followed closely by German and South Korean patients, and Egyptian patients had the shortest distance. Taiwanese patients also had the greatest distance from the root apexes of other posterior mandibular teeth to the mandibular canal. These findings suggest that Taiwanese individuals may have a lower risk of inferior alveolar nerve damage during periapical surgery treatments compared with individuals from the other countries. South Korean and Iranian patients had measurements indicating closer root proximity to the nerve canal, underscoring the need for caution should be exercised when performing periapical surgery treatment involving the mandibular canal in these populations.[26—28]

Males and females differed in the distance from the root apex to the mandibular canal; this distance was greater and smaller in the first and second molars, respectively, among males than among females. Previous studies have reported opposite findings regarding the second molar,[26] potentially attributed to variations in genetic factors, ethnicity, and living environment. Age was also associated with the thickness of the alveolar bone, with a thinner alveolar bone in the 41—70 age group, possibly due to bone loss and calcium deficiency in older adults. The same age group also had a significantly longer distances from the root apex to the mandibular canal.[6,27]

This study had some limitations. First, the sample size was relatively small. Second, the uneven age stratification in this study may have introduced statistical errors; thus, a larger proportion of data from older age groups should be included to ensure a more balanced age distribution. Furthermore, the data and results of this study are specific to the Taiwanese population and should thus be generalized with caution.

This study employed CBCT imaging to measure (a) the alveolar bone and root thickness in the posterior teeth region and (b) the distance from the root apex to the mandibular canal in a Taiwanese population. The distribution of the mental foramen was assessed in each patient. The anatomical structures of the posterior teeth region greatly influence the endodontic microsurgery treatment plan and prognosis for dental procedures such as apicoectomy. This study provides valuable data for dental professionals performing such surgeries, with the goal of minimizing bone loss and mitigating the risk of complications. The conclusions of this study are that 1) The buccal alveolar bone thickness at 3 mm above the root apex of the mandibular second molar demonstrates a significantly higher value when compared to that of the first molar. Nonetheless, concerning the buccolingual root thickness, no significant differences were observed between these two teeth. 2) The buccal alveolar bone thickness and buccolingual root thickness at 3 mm above the root apex may not be influenced by gender and age. 3) The linear distance from the root apex to the mandibular canal decreased in teeth positioned toward the posterior of the mandibular, indicating closer proximity of the root to the mandibular canal. This finding agrees with those of other studies, suggesting an increased risk of nerve damage with surgeries conducted in the mandibular posterior teeth region.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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