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ORIGINAL ARTICLE

Crown morphology of the mandibular first molars with distolingual roots

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KEYWORDS
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Abstract *Background/purpose:* Most mandibular first molars have two roots. A major common variation of this tooth is the presence of a distolingual root, which is a common Mongoloid trait in certain populations. The aim of this article was to examine crown morphology in relation to the presence of the distolingual root.
Materials and methods: Using dental casts, the crown morphology of 141 mandibular first molars from 71 Taiwanese individuals was analyzed. Periapical radiographs were used to detect distolingual roots. The length and width of the crowns and the crown units (i.e., trigonid and talonid) were measured. Ten intercuspal distances and five cusp angles were examined.
Results: The buccolingual dimension of the crown and its ratio to the mesiodistal dimension were significantly increased in molars with a distolingual root, compared to molars without a distolingual root. Mesiodistal crown dimensions were similar; however, the crown unit dimensions were different: molars with a distolingual root had a shorter mesiodistal trigonid dimension but a longer talonid dimension, compared to molars without a distolingual root. The intercuspal distances from the three buccal cusps to the distolingual cusp were significantly longer, however, the distance between the mesiobuccal cusp and mesiolingual cusp was significantly shorter in teeth with a distolingual root than in teeth without a distolingual root. A significantly wider mesiolingual angle and narrower distolingual angle were observed in molars with a distolingual root, compared to molars without a distolingual root.

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Conclusion: The presence of a distolingual root significantly increased the buccolingual dimension of the crown and the location of distolingual cusp is significantly closer to the lingual side.

Introduction

Most mandibular first molars have two roots (one mesial and one distal) and three canals (two mesial and one distal).[1] A major variant of this tooth type is the presence of a third root, or a supernumerary lingual root, called radix entomolaris.[2,3] In Caucasians, the highest reported prevalence of distolingual root is 5%[4–6]; therefore, a distolingual root is an unusual or dysmorphic root morphology.

A high percentage (20—35%) of mandibular first molars with a distolingual root in Taiwanese people has recently been observed in our study and in other studies.[7–13] Similar prevalence rates of three-rooted molars have been demonstrated in populations with Mongoloid traits such as Chinese, major group of Eskimo people, and Native Americans.[14–16] Because of the high prevalence,[12,17] the extra root should be considered a normal morphological variant (i.e., eumorphic root morphology).

Awareness of the presence of a distolingual root is important for successful root canal treatment and periodontal care.[3,7,17] The root morphology correlated with the molars with and without a distolingual root has been examined[12,18,19]; however, there is limited information on crown morphology in relation to the presence of the root. The aim of the study was to analyze the variation in the crown morphology of mandibular first molars with and without the distolingual root by examining the dental cast models.

Materials and methods

The dental stone models were obtained from 71 patients (31 men and 40 women) with a mean age of 33.1 years old. They had attended the dental clinic at Tri-Service General Hospital (Taipei, Taiwan) or a private dental clinic from September 2008 to October 2012. The inclusion criteria were that the patients had: (1) Han Chinese ethnicity; (2) Angle's Class I occlusion with minor or no crowding; and (3) well-aligned dental arches. The rejection criteria were: (1) gross restorations or crowns that may alter the morphology of the tooth; (2) congenital defects or deformed teeth; and (3) obvious interproximal or occlusal wear. The presence or absence of the distolingual root was examined on dental radiographs modified from previous studies.[7,9] Periapical ultraspeed film (Eastman—Kodak, Rochester, NY, USA) and a parallel film holding system (Rinn XCP film holding system, Friadent, Mannheim, Germany) were used. In the present study, 68 teeth with a distolingual root and 73 without a distolingual root were included.

The tooth size variables were divided into the crown dimension,[20] the crown unit dimension (i.e., cuspal component), the intercuspal distance,[21] and the three-cusp angle (Figure 1).[22] The trigonid (TR, the mesial half of the crown) and talonid (TL, the distal half of the crown) were used to define the two crown units.[20] The dimensions of the tooth crown were defined as the maximum mesiodistal (maxMD) and maximum buccolingual (maxBL) crown diameters and measured parallel to the occlusal plane. The dimensions of two crown units, the TR and the TL, were the mesiodistal (MD) and buccolingual (BL) diameters of the TR and TL (i.e., TRMD, TLMD and TRBL, respectively). Furthermore, the buccolingual dimensions of the two distal cusps on the talonid (DcBL) were also measured in the present study. The boundaries between the TR and TL follows the definition used in the study by Kondo and colleagues[20]: the midpoint between the mesial central fossa and the intersection of the buccal groove with the protoconid-hypoconid ridge. The measurement was recorded to the nearest 0.01 mm using a digital caliper.

The cusp tips of the dental casts were first marked with a sharp pencil to create five small dots, based on the anatomy of cusps and grooves on the crown. These five dots were then used as the reference points to calculate the intercuspal distance and the three-cusp angles, which were modified from previous studies.[21,23] In brief, the distances

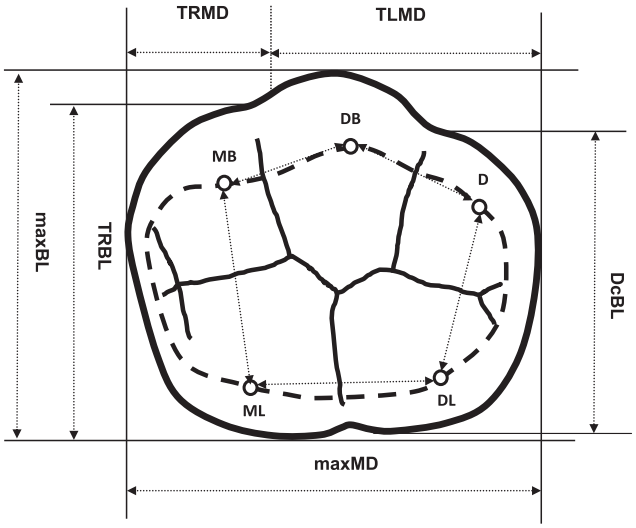

Figure 1 Measurements of the crown dimensions, the crown unit dimensions, and the intercuspal distances of the mandibular molar. DcBL = buccolingual dimension of distal cusp; maxBL = maximum buccolingual dimension of the crown; maxMD = maximum mesiodistal dimension of the crown; TLMD = mesiodistal dimension of the talonid; TRBL = buccolingual dimension of the trigonid; TRMD = mesiodistal dimensions of trigonid.

were recorded with a digital caliper and the angles were recorded with a protractor. Ten intercuspal distances were measured, based on the distances between the two cusps, which included the mesiobuccal (MB) cusp and mesiolingual (ML) cusp, the distal (D) cusp, the distobuccal (DB) cusp, and distolingual (DL) cusp. Therefore, the intercuspal distances are MB-DB, DB-D, D-DL, ML-DL, MB-ML, DB-DL, MB-DL, ML-DB, ML-D, and MB-D. The five occlusal three-cusp angles between the two adjacent cusps, which form an occlusal pentagon, are the DB-MB-ML angle (∠MB), the MB-DB-D angle (∠DB), the DB-D-DL angle (∠D), the ML-DL-D angle (∠DL), and the MB-ML-DL angle (∠ML). In this study, one examiner (CWN) examined and recorded all measurements.

To visualize and interpret each component, two contrasting occlusal pentagons were drawn for each cuspal component, based on the mean values (Figure 2). The pentagons were superimposed in two ways: (1) by registering at the ∠ML and aligning on the line joining the two lingual cusps (i.e., ML and DL; Figure 2, upper schematic diagram); and (2) by aligning on the line joining the two mesial cusps (i.e., MB and ML; Figure 2, lower schematic diagram).

The *t* test was used to evaluate the effect of the presence of the distolingual root on each morphological measurement. The Shapiro—Wilk normality test was essentially selected to examine the distributions of the obtained data sets. The association of the tooth crown morphology with the molars exhibiting a DL root, and with controlling for the variables of sex and age, the molars on the right and left hemimandibles of the same individual were evaluated by a regression model using generalized estimating equation method. In this study, $P < 0.05$ was considered significant.

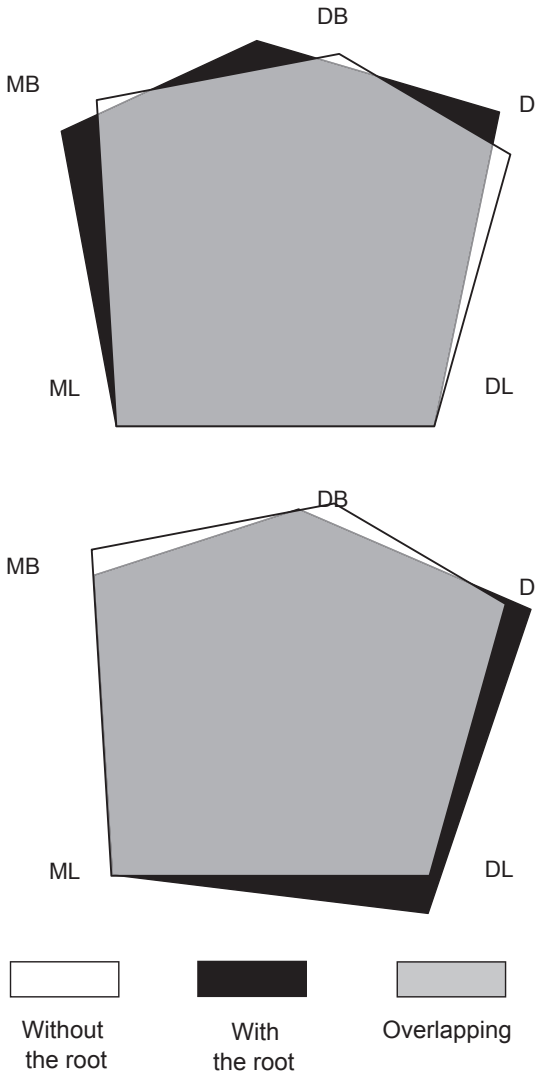

Figure 2 Comparison of the occlusal pentagons for crowns with and without a distolingual root. White indicates the crown without distolingual root; black indicates the crown with a distolingual root. The upper schematic diagram shows alignment on the line joining the two lingual cusps. The bottom diagram shows the alignment on the line joining the two mesial cusps. D = distal cusp; DB = distobuccal cusp; DL = distolingual cusp; MB = mesiobuccal cusp; ML = mesiolingual cusps.

Results

Comparison of crown morphology between molars with and without a distolingual root

The maxBL and the ratio of maxBL to maxMD (BL/MD) of the crown were significantly increased in molars with a distolingual root than in crowns without the root (Table 1 and Figure 3). Different crown unit dimensions between the molars with and without a distolingual root were observed: a smaller TRMD but a larger TLMD were recorded in molars with a distolingual root, compared to TRMD and TLMD in

Table 1 Comparison of the crown and crown unit dimensions for the mandibular first molars with and without distolingual roots.

	Non-DL (n = 73)	DL (n = 68)	P
General crown dimensions			
maxMD	11.13 ± 0.40	11.00 ± 0.41	0.065
maxBL	10.47 ± 0.27	11.16 ± 0.36	<0.01*
BL/MD	0.94 ± 0.04	1.01 ± 0.04	<0.01*
Dimensions for crown units			
TRMD	4.81 ± 0.25	4.51 ± 0.33	<0.01*
TLMD	6.28 ± 0.44	6.48 ± 0.52	0.01*
TRBL	10.28 ± 0.37	10.19 ± 0.38	0.15
DcBL	7.87 ± 0.54	8.61 ± 0.66	<0.01*

The data are presented as the mean ± the standard deviation. All measurements are in millimeters (mm).
* Indicates a significant difference ($P < 0.05$).
BL/MD = ratio of maximum buccolingual diameter of the crown to maximum mesiodistal diameter of the crown; DcBL = buccolingual diameter of the distal cusp; DL = distolingual; maxBL = maximum buccolingual diameter of the crown; maxMD = maximum mesiodistal diameter of the crown; TLMD = mesiodistal diameter of the talonid; TRBL = buccolingual diameter of the trigonid; TRMD = mesiodistal diameter of the trigonid.

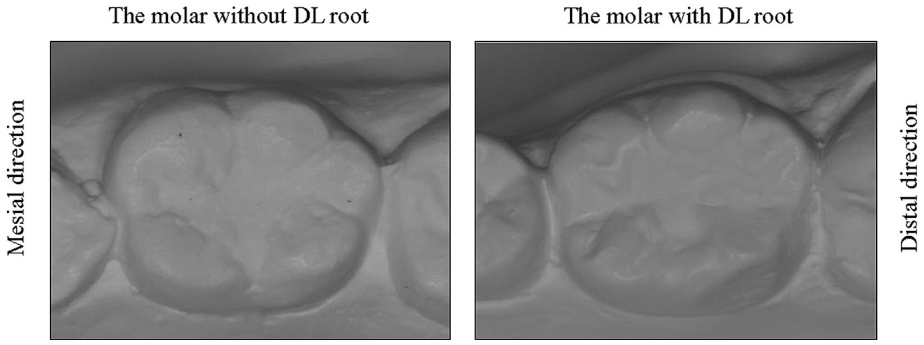

Figure 3 The crown morphology for the first mandibular molars with and without a distolingual root. DL = distolingual.

molars without the distolingual root (Table 1 and Figure 3). Furthermore, the DcBL dimension was longer in molars with a distolingual root than in molars without a distolingual root.

The intercuspal distances from all three buccal cusps to the distolingual cusp (i.e. MB-DL, DB-DL, and D-DL) were significantly longer in teeth with a distolingual root, compared to teeth without the root (Table 2). Furthermore, the distances of ML-DB and ML-D were significantly shorter in teeth with a distolingual root than in teeth without a distolingual root. For the two occlusal three-cuspal angles, the ∠ML and ∠DL—both located on lingual surface—showed significant differences between teeth with and without a distolingual root (Table 2). In addition, a smaller ∠D was noted in teeth with a distolingual root, compared to teeth without a distolingual root.

Table 2 Comparison of the intercuspal distances and the three-cusp occlusal angles of the mandibular first molars with and without a distolingual root.

	Non-DL (n = 73)	DL (n = 68)	P
Intercuspal distance (mm)			
D-DL	4.82 ± 0.47	5.71 ± 0.51	<0.01*
DB-DL	6.22 ± 0.47	6.77 ± 0.37	<0.01*
MB-DL	7.89 ± 0.45	8.35 ± 0.39	<0.01*
ML-DL	5.49 ± 0.51	5.59 ± 0.51	0.26
MB-ML	5.47 ± 0.45	5.38 ± 0.44	0.25
MB-DB	4.27 ± 0.38	4.47 ± 0.47	0.09
ML-DB	7.05 ± 0.44	7.37 ± 0.57	<0.01*
MB-D	7.53 ± 0.51	7.59 ± 0.51	0.56
ML-D	8.51 ± 0.53	8.83 ± 0.53	0.01*
DB-D	3.48 ± 0.42	3.35 ± 0.41	0.62
Occlusal three-cusp angle (degree)			
∠ML	93.30 ± 4.13	98.55 ± 7.41	<0.01*
∠DL	106.99 ± 4.44	101.96 ± 5.20	<0.01*
∠D	94.11 ± 6.20	92.14 ± 4.73	0.04*
∠DB	151.57 ± 7.77	152.67 ± 6.22	0.36
∠MB	93.24 ± 3.88	94.14 ± 4.61	0.22

The data are presented as the mean ± the standard deviation.
* Indicates a significant difference ($P < 0.05$).
∠D = distal angle; ∠DB = distobuccal angle; ∠DL = distolingual angle; ∠MB = mesiobuccal angle; ∠ML = mesiolingual angle; D = distal cusp; DB = distobuccal cusp; DL = distolingual cusp; MB = mesiobuccal cusp; ML = mesiolingual cusp.

The impact of age, sex, and right/left hemimandible on crown morphology

The maxBL was significantly increased in molars with a distolingual root than in molars without the root, based on univariate regression analysis (Table 3A). Furthermore, a significantly increased MaxBL was further observed after adjusting for the variables of sex, age, and molars on right and left hemimandibles. Similar findings were noted on the three-crown unit morphology (TRMD, TLMD, and DcBL), the four intercusp distances related to the DL cusp, and two occlusal three-cuspal angles (i.e., the ∠ML and ∠DL) on the lingual surface (Tables 3B and 3C). However, the significantly smaller ∠D in molars with a distolingual root compared to ∠D in molars without a distolingual root was not observed after the adjustment (Figure 3).

Comparison using superimposed pentagons

On superimposed pentagons aligned on the ML-DL line, there is an increased ∠ML but a decreased ∠DL in the molars with a DL root (Figure 2, upper diagram). When aligning on the MB-ML line, a prominent lingual shift of the distolingual cusp occurs (Figure 2, lower diagram).

Discussion

In the present study, the crown morphology of mandibular first molars with and without a distolingual root was compared. The measurements were examined and analyzed on the right and left molars separately; however, consistent statistical results were obtained. The molars with a distolingual root presented a smaller ∠DL and longer intercuspal distances between the distolingual cusp and the other three buccal cusps, compared to molars without a distolingual root (Table 2). On the superimposed pentagons, increased intercuspal distances and decreased ∠DL in the molars with distolingual roots resulted in a prominent distolingual shift of the whole crown with the distolingual lobe moving towards lingual side (Figure 2, bottom diagram). A similar finding by Calberson and colleagues[17] suggests that a prominent distal/distolingual lobe and a cervical prominence could facilitate the identification of a distolingual root. However, statistical analysis of the measurements was lacking until a recent study by Kim et al[24] in which 86 Korean patients (age, 5–43 years) had a significantly larger

Table 3 The association of the tooth crown morphology with the molars exhibiting a distolingual root, and with controlling for the variables of sex, age, and molars on the right and left hemimandibles of the same individual.

A. Crown and crown unit dimensions (mm)

		MaxBL		TRMD		TLMD		DcBL	
		Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi
Constant		10.471	10.55	4.808	4.797	6.276	6.354	7.831	8.092
DL	Yes	0.693*	0.705*	−0.302*	−0.309*	0.212*	0.238*	0.713*	0.762*
	No	0	0	0	0	0	0	0	0
Sex	Male		0.046		0.134		−0.019		0.072
	F		0		0		0		0
Side	Left		−0.027		−0.062		0.1		−0.009
	Right		0		0		0		0
Age			−0.003		0.0019		−0.004		−0.009

B. Intercusp distance (mm)

		D-DL		DB-DL		MB-DL		ML-DL	
		Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi
Constant		4.812	4.639	6.223	6.279	7.896	8.028	5.5	5.947
DL	Yes	0.916*	0.884*	0.557*	0.572*	0.460*	0.488*	0.1*	0.181*
	No	0	0	0	0	0	0	0	0
Sex	Male		0.105		−0.047		−0.063		0.187
	Female		0		0		0		0
Side	Left		−0.013		0.044		0.035		−0.049
	Right		0		0		0		0
Age			0.005		−0.00		−0.00		−0.16

C. Cuspal angle (degree)

		∠ML		∠DL		∠D	
		Uni	Multi	Uni	Multi	Uni	Multi
Constant		93.328	91.014	106.937	107.599	94.212	96.492
DL	Yes	5.366*	5*	−5.052*	−4.804*	−2.102*	−1.773
	No	0	0	0	0	0	0
Sex	Male		−2.061		0.922		−1.739
	Female		0		0		0
Side	Left		0.887		0.923		−0.588
	Right		0		0		0
Age			0.089		−0.050		−0.042

Morphological dimensions include four crown/crown unit dimensions, four intercuspal distances, and three cup angles, which were related to the distolingual cusp. The β coefficient represents the prediction value in univariate (Uni) or multivariate (Multi) regression analysis.

* Indicates a significant difference ($P < 0.05$), based on the generalized estimating equation method.

∠D = distal angle; ∠DB = distobuccal angle; ∠DL = distolingual angle; ∠MB = mesiobuccal angle; ∠ML = mesiolingual angle; D = distal cusp; DB = distobuccal cusp; DcBL = buccolingual dimension of the two distal cusps on the talonid; DL = distolingual cusp; maxBL = maximum buccolingual crown diameter; MB = mesiobuccal cusp; ML = mesiolingual cusp; TLMD = mesiodistal diameter of the talonid; TRMD = mesiodistal diameter of the trigonid.

DB-DL, MB-DL, and D-DL intercuspal distances and a larger distal buccolingual width on the crowns of first permanent and primary second molars with DL roots, compared to molars than without a DL root.

A permanent mandibular first molar usually has two roots with three root canals.[25] However, the variations in the number of roots and in canal morphology have been noted as a trait in Mongoloid peoples such as the Chinese, major group of Eskimo people, and Native American.[10,17,26] The additional third root in the permanent mandibular first molar, which is usually on the lingual site, is also called the radix entomolaris. This extra root is smaller than the distobuccal root and is usually curved. As a consequence, special attention is suggested when performing root canal treatment. According to the classification of De Moor et al,[3] three types of distolingual root can be identified. Type I refers to a straight root/root canal; Type II, an initially curved entrance that continues as a straight root/root canal; and Type III, an initial curve in the coronal third of the root canal and a second curve beginning in the middle and continuing to the apical third. However, the current study is the first to report and compare the differences in crown morphology between the mandibular molars with and without a distolingual root.

Various methodologies such as the direct inspection of the extracted molars, dental radiography, and computed

tomography have been used to examine the presence and the morphology of distolingual roots.[7–9,12,27] In this study, dental periapical radiographs were used. It may not be as accurate as computed tomography or direct inspection of the extracted molar; however, it is noninvasive and economical, and has a low radiation exposure. In addition, our previous studies demonstrated that computed tomography and conventional dental radiography revealed a similar prevalence of distolingual roots.[7,8] This may be because of the unique morphology of the distolingual roots, which is usually small and curved.[3,12,28]

In this study, dental casts were used to analyze crown morphology. Distortions may occur in the process of making dental cast models[23]; however, the dental cast model has been widely utilized to measure tooth morphology to compare differences between races, etiologies, and morphologic variations.[20,23,29] Our results showed that the general crown width and length dimensions, which are the maxBL and maxMD, were similar between the molars with and without distolingual roots. Detailed differences regarding the dimension of the crown unit (i.e., cuspal component) were further analyzed. For instance, the ratio of maxBL to maxMD was significantly higher, the TRMD was significantly shorter, the DcBL was significantly longer, and the ratio of DcBL to TRBL was significantly increased in molars with distolingual roots, compared to molars without distolingual roots (data not shown). Using superimposed occlusal pentagons, the differences in the intercuspal distances and occlusal three-cuspal angles between the molars with and without distolingual roots can be easily demonstrated. Increased intercuspal distances of D-DL, DB-DL, MB-DL, and ∠ML, and a decreased distance of MB-ML and ∠DL were observed in molars with distolingual roots, compared to molars without distolingual roots. The prominent distolingual component towards the lingual side was noted on the superimposed pentagons when aligned on the line joining the two mesial cusps (Figure 2, lower diagram).

In conclusion, the aim of this study was to evaluate the variations in crown morphology of mandibular first molars with distolingual roots. Our results demonstrated that the presence of a distolingual root significantly increased the buccolingual dimension of the crown, although its presence did not affect the mesiodistal dimension. We also revealed that the molar presenting with the extra root has a more prominent talonid (i.e., the distal half of crown) on its crown, whereas the molar without the root has a noticeable trigonid (i.e., the mesial half of crown). Hence the presence of a DL root will tend to increase the BL dimension of the crown. Clinicians should be aware of this variation in crown morphology when an extra root is present, especially in Asian people.

Conflicts of interest

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

Acknowledgments

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