Original Article

A cone-beam computed tomography study of the root and root canal morphology of maxillary first premolars in young Peruvians

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Abstract

Introduction: Cone-beam computed tomography (CBCT) is an important diagnostic tool today as it allows the evaluation of the internal structures of hard tissues. This study investigated the internal root morphology of the maxillary first premolars by CBCT in a population of young Peruvians.

Materials and Methods: This was a cross-sectional, retrospective, observational, descriptive study, in which CBCT of 307 scans from patients fulfilling the selection criteria were evaluated. External and internal anatomical characteristics were evaluated in sagittal, coronal, and axial sections at different levels of the root portion, and tooth location and gender were recorded.

Results: Only 52.1% presented one root and 49.2% presented two canals. In the analysis of internal morphology according to the Vertucci classification, type IV was the most frequent, with 39.4% in both men and women, being 41.4% on the right side and 37.4% on the left side. Similarly, type IV was significantly more frequent in men (51.1%) than women (30.5%). The most frequent number of roots was one root, and the number of canals was 2 (49.2%), followed by one canal (47.9%) and three canals (2.9%).

Conclusions: The maxillary first premolars showed a predominance of one root and two canals, and the most frequent internal root morphology was Vertucci type IV in both the left and right sides in both genders.

Keywords: Cone-beam computed tomography, morphology, root canal

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INTRODUCTION

The success or failure of endodontic treatment is not only due to factors such as determining the working length or the elimination of the remains of root tissue, but it is also essential to know the root morphology of the dental pieces since the omission of a single root canal can lead to failure of the entire endodontic treatment.[1]

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To determine the presentation of root canals, several methods have been used over time, including the diaphanization of teeth, the use of stereo microscopy, and scanning microscopy. However, cone-beam computed tomography (CBCT) is a noninvasive method that allows more detailed observation of the structures.[2-4] The most

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frequent endodontic treatment is that of premolars, being performed in 15.8%–21.5% of cases[5] and according to the literature, these teeth have the greatest anatomical variability.[6]

Regarding anatomical variations, root canals are generally curved and may have ramifications. Kuttler referred to the classification used by Okumura, which was later completed by Pucci and Reig. The branches of the main canal are (i) collateral or parallel to the main canal; (ii) lateral with branches to a wall of the canal; (iii) interrecurrent; (iv) recurrent; (v) secondary; (vi) accessory; (vii) cavo-inter-radicular; and (viii) delta complementary.[7-9]

Vertucci first classified the number of canals into four and then later into eight types.[6,10]

In relation to the root morphology of the first and maxillary second premolar, a study in Spain determined the location of the tooth, the frequency of roots, and root canal morphology according to Vertucci using CBCT. Regarding the first premolar, the majority presented two roots (51.4%) and only 2.6% presented three roots, with a type IV canal configuration being the most frequent (52.8%).[11] Another study determined the distribution of the Vertucci classification using a sample of 114 first premolars, in which two roots were the most frequent (68.6%) and type I Vertucci canal morphology was the most often observed (68%) followed by type II (12.9%).[12]

A study conducted in Malaysia evaluating internal root morphology in a subpopulation using CBCT showed a type II root morphology in 23.8% of maxillary first premolars.[13] Several studies in different populations have reported ethnic variations. There are few studies on root morphology[1,2,5] of the different dental groups in young Peruvians, and knowledge of these canals in this population is essential to achieve successful endodontic treatment.

Thus, the objective of this study was to evaluate by CBCT the root and root canal morphology of maxillary first premolars in young Peruvians.

MATERIALS AND METHODS

Ethical aspects

The study was registered with code N°055-2019 by the Faculty of Dentistry of the Universidad Nacional Federico Villarreal, Lima, Peru.

Study design

This observational, descriptive research was conducted from a secondary database of the Panoral radiology center in the city of Lima, with CBCT that was taken performed from January 2018 to January 2020.

Inclusion criteria

The inclusion criteria included CBCT scans of patients aged 15–24 years, presenting both maxillary first premolars with fully developed roots, intact and with closed apex. Premolars with root resorption and with previous root canal treatment, carious lesions, or CBCT scans containing any distortion or artifact were excluded.

Sample size determination

The sample size was determined using the formula to estimate a proportion $N = (Z^2 \times p \times q)/\delta^2$. A beta of 0.80 and a significance level of 0.05 were used for the calculation using Stata 15.0 software (Copyright 1985-2021 StataCorp LLC. StataCorp 4905 Lakeway Drive College Station, Texas 77845 USA). A total of 307 tomographies were used. The training and calibration were carried out by a specialist of the radiological center with more than 10 years of experience. The kappa index was applied ($\kappa = 1$) for the qualitative variables and the intraclass correlation coefficient was used (ICC = 0.98) for quantitative variables obtaining good concordance.

Tomographic assessment

To perform the morphology studies, an *Instrumentarium OP300 Maxio CBCT* was used with a field of view of 15 × 10, a voxel size of 0.18 mm, and values of 89 kV and 13 mA. Data collection was done remotely with the help of the TeamViewer application that allowed access to the CT scans from the computer of the radiology center. A Huawei 2.1 GHz laptop with 8.19 GB of RAM and Windows 10 with a resolution of 2160 × 1440 pixels was used to observe the set of CBCT scans. To evaluate the CBCT scans of the first premolars, the longitudinal axis of the tooth was used as a reference, which was located with the help of the three planes (axial, coronal, and sagittal). First, the tooth was divided into three portions or planes; cervical, middle, and apical, and then, the axial cuts were made in the different portions, taking as reference the cementoenamel junction (CEJ) for the crown and root portion. Reconstruction of the axial, coronal, and sagittal planes was performed to evaluate the root morphology according to Vertucci's classification. The crown was measured from the buccal cusp to the CEJ, while the root was assessed from the CEJ to the root apex, and the total tooth length was measured from the cusp to the root apex [Figure 1].

Statistical analysis

Statistical analysis was performed using SPSS 25.0 (IBM Corporation, Armonk, NY, 10504, USA). For the inferential

analysis, the Chi-square test was used to associate gender and the types of canal morphology proportions and the Student's *t*-test was used to compare the means of the number of root canals and number of roots according to gender. The data presented a normal distribution. The significance level for statistical tests was set at $P < 0.05$ in all cases.

RESULTS

Table 1 shows the frequency distribution of the number of roots and root canals, with two roots showing the highest frequency (51.2%), with 52.0% found on the right side and 52.3% on the left side.

The internal configuration of the maxillary first premolars according to Vertucci's classification and location is shown in Table 2. Type IV was more frequent in 39.4%, 41.4% being on the right, and 37.4% on the left. Furthermore,

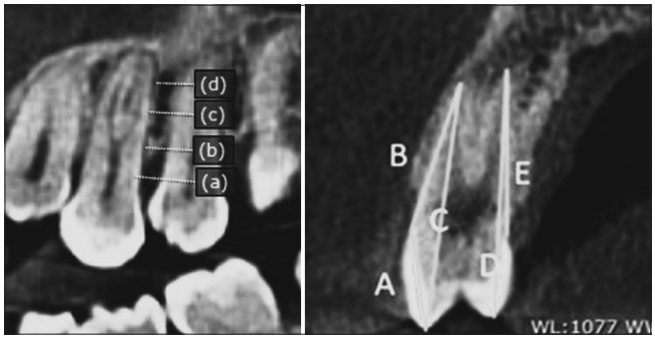


Figure 1: Reference planes of the axial slices are indicated by the blue arrow through the thirds of the root, being a and b (cervical), c (middle), and image d (apical). The planes and points of reference for taking the measurements are the crown cusp, the cementoenamel junction, and the root apex, where A: Crown length; B: Length of the buccal root, C: Total length of the buccal root, D: Total length of the palatal root, E: Length of the palatal root

Table 2 shows the internal configuration according to gender. Among women, 30.5% presented type IV, followed by type I with 29.9%, while 51.1% of men presented type IV, followed by type I with 15.8%, being statistically significant differences ($P = 0.0001$).

Table 3 describes the length measurements according to gender and location, showing that the mean lengths of the crown and the buccal and palatal roots were 8.05 mm, 13.61 mm, and 13.18 mm, respectively.

DISCUSSION

In a previous investigation, a higher frequency of Vertucci type IV configuration was observed, followed by type I. While type IV was described in 50.6% of cases in the Colombian population and in 52.8% in the Spanish population, these variant features could be related to the genetics of South American populations.[14]

While the Spanish study reported a higher frequency of 52.8% of type IV,[11] a Chinese population from Shandong found a higher frequency of 58.6%,[15] and in an Iranian population, the frequency of type IV was 71.64%.[16] In contrast, the Pakistani population reported a higher prevalence of type I of 68%.[12] In Malaysia, the prevalence of type II was observed at 23.8%.[14] These anatomical variabilities may indicate the proximity or remoteness of ethnic groups in which some morphological similarity with Europeans may be found, although the frequency with which they occur varies.

The internal configuration of the roots, according to Vertucci's classification by gender showed that women presented a greater frequency of type IV with 30.5%, while 51.1%. Men presented this type. In the comparative

Table 1: Frequency distribution of the number roots and canals in the maxillary first premolars according to location

Maxillary first premolars	Number of root			Number of canals			Total, *n* (%)
	1, *n* (%)	2, *n* (%)	3, *n* (%)	1, *n* (%)	2, *n* (%)	3, *n* (%)	
Maxillary first premolars (right side)	79 (52.0)	68 (44.7)	5 (3.3)	71 (46.7)	76 (50.0)	5 (3.3)	152 (100)
Maxillary first premolars (left side)	81 (52.3)	70 (45.2)	4 (2.6)	76 (49.0)	75 (48.4)	4 (2.6)	155 (100)
Total	160 (52.1)	138 (45.0)	9 (2.9)	147 (47.9)	151 (49.2)	9 (2.9)	307 (100)

Table 2: Internal configuration of the roots of maxillary first premolars according to Vertucci's classification, location, and gender

Maxillary first premolars	Types of canal morphology								Others, *n* (%)	Total
	Type I, *n* (%)	Type II, *n* (%)	Type III, *n* (%)	Type IV, *n* (%)	Type V, *n* (%)	Type VI, *n* (%)	Type VII, *n* (%)	Type VIII, *n* (%)		
Right side	35 (23.0)	14 (9.2)	19 (12.5)	63 (41.4)	6 (3.9)	1 (0.7)	4 (2.6)	5 (3.3)	5 (3.3)	152
Left side	38 (24.5)	20 (12.9)	15 (9.7)	58 (37.4)	10 (6.5)	2 (1.3)	7 (4.5)	4 (2.6)	1 (0.6)	155
Total	73 (23.8)	34 (11.1)	34 (11.1)	121 (39.4)	16 (5.2)	3 (1.0)	11 (3.6)	9 (2.9)	6 (2.0)	307
Female	52 (29.9)	25 (14.4)	25 (14.4)	53 (30.5)	10 (5.7)	2 (1.1)	3 (1.7)	2 (1.1)	2 (1.1)	174
Male	21 (15.8)	9 (6.8)	9 (6.8)	68 (51.1)	6 (4.5)	1 (0.8)	8 (6.0)	7 (5.3)	4 (3.0)	133
Total	73 (23.8)	34 (11.1)	34 (11.1)	121 (39.4)	16 (5.2)	3 (1.0)	11 (3.6)	9 (2.9)	6 (2.0)	307

Statistical significance level with $P<0.05$ (Chi-square test). Significance $P=0.001$

Table 3: Tooth length of the maxillary first premolars according to location and comparison of length measurements according to gender

Maxillary first premolars	Location				Gender				
	Side	*n*	Mean (mm)	SD (mm)		*n*	Mean (mm)	SD (mm)	*P*
Tooth crown length	Right	152	8.00	0.73	Female	174	7.94	0.69	0.004
	Left	155	8.10	0.76	Male	133	8.19	0.78	
Tooth root length									
Buccal	Right	152	13.56	1.86	Female	174	13.38	1.78	0.010
	Left	155	13.66	1.76	Male	133	13.92	1.81	
Palatal	Right	73	13.14	2.02	Female	63	12.81	1.81	0.047
	Left	74	13.21	1.88	Male	84	13.45	2.01	
Total length of tooth root									
Buccal	Right	152	20.80	2.06	Female	174	20.63	2.01	0.006
	Left	155	21.01	1.97	Male	133	21.26	1.98	
Palatal	Right	73	19.66	2.26	Female	63	19.37	2.10	0.103
	Left	74	19.74	2.00	Male	84	19.95	2.12	
Third root	Right	6	20.52	1.90	Female	2	18.30	0.14	0.029
	Left	4	20.60	1.72	Male	8	21.11	1.43	
Total			307				307		

Statistical significance level with $P<0.05$ (Student's *t*-test). SD: Standard deviation

analysis, a statistically significant difference was found in the proportion of the frequency of the Vertucci classification type between men and women ($P = 0.0001$), with type I in 29.9%, type II in 14.4%, and type III which were more prevalent in women with 14.4%. Similarly, in the Chinese population, 28.2% was observed in women and 30.4% in men.[15] On the other hand, in a German population, a higher frequency was found in women with 61.8%, followed by type VI with 12.6% in women and 76.8% in men.[17]

Regarding the number of roots, the presence of one root was more frequent in 52.1% of young Peruvians. Similarly, in an *in vitro* study of an Indian population, 53.6% presented one root,[18] while 67.4% of the Chinese population found the same.[16] On the contrary, a study in the Spanish population reported a higher frequency of two roots with 51.4%.[11] In the Pakistani population, two roots were observed in 68.6%.[12] Similarly, in the Colombian population, the frequency of two roots was 53.4%.[14] Regarding the number of canals, the present study found a higher frequency of two canals in 49.2%, followed by a single canal in 47.9%, and 2.9% presented three root canals. In the evaluation by the side of the maxillary first premolars, we found that 50% presented two canals on the right side, while only one canal was found in 49.7% on the left side.

Regarding the measurements, the mean lengths of the crown and the buccal and palatal roots were 8.05 mm, 13.61 mm, and 13.18 mm, respectively, and the total length of the buccal and palatal root was 20.90 mm and 19.70 mm, respectively. Similar data were found in the Pakistani population, in which the total length of the buccal root was 20.60 mm and that of the palatal root was 19.5 mm.[12] However, a study[19] performed in the equatorial basin found that the total lengths of the buccal and palatal roots were similar with 19.6 mm and 19.9 mm, respectively. Similarly, in a Turkish population, the total length of the buccal and palatal roots was 19.88 mm and 19.09 mm, respectively.[20]

In the evaluation of the measurements according to gender, in women, the length of the crown and the buccal and palatal roots was 7.94 mm, 13.38 mm, and 12.81 mm, respectively, and the total length of the buccal and palatal roots was 20.63 mm and 19.37, respectively. On the other hand, in men, the length of the crown and the buccal and palatal root was 8.19 mm, 13.92 mm, and 13.45, respectively, while the total buccal and palatal root length was 19.37 mm and 9.95 mm, respectively.

In a North American population, the crown length in females was 7.4 mm, while the root length was 13 mm, and the total root length was 20.1 mm. In males, the crown length was 8.1 mm, the root length was 13.8 mm, and the total root length was 21.4 mm.[21]

The main limitation of this study was that the literature of the root morphology of maxillary first premolars[22] is related to other ethnic groups and countries but not Peru, and therefore, the results of the present study are important because they contribute to the knowledge of the morphological characteristics of the root canal,[23] as well as the measurements of crown, root, and total root lengths of maxillary first premolars in a young Peruvian population.

This study is important because it makes it possible to identify the characteristics of the anatomy of the

upper premolars by means of an accessible tool such as tomography. For this reason, the anatomical variants of the root canals could be established. This would generate an interesting concept to take care of during root instrumentation.

CONCLUSIONS

The predominant root morphology of the maxillary first premolars was Vertucci type IV, with 39.4%, presenting a frequency of 41.4% on the right side and 37.4% on the left side. In addition, type IV was the most frequent in both genders. The number of roots most frequently present in the upper first premolar was one in 52.1%, and the most frequent number of canals was two in 49.2%. The mean length of the crown and buccal and palatal roots was 8.05 mm, 13.61 mm, and 13.18 mm, respectively. All length measurements were greater in males than females, except for the length of the palatal root, which showed no significant difference between genders.

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Conflicts of interest
There are no conflicts of interest.

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