



ORIGINAL ARTICLE

# Morphological variations of mandibular first premolar on cone-beam computed tomography in a Saudi Arabian sub-population

Youssef A. Algarni<sup>a,\*</sup>, Muna J. Almufarrij<sup>b</sup>, Ibrahim A. Almoshafi<sup>c</sup>,  
Haneen H. Alhayaza<sup>b</sup>, Nuha Alghamdi<sup>a</sup>, Suheel Manzoor Baba<sup>a</sup>

<sup>a</sup> Department of Restorative Dental Science, King Khalid University, Abha, Aseer, Saudi Arabia

<sup>b</sup> Dental Intern, King Khalid University, Saudi Arabia

<sup>c</sup> General Dentist Ministry of Health KMMCH, Saudi Arabia

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## KEYWORDS

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**Abstract** In-depth knowledge of common and aberrant pulp morphology is essential for appropriate diagnosis and treatment planning prior to commencing root canal treatment. Radicular morphology of mandibular premolars has been extensively studied. Considerable variation in the number of canals and roots found in these teeth has been reported.

**Aim:** The purpose of this study is to investigate the root and root canal morphology of mandibular first premolar among Saudi Arabian subpopulation in Aseer using CBCT.

**Methods:** Cone-beam computed tomography images of Mandibular first premolar were taken from 166 patients which were referred to Armed Forces Hospitals Southern Region (AFHSR), Khamis Mushayt, Asir region Saudi Arabia. All the images were assessed by two Evaluators (An Endodontist and a Radiologist). Inter-examiner reliability was determined and was assessed by KAPPA value.

**Results:** The mandibular first premolar (n = 216) distributed as 120 teeth in female and 96 teeth in male. Out of the 120 teeth examined in female groups one canal was seen in 95 (79.2%) teeth, two canals in 19 (15.8%) teeth and three canals in 6 (5%) teeth where as in the Male group out of 96 teeth, 52 (54.1%) teeth showed one canal, 32 (33.3%) teeth with two canals whereas 12 (12.5%) teeth showed presence of three canals.

**Abbreviations:** RCT, root canal treatment; CT, computed tomography; CBCT, cone-beam computed tomography; ICC, intraclass correlation, mandibular premolars, first premolars

\* Corresponding author at: Department of Restorative Dental Science, Faculty of Dentistry, King Khalid University, Abha, Aseer, Saudi Arabia.

E-mail address: dryalgarni@gmail.com (Y.A. Algarni).

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Chi-Square test for mandibular first premolars demonstrated the chance of second canal in the mandibular first premolar more in male than female and these differences was statistically significant ( $P \leq 0.05$ ).

*Conclusion:* Endodontic therapy of mandibular premolars is a challenge for clinician because of their frequent morphological and anatomical abnormalities. Proper knowledge about number of root canals and canal configuration is a key to success in Endodontic. There is a great variability in different population regarding the root canal configuration in mandibular pre-molars. However, most studies state the mandibular first premolar has one root canal. Also, the most prevalent type of root canal found was Type I vertucci.

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## 1. Introduction

Knowledge of the common and aberrant varying pulp morphologies is essential for an appropriate diagnosis and treatment plan before commencing root canal treatment (RCT). Appreciating the complexity of the root canal system and modifying the treatment protocol based on the individual root canal system establish the roadmap to aids in establishing successful endodontics for difficult cases (Sachdeva et al., 2008).

Studies on the radicular morphology of the mandibular premolars have shown that there is a considerable variation in the number of canals and roots found in these teeth as reported by (Barbizam et al., 2004). The mandibular first premolar is typically a single rooted tooth. Although rarely, two, three, and four- rooted variations have also been reported but rare (Trope et al., 1986). Approximately 24% of mandibular premolars demonstrate two or more canals (Trope et al., 1986; Lu et al., 2006).

Root canal system and its morphological variations have been classified by several investigators. The most widely used is Vertucci's classification where He classified the root canal configuration into eight categories: Type I (1), Type II (2-1), Type III (1-2-1), Type IV (2), Type V (1-2), Type VI (2-1-2), Type VII (1-2-1-2) and Type VIII (Vertucci, 1984).

The internal dental anatomy is mostly studied using tooth clearing, sectioning, radiography (Zillich and Dowson, 1973), in vitro endodontic access through radiographs and instruments, in vitro macroscopic examination and in vitro RCT with magnification (Walker, 1988). Clinical examination and conventional periapical radiography are traditional methods to identify roots and root canals. However, they are complicated, time-consuming, and could or result in sample destruction (Cleghorn et al., 2007). Computed tomography (CT) and micro-CT ( $\mu$ CT), have been used to evaluate the root canal anatomy in a three-dimensional (3D) orientation because of the high resolution and non-destruction of the specimen (Sert et al., 2004; Khedmat et al., 2010). CBCT technique has become a successful method for studying root canal anatomy as it is as precise as root canal staining and clearing techniques which were used in past since they are superior to conventional techniques because of their ability to produce a nondestructive 3D views and complete morphologic details.

To the best of our knowledge, no study has so far evaluated the root canal morphology of mandibular first premolar in

Saudi subpopulation using CBCT. Therefore, the purpose of this study was to investigate the roots and root canal morphologies of the mandibular first premolar in a Saudi Arabian subpopulation (Aseer region) using CBCT

## 2. Materials and methods

### 2.1. Patient's selection

Cone-beam computed tomography (CBCT) of the mandibular first premolar was performed in 166 patients which were referred to the Armed Forces Hospitals, Southern Region (AFHSR), Khamis Mushayt, Aseer Region, Saudi Arabia. Written consent was obtained from all patient's, and approval was obtained from the Ethics Committee of College of Dentistry, King Khalid University.

The CBCT indications included those suffering from dento-alveolar trauma, tooth fracture, patients required a pre-operative assessment for implants and endodontic surgery, and location of the impacted teeth before orthodontic treatment. Furthermore, CBCT was performed; RCT in difficult cases and after RCT in cases of teeth with symptoms after RCT.

The inclusion criteria for the:

- (i) Mandibular permanent premolars were the presence of no periapical lesions.
- (ii) No root canal filling material.
- (iii) No root canals with an immature apex, resorption, or calcification.
- (iv) CBCT images of good quality.

A total of 216 mandibular first premolar teeth from the patient database met the above inclusion criteria.

### 2.2. Image acquisition/r OR radiographic techniques

CBCT images was performed using CS 3D Imaging Software (Carestream Dental), operating at a voltage of 80 kV, a current of 5.0 mA, and an exposure time of 17 s. The voxel size the slice thickness were 0.125 mm and 1.0 mm, respectively. The field of view was 40 × 40 mm or 60 × 60 mm depending on the examination requirement. A licensed oral radiologist performed all the CBCT scans in accordance the manufacturer's recommended protocol.

### 2.3. Evaluation of the images

All images were assessed by two evaluators (an endodontist and a radiologist). All the samples evaluated simultaneously and separately and a consensus was reached. In cases of failure of consensus after discussions, a second endodontist was asked to perform the third evaluation, and further discussions were conducted to reach the final consensus. Tooth position (left or right), number of roots, canal configuration, number of canals and apical foramina per root were recorded based on Vertucci's classification (Fig. 1).

### 2.4. Statistical analysis

The inter-examiner reliability was determined and assessed using the intraclass correlation coefficient (ICC) and coefficient of variation. ICC values range from 0 to 1 and those greater than 0.75 indicate good reliability. A low coefficient of variation demonstrates precision error, which is an indicator for reproducibility. Differences in distribution between the sexes and between the two sides were calculated. Associations of the sex and side with the incidence of additional canals were determined using the chi-squared test.  $P > 0.05$  was considered statistically significant. All statistical analyses were performed using the Statistical Package for the Social Sciences Statistics software (ver. 22.0; SPSS, Inc., Chicago, IL, USA).

## 3. Results

A total of 216 mandibular first premolars was evaluated by an endodontist and a radiologist two evaluators. The evaluators differed in 51 readings (19.84%), and the third evaluation was performed by another endodontist to reach the final consensus.

The Kappa coefficient was 0.8. The mandibular first premolar ( $n = 216$ ) distributed as number of women and men in the study were 120 teeth in female and 96, respectively teeth in male. Fig. 2 shows the percentage of the number of canals in

the mandibular first premolars included in the study (see Fig. 3).

Among the 216 patients having right and left mandibular first premolar teeth, Out of the 120 teeth One, two, and, three canals were seen in 95 teeth, 2 canals in 19 and teeth three canals in 6 teeth, respectively, in women and where as in the Male group out of 96 teeth, 53 teeth showed one canal, 33, and teeth with 2 canals whereas 12 teeth, respectively, in men showed presence of 3 canals.

Table 1 shows the incidence of canals in the mandibular first premolars included in the study (see Tables 2 and 3).

One canal was seen in 72.2% of the mandibular right premolars and 76.7% of the mandibular left premolars. Two and three canals were seen in 26.2% and 1%, respectively, of the mandibular right first premolars and 22.2% and 2%, respectively, of the mandibular left premolars, indicating equal distribution of the number of root canals irrespective of the tooth position.

In mandibular first premolars, canal configurations of types I, II, III, V, and VI were exhibited by 74%, 10%, 6.5%, 8.1%, and 1.1% of the single-rooted premolars, respectively, while

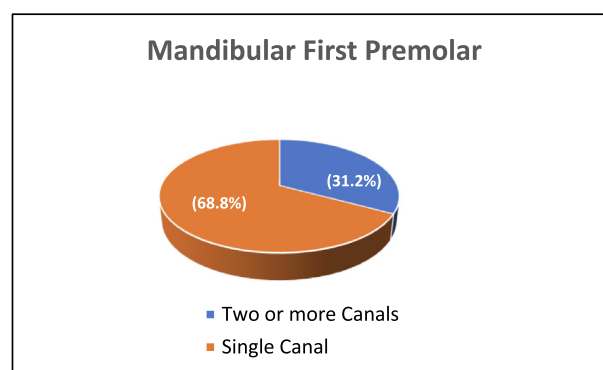


Fig. 2 Percentage of single and multiple canals.

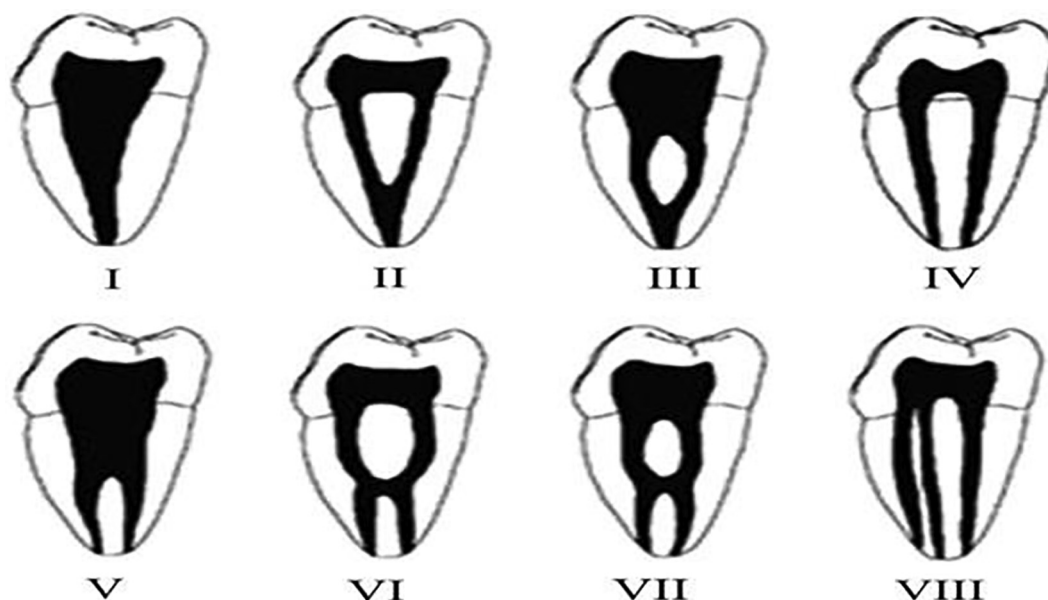
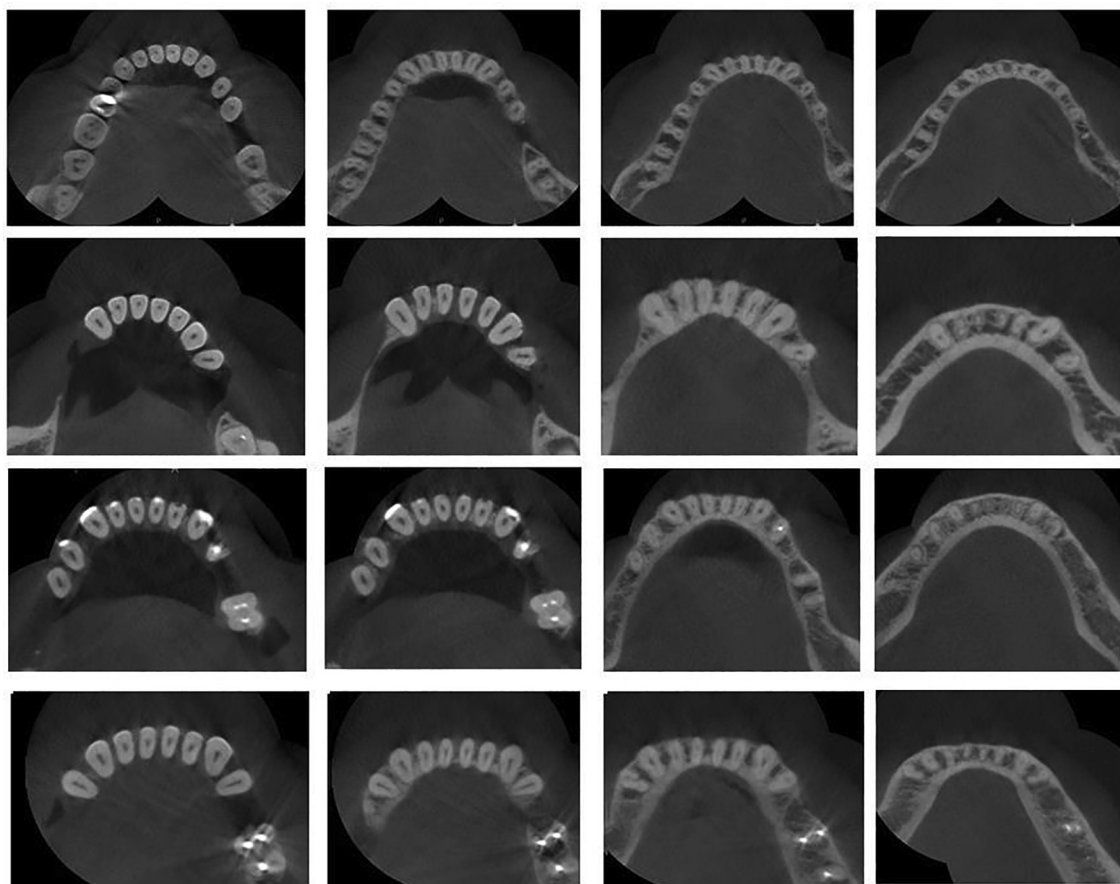


Fig. 1 Vertucci's classification of canal configuration.



**Fig. 3** A, Single root with a single root canal system (Type I). B, Single root with two apically joined canals (Type II). C, Single root with two apically separate canals (Type V). D, Two Roots with two root canals.

**Table 1** Incidence of canals (% of teeth) based on the sex of the patient.

Tooth position	One canal (%)	Two canals (%)	Three canals (%)	Total
Mandibular first premolar				
Men	52 (54.1)	32 (34.3)	12 (12.5)	96
Women	95 (79.2)	19 (15.8)	6 (5)	120
Total	147 (68.05)	51 (23.61)	18 (8.33)	216

**Table 2** Distribution of the Number of Root Canals based on the Tooth Position.

Tooth position	One canal (%)	Two canals (%)	Three canals (%)	Total
Mandibular first premolar				
Right	72 (72.7)	26 (26.2)	1 (1)	99 (45.83)
Left	89 (76.7)	26 (22.2)	2 (1.7)	117 (54.16)
Total	161 (74.5)	52 (24.1)	3 (1.3)	216

types IV, VII, and VIII were not seen. Canal configurations of types I, II, IV, and V were exhibited by 5.5%, 22.2%, 16.6%, and 55.5% of the two-rooted premolars, respectively, while types III, VI, VII, VIII were not seen.

Type I was the most prevalent canal configuration in mandibular first premolar.

Chi-Square test for mandibular first premolars demonstrated the chance of second canal in the mandibular first premolar more in male than female and these differences was statistically significant ( $P \leq 0.05$ ).

No correlation was found between root canal number and tooth position in the mandibular first premolar ( $P = 0.58$ ).

**Table 3** Prevalence of root canal types.

Tooth	No. of Roots	Types of canal configuration								Total
		I (%)	II (%)	III (%)	IV (%)	V (%)	VI (%)	VII (%)	VIII (%)	
Mandibular First Premolar	One	147 (74.2)	20 (10.1)	13 (6.5)	0 (0)	16 (8.1)	2 (1.1)	0 (0)	0 (0)	198 (91.6)
	Two	1 (5.5)	4 (22.2)	0 (0)	3 (16.6)	10 (55.5)	0 (0)	0 (0)	0 (0)	18 (8.33)
	Total	148 (68.5)	24 (11.1)	13 (6.01)	3 (1.38)	26 (12.1)	2 (0.92)	0 (0)	0 (0)	216

#### 4. Discussion

Knowledge on variations in the root canal anatomy and morphology is important in endodontic treatments. Tooth staining and clearing techniques are the gold-standard methods to study the root canal system. CBCT is a non-invasive method compared to techniques such as clearing and can be used both in vivo and in vitro (Fan et al., 2008; Neelakantan et al., 2010).

Different techniques have been used for the evaluation and assessment of root canal morphology. Recently, the use of CBCT has been considered an excellent clinical tool for this purpose due to its three-dimensional evaluation of the tooth anatomy (Alfawaz et al., 2018; Alqedairi et al., 2018; Al-Shehri et al., 2017; Patel et al., 2009) In the present study, CBCT was used to evaluate the morphology of the root canal system and to determine the location of the root canal orifice and apical foramina of the mandibular first premolars in a Saudi population. One and two roots were present in 91.66% and 8.33% of the mandibular first premolars, respectively. The most common canal morphology was one root and one canal, similar to previous findings, even in different ethnic populations (Fan et al., 2008; Neelakantan et al., 2010; Velmurugan and Sandhya, 2009). The number of root canals were not different between the mandibular premolars of the left and right sides, similar to previous findings (Jain and Bahuguna, 2011; Awawdeh and Al-Qudah, 2008).

In the present study, Vertucci's type I was the most common canal configuration, exhibited by 74.2% of the single-canal and 5.5% of the two-canal mandibular first premolars. Type II the second most common canal configuration, exhibited by 10% of the single-canal and 22.2% of the two-canal mandibular first premolars. Type V was exhibited by 8% of the single-canal and 55.5% of the two-canal mandibular first premolars. Types III and VI were exhibited by 6.5% and 1.1% of the single-canal mandibular first premolars, respectively. Type IV was exhibited by 16.6% of the two-canal premolars. Previous studies have reported type I as the most common canal configuration in both premolars (Awawdeh and Al-Qudah, 2008; Poorni et al., 2010; Vertucci, 1984; Cleghorn et al., 2008). Type II was the second most common canal configuration in our study, similar to previous findings (Awawdeh and Al-Qudah, 2008; Poorni et al., 2010; Hosseinpour et al., 2016). The prevalence of two rooted mandibular first premolars was higher in this study when compared to other studies using the clearing method of extracted teeth in Turkey (0%) (Çalışkan et al., 1995), Iran (2%) (Rahimi et al., 2007), and Jordan (3%) (Awawdeh and Al-Qudah, 2008). In our study, no mandibular first premolar exhibited type VII or VIII canal configuration.

#### 5. Conclusions

Endodontic therapy of the mandibular premolars is a challenge for clinicians because of the frequent morphological and anatomical variations. Proper knowledge on the number of root canals and canal configuration is a key to endodontic success. Root canal configuration of the mandibular premolars varies greatly among populations. However, most studies have reported that the mandibular first premolar has one root canal. Further, Vertucci's type I is the most common root canal configuration. Clinicians should be aware of the complexity of root canal anatomy using the most recent and reliable armamentarium to achieve favorable treatment outcomes.

#### Ethical statement

The study was independently reviewed and approved by The Research Ethics Committee in King Khalid University review board (No. 114-08-8-001).

#### Declaration of Competing Interest

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

#### Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sdentj.2019.11.013>.

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