ORIGINAL ARTICLE

Cone Beam Computed Tomography Evaluation of Root Morphology of the Premolars in Saudi Arabian Subpopulation

Azhar Iqbal[1], Osama Khattak[1], Rakhi Issrani[2], Meshal Aber Alonazi[1], Algarni Hmoud Ali[1]

[1]Department of Conservative Dentistry, College of Dentistry, Jouf University, Sakaka, Kingdom of Saudi Arabia.
[2]Department of Preventive Dentistry, College of Dentistry, Jouf University, Sakaka, Kingdom of Saudi Arabia.

Correspondence: Rakhi Issrani, Department of Preventive Dentistry, College of Dentistry, Jouf University, Sakaka, Kingdom of Saudi Arabia. **E-mail:** dr.rakhi.issrani@jodent.org

Academic Editor: Alidianne Fábia Cabral Cavalcanti

ABSTRACT

Objective: To evaluate root canal configuration and morphology of premolar teeth among Saudi subpopulations using cone beam computed tomography (CBCT). **Material and Methods:** In this retrospective cross-sectional study, CBCT images of 314 patients comprising 346 maxillary and 412 mandibular first premolar (FPM) teeth, 298 maxillary and 387 mandibular second premolar (SPM) teeth were analyzed to evaluate the number of roots, root canal morphology, and configuration based on the Vertucci's classification. The average intra-class correlation coefficient value was 0.931. **Results:** In the maxillary first premolar, 52.6% were two separate rooted and single rooted teeth, with one canal in 81.2% of the maxillary second premolar. Among the mandibular FPM, 96.6% of the teeth had one root and canal, and 97.9% of mandibular SPM had one root and canal. Type 1 canal configuration was seen as most common in all premolars. The number of roots in mandibular premolars did not reveal the difference among gender. **Conclusion:** Wide variations in root canal morphology and canal configuration system exists among maxillary and mandibular premolar teeth.

Keywords: Cone-Beam Computed Tomography; Dental Pulp Cavity; Endodontics; Dentition.

Introduction

The success of endodontic therapy relies upon the ideal biomechanical preparation of the root canal [1]. Teeth having structural variations are a major concern in root canal treatment (RCT) [2]. Untreated root canals may also comprise tissue remnants and microorganisms. Later, these organisms may multiply and leads to periapical pathologies. For this reason, dental practitioners must be knowledgeable about complex root canal systems [2].

Premolar teeth may pose demanding situations for RCT due to the variation in their root canal morphology (RCM) and the varieties in the anatomy of the pulp cavity. Consequently, they are likely the maximum difficult teeth for RCT [3]. A substantial disparity in the roots and root canals of premolar teeth has been reported in the literature. Elements that could accord to variations in the RCM encompass ethnical diversities, age, gender, and study design [4].

Diverse methods have been used to evaluate RCM in preceding research. Usually, these methods comprised impressions taken with polyester resin, transparent sample fabrication, and radiographic analysis [5-7]. Unfortunately, conventional radiographic imaging provides images in only two dimensions, and anatomic structures may be overlapped in these radiographic images. Consequently, they fail to replicate detailed RCM of teeth. However, of late Cone Beam Computed Tomography (CBCT) has been used to evaluate RCM of various teeth as it enables clinicians to evaluate the morphology of the roots, canal configuration, and their discrepancies [8]. In addition, the images obtained by CBCT can be assessed in all three dimensions without superimposition. These advantages help dental practitioners to understand the RCM of any tooth [9,10].

Studies have been carried out previously to evaluate the RCM of maxillary First Premolar (FPM) and mandibular Second Premolar (SPM). However, limited studies regarding the RCM of maxillary and mandibular premolar teeth have been carried out using CBCT among Saudi population. Therefore, this study aimed to evaluate the RCM and root canal configuration of maxillary and mandibular premolars using CBCT among the Saudi subpopulations.

Material and Methods

Study Design, Duration, and Ethical Clearance

This retrospective cross-sectional study of secondary data was developed from May 2018 to July 2020. Approval for the study was obtained by the Institutional Ethical Committee (Protocol no. #5-01-43) and all the study procedures follow the ethical principles of the Helsinki Declaration.

Sample Population, Size, and Characteristics

The sample size was assessed using nMaster software (version 2, CMC, Vellore). Anticipating, a 60% variation in root canal morphology and configuration in the study population, an absolute precision of 5% and a 95% confidence interval, a sample size of 341 was found to be sufficient. Therefore, this sample size was doubled for the current study.

The data source was CBCT volumetric data from the archives of the College of Dentistry, Jouf University, and samples were selected using a simple random technique. A database of 682 CBCT scans of patients attending the dental clinics with various complaints was searched and evaluated. Permanent premolars with no periapical pathology were only included in this study. Patients with RCT, root canals with open apices, resorbed roots or calcification, teeth with incomplete root formation, and coronal or post-coronal restorations were considered as exclusion criteria.

Procedure

SCANORA 3D CBCT unit (Soredex Inc., Tusula, Finland) was used to examine and evaluate the CBCT images of 314 patients comprising 346 maxillary and 412 mandibular FPM teeth, 298 maxillary and 387 mandibular SPM teeth. Using software On Demand 3D, the premolars were examined and evaluated for their RCM, root canal configuration, and the number of roots according to Vertucci's classification [11].

Measurement of error: Twenty percent of the scans were randomly selected and re-evaluated after 14 days. The intra-class correlation coefficient was used to test the error. The average intra-class correlation coefficient value was 0.931, which showed excellent reliability. Outcomes from these variables showed that there were no random errors. All pairs of measurements showed a p-value>0.1, suggesting no systemic bias in these analyses.

Statistical Analysis

Statistical Package for the Social Sciences, version 20.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis by applying Chi-square test and considering p-value<0.001 to be statistically significant.

Results

The data of 166 males (53.2%) and 148 females (47.4%) patients with a mean were analyzed. The average age of the patients involved was 36.7 years (SD±16.9), varying from 14 to 81 years.

In the FPM, the majority (52.6%) were two separate rooted teeth, followed by 92 (26.5%) single rooted with one canal, 19.3% had two fused roots, and 0.8% were seen with two roots that were separated at the apex. Only two (0.5%) of teeth had three roots. Type 1 canal (58.0%) had a high predominance, with Type 2, 3, and 4 trailings subsequently (Tables 1 and 2). Single rooted teeth with one canal were the most common (81.2%) type seen in SPM, followed by teeth having two separate roots (10.4%) and two roots that were fused. None of the teeth had three roots. Even in the SPM, the Type 1 canal was predominant (70.8%), trailed by Type 2 and 4 configurations. There was no difference in the number of roots between the genders. Out of two teeth with three roots, one was seen in males and the other in females. The type 7 and 8 shapes were not detected in any of the maxillary premolar teeth.

Table 1. Distribution of maxillary first premolar and second premolar according to the number and configuration of the canal.

Distribuition	First Premolar		Second Premolar	
	N	%	N	%
Number of Roots				
One root	92	26.5	242	81.2
Two separate roots	182	52.6	31	10.4
Two fused roots	67	19.3	23	7.7
Two apically separate roots	3	0.8	2	0.6
Three roots	2	0.5	0	0
Canal Configuration				
Type 1	201	58.0	211	70.8
Type 2	134	38.7	47	15.7
Type 3	4	1.1	12	4.0
Type 4	4	1.1	18	6.0
Type 5	3	0.8	6	4.0
Type 6	0	0	4	1.3
Type 7	0	0	0	0
Type 8	0	0	0	0

Table 2. Gender wise distribution of maxillary first premolar and second premolar according to the number of roots.

Side	Teeth	Males			Females			p-value
		One Root	Two Roots	Three Roots	One Root	Two Roots	Three Roots	
		N	N	N	N	N	N	
Right Side	First Premolar	19	61	1	20	57	1	0.810
	Second Premolar	57	19	0	65	12	0	
Left Side	First Premolar	26	65	0	27	69	0	
	Second Premolar	57	14	0	63	11	0	

NS: Non-significant.

Among the FPM, most of the teeth had one root and canal (96.6%), followed by teeth with two fused roots (2.1%) and teeth with two separate roots (0.7%). None of the teeth had three roots. Type 1 shape was witnessed in 95.1% of the cases, while Type 5 and 3 were detected in 2.1% and 1.2% (Tables 3 and 4). Similarly, 97.9% of mandibular SPM had one root and canal, followed by teeth having two separated roots (0.7%) and two fused roots (0.7%). Three roots were not seen among any of the SPM teeth. Type 1 canal configuration was considered the most common variety (98.6%), followed by Type 5 and Type 2. None of the teeth had Type 6, 7, or 8 canal configurations. Upon comparison, the root count revealed no difference among gender.

Table 3. Distribution of mandibular first premolar and second premolar according to the number and configuration of the canal.

Distribuition	First Premolar		Second Premolar	
	N	%	N	%
Number of Roots				
One root	398	96.6	379	97.9
Two separate roots	3	0.7	3	0.7
Two fused roots	9	2.1	3	0.7
Two apically separate roots	2	0.4	2	0.5
Three roots	0	0	0	0
Canal Configuration				
Type 1	392	95.1	383	98.6
Type 2	3	0.7	1	0.2
Type 3	5	1.2	1	0.2
Type 4	3	0.7	0	0
Type 5	9	2.1	2	0.5
Type 6	0	0	0	0
Type 7	0	0	0	0
Type 8	0	0	0	0

Table 4. Gender wise distribution of mandibular first premolar and second premolar according to the number of roots.

Side	Teeth	Males		Females		p-value
		One Root	Two Roots	One Root	Two Roots	
		N	N	N	N	
Right Side	First Premolar	104	5	95	3	0.563
	Second Premolar	98	2	84	1	
Left Side	First Premolar	102	4	97	2	
	Second Premolar	101	3	96	2	

NS: Non-significant.

Discussion

The current research outcome discloses prevalent variation regarding the premolar root and canal morphology and configuration of both jaws in a Saudi population using CBCT. Many modalities have been used

by previous studies for evaluating the RCM and root canal configuration. However, most of them have failed to provide accurate information. Tooth clearing and canal staining have been used to assess the morphology of the root canal, macroscopic examination, magnification tools, plastic resin injection, sectioning of tooth using scanning electron microscopy, and radiographic methods with contrast enhancement, conventional radiographic imaging and computed tomography [7,12-19].

The complicated RCM of premolar teeth makes it arduous to evaluate their exact anatomy with conventional radiographic images. In most circumstances, while employing traditional radiographic methods of periapical radiography, the existence of variations in the shape and form of the root canal system is visualized only after variation in shape or course is manually detected or while the root canal is not always absolutely visible [20,21]. The CBCT imaging system produces high-resolution accurate volumetric images with no superimposition, less scan time, and less radiation dose [4,10]. CBCT imaging system has enabled clinicians to take a close look at the anatomy of the tooth and root canal system with precision [4].

In this study, 26.5% of maxillary first premolar had a single root and canal. This observance was comparable and less than that of Bulut et al. [22] (28.2%) and higher than that of other studies [23,24]. The majority (72.8%) of the maxillary first premolars had two roots, and this was higher than that of Bulut et al. [22] and lesser than that of other studies [23,24]. Only two (0.5%) first premolar had three roots; this was less than that of Bulut et al. [22], Kartal et al. [23], Ok et al. [25], and Celikten et al. [26].

Vertucci's type I classification is predominant among all the types [5]. In accordance with this, the type 1 configuration was predominantly noted in maxillary first premolar of this study with a ratio of 58.0%. Ok et al. [25] and Celikten et al. [26] observed in their study that most root canal configurations were of type IV variety. Among the maxillary second premolars, 81.2% were single rooted and had a single canal. This finding was almost similar to that of Bulut et al. [22] (82.1%) and was higher than that of other studies [23,24]. Two roots and canals were noted in 18.78% of maxillary second premolars; this observation was higher than that of Bulut et al. [22] and lower than that of previous similar studies [23,24]. None of the maxillary second premolars had three roots, whereas 0-1% of three roots were reported previously [23,24].

Previously, the incidence of one canaled lower FPM and SPM were found to be 74-89.5% and 81.5-98.8%, respectively [3,18,24,27,28], and in the present study, 96.6% of mandibular FPM and 97.9% of mandibular SPM showed one canal respectively. Furthermore, Khedmat et al. [20] observed that 88.4% of mandibular FPM have a single root canal. Also, in the present study, when the mandibular FPM and SPM were evaluated, no gender disparity was noted.

In this study, the type I configuration was the predominant finding in lower SPM with a markedly elevated frequency of 98.6%. This observation was similar to that of Bulut et al. [22] and more than that of other studies [23,24]. Observations in this study regarding the premolar teeth root morphology and canal configuration among both jaws differ from the findings of some contemporary research conducted in different populations. This discrepancy may be attributed to certain factors like differences in examination techniques, classification systems employed, sizes, and ethnic background of the selected sample [29,30].

As a limitation, the present study did not compare the canal configuration and morphology in the large sample for unilateral and bilateral presence concerning tooth position and decade wise distribution.

Considering the present study's limitations, we recommend that more longitudinal studies should be designed involving a large number of samples comparing canal morphology and canal configuration for unilateral and bilateral presence.

Conclusion

It can be inferred that wide variations in root morphology and canal configuration system exist among maxillary and mandibular premolar teeth. Therefore, it emphasizes careful and accurate radiographic examination for successful endodontic treatment. Additionally, the results of this study give significant knowledge to clinicians about the root canal morphology of maxillary and mandibular premolar teeth in a Saudi subpopulation.

Authors' Contributions

AI		https://orcid.org/0000-0002-4769-6653	Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Supervision, Project Administration
OK		https://orcid.org/0000-0003-3502-3555	Software, Validation, Formal Analysis, Resources, Data Curation, Visualization, Supervision
RI		https://orcid.org/0000-0002-0046-3529	Writing - Review and Editing, Visualization
MAFA		https://orcid.org/0000-0002-1961-0840	Methodology, Investigation, Writing - Original Draft, Project Administration
AHA		https://orcid.org/0000-0001-6521-6468	Data Curation, Writing - Review and Editing

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] Estrela C, Holland R, Estrela CR, Alencar AH, Sousa-Neto MD, Pecora JD. Characterization of successful root canal treatment. Braz Dent J 2014; 25(1):3-11. https://doi.org/10.1590/0103-6440201302356

[2] Ravanshad S, Nabavizade MR. Endodontic treatment of a mandibular second molar with two mesial roots: report of a case. Iran Endod J 2008; 3(4):137-40.

[3] Dou L, Li D, Xu T, Tang Y, Yang D. Root anatomy and canal morphology of mandibular first premolars in a Chinese population. Sci Rep 2017; 7:750. https://doi.org/10.1038/s41598-017-00871-9

[4] Altunsoy M, Ok E, Nur BG, Aglarci OS, Gungor E, Colak M. A cone-beam computed tomography study of the root canal morphology of anterior teeth in a Turkish population. Eur J Dent 2014; 8(3):302-6. https://doi.org/10.4103/1305-7456.137630

[5] Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984; 58(5):589-99. https://doi.org/10.1016/0030-4220(84)90085-9

[6] Hosseinpour S, Kharazifard MJ, Khayat A, Naseri M. Root canal morphology of permanent mandibular premolars in Iranian population: a systematic review. Iran Endod J 2016; 11(3):150-6. https://doi.org/10.7508/iej.2016.03.001

[7] Abraham SB, Gopinath VK. Root canal anatomy of mandibular first premolars in an Emirati subpopulation: a laboratory study. Eur J Dent 2015; 9(4):476-82. https://doi.org/10.4103/1305-7456.172618

[8] Abella F, Teixido LM, Patel S, Sosa F, Duran Sindreu F, Roig M. Cone beam computed tomography analysis of the root canal morphology of maxillary first and second premolars in a Spanish population. J Endod 2015; 41(8):1241-7. https://doi.org/10.1016/j.joen.2015.03.026

[9] Patel S, Dawood A, Ford TP, Whaites E. The potential applications of cone beam computed tomography in the management of endodontic problems. Int Endod J 2007; 40(10):818-30. https://doi.org/10.1111/j.1365-2591.2007.01299.x

[10] Scarfe WC, Levin MD, Gane D, Farman AG. Use of cone beam computed tomography in endodontics. Int J Dent 2009; 2009:634567. https://doi.org/10.1155/2009/634567

[11] Vertucci FJ, Williams RG. Root canal anatomy of the mandibular first molar. J N J Dent Assoc 1974; 45(3):27-8 passim.

[12] Gulabivala K, Opasanon A, Ng YL, Alavi A. Root and canal morphology of Thai mandibular molars. Int Endod J 2002; 35(1):56-62. https://doi.org/10.1046/j.1365-2591.2002.00452.x

[13] Pecora JD, Woelfel JB, Sousa Neto MD. Morphologic study of the maxillary molars. 1. External anatomy. Braz Dent J 1991; 2(1):45-50.

[14] Buhrley LJ, Barrows MJ, BeGole EA, Wenckus CS. Effect of magnification on locating the MB2 canal in maxillary molars. J Endod 2002; 28(4):324-7. https://doi.org/10.1097/00004770-200204000-00016

[15] Skidmore AE, Bjorndal AM. Root canal morphology of the human mandibular first molar. Oral Surg Oral Med Oral Pathol 1971; 32(5):778-84. https://doi.org/10.1016/0030-4220(71)90304-5

[16] Seidberg BH, Altman M, Guttuso J, Suson M. Frequency of two mesiobuccal root canals in maxillary permanent first molars. J Am Dent Assoc 1973; 87(4):852-6. https://doi.org/10.14219/jada.archive.1973.0489

[17] Sperber GH, Moreau JL. Study of the number of roots and canals in Senegalese first permanent mandibular molars. Int Endod J 1998; 31(2):117-22. https://doi.org/10.1046/j.1365-2591.1998.00126.x

[18] Fan B, Gao Y, Fan W, Gutmann JL. Identification of a C-shaped canal system in mandibular second molars-part II: the effect of bone image superimposition and intraradicular contrast medium on radiograph interpretation. J Endod 2008; 34(2):160-5. https://doi.org/10.1016/j.joen.2007.10.010

[19] Demirbuga S, Sekerci AE, Dinçer AN, Cayabatmaz M, Zorba YO. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular first and second molars in Turkish individuals. Med Oral Patol Oral Cir Bucal 2013; 18(4):e737-44. https://doi.org/10.4317/medoral.18473

[20] Khedmat S, Assadian H, Saravani AA. Root canal morphology of the mandibular first premolars in an Iranian population using cross-sections and radiography. J Endod 2010; 36(2):214-7. https://doi.org/10.1016/j.joen.2009.10.002

[21] Tzanetakis GN, Lagoudakos TA, Kontakiotis EG. Endodontic treatment of a mandibular second premolar with four canals using operating microscope. J Endod 2007; 33(3):318-21. https://doi.org/10.1016/j.joen.2006.08.006

[22] Bulut DG, Kose E, Ozcan G, Sekerci AE, Canger EM, Sisman Y. Evaluation of root morphology and root canal configuration of premolars in the Turkish individuals using cone beam computed tomography. Eur J Dent 2015; 9(4):551-7. https://doi.org/10.4103/1305-7456.172624

[23] Kartal N, Ozcelik B, Cimilli H. Root canal morphology of maxillary premolars. J Endod 1998; 24(6):417-9. https://doi.org/10.1016/S0099-2399(98)80024-1

[24] Caliskan MK, Pehlivan Y, Sepetçioglu F, Turkun M, Tuncer SS. Root canal morphology of human permanent teeth in a Turkish population. J Endod 1995; 21(4):200-4. https://doi.org/10.1016/S0099-2399(06)80566-2

[25] Ok E, Altunsoy M, Nur BG, Aglarci OS, Çolak M, Gungor E. A cone-beam computed tomography study of root canal morphology of maxillary and mandibular premolars in a Turkish population. Acta Odontol Scand 2014;72(8):701-6. https://doi.org/10.3109/00016357.2014.898091

[26] Celikten B, Orhan K, Aksoy U, Tufenkci P, Kalender A, Basmaci F, et al. Cone-beam CT evaluation of root canal morphology of maxillary and mandibular premolars in a Turkish Cypriot population. BDJ Open 2016; 2:15006. https://doi.org/10.1038/bdjopen.2015.6

[27] Vertucci FJ. Root canal morphology of mandibular premolars. J Am Dent Assoc 1978; 97(1):47-50. https://doi.org/10.14219/jada.archive.1978.0443

[28] Llena C, Fernandez J, Ortolani PS, Forner L. Cone-beam computed tomography analysis of root and canal morphology of mandibular premolars in a Spanish population. Imaging Sci Dent 2014; 44(3):221-7. https://doi.org/10.5624/isd.2014.44.3.221

[29] Yu X, Guo B, Li KZ, Zhang R, Tian YY, Wang H, D D S TH. Cone beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. BMC Med Imaging 2012; 12:18. https://doi.org/10.1186/1471-2342-12-18

[30] Awawdeh L, Abdullah H, Al-Qudah A. Root form and canal morphology of Jordanian maxillary first premolars. J Endod 2008; 34(8):956-61. https://doi.org/10.1016/j.joen.2008.04.013