



Frequency of Multiple Canals in Mandibular Premolars and its Correlation with Other Anatomical Variants (C Shaped Canals in Mandibular Second Molars): A Retrospective and Cross-sectional Study

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Introduction: Recognition of variations in molar root morphology is critically important for dental procedures such as root canal treatment and apical surgery. Usage of CBCT enables systemic evaluation of teeth including the number of roots and canals, location of roots, etc. The aim of this study was to determine the frequency of multiple canals in mandibular first and second premolars and to evaluate correlations between other anatomical variants using Cone beam computed tomography (CBCT).

Methodology: The protocol of this retrospective, cross-sectional study was approved by the Ethics Committee of Saveetha Dental Hospital, Chennai, India. Images of mandibular premolars were obtained from patients who had undergone CBCT scanning at the hospital between January 2018 and November 2020. Cross-sectional images in the axial, coronal, and sagittal planes were reconstructed using GALILEOS Comfort^{PLUS} (Sirona 3D) is an advanced CBCT that provides seamless workflow integration. Serial axial, coronal and sagittal-plane CBCT images were closely examined at 1.0-mm intervals from the canal orifice to the apex.

Results: Using SPSS software (ver. 21; SPSS, Inc., Chicago, IL, USA), chi-squared test was performed for analyses of different parameters involved. Various anatomical variants such as

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distolingual roots of first molars, C shaped canals of second molars are highly correlated with different canal configurations of mandibular premolars.

Conclusion: This retrospective study showed that different configurations of mandibular premolars canals was significantly correlated with the presence of Distolingual root (DLRs) in first molars, and C shaped canals in second molars. Understanding and identifying anatomical variants is important in comprehensive success of endodontic treatment.

Keywords: Canal variations; CBCT; anatomic variants; C shaped roots; distolingual roots; multiple canal configuration.

1. INTRODUCTION

Recognition of variations in molar root morphology is crucial for dental procedures such as root canal treatment and apical surgery. Adequate knowledge regarding anatomical variants of canal helps in achieving success in root canal treatment [1,2]. Mandibular premolars are known as enigma to endodontists as it exhibits enormous variations in canal morphology [3,4]. "Previous studies have shown high frequencies of multiple canal systems in mandibular premolars (12.9–34.8% and 2–9.9% in mandibular first and second premolars, respectively). These variations are caused by differences in methodology, ethnicity, and characteristics of participants, such as age and gender" [5,6].

"Permanent mandibular first molars usually have 2 roots, mesial and distal. Later, a third root, distolingual (DL) root, develops in a number of individuals. Literature reviews have shown the high prevalence of 3-rooted mandibular first molar from 5% to more than 40% in Asian populations" [7-10]. Therefore, it would be advantageous for CBCT usage in many treatments.

"In the routine diagnostic periapical radiograph, the X ray cone tube is placed perpendicular to the mandibular first molar and the film. Therefore, the image of the DL root is easily super-imposed by the distobuccal (DB) root, and it is unclear." [1,11] "Recently introduced Cone-beam computed tomography (CBCT) is designed for dental use and serves as noninvasive and 3-dimensional reconstruction imaging. CBCT images can be used to evaluate morphologic analysis of the DL root of the permanent mandibular first molars" [12,13]. "In apical surgery, the use of CBCT enables systematic evaluation of teeth in all manners. Previously, our team had a rich experience in working on various research projects across multiple disciplines" [14–28]. Now the growing trend in this area motivated us to pursue this project.

The goal of this research was to determine the frequency and morphologic characteristics of multiple canals of mandibular first and second premolars using Cone beam computed tomography (CBCT).

2. METHODOLOGY

2.1 Study Design

The protocol of this retrospective, cross-sectional study was approved by the Ethics Committee of Saveetha Dental Hospital, Chennai, India. Images of mandibular premolars were obtained from patients who had undergone CBCT scanning at the hospital between January 2018 and November 2020. CBCT images were acquired with the following parameters: 80 kVp, 9.0 mA, 10 × 10-cm field of view, 0.167-mm³ voxel size, and the slice thickness was 1.0 mm.

2.2 Sample Size

100 patients were examined in vivo by CBCT. The inclusion criteria applied were the patients aged between 18 and 70 years; presence of mandibular premolars with fully matured apices and without apical periodontitis; presence of mandibular premolars without root canal fillings, posts, and crown restorations, patients undergoing orthodontic treatment and patients with calcified canals. The Vertucci classification and the Fan classification will be used to define root canal configurations and C-shaped canals, respectively. In a logistic regression study, the connection between non-single canals in PM1s and DLRs in M1s was employed.

2.3 Image Assessment

Cross-sectional images in the axial, coronal, and sagittal planes were reconstructed using GALILEOS Comfort^{PLUS} (Sirona 3D). Implant surgery or surgical removal of impacted molars were the most common reasons for CBCT scans.

As a result, no subjects in this study were subjected to excessive radiation in order to gather information about root canal anatomy; also, the "as low as reasonably achievable" principle was applied to radiation dose. To avoid any possible bias, data were anonymised by numbering the participants from 1 to 300 before examining the images.

Axial-plane images were used to determine the number of roots in premolars. Single-rooted teeth, such as teeth with two canals and a fused root, had conical-shaped roots. Teeth with two canals in a single fused root and a third canal in a separate root showed bifurcation at a particular root level, as did teeth with two canals in a single fused root and a third canal in a separate root. Teeth with three independent roots were known as triple-rooted teeth. C-shaped canal configurations were determined in accordance with the Fan classification as follows: C1 (continuous C-shaped canal: an uninterrupted "C" without separation or division); C2 (semicolon-shaped canal: caused by discontinuation of the "C" outline); C3 (separated canals: two or three separate canals); C4 (a single canal subdivided into round (C4a), oval (C4b), or flat canals (C4c)); C5 (≥ 3 separate canals); or C6 (no visible canal lumen) [29].

2.4 Statistical Analysis

Statistical analyses were performed using SPSS software (ver. 21; SPSS, Inc., Chicago, IL, USA). The chi-squared test was performed for analyses of differences based on sex, and premolar canal configurations. The chi-squared test was also used to compare the frequencies of disto lingual roots in first molars and C-shaped canals in second molars according to premolar root canal configuration and to compare unilateral and bilateral molar DLRs and C-shaped canal configurations.

3. RESULTS

Among 100 patients (52 women and 48 men; mean age, 25.61 ± 10.02 years), a total of 460 premolars were examined (232 first premolars and 228 second premolars). The majority of premolars had one root (95.9%) and one canal (76.78%).

The respective frequencies of DLRs in first molars and C-shaped canals in second molars were 28.4% and 32.8%. Chi-squared analysis revealed that the frequency of molar DLRs varied

significantly according to premolar root canal configuration ($p < 0.05$).

4. DISCUSSION

"The primary goal of endodontic treatment often got vulnerable because of the complexity of the root canal anatomy and lack of its knowledge and clinical challenges raised because of it. Thus, for any endodontic therapy, one must precede with a thorough knowledge of pulp chamber and root canal configuration and number of canals as the success of the therapy is directly related to the elimination, prevention of microbial contamination, and complete disinfection by the proper endodontic procedure" [30,31].

"The mandibular first molar is the first posterior tooth that erupts in the oral cavity and frequently requires root canal treatment. This tooth has two roots, but occasionally, it has three roots with two or three canals in the mesial root and one, two, or three canals in the distal root. Over the years, there have been numerous reports that described the morphology of teeth including mandibular first molar" [32,33]. The major variant in this group is the mandibular molar with five, six, and seven canals. According to Martinez-Berna and Badanellis, who reported a mandibular molar with six canals, three in the mesial root that were independent throughout the root and three canals in distal root with independent orifices in the pulpal floor but join immediately to form two canals. Ghodduzi et al. also reported "a mandibular molar with four distal canals. The intracanal communication frequency is higher in the mesial root of mandibular molars which make the variant morphology and so the disinfection more difficult to achieve. Cohen and Burns described maxillary first molar as "The most treated, but least understood posterior tooth with the highest endodontic failure rate." It reported that many treatment failures in the maxillary permanent first molar were related to the inability to locate and clean the MB canal" [34,35].

"The significance of advanced diagnostic tools such as dental operating microscope (DOM) and cone-beam computed tomography (CBCT) over the traditional diagnostic tools has been proven by various researchers till now. CBCT assists the practitioner to identify canal morphology, numbers of canals, and relative positioning even in the presence of calcific metamorphosis and dystrophic calcifications. Identification and treatment of lateral canals are supported by

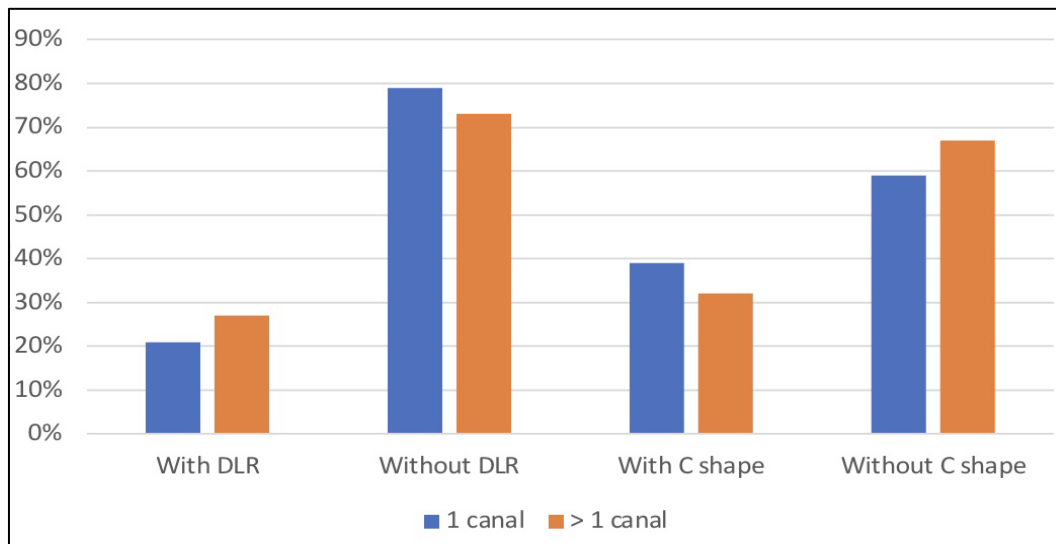
viewing their specific location with the use of narrow field of view CBCT before or during endodontic therapy” [36,37].

“The C-shaped canal configuration presents with variations in both the number and location of the canal(s), as the canal(s) courses from the coronal to the apical third. The complexity of this canal configuration proves to be a challenge with respect to debridement and obturation, and possibly the prognosis during root canal therapy. Recognition of a C-shaped canal configuration before treatment can facilitate effective management, which will prevent irreparable damage that may put the tooth in severe jeopardy.” [38,39] “The C-shaped canal configuration shows an ethnic predilection. It has frequently been reported in countries belonging to the Asian continent. East Asian population groups like the Chinese (0.6%-41.27%) and Koreans (31.3%-45.5%) display a high prevalence of this variant. Among the South Asian countries, Burmese population showed a prevalence of 22.4%, which was much higher than the Indian, Thai or Sri Lankan population.

Higher incidence of C-shaped anatomy was documented in Lebanese population (19.1%) as compared to the other West Asian population groups (Iranian, Jordanian, Saudi Arabian)” [39,40].

“The frequency of first premolars with a single canal (760 of 971, 78.27%) was comparable to those reported in two systematic reviews (75.8 and 73.55%) as well those reported in East Asian populations (e.g., Chinese and Taiwanese [65.2–87.1%]). Regarding the root canal morphology of second premolars, a recent review reported a markedly lower incidence of a second canal (2%) in East Asian populations compared with other populations. Our institution is passionate about high quality evidence based research and has excelled in various fields” [18,41–50]

The thorough knowledge of root canal space anatomy is a basic prerequisite for the successful completion of endodontic treatment, especially in cases where extra root canals are suspected. Proper care and attention must be given in identifying extra roots and canals.



Graph 1. Canal Variations in Mandibular Premolars and Molars

The graph represents the correlation of anatomical variants such as distolingual roots of first molars, C shaped canals of second molars with canal configuration of mandibular premolars

Table 1. Frequencies of the root and root canal configurations of mandibular premolars

Number of roots	Number of canals	Mandibular first premolar	Mandibular second premolar
1 Root	1 canal	75.2%	74.3%
	2 canals	19.3%	22.3%
	3 canals	5.7%	4.9%
2 Roots	2 canals	3.1%	6.2%
	3 canals	1.7%	2.6%
Total		232	228

Table 2. Canal configuration frequencies based on gender

Mandibular Premolars	Sex	Number of canals	Percentage	p value
First premolars	Female-52	1 canal	45.2%	>0.05
		More than 1 canal	14.2%	
	Male-48	1 canal	32.4%	
		More than 1 canal	12.7%	
Second premolars	Female-52	1 canal	42.2%	>0.05
		More than 1 canal	16.7%	
	Male-48	1 canal	30.2%	
		More than 1 canal	14.1%	

5. CLINICAL SIGNIFICANCE

A thorough knowledge regarding anatomical variants may result in treating all canals space, potentially paving to higher endodontic treatment success rate .Thus, understanding the canal variations and morphology is crucial in success of endodontic treatment in clinical practice

6. CONCLUSION

This retrospective study showed that different configurations of mandibular premolars canals were significantly correlated with the presence of DLRs in first molars, and C shaped canals in second molars. Understanding and identifying anatomical variants is important in comprehensive success of endodontic treatment.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

As per international standard or university standard, patients’ written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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