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ORIGINAL ARTICLE

Root Canal Morphological Variations of Mandibular Third Molars Using Cone Beam Computed Tomography

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ABSTRACT

Objective: To evaluate the variations in the root canal morphology of mandibular third molars (M3M) using cone beam computed tomography (CBCT). **Material and Methods:** A total of 186 CBCT images were analyzed to assess the root and root canal morphology of M3M using Vertucci classification. Gender influence on morphology was also examined. Statistical analysis was performed using Chi-square or Fisher's exact test. **Results:** Most M3M exhibited two roots, followed by a single root and three roots, with no significant difference in number of roots between sexes on either side (p=0.512 and p=0.598). Three canals were most common in both sexes, but four canals were significantly more common in males on the right side. No significant sex difference was observed for the left side (p=0.245). Distal roots predominantly showed Type I canal configuration on both sides, while mesial roots exhibited Type IV on the right and Type I on the left. **Conclusion:** Mandibular third molars in the South Indian population had two roots and three canals, with four canals more common in males on the right. Distal root mostly exhibited Type I canal configuration, whereas mesial root varied, highlighting the importance of understanding the complexity for endodontic treatment planning.

Keywords: Tomography, X-Ray Computed; Endodontics; Molar, Third.

Introduction

Successful endodontic treatment depends on proper access cavity preparation, thorough biomechanical preparation, and achieving fluid-tight seal obturation of the root canal [1]. Before beginning the endodontic treatment, it is important to understand the tooth root canal anatomy and identify any abnormalities [2]. Research indicates that a common reason for endodontic treatment failure is inadequate cleaning and obturation of canals, often due to untreated or missed canals [3].

Various methods have been employed to study the root and root canal morphology, such as conventional radiographs, digital radiographs, contrast medium radiographs, root canal staining and clearing, plastic resin injections, tooth sectioning, in-vitro microscopic examinations, Cone Beam Computed Tomography (CBCT) and micro-computed tomography [4-9]. Conventional radiographs, while commonly used, provide only two-dimensional images and do not fully capture the complexity of the root canal systems. *In-vitro* methods like sectioning, root canal staining, and clearing techniques can compromise the tooth's external morphology, making them less ideal for certain studies [10].

CBCT, developed in the 1990s by Italian and Japanese researchers, enables three-dimensional visualization of root canal anatomy [11,12]. This imaging modality is useful in complex cases where localization and description of root canal systems are needed [13,14]. It allows visualization of the images in sagittal, coronal, and axial planes and overcomes the limitations of conventional radiographs, such as the superimposition of anatomic structures and the production of two-dimensional images [13]. Consequently, it enables dentists to make faster and more accurate diagnosis, treatment plans, and evaluations.

The anatomy of the mandibular third molar (M3M) is complex and often poses a challenge to dentists during endodontic treatment. Despite this complexity, endodontic treatment of M3M is frequently necessary for various dental considerations, including restoration, prosthodontics, and orthodontics, to considerations to continue serving as essential elements of the dental arch [15,16]. Various studies have assessed the root canal morphology of M3M in different populations [17]. Given that genetic factors can influence the anatomy of the root and root canal across different species, it is essential to evaluate the root morphology in diverse populations [2].

Therefore, we aimed to analyze the root canal morphology of M3M. Our objective was to evaluate the number of roots, root canals, and their configuration, as well as potential differences in the distribution of these between males and females among the South Indian population using CBCT as the imaging modality. The null hypothesis was that there would be no difference between males and females concerning the various morphological variations.

Material and Methods

Study Design and Ethical Clearance

This retrospective study was conducted on CBCT images selected from the archives of the Oral and Maxillofacial Radiology Department. The protocol was approved by the institutional ethics committee (IEC number: 514/2021).

Data Collection

Anonymized CBCT images from the archives between January 2021 and June 2021 were screened for the presence of M3M. Teeth with complete root formation, absence of periapical lesions, and no evidence of any restoration or endodontic treatments, calcifications, fractures, or resorption were included. M3Ms with distorted

images, with posts or crowns, were excluded. All the CBCT images were obtained using the i-CAT 17-19 Imaging system (Imaging Sciences International LLC, Hatfield, PA, USA) by an experienced radiologist following the recommended protocol with minimum necessary exposure for adequate image quality.

All the images were evaluated by an experienced Oral and Maxillofacial radiologist for the number of roots, root canal configuration (Vertucci classification system), and presence of C-shaped root canals. Image enhancement techniques including zooming and adjustments to contrast and brightness, were employed for better visualization and analysis of the root canal patterns. A 10% of the sample was re-examined to evaluate intra-observer reliability using the Kappa Coefficient. There was substantial agreement between the observations (Kappa = 0.79).

Data Analysis

All the analysis was performed using SPSS version 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.). A p-value of <0.05 was considered statistically significant. Comparison of categorical variables was done using Chi-square or Fisher's exact test.

Results

A total of 186 M3M were included in the study, with 50.8% of the samples being from males. In both males and females, the majority of the teeth had two roots in both right and left M3M. However, there was no significant difference in the distribution of the number of roots between males and females for left and right M3M (p=0.512 and p=0.598, respectively) (Table 1).

Table 1. Distribution of number of roots in M3M between male and female.

Mandibular Third Molars	Number of Roots	Sex		p-value
		Male N	Female N	
Left (38)	1	3	3	0.512
	2	40	47	
	3	2	0	
Right (48)	1	5	3	0.598
	2	40	42	
	3	1	0	

The majority of the M3Ms have 3-canals in both males and females on the right and left side. Four canals were significantly higher in males, while 2-canals were higher in females in the right M3M (p=0.035). However, there was no significant difference in the distribution of the number of canals between males and females in the left M3M (p=0.245).

Table 2. Distribution of the number of canals between males and females in M3M

Mandibular Third Molars	Number of Canals	Sex				p-value
		Male		Female		
		N	%	N	%	
Right (48)	1	1	2.3	0	0.0	0.035
	2	4	9.3	11	27.5	
	3	30	69.8	27	67.5	
	4	8	18.6	2	5.0	
Left (38)	1	0	0.0	1	2.1	0.245
	2	8	19.0	15	31.9	
	3	29	69.0	29	61.7	
	4	5	11.	2	4.3	

In 2-rooted right M3M, the most common root canal configuration was Type I in the distal root (85.7%), while the mesial root showed Type IV variation (28.2%). For left M3M, Type I was the most common variant for distal (92.7%) and the mesial root (25.0%) (Table 3).

Table 3. Root canal configuration of two rooted M3M according to Vertucci classification.

M3M		Root Canal Configuration of 2-rooted M3M											
		Type I		Type II		Type III		Type IV		Type V		Type VI	
		N	%	N	%	N	%	N	%	N	%	N	%
48	D	60	85.7	4	5.7	3	4.3	1	1.4	1	1.4	1	1.4
	M	13	18.3	17	23.9	14	19.7	20	28.2	7	9.9	0	0.0
38	D	76	92.7	3	3.7	1	1.2	1	1.2	1	1.2	0	0.0
	M	21	25.0	20	23.8	16	19.0	11	13.1	16	19.0	0	0.0

D: Distal; M: Mesial.

In 3-rooted M3M (Figure 1A), six teeth exhibited Type I canal configuration, whereas Types III, IV, and V were found in a single tooth. Among single-rooted M3M, Type II canal configuration was seen in four teeth, followed by Type I configuration in three teeth and Type IV and Type V in one tooth each. Additionally, C-shaped canals were noted (Figure 1B) in eight teeth on the left side and 15 teeth on the right side.

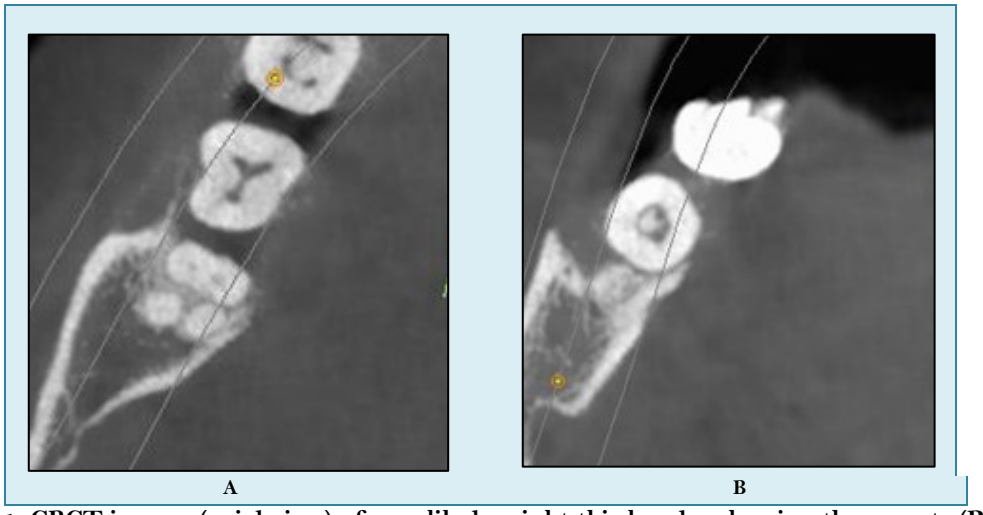

Figure 1. CBCT images (axial view) of mandibular right third molar showing three roots (Radix Entomolaris).

Discussion

M3M teeth pose difficulties for endodontic treatment because of the hard-to-reach position in the jaw and unpredictable root and root canal morphology. As a result, these teeth are extracted when there is pulpal involvement rather than undergoing endodontic therapy. However, if these teeth are intended to be abutments for fixed prostheses, endodontic treatment is indispensable. Hence, a thorough understanding of the root canal morphology is a prerequisite.

We analyzed the root and root canal morphology of 186 M3M using multiplanar CBCT images. Our findings revealed that the majority of M3M had two roots followed by a single root, which was consistent with the previous studies [5,18]. Additionally, no significant difference was found between males and females, which was similar to findings in Koreans [19]. Also, the incidence of three rooted M3M (Radix Entomolaris) was very low, which is consistent with the findings of a previous study [19].

Our study found that most of the M3Ms had three canals, which contrasts with the findings of Faramarzi et al. [18] and Ahmed et al. [20], who reported that most of M3Ms had two canals, followed by three canals. In this study, canals were categorized according to Vertucci, which is simple and easy to use to classify canal configurations. The predominant type of root canal configuration observed in the distal root of two rooted M3M was Type I, consistent with the previous literature [21,22]. A total of 23 teeth showed C-shaped canals, which was higher than those of Priyank et al. [22] and lower than the findings of Madani et al. [23]

Understanding the root and root canal morphology prior to the endodontic treatment enhances the success rate of the treatment. Advanced imaging modalities like CBCT provide a detailed anatomical map for precise and effective treatment planning. Owing to the complex variations in the root canal morphology, CBCT imaging is a prerequisite before the initiation of endodontic treatment of M3M.

The inclusion of samples from a single center and a small sample size are a few limitations of this study. Future studies with large sample sizes and diverse populations are needed to get an insight into the diverse root canal patterns of M3M.

Conclusion

Mandibular third molars in the South Indian population predominantly had two roots and three canals, with no significant difference between males and females but a notable occurrence of four canals in males on the right side. Additionally, Type I canal configuration was more prevalent in the distal root and varying patterns in the mesial root in two rooted M3M, highlighting the anatomical complexity.

Authors' Contributions

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

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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.

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