Original Research Paper

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Assessment of "Maxillary First Premolar" Root canal configurations in population of Jaipur Rajasthan using Cone Beam Computed Tomography analysis: An observational study

Abstract:

This observational study aimed to assess the root canal morphology of maxillary first premolars in the Jaipur population using Cone Beam Computed Tomography. The scans of patients referred fromprivate radiology centres were analysed for the number of roots, canal configurations, and bilateral symmetry. Significant anatomical variation was observed, highlighting the need for population-specific data in endodontic treatment planning. Bilateral symmetry was present in many cases but was not consistent across all samples. The findings reinforce the utility of cone beam computed tomography as a reliable, non-invasive tool for accurate identification of complex root canal systems, ultimately aiding in improved clinical outcomes.

Key-words: Complex root canal morphology, Cone Beam Computed Tomography, Jaipur population, Maxillary first premolar, Root Canal Anatomy

Introduction:

Successful endodontic outcomes are based upon comprehensive cleaning and shaping of the root canal system, three-dimensional obturation, and adequate coronal restorations—each of which is grounded in a precise understanding of the tooth's anatomical complexities.[1] There's a wide range of variations reported in the literature concerning the number and shape of canals in each root, and the total number of roots.[2]

The maxillary first premolars are among the most delicate teeth to be treated endodontically due to their morphological variations in the direction and longitudinal depressions of the roots, pulp chamber, number of roots, and canal configuration .[3]

Root canals often go undetected, as dentists may overlook their true anatomy, especially in teeth that exhibit anatomical variations or redundant root canals. Understanding the root canal structure and thoroughly assessing preoperative radiographs is crucial for effective endodontic treatment. Nonetheless, Intraoral periapical radiographs (IOPA) represent two-dimensional views of a three-dimensional object, and clinicians need to see this constraint while interpreting these images. Thus, the clinicians should be well-clued about the detailed anatomical analysis of the tooth during endodontic treatment.[4]

Clinical assessments and traditional 2D radiographs are classic methods for detecting variations in the structure of roots and root canals; however, these methods can be labour-intensive. Conversely, cone-beam computed tomography

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(CBCT) and micro-computed tomography are advanced three-dimensional (3D) imaging techniques that deliver more precise and high-resolution.[5]

The adoption of CBCT in Endodontics is soaring globally, and this surge is evident in the position statements released by various specialized organizations (European Society of Endodontology,2014; American Association of Endodontists/American Academy of Oral & Maxillofacial Radiology CBCT position statement, 2015).[6]

The existing protocols for utilizing CBCT highlight the importance of balancing the exposure to ionizing radiation with the advantages for patient results, following the principles of minimizing exposure to levels 'as low as feasibly achievable' (ALARA) or 'as low as clinically acceptable' (ALADA).[7] Due to its capability to visualize dental conditions and detailed anatomical features, it plays a crucial role in contemporary dental practice. Its diagnostic skills are further enhanced by the incorporation of AI, which expedites the analysis process and enhances results.[8]

The American Association of Endodontists (AAE), alongside the Joint Position Committee of the American Academy of Oral and Maxillofacial Radiology (2015) stated in their third recommendation that "Limited FOV CBCT should be regarded as the preferred imaging technique for the initial management of teeth exhibiting potential for additional canals and suspected intricate anatomy.[9] Clinical examination of the floor of the pulp chamber gives some clues about the existing root canal types. When there is only one canal exposed, it is usually located in the centre of the pulp chamber and can be found easily. If only one orifice is found that is not in the centre of the pulp chamber, another canal is probably present and should be searched for on the opposite side.[10]

A study was conducted in 1979 by Vertucci and Gagauffon US population on 400 extracted maxillary first premolars. The teeth were decalcified, injected with dye, rendered transparent through a clearing process, and meticulously examined. This technique allowed for three-dimensional visualization of the internal canal system. They concluded 26% of the teeth had a single canal, 69% exhibited two canals, and 5% showed three canals.[11]

Ozcan et al. in 2012 conducted a study on653 extracted maxillary first premolars from Turkish individuals and evaluated root number and canal configuration byex vivo analysis by applying a clearing and dye-staining (tooth-clearing) technique and they foundOnly 3 premolars (1.1%) had three separate roots, indicating that this configuration is rare in the Turkish population.10 teeth (1.5%) were found to have three canals, regardless of the number of roots. These three-rooted premolars shared anatomical similarities with maxillary molars and are sometimes referred to as “small molars” or “radiculous molars “. The most common canal pattern in these rare cases consisted of mesiobuccal, distobuccal, and palatal canals.[12]

The intricate and diverse nature of root canal systems shaped by factors like ethnicity, age, and unique anatomical features necessitates careful and precise diagnostic strategies, especially for maxillary first premolars, to achieve successful endodontic outcomes.[13]

Methods:

This observational study was conducted at Mahatma Gandhi Dental College and Hospital, Jaipur, and utilized cone-beam computed tomography (CBCT) scans acquired from the Department of Oral Radiology at Mahatma Gandhi Dental College and Hospital, along with various private radiology centers. The study population comprised CBCT images, specifically focusing on the maxillary first premolars of patients who had been referred to these radiology centres for diagnostic imaging. These scans were selected based on predetermined inclusion and exclusion criteria to ensure the relevance and quality of the data for the study.

The inclusion criteria comprised the images of maxillary first premolars and with a small field of view (4 x 4 cm) and a voxel size of 0.125 mm to maximize spatial resolution, and the teeth that had not undergone root resorption. The exclusion criteria included calcified and immature maxillary first premolar.

The sample size of 400 was taken with 95% confidence interval, 5% Type I error (α), 5% allowable error (c), and an expected response distribution of 70%. To compensate for a potential attrition rate of 5%.

The data for the present study was entered in Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The level of significance was fixed at 5%. The comparison of the ordinal variable was done using chi-square test.

Results:

The study evaluated the root and canal morphology of maxillary first premolars with respect to gender and tooth position (right or left). Among 400 teeth assessed, double roots (58.5%) and double canals (79%) were the most common canals, while triple roots and canals were rare (0.8%). Gender-wise analysis revealed a statistically significant difference in root number ($p = 0.001$), with females exhibiting a higher prevalence of single roots (61.5%) compared to males (33.5%), whereas males more frequently had double roots (65.5%). However, no significant gender differences were found in no. Of canals($p = 0.330$). Additionally, comparisons between the right (tooth 14) and

left (tooth 24) premolars showed no statistically significant differences in either root (p = 0.345) or canal (p = 0.384) numbers (Table 1).

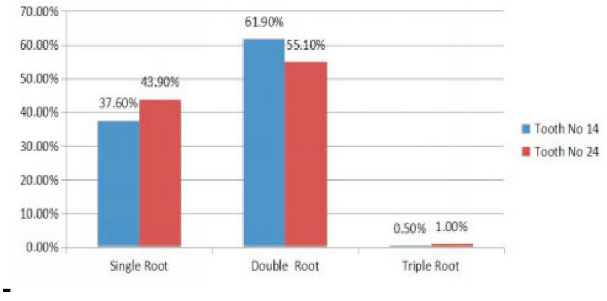
TABLE NO. 1-Comparision between right and left premolars

Block	Subgroup	Category	n	%	χ^2	p value	Sig.
Gender distribution	—	Female	104	26.0	—	—	—
		Male	296	74.0	—	—	—
Overall number of roots	—	One root	163	40.8	—	—	—
		Double root	234	58.5	—	—	—
		Triple root	3	0.8	—	—	—
Overall number of canals	—	One canal	81	20.2	—	—	—
		Double canal	316	79.0	—	—	—
		Triple canal	3	0.8	—	—	—
Number of roots × Gender	**Female (n=104)**	Single	64	61.5	**26.067**	**0.001**	**Sig**
		Double	40	38.5			
		Triple	0	0.0			
	Male (n=296)	Single	99	33.5			
		Double	194	65.5			
		Triple	3	1.0			
Number of canals × Gender	**Female (n=104)**	Single	25	24.0	**2.214**	**0.330**	Non-Sig
		Double	79	76.0			
		Triple	0	0.0			
	Male (n=296)	Single	56	18.9			
		Double	237	80.1			
		Triple	3	1.0			
Number of roots × Tooth	**Tooth 14 (Right max premolar, n=202)**	Single	76	37.6	**2.124**	**0.345**	Non-Sig
		Double	125	61.9			
		Triple	1	0.5			
	Tooth 24 (Left max premolar, n=198)	Single	87	43.9			
		Double	109	55.1			
		Triple	2	1.0			
Number of canals × Tooth	**Tooth 14 (Right max premolar, n=202)**	Single	36	17.8	**1.914**	**0.384**	Non-Sig
		Double	165	81.7			
		Triple	1	0.5			
	Tooth 24 (Left max premolar, n=198)	Single	45	22.7			
		Double	151	76.3			
		Triple	2	1.0			

1. Tooth Position Wise Prevalence of The Number of Roots Among Study Subjects

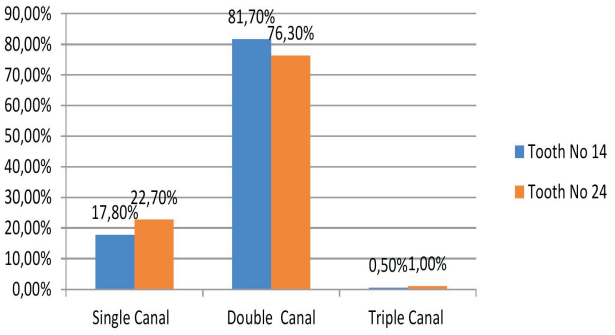
The prevalence of single root was 37.6%, double root was 61.9% and triple root was 0.5% among the Right Maxillary premolars. In the Left Maxillary Premolar, the prevalence of single root was 43.9%, double root was 55.1% and triple root was 1.0% The chi-square association of Tooth Number with the prevalence of the number of roots was statistically non-significant (p=0.432) (graph 1)

GRAPH NO. 1-Tooth position wise prevalence of the number of roots among study subjects.



2. Tooth Position Wise Prevalence of Number of Canals Among Study Subjects

The prevalence of single canals was 17.8%, double canal was 81.7% and triple canal was 0.5% among the Right Maxillary premolars. In the Left Maxillary Premolar, the prevalence of single canals was 22.7%, double canal was 76.3% and triple canal was 1.0% The chi-square association of Tooth Number with the prevalence of the number of canals was statistically non-significant (p=0.472) (graph 2)



GRAPH NO. 2- Tooth position wise prevalence of number of canals among study subjects.

Discussion:

This observational study provides valuable anatomical insights into the root canal morphology of maxillary first premolars in a representative population from Jaipur, using high-resolution CBCT—a modality that has revolutionized endodontic diagnostics by enabling enhanced three-dimensional visualization.

A notable aspect of the present study was the gender distribution, with male subjects comprising the majority of the sample (74%). This skew is more likely attributable to referral trends than to genuine anatomical differences Some authors have suggested subtle demographic and biological influences on root configuration, indicating the need for further region-specific studies to clarify whether gender-linked trends hold clinical significance.[14]

Similer findings were observed in a Saudi cohort study (2024), based on analysis of 399 CBCT images of maxillary first premolars in females exhibited a higher incidence of one-rooted first premolars and slightly more frequent second canals, whereas males demonstrated a greater occurrence of three-rooted forms and complex multi-canal variations.[15] In a large-scale Portuguese CBCT study (2017) analyzed 12,325 maxillary 1st and 2nd premolars from 670 patients, females typically exhibited simpler canal configurations (Vertucci Type I), whereas more complex three-canal systems were more prevalent in males.[16]

The CBCT analysis revealed considerable variability in root and canal configurations. These findings corroborate earlier literature that consistently emphasizes the anatomical diversity of maxillary first premolars. For example, Gupta et al. (2015) studied250 extracted human adult maxillary first premolar teeth and reported that 53.6% were single-rooted, while a small subset (0.4%) exhibited three distinct roots. Type IV was the most frequently observed configuration (33.2%), alongside lateral canals (34.8%) and inter-canal communications (16%),visualization was done by steriomicroscopy. A comparable studies from Turkish, Chinese, and Middle Eastern populations have demonstrated both overlaps and significant deviations, underscoring the influence of ethnicity and geography on canal morphology. In the Turkish population, CBCT studies revealed that about half of the premolars were single-rooted, with nearly 80% exhibiting two canals, and Vertucci Type IV being the most common configuration (~77%).[17-18] In contrast, Chinese studies reported a predominance of single-rooted premolars (~70%), with lower prevalence of Type IV canals (~42–44%), suggesting simpler anatomy compared to Turkish samples.[19] Middle Eastern data, particularly from Saudi and Egyptian populations, demonstrated patterns more similar to Turkish findings, with a higher frequency of two-rooted maxillary first premolars (~70–75%) and Vertucci Type IV as the dominant canal type, along with high bilateral symmetry in root and canal configuration.[20-21] These differences underscore how ethnicity and geography influence canal morphology, highlighting the importance of population-specific anatomical knowledge in endodontic diagnosis and treatment. Collectively, these results highlight the importance of integrating regional datasets into global endodontic understanding.[3]

From a clinical perspective, early identification of additional roots and canals is paramount. Missed anatomy remains one of the leading causes of endodontic failure, resulting in incomplete debridement, inadequate irrigation, or compromised obturation. The identification of lateral canals and inter-canal communications in a substantial proportion of cases is particularly significant, as these microanatomical features may harbor persistent microorganisms despite comprehensive biomechanical preparation. Hence, access cavity design and coronal preflaring should be modified based on preoperative imaging, reducing the risk of perforations or untreated spaces.[22]

The sample population was restricted to patients requiring CBCT imaging, which may not reflect the general population. Moreover, CBCT, while offering excellent resolution, is associated with higher radiation exposure compared to conventional radiographs, limiting its routine use. These factors highlight the need to balance diagnostic accuracy with radiation safety and cost-effectiveness.[23]

In conclusion, the present CBCT-based study adds region-specific data to the existing body of knowledge on maxillary first premolar morphology, reaffirming the high degree of anatomical variability in the tooth. By contextualizing these findings within broader literature, this study emphasizes the necessity of anticipating anatomic complexities in routine and retreatment cases. Future investigations with larger and more geographically diverse samples are warranted to deepen our understanding of population-specific anatomical trends and their clinical implications.

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