

CBCT Analysis of Canal Configuration of Mandibular Incisors in Mithilanchal Population- An In-Vitro Study

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Abstract

Background: Root canal morphology is a key factor for preventing treatment failure and ultimately the success of endodontic therapy, since anatomical variations can impact treatment outcomes. Mandibular incisors are often thought to possess straightforward root canal systems, but in reality, may present complex configurations that are challenging defective through traditional radiographic techniques. Cone Beam Computed Tomography (CBCT) gives a three-dimensional imaging, enhancing it an acceptable modality for the detection of these variations.

Materials and Methods: This retrospective observational study from October 2023 to January 2026 in vitro on extracted mandibular incisors, total small sample of the study included 92. Inclusion criteria were applied in order to clean, store in saline, and perform the CBCT scan on each tooth. Evaluation of canal configurations was performed in axial, sagittal and coronal planes and classified according to Vertucci's classification. Data were analysed using descriptive statistics and reported as counts and percentages.

Results: It was found 65.2% Type I, 19.6% Type III, 8.7% Type II and 6.5% Type IV canal configuration. One canal was found in 65.2% of teeth, and two canals were identified in 34.8%. The canal bifurcation as well as the anatomical variations were clearly identified by CBCT imaging.

Conclusion: The current study represents significant diversity in its canal morphology of mandibular incisors within the Mithilanchal population. The presence of such variations has an adverse effect on the prognosis of endodontic treatment and CBCT is a useful diagnostic tool in recognizing them, which will aid in diagnosis and treatment planning, thereby enhancing therapeutic success.

Keywords: CBCT, Mandibular incisors, Root canal morphology, Vertucci classification, Mithilanchal population, Endodontics.

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Introduction

A complete understanding of root canal morphology is crucial for the success of endodontic therapy, as anatomical details in canals can alter treatment outcomes significantly [1,2]. The most common causes of endodontic failure include missed canals or incomplete cleaning of complicated canal systems [3].

The mandibular incisors, while usually thought to possess a simple anatomy, often contain anatomical anomalies (like two canals or bifurcations and lateral canals), which may be undetected during

standard clinical processes [4,5]. This heterogeneity highlights the need for comprehensive anatomical assessment prior to treatment. Intraoral periapical radiography, a conventional technique for assessing root canal morphology, is limited by being bidimensional causing overlapping of anatomical structures and an inability to accurately depict complex canal configurations [6,7]. These limitations may cause underdiagnosis of additional canals or variations. CBCT has a great importance in the diagnosis of endodontic cases because it produces 3D images of

the root canal system in axial, sagittal and coronal planes [8].

CBCT offers better ability for the clinician to visualize anatomical complexities, advancing diagnosis, treatment planning and outcomes [9,10]. Several studies from different parts of the world as well as within India have documented variations in mandibular incisors canal configuration with majority population showing dual canals [11]. These observations exhibit diversity among various ethnic and geographic groups, suggesting possible population specificity in the root canal morphology. While there is an increasing number of studies, the data on Mithilanchal population are limited as this region has a unique demographic and genetic composition [12]. This limits the ability to generalize findings and may reduce clinical decision-making implications for patients from this population. Hence, a study using sophisticated imaging modalities like CBCT needs to be conducted on the canal anatomy of mandibular incisors in this particular population.

Objectives of the Study

- To assess the root canal system of mandibular incisors in Mithilanchal population
- To assess the number of canals in mandibular incisors using CBCT.
- To classify the canal configurations according to the Vertucci's classification system.

Materials and Methods

Study Design: This study was designed as an in-vitro observational investigation was performed to determine the root canal configuration of mandibular incisors using CBCT. This in-vitro method allowed for detailed investigation of extracted teeth free from patient-related factors and facilitated spatial evaluation of the anatomical structures.

Study Duration: From October 2023 to January of 2026, the study was conducted. This time frame was sufficient for the sample collection, preparation, and imaging as well as for the analysis.

Sample Size: A total of 92 extracted mandibular incisors were included. The teeth collected were extracted from patients for different clinical reasons. Samples were anonymized for all participants and ethical standards for extracted human teeth were strictly followed.

Inclusion Criteria

- Healthy teeth (no signs of structural integrity issues)
- Roots with full apical formation only
- No root fractures or resorptive defects

Exclusion Criteria

- History of previous endodontic treatment
- Calcified or obliterated canals
- Damaged roots, Fractures or Developmental Anomalies

Sample Preparation: After extraction, all the teeth were cleaned with ultrasonic scalers and manual instruments to remove debris, calculus, and attached soft tissue. The cleaned specimens were then disinfected and stored in normal saline solution to keep hydrated and avoid structural modifications. Tissue preparation was standardized to maintain the internal anatomy intact for correct evaluation through the volumetric data provided by CBCT.

CBCT Imaging Procedure: High-resolution dental CBCT system was used for imaging. This involved individually scanning each tooth and obtaining detailed three-dimensional images of everyone. Image acquisition was performed with the same imaging parameters including small voxel size (0.125 mm to 0.2 mm), of a slice thickness that allowed optimal image visibility. The retrieved images were reconstructed and interpreted as axial, sagittal, and coronal planes that offered complete access to the visualization of the root canal system and its variants.

Evaluation Criteria: Vertucci's classification system was used to evaluate the root canal anatomy of each mandibular incisor, which describes a diverse range of canal morphologies into different types based on the number and configuration of canals. The number of canals in each specimen, the presence of canal bifurcations and other features like lateral canals were examined. The analysis was performed because parts of the observers had to ensure consistency and minimize observational bias.

Data Analysis: The data were analyzed using SPSS software. Frequencies and percentages were obtained as descriptive statistics to summarize the distribution of canal configurations. Inferential statistical analysis like Chi-square test was used to assess the associations among the variables. Statistical significance was defined as p-values <0.05.

Results

Distribution of Canal Configurations: In the current study, 92 extracted mandibular incisors were analyzed with CBCT to evaluate the root canal system according to Vertucci classification. The findings revealed that most common canal configuration in samples to be type I (single canal from pulp chamber to apex). A significant proportion of teeth also had more complex canal morphologies (Type III) with canals bifurcating and rejoining inside the root. Types II and IV were

less often observed, representing anatomical features inside the study population.

Table 1: Distribution of Canal Configurations (Vertucci's Classification)

Canal Type	Description	Frequency (n)	Percentage (%)
Type I	Single canal	60	65.2%
Type II	Two canals merging into one	8	8.7%
Type III	One canal dividing and rejoining	18	19.6%
Type IV	Two separate canals	6	6.5%
Total		92	100%

Number of Canals: The number of canals was analyzed and the results indicated that most mandibular incisors had a single canal while a considerable percentage had two canals. The teeth contained 65.2% of one canal, while the 34.8%

exhibited the presence of two canals, either merging or the remaining distinct. This underscores the clinical relevance of meticulous evaluation, as many teeth may contain additional canals that could be observed during treatment.

Table 2: Frequency of Number of Canals

Number of Canals	Frequency (n)	Percentage (%)
One Canal	60	65.2%
Two Canals	32	34.8%
Total	92	100%

Bilateral Symmetry and Additional Findings:

Although this was an in-vivo study based on extracted teeth, and thus ideally for paired samples suggestive patterns of bilateral symmetry have been available. Canal configuration showed a moderate symmetry specifically in Type I teeth. But variation was also found, suggesting that intrasubject anatomy of the canal may vary. Moreover, enabling the identification of some anatomical complexities such as canal bifurcations and occasional lateral canals associated with these teeth which categorize under Type III and Type IV configurations through CBCT imaging. All these variations were distinctly demonstrated in the axial, sagittal and coronal sections of CBCT scans. Various representative CBCT images are presented illustrating the different canal configurations and anatomical variations, emphasizing three-dimensional imaging benefits in endodontic diagnosis.

Discussion

This study uses CBCT imaging to give insights on it in Mithilanchal population. The most significant finding was the notable predominance of Vertucci's Type I canal configuration, detected in a high percentage of the samples, corresponding to a single canal extending from the pulp chamber to the apex. Fewer studies reported Type III root canal variation, but a relatively large percentage of some teeth exhibited this feature. Finding configurations Type II and Type IV is a rarer occurrence but only adds to the complexity of mandibular incisor anatomy. The results show that mandibular incisors do not necessarily have a simple canal system.

Comparison with Previous Studies: The findings of the current study are in accordance with some earlier Indian studies that stated Type I as the

predominant canal configuration, followed by Type III in mandibular incisors. Similar trends have been reported from India in other settings with few variations [13]. Though the presence of two canals was relatively higher in this study than that of a few previous Indian studies, which might be due to variations in methodology or evaluation with sophisticated imaging techniques like CBCT [14].

Variation of canal configurations between different national and geographic backgrounds [15]. Higher prevalence of dual canals with respect to Western populations has been observed in studies performed on Middle-Eastern and East-Asian population. The resemblance noted in the outlook of Type I canals among different studies reflects the general anatomical formation whereas variations of prevalence of complex arrangements facilitate the role of population-dependent determinants. In contrast to earlier researches where progress was estimated with standard radiographic methods, the present study used CBCT technique which can further facilitate source identification in terms of detection.

Clinical Significance: Understanding the root canal morphology of the mandibular incisors in human permanent dentition is essential for the successful endodontic treatment. The presence of additional canals or complex configurations increases the risk of missed canals, which can result in treatment failure and persistent infection.

The results of this study shows that the clinicians should be careful when treating the mandibular incisors, as they may seem simple anatomically. By allowing three-dimensional visualization, CBCT imaging should aid in the diagnosis and improve treatment planning of such complexities.

Considering the use of CBCT specifically in those cases can enhance treatment outcomes and increase the chances of eradication, avoiding procedural errors.

Strengths of the Study: This study uses CBCT imaging, which provides the detailed photographic visualization which is three-dimensional as well as the accurate assessment of overall root canal morphology. Unlike traditional radiographic techniques, CBCT avoids problems of superimposition and distortion. Also, the study is based on Mithilanchal population, thus it contributes to a gap in literature and provides region-specific statistics which can help clinicians working in this area.

Limitations: As it is an in-vitro study, the findings may not entirely correspond to in-vivo clinical settings. While the sample (n = 92) was sufficient for a preliminary analysis, it may not be representative of the greater population. Moreover, data on demographics (e.g., age and gender) are not available, delaying the examination of heterogeneity by these factors. Large, diverse samples in future studies are recommended.

Conclusion

The present study highlighted that the root canal morphology of mandibular incisors in Mithilanchal population has a clear variability. Type I (single canal most common), while only a minority shown all types of complex canals, with Type III being present or noted often where it appeared. The results indicated that mandibular incisor's structure may not always present with a simple anatomical structure, as traditionally assumed.

These variations have significant clinical implications, with omission of identification and treatment of supplemental canals possibly leading to unsuccessful endodontic outcomes. CBCT imaging was better at detecting such anatomical complexities and may serve as a reliable non-invasive diagnostic tool. Clinicians must consider the probability of an extra canal forming during treatment and should use advanced image modalities such as CBCT where conventional x-ray may not reveal it. Knowledge of canal morphology is important to improving the success rate of endodontic treatment.

Recommendations: This study suggests that larger samples might be studied which result in more general results. However, future studies should implement in-vivo designs as they would better clinical conditions and improve applicability to routine dental practice. The other aspect is demographic variables including age, gender and ethnic background might add significant value to better understand individual differences in root canal morphology. Comparative studies in other

regions would help to explore differences specific to populations. However, advanced imaging modalities such as CBCT continue to be widely used in endodontics and recommended to enhance diagnostic accuracy and treatment outcome.

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