Original Article

Variations in Root Canal Morphology of Mandibular Incisors in a North Indian SubPopulation: A Retrospective Cone-Beam Computed Tomography Analysis

Abstract

Background: There is a high failure rate of endodontic treatment in the mandibular incisors due to insufficient knowledge of the morphology. **Aim:** The aim of this study was to analyze the root canal morphology in mandibular incisor teeth in the North Indian subpopulation to improve the outcome of endodontic treatment. **Setting and Design:** A cross-sectional study was conducted at the OPD of a tertiary care institute. **Materials and Methods:** A total of 200 mandibular central incisors and 200 mandibular lateral incisors were selected from available cone-beam computed tomography examinations of 100 patients aged 18–79 years. They were evaluated for root canal system configuration and symmetry between right and left elements in the same individual. **Statistical Analysis:** Chi-square/Fisher's exact test was used to find the association between different study variables. **Results:** For mandibular central incisors, type I Vertucci classification was present in 69% of cases, type II in 3.5%, type III in 18.5%, type IV in 2%, and type V in 7% of cases. For mandibular lateral incisors, type I was present in 70.5% of cases, type II in 4% of cases, type III in 19.5%, type IV in 2%, and type V in 4% of cases. There was no evidence of types VI, VII, and VIII. Symmetry of root canal morphology between left and right teeth was observed in 90% of central incisors and 93% of lateral incisors. **Conclusion:** Type I Vertucci configuration was the most prevalent; however, the prevalence of other configurations is also evident. Therefore, endodontists should explore the morphology of these teeth carefully while performing root canal treatments.

Keywords: *Endodontics, mandibular incisors, Vertucci*

Brar Prabhleen Kaur[1], Brar Rajdeep[2], Vashisht Ruchi[1], Mehta Nishant[3], Shrivastava Richa[3], Tamchos Rigzin[4]

[1]Oral Health Sciences Centre, Unit of Conservative Dentistry, Postgraduate Institute of Medical Education and Research, Chandigarh, India, [2]Department of Oral Medicine and Radiology, Dr. Harvansh Singh Judge Institute of Dental Sciences, Punjab University, Chandigarh, India, [3]Oral Health Sciences Centre, Unit of Community Dentistry, Postgraduate Institute of Medical Education and Research, Chandigarh, India, [4]Oral Health Sciences Centre, Unit of Paedetric Dentistry, Postgraduate Institute of Medical Education and Research, Chandigarh, India

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Address for correspondence:
Dr. Brar Prabhleen Kaur, Oral Health Sciences Centre, Unit of Conservative Dentistry, Postgraduate Institute of Medical Education and Research, Chandigarh, India. E-mail: prabhleen_brar@yahoo.com

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Introduction

The main objective of endodontic therapy is the thorough mechanical and chemical cleansing of the entire pulp cavity and its complete obturation with an inert filling material. However, failures do occur. There are a number of causes documented for these and untreated canals are the most common.[1] A canal is often left untreated because the dentist fails to locate it. Hence, a thorough knowledge of root canal morphology is important to successfully treat a tooth endodontically.

There is a significant rate of failure of the endodontic treatment in mandibular incisors. This failure has been traced to a missed canal in many cases. This happens due to inadequate knowledge of the root canal morphology. A dentist with adequate knowledge about root canal morphology will be able to search for and locate any extra canal and hence appropriately treat the same thereby, increasing the success of root canal treatments.[2]

The first research on canal morphology was conducted by Rankine-Wilson and Henry and Henry after an extra root canal was found in lower incisors.[2] A wide variety of methods have been used in studies for evaluating the root canal morphology such as decalcification, dye injection,[3] *ex vivo* radiography,[4] *in vitro* macroscopic examination, scanning electron microscope examination of the pulpal floor, and grinding or sectioning.[5] Clinical methods include evaluation of endodontic access openings during endodontic treatment using magnification or retrospective evaluation of endodontically treated teeth in patient records using cone-beam computed tomography (CBCT) and *in vivo* radiographic examination.[5]

Conventional periapical radiographs are also valuable diagnostic tools in assessing root

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canal morphology *in vivo*. However, they are not absolutely reliable because of inherent limitations such as distortion and superimposition of bony and dental structures.[6] Oral CBCT is a quick, convenient, and noninvasive method that can provide images displayed in coronal, sagittal, and axial planes. It also describes precisely the position of the tooth and allows the study about symmetry. Hence, it can serve as a useful tool for the study of root canal morphology.[6,7]

The aim of the present study was to analyze the root canal configuration of mandibular central and lateral incisors *in vivo* using CBCT.

Materials and Methods

Study design and setting

We carried out a cross-sectional retrospective examination of the images obtained from CBCT examinations as part of the diagnosis and treatment planning of patients who required large field of view for other reasons at a dental OPD of a tertiary health-care center. The research was approved by the Institutional Ethics Committee (ref. INT/IEC/2021/SPL-1681). The study was reported in accordance with Reporting of Studies Conducted using Observational Routinely Collected Health Data.[8]

Eligibility criteria

The available CBCT images without significant scattering, with the presence of all four lower incisors with complete root formation and absence of root canal treatment, crowns and posts were selected for the study. Teeth with immature apexes and root resorption were excluded.

Sample size estimation and sampling methodology: The sample size estimation was done using the formulae for the cross-sectional studies, i.e., $n = Z^2_{1-\alpha/2}P\ (1 - P)/d2$ (where n is the desired sample size, $Z_{1-\alpha}$ is the statistic corresponding to the level of confidence = 1.96, P is expected prevalence = 45%, and d is precision = 5%).[1] As per the study by Valenti-Obino *et al*. 2019,[9] the prevalence of mandibular central incisor with two canals was 45%, hence the expected prevalence was kept at 45% to calculate the sample size for this study. Using the formula, the desired sample size came out to be 381 incisors (rounded off to 400) which should be sufficient to calculate the variations in the root canal morphology of the mandibular incisors. Hence, a total of 200 mandibular central and 200 mandibular lateral incisors were randomly selected using computer-generated sequences from CBCT examinations of 100 patients between 18 and 79 years of age.

Data collection

The images were taken using the CBCT device (Kodak 9500 Cone beam 3D system), with the exposure parameters: 90 kvp, 10 mA, 10.80 s scan time with voxel size of 0.25 mm, scanning angles of 360°, and field of view of 60 mm × 60 mm for all images. The images were taken following the manufacturer's instructions with the lowest dose of radiation.

The 3D Slicer 4.11.20210226 software was used as the image reconstructing and measuring tool. Images were viewed on reconstructions according to the plane, scrolling the cursor in the coronal-apical direction and then in the apical–coronal direction to get a detailed view of the root canal system of the examined teeth. Two endodontists evaluated the images individually with an oral radiologist's opinion as the final golden standard when a discrepancy occurred. Data of teeth on both sides were noted. The root canal system configuration according to Vertucci's classification[3,10] was recorded [Figure 1]. The symmetry between right and left elements in the same individual was seen.

Statistical analysis

Number of teeth under each category of Vertucci's classification was identified and data were entered into Microsoft Excel sheet. All variables were expressed as frequencies and Chi-square test/Fisher's exact test was used to find association between different study variables. Statistical analysis was done using SPSS 21.0 (SPSS, Inc., Armonk, New York, USA) and the level of significance was kept at $P < 0.05$.

Results

For mandibular central incisors, type I Vertucci classification was present in 69% of cases, type II in 3.5%, type III in 18.5%, type IV in 2%, and type V in 7% of cases. For mandibular lateral incisors, type I was present in 70.5% of cases, type II in 4% of cases, type III in 19.5%, type IV in 2%, and type V in 4% of cases [Table 1]. Types VI, VII, and VIII were not found in the population evaluated. No statistically significant difference was found between central and lateral incisors ($P = 0.775$). Symmetry of root canal morphology between left and right teeth was seen in 90% of mandibular central incisors and 93% of cases in mandibular lateral incisors, whereas no symmetry was seen in 10% of central and 7% of lateral incisors. No statistically significant difference was found in the symmetry between central and lateral incisors ($P = 0.447$) [Table 2].

Table 1: Distribution of the categories in the root canal anatomy of mandibular incisors

Tooth	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII
Mandibular central incisor, *n* (%)	138 (69)	7 (3.5)	37 (18.5)	4 (2)	14 (7)	0	0	0
Mandibular lateral incisor, *n* (%)	141 (70.5)	8 (4)	39 (19.5)	4 (2)	8 (4)	0	0	0

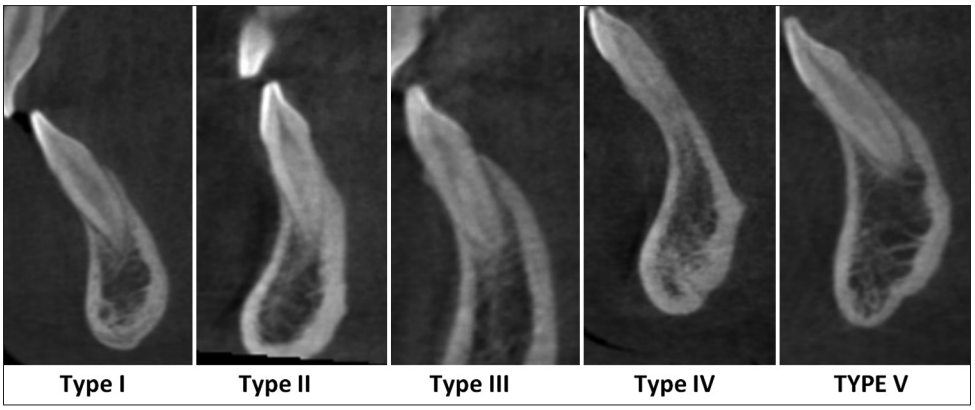

Figure 1: CBCT images showing the five variants in permanent mandibular incisors according to the Vertucci's classification

Table 2: Distribution of symmetry in central and lateral incisors

Tooth symmetry	Unilateral (%)	Bilateral (%)
Central incisors	10	90
Lateral incisors	7	93

Discussion

A thorough knowledge is the prime prerequisite for performing a successful root canal treatment. The inability to detect the presence of an extra canal which can then not be prepared and filled during treatment can lead to failure of the root canal treatment. Various studies have been conducted from time to time to study the root canal morphology of the teeth and also different methods have been employed for the same.[11-14]

The present study used CBCT to investigate the root canal configuration of mandibular incisors in an Indian subpopulation. CBCT imaging is a noninvasive technique that has been reported to be as accurate as the modified canal staining and clearing technique for evaluating root canal systems. In contrast to traditional radiography, CBCT scanning provided 3-dimensional images in axial, sagittal, and coronal sections that could avoid geometric distortion and anatomic superimposition. Although it is not recommended to advise CBCT for routine examinations, its value in examination of root canal morphology in root canal retreatment cases cannot be underestimated.[14]

The study shows that single canal is the most prevalent in the central and lateral incisors. Type II was the third most prevalent type. Type III was the second most prevalent configuration. The above results confirm the study done by Haghanifar *et al*.[15] who reported that most mandibular anterior teeth had a single root and single root canal.

Han *et al*.[16] also conducted a CBCT study on mandibular anterior teeth and reported that type I was the most prevalent configuration. Sroczyk-Jaszczyńska *et al*.[7] conducted a study in a Polish population and showed that type I is the most prevalent, followed by type III. However, our results are in contrast to Valenti-Obino *et al*.[9] who showed that type II was more frequent than type III.

An important point is that if two canals are present, they usually join together 1–2 mm from the apex. If root canal filling is shorter than this joining point, then the unfilled canal can cause failure. Finally, if apical resection is attempted in the presence of a second canal, one apical foramen will become two separate foramen and this will influence the prognosis negatively.

Symmetry in canal morphology between right and left teeth in our study was seen in 90% of central and 93% of lateral incisors. However, no statistically significant difference was found between the central and lateral incisors. Similar results were shown by Valenti-Obino *et al*.[9] who showed no significant difference between the two groups. Lin *et al*.[17] have also shown that symmetry exists between the right and left teeth in 90% of the cases.

This study used meticulous methodology involving a team of two endodontists and an oral radiologist for patient data assessments. However, the study has certain limitations due to the study design and the likelihood of selection bias due to the involvement of patient data from a tertiary care hospital. In addition, this being a hospital-based study, results cannot be extrapolated to the entire North Indian population.

Conclusion

In our study, type I Vertucci configuration was the most prevalent type, and no evidence of type VI, VII, and VIII was seen in the studied population. The current data may help to increase the knowledge of the clinicians practicing in the studied geographical area about the root canal morphology of the mandibular incisors. We also recommend using CBCT to study the canal morphology in cases of retreatment of lower incisors.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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