Research Article

Cone-beam computed tomography evaluation of root canal morphology of permanent mandibular incisors in Chennai population

Nurul Syamimi Binti Mohd Azlan Sunil, Dhanraj Ganapathy*, R. M. Visalakshi

ABSTRACT

Aim: The aim of this study is to evaluate the root canal morphology of permanent mandibular incisors using cone-beam computed tomography (CBCT) in Chennai population based on Vertucci classification. **Methods and Materials:** The study was conducted on 40 CBCT scans of bilateral mandibular sides of patients of both sexes and ranging in the age of 18–49 years. The CBCT was collected from the Department of Oral Radiology, Saveetha Dental College. The inclusion criteria of this present study were included in the study: (i) No obvious dental caries, (ii) fully formed root canal apices without resorption or calcification, (iii) absence of root canal fillings, posts, and crown restoration, (iv) CBCT images of good quality, and (v) CBCT images which included the desired area of interest. The teeth involved were investigated for the number of roots, number of root canal per tooth, and root canal pattern (Vertucci 1984). **Results:** All the permanent mandibular incisors have a single root. Majority of the incisors had single canal. The prevalence of the second canal was found in 7.5% of mandibular central incisors and 13.7% mandibular lateral incisors. According to gender, 12.1% of mandibular incisors of males and 9.9% of mandibular incisors of females had second canal. Vertucci Type I (55.2%) was the most commonly seen root canal configuration in central incisors, followed by Type III (28.4%), Type V (9%), Type IV (4.5%), and Type II (3%). In case of lateral incisors, the most common was Type I (57.5%), followed by Type III (22.5%), Type IV (8.8%), Type V (6.3%), and Type II (5%). **Conclusion:** Vertucci Type I was the most common configuration in the mandibular incisors of Chennai population. Type II was the least common configuration. Incidence of two canals is higher in males than females and higher in mandibular lateral incisors than in mandibular central incisors. Proper attention should be given to the detection of a second canal during root canal treatment. CBCT provides an excellent imaging modality for the detection of different canal configurations of mandibular incisors.

KEY WORDS: Cone-beam computed tomography, Endodontics, Mandibular incisors, Root canal morphology, Vertucci's classification

INTRODUCTION

A detailed understanding and knowledge of the morphology of root canal system is one of the stems of a successful management of endodontic cases. Based on knowledge of normal root canal morphology and variations of root canal from the norm that can be obtained from studies of root canal anatomy, proper chemicomechanical preparation and effective filling of root canal can be done.[1] Some canals may be undetected due to lack of knowledge on root canal system or insufficient investigation on additional canals. Failure to treat all the root canals properly and effectively can lead to poor endodontic treatment outcome.[2,3] Different ethnic population may have variation in root canal anatomy because root canal of tooth is thought to be genetically and racially determined.

The root canal morphology of mandibular incisors varies depending on the population.[4,5] The most

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common form of permanent mandibular incisors is a single root with a single root canal. However, a high percentage of mandibular incisors may have two canals.[6] A previous study reported the incidence of mandibular incisor teeth with more than one canal has been reported to be 11.5%–50%.[7,8] Another study reported the prevalence of two canals to be 7.6% in incisors and 4.17% for lateral incisors.[9] Other variations of root canal morphology in mandibular have been reported. In one reported type, the presence of the second canal that extends from the pulp chamber and the lingual canal branches off into two. Another reported type, three separate canals pass through root and join together forming one canal at the apical third. In another type, one canal extends from the pulp chamber, branches into two canals at the middle third, joins together to form one canal short of the apex, and branches off again into three canals short of the apex into three distinct apical foramina.[10] A case study reported more than one root may be present in mandibular incisors.[11] Variations in the mandibular incisors may result in missing root canals, non-surgical endodontic failure, and need for surgical procedures.

Various techniques have been previously used to study the root canal morphology. This includes staining and clearing technique, tooth sectioning, conventional radiographs, contrast-enhanced radiography, computed tomography (CT), micro-CT, and cone-beam CT (CBCT). The previous studies by Kartal and Yanıkoğlu[7] and Sert and Bayirli[12] used clearing technique followed by a microscope to evaluated mandibular incisors. Conventional radiographs have long been used as it is a very important tool for the identification of root canal morphology *in vivo*.[13] Bellizi and Hartwell conducted a clinical *in vivo* study using radiographs to evaluate root canal systems of mandibular incisors.[14] However, conventional radiographs are not completely reliable as there are shortcomings such as distortion and overlapping of bony and dental structures.[15]

CBCT has recently been introduced into dental imaging and is one of the suggested techniques to determine root canal morphology. It is a practical tool for non-invasive and three-dimensional (3-D) reconstruction imaging of dental and maxillofacial structures and explains the internal structure of an object with the used of cone-shaped radiation beams that can obtain data in a single 360° rotation.

CBCT in endodontics should be used limitedly to assess and treat complex endodontic cases such as identification of potential additional canal in suspected complex root canal morphology, identifications of anomalies and root canal and assessing root curvature, diagnosis of dental periapical pathosis in patients with contradictive clinical or radiographic signs and symptoms, intraoperative and post-operative assessment of complications in endodontic treatment, assess the proximity of adjacent anatomic structure, and determination of exact location of tooth apex.[16] CBCT has a combination of axial, coronal, and sagittal sections which minimize distortion and overlapping of anatomical structures when compared to conventional periapical radiographs. The image in the CBCT can be rotated in any plane and analyze internally and externally and can also be sectioned longitudinally and transversely.[17] Another advantage of using CBCT in endodontics is the multiplanar reformation (including oblique and curved) and transplanar reformation can improve the assessment of concerned region. Imaging errors caused by subject movement can be reduced as CBCT has a fast scanning time.[18] Besides, identifying the number and shape of roots and canals, CBCT can be used to determine the functional length, type, and size of roots and canals.[19] Compared to conventional CT imaging, CBCT is far superior as it provides excellent resolution and much lower radiation exposure.[20] Besides that, CBCT scans can better visualize additional canals than compared to other techniques such as digital radiography and cross-sectioning.[21] These advantages of CBCT allow clinicians a more detailed understanding of root canal morphology systems.

Hence, due to the importance of root canal anatomy and morphology in cleaning and shaping or the root canal, this study aims to evaluate the root canal anatomy of permanent mandibular incisors in Chennai population based on Vertucci's classification by CBCT.

MATERIALS AND METHODS

A total of 40 previously obtained CBCT images from the archive of the Department of Oral Radiology of Saveetha Dental College, Chennai. All CBCT scans in the present study were analyzed with a built-in software Sirona 3D Galaxis GALILEOS Viewer Version 1.9. The study was conducted on 40 CBCT scans of bilateral mandibular sides of patients of both sexes and ranging in the age of 18–49 years. The gender of the patients was also recorded. The CBCT images of permanent mandibular incisors that were included fulfilled the following inclusion criteria: (i) No obvious dental caries, (ii) fully formed root canal apices without resorption or calcification, (iii) absence of root canal fillings, posts, and crown restoration, (iv) CBCT images of good quality, and (v) CBCT images which included the desired area of interest. Teeth with physiological and/or pathological defects were excluded to obtain clear images of the mandibular incisors.

The CBCT images of root canal morphology of permanent mandibular incisors were assessed in the axial, sagittal, and transverse sections. The parameters that were recorded in the study include:

I. The number of roots.
II. Number of canals.
III. Pattern of root canal configuration (Vertucci's classification).

The axial view section of the first mandibular incisors of 1 mm thickness was examined. The images were scrolled down from the cementoenamel junction till the apical foramen to determine the number of canals. The coronal view section of the first mandibular incisors was scrolled from mesial to distal surface to determine the root canal configuration of tooth. The root canal configurations were categorized based on Vertucci's classification as follows:

- Type I: Single canal extends from the pulp chamber to the apex (1).
- Type II: Two separate canals leave the pulp chamber and join short of the apex to form one canal (2-1).
- Type III: One canal leaves the pulp chamber and divides into two in the root; the two then merge to exit as one canal (1-2-1).
- Type IV: Two separate distinct canals extend from the pulp chamber to the apex (2).
- Type V: One canal leaves the pulp chamber and divides short of the apex into separate distinct canals with separate apical foramina (1-2).
- Type VI: Two separate canals leave the pulp chamber, merge in the body of the root, and redivide short of the apex to exit as two distinct canals (2-1-2).
- Type VII: One canal leaves the pulp chamber, divides and then rejoins in the body of the root, and finally redivides into two distinct canals short of the apex (1-2-1-2).
- Type VIII: Three separate distinct canals extend from the pup chamber to the apex (3).

To avoid confusing the definition of root canal complexity, two distinct categories were used, namely non-complex and complex categories. Non-complex category includes only Vertucci Type I canal pattern while the remaining types were categorized as complex. The collected data were tabulated using Microsoft Excel 2013 and analyzed statistically. Chi-square test was performed to assess the relationship between different variables. *P*-value for statistical significance was set at <0.1.

RESULTS

In this study, 40 CBCT scans of patients (18 males and 22 females) were studied. The CBCT images of 147 permanent mandibular incisors were evaluated which include 67 central incisors and 80 lateral incisors.

All of the mandibular incisors examined in this study were single rooted (100%). The number of roots and root canals is summarized in Table 1. 92.5% of the central incisors had one canal, whereas 7.5% was found to have two canals. It was found that 86.3% of lateral incisors had one canal and the prevalence of two canals was seen in 13.7%. There was no statistically significant difference between number of canals and tooth type (P=0.223). According to gender, 6.7% of mandibular central incisors of males and 8.1% of mandibular central incisors of females had two canals. The presence of the second canal of lateral incisors was found in 16.7% of male incisors and 11.4% of female incisors. In total, 12.1% of mandibular incisors of males and 9.9% of mandibular incisors of females had two canals. There was no statistically significant difference between males and females (P=0.664).

Table 2 summarizes the distribution of root canal type based on Vertucci's classification in mandibular central and lateral incisors. Vertucci Type I (55.2%) was the most commonly seen root canal configuration in central incisors, followed by Type III (28.4%), Type V (9%), Type IV (4.5%), and Type II (3%). In case of lateral incisors, the most common was Type I (57.5%), followed by Type III (22.5%), Type IV (8.8%), Type V (6.3%), and Type II (5%).

Figure 1 shows the distribution of root canal morphology of mandibular central incisors in males and females. Both males and females showed almost a similar prevalence of root canal pattern. About half of mandibular central incisors of males (53.3%) had Type I root canal configuration. This is followed by Type III (26.7%), Type V (13.3%), Type II (33%), and Type IV (33%). The prevalence of Type I canal configuration was seen in more than half of female mandibular central incisors (56.8%). The second common configuration

Table 1: Number of root canals in mandibular central and lateral incisors based on gender

Gender	Tooth type	Number of canals		
		One canal (%)	Two canal (%)	Total (%)
Male	Central incisor	28 (93.3)	2 (6.7)	30 (100)
	Lateral incisor	30 (83.3)	6 (16.7)	36 (100)
Female	Central incisor	34 (91.9)	3 (8.1)	37 (100)
	Lateral incisor	39 (88.6)	5 (11.4)	44 (100)
Total	Central incisor	62 (92.5)	5 (7.5)	67 (100)
	Lateral incisor	69 (86.3)	11 (13.7)	80 (100)

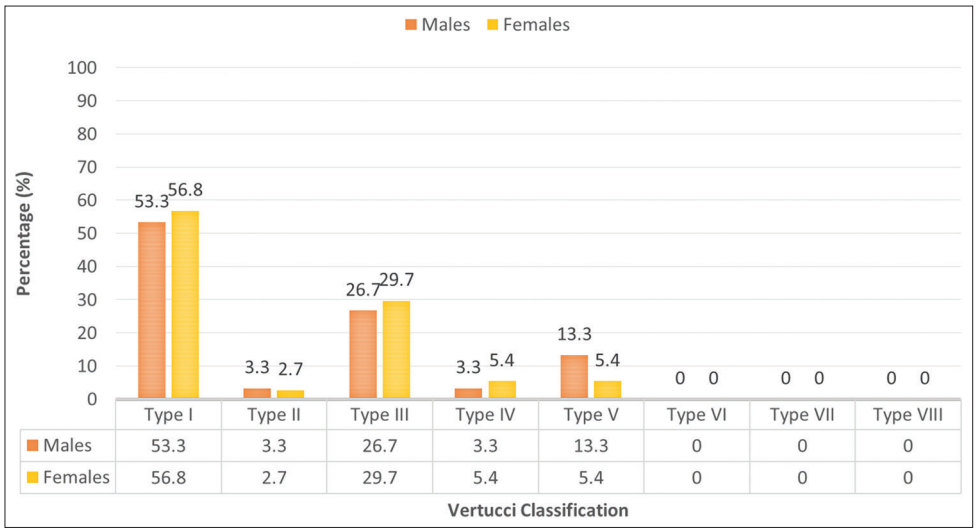

Figure 1: Distribution and percentage of root canal morphology of mandibular central in males and females

Table 2: Distribution and percentage of root canal morphology of mandibular central and lateral incisors

Features	Central incisor	Lateral incisor
Number of tooth	67	80
Root canal configuration (%)		
Type I	37 (55.2%)	46 (57.5%)
Type II	2 (3%)	4 (5%)
Type III	19 (28.4%)	18 (22.5%)
Type IV	3 (4.5%)	7 (8.8%)
Type V	6 (9%)	5 (6.3%)
Type VI	-	-
Type VII	-	-
Type VIII	-	-

was Type III (29.7%), followed by Types IV (5.4%) and V (5.4%) and lastly Type II (2.7%).

Distribution of root canal morphology of mandibular lateral incisors in males and females is shown in Figure 2. The most common type seen in mandibular lateral incisors in males and females was Type I, with 52.8% and 61.4%, respectively. This is followed by Type III seen in mandibular lateral incisors of males and females with 25% and 20.5%, respectively. Type IV, Type V, and Type II were seen in 11.1%, 5.6%, and 5.6% in male mandibular lateral incisors, respectively. 6.8% of female mandibular lateral incisors had Type IV and Type V. The least common in female mandibular lateral incisors was Type II with 4.5%. There was no statistically significant difference between the root canal complexity of males and females (P=0.449). There was also no statistically significant difference between the complexity and the tooth type (P=0.782).

DISCUSSION

Variation in the root canal anatomy is common and considered as a normal phenomenon in different population. A thorough understanding of root canal morphology is necessary for a successful endodontic treatment. It is always difficult for an endodontist to adequately and effectively clean, shape, and obturate when the root canal anatomy deviates from the normal or expected anatomy. With the invention of CBCT, clinicians are now able to observe an area in three different planes and thus acquire a 3D information. The combination of three different planes (coronal, sagittal, and axial) in CBCT eliminates superimposition of anatomic structure and prevents errors during diagnosis. Although CBCT imaging has a number of advantages for root canal anatomy investigation, the use of CBCT should depend on outweighing the benefit with the risks, according to the current recommendations. This is because CBCT results in exposing the patient with ionizing radiation that may pose increased risks to some patients.[22] Therefore, CBCT should be reserved for selected cases when conventional radiographs fail to provide adequate information on complex endodontic cases.[22] The CBCT images that were used in this study were images that were previously taken for different dentomaxillofacial problems.

The main focus of this study was to evaluate the root canal morphology of permanent mandibular incisors. In this study, all the mandibular central and lateral incisors had a single root. This result was in line with the previous studies by Al-Qudah and Awawdeh,[23] Han *et al.*,[24] and Lin *et al.*[25] which reported that all central and lateral incisors had one single root in their study. A previous literature review reported that the prevalence of the second canal in permanent mandibular incisors varies from 11.5% to 45%.[7] Madeira and Hetem[8] reported the lowest incident of the second canal in mandibular incisors with 11.5%, followed by 12.4% in Japan,[5] in Greece with 20%,[26] 25.7% by Vertucci,[10] 29% by A Aminsobhani *et al.*,[27] 36% by Kamtane and Ghodke,[28] and 45% in a study

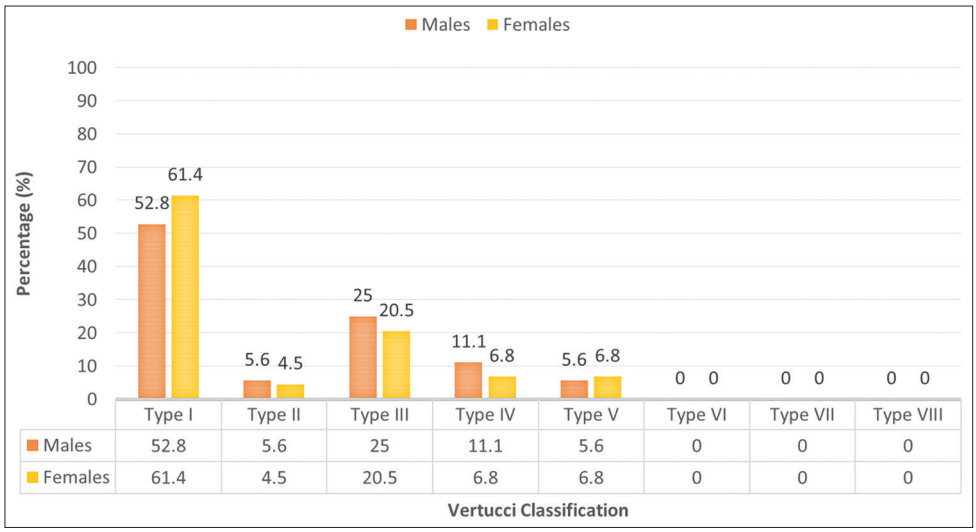

Figure 2: Distribution and percentage of root canal morphology of mandibular lateral incisors in males and females

by Kartal and Yanıkoğlu.[7] In this study, the prevalence of the second canal in mandibular incisors was 10.9%, which was slightly lower than in the study by Madeira in which the prevalence was 11.5%. The differences may be due to different racial origin of population and may also depend on different techniques, sample size, sex, and age.[28,29]

According to gender, the occurrence of the second canal was higher in males as compared to females, which was in consensus with a study conducted by Liu *et al*.[30] but in contrast to the study conducted by Verma *et al*.,[31] which suggested a higher incidence of the second canal in females as compared to males. However, studies reported by Sert and Bayiri[12] and Zhang *et al*[32] had almost the same prevalence of two canals in males and females, the results of this study also suggested that the incidence of the second canal was higher in mandibular lateral incisors as compared to mandibular central incisors. This finding was in agreement with a study conducted by Gaurav *et al*.[31] which also reported a higher prevalence of the second canals in mandibular lateral incisors than compared to central incisors.

In the present investigation, based on Vertucci's classification, most of the mandibular central and lateral incisors (55.2% and 57.2%, respectively) had Type I configuration, which was in agreement with the results of Assadian *et al*. with 43.4%,[21] Zhang *et al*. with 61%,[32] and Scarlatescu *et al*. with 65.6%.[33] This result is contrary to the results reported by Altunsoy *et al*. who reported that Type III configuration was the most prevalent.[34] Type III was the second common type which was found in 28.4% of central incisors and 22.5% of lateral incisors. The least common root canal pattern was Type II which was only seen in 3% of mandibular central incisors and 5% mandibular lateral incisors. This result was in line with a study by Altunsoy *et al*.[34] who reported that Type II pattern was the least common configuration is mandibular incisors.

CONCLUSION

All the permanent mandibular incisors were single rooted (100%). Incidence of the second canal was found to be 10.9% in this study. Higher incidence of the second canal was found in males than in females and higher in mandibular lateral incisors than mandibular central incisors. Proper attention should be given to the detection of additional canal during root canal therapy. This finding gives important information to the endodontist during root canal treatment. Vertucci Type I was the most common configuration found in mandibular central and lateral incisors. The least common type of canal configuration for both mandibular central and lateral incisors was Vertucci Type II. CBCT allows better identification of anatomic features and variations of root canal morphology.

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