ABSTRACT

Aim: The current study evaluated the root and root canal anatomy of permanent mandibular first molar teeth of an Indian population.

Materials and Methods: A total of 486 freshly extracted human permanent noncarious mandibular first molar teeth were acquired from a pool of extracted teeth of patients of indigenous Indian population. The root canal morphology (including the root numbers) and the anatomy of the root canal system (including the number and type of canals based on Vertucci's classification) were evaluated using cone-beam computed tomography.

Results: Predominantly, the studied specimens exhibited two roots with a prevalence of 86.84%, followed by three roots with a prevalence of 13.16%. The third root was exclusively found on the lingual aspect of distal roots. The two- and three-rooted permanent mandibular first molars exhibited two, three, and four in 1.64%, 55.34%, and 43.02% of teeth, respectively. In the mesial roots, the most common pattern was Type IV (54.94%), followed by Type II (42.38%) and Type I (2.68%). In the distal roots, the most common pattern was Type I (53.29%), followed by Type II (31.06%), Type IV (9.47%), Type III (4.74%), and Type V (1.44%). The three-rooted permanent mandibular first molars exhibited Type I canal configuration in 100% of the specimens in the extra root.

Conclusion: The most common morphology of permanent mandibular first molars of an Indian population was the two-rooted teeth with three canals (two mesial and one distal). The root canal configurations most commonly seen were Type IV in mesial roots and Type I in the distal roots. In teeth with three roots, the extra root it was located linguually and exhibited Type I root canal configuration.

Keywords: Cone-beam computed tomography, Indian population, mandibular first molars, root canal anatomy, Vertucci’s classification

INTRODUCTION

The main goal of endodontic therapy is to prevent or heal apical periodontitis by cleaning, shaping, and disinfection that would allow for three-dimensional obturation of the root canal system.[1] However, the complexity of the root canal anatomy presents clinical challenges and difficulties that often jeopardize the primary goal of such therapy. Knowledge of both normal and abnormal anatomy dictates the parameters of root canal therapy, directly affecting the success.[2,3]

Mandibular first molar is the most frequently endodontically treated tooth and may present a wide variety of roots and root canal configurations. The relative simplicity and uniformity of the external surface of its roots often mask the internal complexity. The mandibular first molars may present variations such as three roots, mandibular molar with four roots, the C-shaped root and canal configuration, fused roots, one conical root, and two separate roots. It is important to study and know the anatomy of mandibular first molars because of their diverse anatomical nature and being most frequently treated endodontically.[4-7]
Several methods commonly used for analyzing the root canal morphology are canal staining and tooth clearing, conventional radiographs, and digital and contrast medium-enhanced radiographic techniques to microcomputed tomographic techniques.\(^8\) Computed tomography (CT) imaging is a nondestructive technique and hence widely used for such studies.

It has been reported that root canal anatomy varies according to the race.\(^{[8]}\) Starting from the Caucasians to the Africans and Asians, root canal anatomy patterns follow a racial characteristic, making endodontic treatment more challenging for the practitioners.\(^{[12]}\) A literature search reveals that studies done on the root canal morphology of permanent mandibular first molar teeth from an Indian population are scarce.\(^{[13‑17]}\) Hence, the current study was carried out to analyze the root canal anatomy of permanent mandibular first molar teeth of an Indian population. Due to limited availability of micro-CT, the next best imaging tool (cone‑beam CT [CBCT]) was used in the current study for evaluation.

**MATERIALS AND METHODS**

**Specimen collection, sample size, and storage**

Keeping the confidence level at 95%, margin of error at 5%, and sample size at 385 or more is acceptable for the current study type. For the current study, 486 freshly extracted human permanent noncarious mandibular first molar teeth were acquired from a pool of extracted teeth of patients of indigenous Indian origin from dental schools in the state of Maharashtra. The collection of every tooth was accompanied by a case record stating and confirming the ethnicity of the patients. All the acquired specimens possessed intact root and fully developed apices, without restorations. As the samples were acquired of a pool, the reason of extraction was not known. Furthermore, the age, gender, and systemic condition of the patient were unknown. The storage and handling of the teeth were performed as per the Occupational Safety and Health Administration guidelines and regulations.

**Scanning of the specimens**

The specimens were stored in formalin, and any attached soft tissue and calculus were removed with an ultrasonic scaler. The specimens were then rinsed under running water and left to dry. The teeth were stored in 0.9% saline solution at room temperature until used. To integrate sample position, the specimens were mounted on molds made of silicone impression material (Zeta Plus, Zhermack, Badia Polesine Rovigno, Italy) in teeth groups (ten each) for scanning.

**Cone-beam computed tomography acquisition and evaluation**

The mounted specimens were scanned with a CBCT scanner machine with image capture parameters set at 60 kV, 2 mA for 32.4 s, and dose of radiation at 100 mGy/cm\(^2\). The voxel size was 200 µm × 200 µm × 200 µm. The CBCT images were analyzed using CS 3D Kodak imaging software. The contrast and brightness of the images were adjusted using the image-processing tool in the software to ensure visualization. All CBCT exposures were performed by a licensed expert oral radiologist. The specimens were thoroughly examined in the three planes (axial, sagittal, and coronal) at 1-mm intervals by continuously moving the toolbar from the floor of the pulp chamber to the apex. The analysis was done for number of roots, number of root canals, and root canal configuration of permanent mandibular first molar according to Vertucci’s classification.\(^{[18]}\)

**RESULTS**

**Number of roots**

Of the 486 extracted permanent mandibular first molars evaluated, the most common morphology exhibited was two roots with a prevalence of 86.84% (422 of 486), followed by three roots which were exhibited in 13.16% of the specimens (64 of 486) [Table 1]. The third root was exclusively found on the lingual aspect of distal roots.

**Number of root canals and canal configuration**

Of the 486 two- and three-rooted permanent mandibular first molars evaluated, the number of canals prevailed were two, three, and four in 1.64% (8 of 486), 55.34% (269 of 486), and 43.02% (209 of 486) teeth, respectively [Table 1]. The canal configuration was categorized according to Vertucci’s classification for the permanent mandibular first molars. In the mesial roots of 486 first permanent molars, the most common pattern was Type IV (54.94%) (267 of 486), followed by Type II (42.38%) (206 of 486) and Type I (2.68%) (13 of 486). In the distal roots, the most common pattern was

| Number of roots of 486 permanent mandibular first molars | n (%) |
|---------------------------------------------------------|-------|
| One                                                     | -     |
| Two rooted                                              | 422 (86.84) |
| Three rooted                                            | 64 (13.16) |

| Number of root canals of 486 permanent mandibular first molars | n (%) |
|----------------------------------------------------------------|-------|
| One                                                            | -     |
| Two                                                            | 8 (1.64) |
| Three                                                          | 269 (55.34) |
| Four                                                           | 209 (43.02) |

| Table 1: Prevalence of the number of roots and root canals in 486 permanent mandibular first molars | n (%) |
|------------------------------------------------------------------------------------------------|-------|
| Number of roots of 486 permanent mandibular first molars | n (%) |
| One | - |
| Two rooted | 422 (86.84) |
| Three rooted | 64 (13.16) |

| Number of root canals of 486 permanent mandibular first molars | n (%) |
|----------------------------------------------------------------|-------|
| One | - |
| Two | 8 (1.64) |
| Three | 269 (55.34) |
| Four | 209 (43.02) |
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Type I (53.29%) (259 of 486), followed by Type II (31.06%) (151 of 486), Type IV (9.47%) (46 of 486), Type III (4.74%) (23 of 486), and Type V (1.44%) (7 of 486). In three-rooted permanent mandibular first molars, the extra root was seen on the lingual aspect and exhibited Type I canal configuration in 100% (64 of 64) of the specimens [Table 2]. The representative CBCT sections of the variations exhibited by the specimens tested are shown in Figure 1.

DISCUSSION

The available literature related to root anatomy and root canal configuration of the permanent mandibular first molar varies significantly. Variations in root canal anatomy are considered as a normal phenomenon.[19]

Several studies on root canal anatomy were performed using demineralizing and injecting a dye technique. This technique is considered the gold standard, however this technique had the disadvantage of producing irreversible changes to the studied sample. With technological development, CBCT systems are used widely for dental practice. Currently, CBCT systems are mainly of two categories: limited (dental or regional) and full (orthodontic or facial) CBCT. Limited CBCT systems offer higher resolution with a voxel size of 0.1–0.2 mm and hence are better suited for endodontic applications.[20] Hence, in the current study, the resolution we used was 2 line pairs per millimeter, with the detailed images having a voxel size of 0.125 mm/side, isotropic in all the three planes.

The root canal systems vary according to race, and reports on anatomical variations in root canals of permanent teeth are based largely on studies mainly on a population of Caucasoid origin, which is not applicable entirely to the teeth of non-Caucasoid origin. Literature also reveals that very few studies have been performed on the root canal morphology of teeth in an Indian population.[7,13,16,17,21] In our study, 86.84% (422 of 486) and 13.16% of the specimens (64 of 486) exhibited two and three roots, respectively. Furthermore, in these specimens, three canals had the most common canal configuration with a prevalence of 53.34% (269 of 486),

Table 2: Root canal configuration for mesial roots of 486 permanent mandibular first molars according to Vertucci’s classification

| Root canal anatomy | Mesial (%) | Distal (%) | Extra root (%) |
|--------------------|------------|------------|----------------|
| Type I (1-1)       | 13 (2.68)  | 259 (53.29)| 64 (100)       |
| Type II (2-1)      | 206 (42.38)| 151 (31.06)|               |
| Type III (1-2-1)   | -          | 23 (4.74)  |                |
| Type IV (2-2)      | 267 (54.94)| 46 (9.47)  |                |
| Type V (1-2)       | -          | 7 (1.44)   |                |
| Total              | 486 (100)  | 64 (100)   |                |

Figure 1: Representative cone-beam computed tomography sections of variations seen in permanent mandibular first molar teeth of the studied population according to Vertucci’s classification
followed by four canals in 43.02% (209 of 486) and two canals in 1.64% (8 of 486) of specimens.

In this study, 43.02% of the studied mandibular first molars had four canals. These results are lower to those found in Taiwanese, Jordanian, Saudi Arabian, and Western Chinese populations, but higher than that reported by Skidmore and Bjorndal, Sperber and Moreau, Gulabivala et al., and Reuben et al. Owing to the high percentage of two distal canals, classical triangular access preparation during root canal treatment should be extended toward the distolingual direction in a rectangular form to improve canal identification.

In the mesial root, Type IV root canal configuration was most common (54.94%), followed by Type II (42.38%) and Type I (2.68%). These findings are congruent with the studies reported in literature for different populations except Zaatar et al. and Al-Nazhan that reported Type II to be more common than Type IV. There are published reports indicating the presence of Type VIII configuration in the mesial root, with the incidence of 0.2%–5%. None of the mesial roots of the samples in the present study exhibited three canals. This finding is in accordance with the results of Chourasia et al.

In the distal root, Type I root canal configuration was most common (53.29%), followed by Type II (31.06%) and Type IV (9.47%). The prevalence of Type II and Type IV root canal configurations has been reported to be higher in Saudi Arabian, Turkish, and Sudanese populations compared to the current study. However, these findings are higher compared to the prevalence of Type II and Type IV by Vertucci, Skidmore and Bjorndal, Gulabivala et al., and Pineda and Kuttler. The external morphology of the distal root in the studied teeth presents a round shape compared to the mesial root, hence it is less likely to accommodate two separate canals. However, Type III and Type V configurations in distal root need extra efforts to negotiate and prepare. In the current study, Type III root canal configuration was seen in 4.74% and Type V in 1.44% of the studied samples. One of the two canals, the one most continuous with the large main passage, is usually amenable to adequate enlarging and filling procedure, and the preparation and filling of the other canal is often extremely difficult.

Mandibular first permanent molars usually have two roots located mesially and distally, but in populations with Mongoloid traits, an additional root located distolingually is considered to be a normal morphologic variant and can be identified as an Asian trait. In the current in-vitro study, we detected that 13.16% of the specimens had an extra distolingual root. This percentage was higher than that of the previously reported studies on Indian population, which exhibited 4.55%, 4.67%, and 5.3%, but lower than the studies on Korean (24.5%), Taiwanese (25.3%), and Baffin Eskimos (21.7%) populations.

CONCLUSION

The most common morphology of permanent mandibular first molars of an Indian population was the two-rooted teeth with three canals (two mesial and one distal). The root canal configurations most commonly seen were Type IV (54.94%) in mesial roots and Type I (53.29%) in the distal roots. Extra root located lingually was found in 13.16% of the samples that had Type I root canal configuration.

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Conflicts of interest

There are no conflicts of interest.

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