

Diversity of Root Canal Morphology in Mandibular First Premolar

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ABSTRACT

Background

Mandibular first premolars have been reported to have complex anatomical aberration making them one of the most difficult teeth to manage endodontically.

Objective

To determine the root canal anatomy of mandibular first premolar in a Nepalese population using decalcification and clearing technique.

Method

One hundred and fifty extracted mandibular first premolars were collected from Nepalese population. Access cavities were prepared on the occlusal surface of each tooth. Teeth were decalcified by immersing in 5% nitric acid, dehydrated in ethyl alcohol and made transparent using methyl salicylate. Methylene blue dye was injected through access cavity and canal anatomy were observed and classified according to Vertucci's classification.

Result

The average length of mandibular first premolar was 20.43mm. One rooted teeth were 96% and two rooted were 4%. Vertucci's type I canal configuration was most prevalent (72%) followed by type V (18.6%), type III (3.3%), type II (2.6%) and type IV (2.6%). An unusual configuration was found in one tooth. Isthmus and apical deltas were found in 8.6% and 14.6% of the cases respectively.

Conclusion

Type I canal configuration were the most frequently observed root canal configuration in mandibular first premolar followed by type V configuration. Such variation in root canal anatomy should be taken into consideration to ensure successful endodontic therapy of these teeth.

KEY WORDS

Decalcification and clearing, Mandibular first premolar, Nepalese, Root canal morphology

INTRODUCTION

The success of a root canal therapy depends upon the clinician's knowledge and understandability of the root canal morphology. This understanding is essential for localization of root canals, proper cleaning, shaping and three dimensional obturation of the canal space.¹ The internal anatomy of the teeth shows wide variation and can be extremely complex. Such variations in the morphology of root canal are shown to be caused by various factors including ethnicity, age, gender and genetics.^{2,3}

A number of methods have been used, both in-vitro and in-vivo, to study the canal morphology such as; teeth sectioning, radiography, teeth decalcification and clearing and computed tomography.⁴ Among these, teeth decalcification followed by clearing method is the simplest, inexpensive and provides the most detailed information.⁴ Amid the teeth most frequently requiring a root canal treatment, is the mandibular permanent first premolar. Among others, it is one of the most difficult teeth to be treated endodontically due to a wide variety of root canal configuration that can be extremely complex.⁵ Thus, several studies, using different techniques, have investigated its root canal morphology in various population including Jordanian, Turkish, Chinese, Iranian, Japanese, Sri Lankan, Americans and Egyptian.^{2,3,6-13} However, there are no published reports regarding the root canal anatomy of the tooth in Nepalese population till date.

Hence, this study was undertaken to investigate the root canal anatomy of mandibular first premolar in selected Nepalese population by using teeth decalcification and clearing technique.

METHODS

A descriptive study on root canal morphology of mandibular first premolar was performed at Dhulikhel hospital. A total number of 150 mandibular first premolars were collected using purposive sampling method, from the dental department, which were extracted due to orthodontic reasons. Written consents were taken from all the patients to use their extracted teeth for the research purpose.

The research was conducted with approval of Kathmandu University School of Medical Sciences Institutional Review Committee (KUSMS/IRC).

The age and gender of each individual patient was not recorded during extraction. Only teeth which were sound and intact were included in this study. Teeth with caries, cracks, fractures, restorations or incomplete root formation were excluded from the study.

Teeth after extraction were immediately washed under running tap water and stored in 10% formaldehyde solution (Fisher Scientific India Pvt.). The residual soft tissues, bone fragments, and calculus was cleansed and removed by

ultrasonic scalars (Woodpecker). The length of the tooth was measured from the tip of the buccal cusp to the apex of the root using digital caliper (Baker). In case of curved root, tangents were drawn to the curved portions of the tooth and the length measured by connecting the points of tangency. Initially all the extracted teeth were visualized under optimum light to categorize the number of roots. Diamond round abrasives (no.2, Mani) was used to prepare the access cavity. After the access cavity preparation the specimens were placed in sodium hypochlorite solution (5.25%, Prime Dental Products Pvt. Ltd, Mumbai, India) for 24 hours to dissolve the organic remains and residues of the pulp, after which they were placed under running tap water for two hours. Decalcification of the teeth were done using 5% nitric acid (Prime Dental Products Pvt. Ltd, Mumbai, India), which was changed consecutively for three days. Periodic radiographs of random samples were taken to check the end point of decalcification. After sufficient decalcification, the specimens were again washed under running tap water for four hours to remove traces of nitric acid. Ascending concentrations of ethanol (Bengal chemicals and pharmaceuticals Ltd., Calcutta, India) was used to dehydrate the specimen starting with 80% for twelve hours, followed by 90% and 95% each for an hour. The dehydrated specimens were then placed in clearing agent methyl salicylate (Rankem Fine Chemicals Ltd., New Delhi, India) for three days to render them transparent. Methylene blue dye (Emichem Pvt. Ltd., Kolkata, India) was infused into the pulp chamber with the help of a 27-gauge needle attached to disposable syringe. As the pulp canals were too narrow, negative pressure was created by placing tip of the high vacuum suction at the apex of the tooth for easy flow of the dye. All the teeth were evaluated using magnifying glasses.

The root canals were categorized using Vertucci's classification as follows:

- (1) Type I: A single canal extends from the pulp chamber to the apex.
- (2) Type II: Two separate canals leave the pulp chamber and join short of the apex to form one canal.
- (3) Type III: One canal leaves the pulp chamber, divides into two within the root, and then merges to exit as one canal.
- (4) Type IV: Two separate and distinct canals extend from the pulp chamber to the apex.
- (5) Type V: One canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina.
- (6) Type VI: Two separate canals leave the pulp chamber, merge in the body of the root, and re-divide short of the apex to exit as two distinct canals.
- (7) Type VII: One canal leaves the pulp chamber, divides and then rejoins within the body of the root, and finally re-divides into two distinct canals short of the apex.

(8) Type VIII. Three separate and distinct canals extend from the pulp chamber to the apex.

All the specimens were photographed to provide the permanent image of their root canal anatomy. The recorded data were analyzed for descriptive statistics using SPSS program version 16 (SPSS Inc., Chicago, USA).

RESULTS

A total of 150 mandibular first premolar teeth were studied and classified based on root number, in which 96% had one root and 4% had two roots. The tooth length recorded for the teeth ranged from 17.43 to 24.29 mm with an average length of 20.43 mm. A 95% confidence interval of the tooth length based on mean and standard deviation of data was (20.20-20.66 mm).

As regards to number of canals for mandibular first premolar, 145 teeth had one canal orifice per root which also includes the two-rooted teeth that has one canal orifice in each root. Whereas, eight of the one-rooted teeth (5.3%) had two canal orifices. As regard to apical foramina, single apical foramina were found in 118 teeth (78.6%) and 32 teeth (21.3%) had two or more apical foramina.

In the present study, variable root canal configurations were found in mandibular first premolar. Vertucci's classification Type I configuration was most prevalent (72%) followed by type V (18.6%), type III (3.3%), type II(2.6%) and type IV(2.6%) (Table1). Figure 1 shows different types of root canal configuration of mandibular first premolar observed in the present study. Type VI, VII and VIII canals were not found in our study. One tooth was found to have a morphology not explained in Vertucci's classification (fig. 1). Isthmi and apical deltas were found in 8.6% (13 teeth) and 14.6% (22 teeth) of the cases respectively (fig. 2).

Table 1. Frequency of root canal configuration of mandibular first premolar

| Canal type | Frequency | Percentage (%) |
|------------|-----------|----------------|
| Type I | 108 | 72 |
| Type II | 4 | 2.6 |
| Type III | 5 | 3.3 |
| Type IV | 4 | 2.6 |
| Type V | 28 | 18.6 |
| Type VI | 0 | 0 |
| Type VII | 0 | 0 |
| Type VIII | 0 | 0 |
| Unusual | 1 | 0.66 |

DISCUSSION

Extracted mandibular first premolars were collected from patients undergoing orthodontic treatment from Dhulikhel

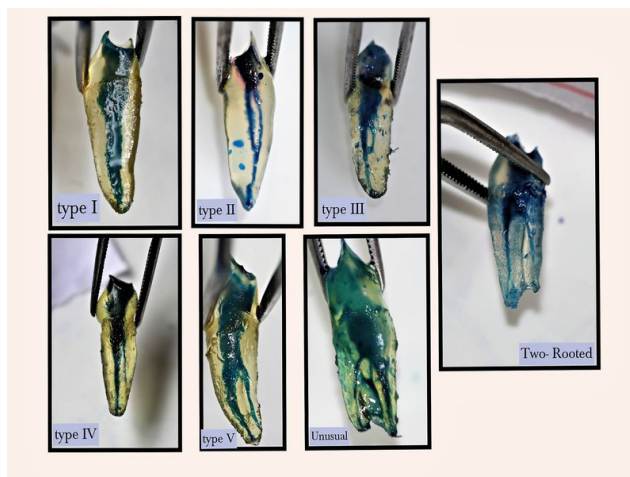


Figure 1. Roots of mandibular first premolar showing Vertucci's canal configuration Type I, Type II, Type III, Type IV, Type V unusual configuration two rooted premolar

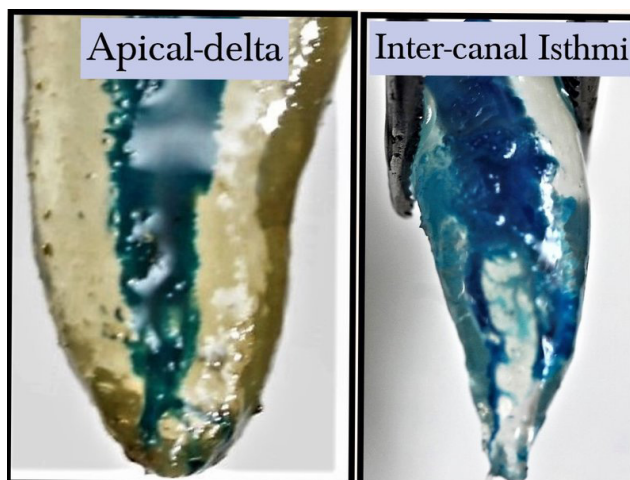


Figure 2. Apical delta and Inter-canal isthmi

hospital in Kavre district of Nepal. The patient from various regions such as Kavrepalanchowk, Kathmandu, Sindhupalchowk, Dolakha, Pachthar etc. visit the hospital. However the current study may not include all the ethnic group of Nepal. In addition age and gender of the patient were not recorded for the current study.

Among the various methods of studying root canal morphology, clearing technique is used for this study because it provides a three dimensional view of the root canal along with being simple and inexpensive. Furthermore, the original form and relation of the canal is maintained since negotiation of the canal with instruments is not required.

In this study, the average length of the mandibular first premolar was found to be 20.43 mm which is slightly shorter than the other studies (Table 2). This may be due to the fact that the height of the Nepalese population is shorter in comparison to other countries and studies have shown positive association between stature and tooth length.^{16,17}

The most commonly observed root morphology was mandibular first premolar with single root (96%) and only

Table 2. Length of the tooth of mandibular first premolar for different studies compared to current study

| Country | Minimum (mm) | Maximum (mm) | Average (mm) |
|------------------------|--------------|--------------|---------------|
| Egypt ⁹ | 17.80 | 26.60 | 22.48 |
| Indian ¹⁴ | 17 | 26 | 21.2 |
| Jordanian ² | 18 | 27 | 22.6 |
| Turkish ¹⁵ | - | - | 21.224 ±1.743 |
| Nepal (present study) | 17.43 | 24.29 | 20.43 |

4% had two roots. The result of this study is similar to the other studies conducted in India and Jordan (97%) and lower than that in Turkey, China and Korea (> 99%).^{2,6,14,15,19} The list of root anatomy in various studies is enumerated in table 3. Three rooted mandibular first premolar was not present in our study which is comparable to other studies.^{2,6,9,14,15,18,19} In a literature review of the year 2007, it was reported that globally, the percentage of three and four rooted mandibular first premolar is only 0.2% and 0.1% respectively.²⁰ However, in recent study by Chourasia et al. the percentage of mandibular first premolar with two roots was reported to be 18% and the percentage of mandibular premolar with more than two roots was reported to be 2%. Both these values are highest among the studies.²¹

Vertucci's canal classification was used in this study because it is considered as a base line point for root canal anatomy comparison and is commonly used by authors in literature and text books.²⁻⁵ In this study 72% of the tooth had Vertucci's Type I canal configuration. This is comparable to other study results where the incidence is 72% (India), and 70.6% (Iran).^{11,18} The highest frequency of single canal (type I) was reported as 90.8% in Iranian population and lowest was 50% in an Indian population.^{13,26} Table 4 compares the result of present study with other studies of canal configuration of mandibular first premolar.

In the present study, type II canal was seen in 2.6%, type III in 3.3%, type IV in 2.6% and type V in 18.6% of the sample. The highest percentage of type II canal was reported by Sert and Bayirli in Turkish population where the value was 18.5%.³ They also reported the highest percentage of type III canal configuration (10.5%). Park et al. in his study in an Indian population reported the highest percentage of type IV canal configuration of 25%.¹³ Interestingly, our study observed higher percentage of type V canal configuration and this is similar to the studies done in India by Jain and Bahuguna where the percentage of type V canal configuration was reported to be 17.4%.¹⁴ The highest percentage of type V canal configuration was reported in Sri Lankan population where the value was 28.4%.⁸ These variations in canal configuration may be attributed to the racial or genetic factors. Furthermore, the method of the study and sample size too might have led to such differences.

Table 3. Percentage of number of roots in the mandibular first premolar in different geographic distribution

| Geographic distribution | Materials and methods | No. of teeth in the study | Root anatomy | | |
|----------------------------|-----------------------|---------------------------|--------------|---------|----------|
| | | | 1 root | 2 roots | >2 roots |
| Turkey ¹⁵ | In vitro: clearing | 100 | 100% | 0% | 0% |
| Iran ¹⁸ | In vitro: clearing | 163 | 98% | 2% | 0% |
| Jordan ² | In vitro: clearing | 500 | 97% | 3% | 0% |
| India ¹⁴ | In vitro: clearing | 138 | 97.1% | 2.89% | 0% |
| Egypt ⁹ | In vitro: clearing | 250 | 96.8% | 3.2% | 0% |
| Korea ¹⁹ | In vivo: CBCT | 797 | 99.9% | 0.1% | 0% |
| China ⁶ | In vitro: Micro-CT | 178 | 99.4% | 0.6% | 0% |
| Saudi Arabia ²⁰ | In vitro: clearing | 100 | 80% | 18% | 2% |

Micro-CT: Micro computed tomography, CBCT: Cone beam computed tomography

Root canal treatment of type I and type IV canal system are relatively simple due to the fact that each of the canals in these configurations is separate and distinct between orifice and apex. On the other hand, type II, type III, type V, type VI, Type VII and type VIII configuration are difficult to treat due to their complexity. The clinician should be aware of such complexity during the treatment to obtain most desirable result with long term prognosis.

There was an unusual configuration observed in one of the sample tooth that did not fall under any of the Vertucci's classification. In literature, uncommon configurations have been reported to vary from 0.4-3.7%.^{2,8,9,11} Though such complex anatomies are not usual finding, such configuration can make routine root canal treatment challenging and compromising, often resulting in a failure of the treatment. Therefore, clinicians should be conscious of such additional canal configuration during the root canal treatment of mandibular first premolar.

An isthmus, also known as intra-canal communication or transverse anastomoses, is a narrow ribbon shaped communication between two root canals that contain pulp or pulpally derived tissues.¹ Since it contains pulp or pulpally derived tissue, it can act as a bacterial reservoir. Proper cleaning of this area during root canal treatment is difficult and requires special techniques. In this study isthmus were observed in 8.6% of the sample which is lower than that reported by Alhadainy (28%), Vertucci (32%) and Chourasia (16%) but similar with findings of Sert and Bayirli.^{1,3,9,21} Regarding the apical deltas, 14.6% of mandibular first premolar was found to have it, which is similar to data of study of Egypt (11.2%), but lower than reported by Awawdeh and Al-Qudah (29.2%). The apical delta is difficult to debride and may predispose to endodontic failure.

Table 4. Canal configuration in the mandibular first premolar according to percentage of Vertucci's classification

| Country | Method | Sample | I | II | III | IV | V | VI | VII | VIII | Unusual |
|----------------------------|-----------------------|--------|------|------|------|------|------|-----|-----|------|---------|
| USA ²² | In vitro: sectioning | 106 | 76% | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 0 |
| India ¹² | In vitro: SCT | 100 | 80 | 9 | 3 | 2 | 4 | 0 | 0 | 0 | 2 |
| India ¹¹ | In vitro: clearing | 100 | 72 | 6 | 3 | 10 | 8 | 0 | 0 | 0 | 0 |
| India ¹³ | In vitro: clearing | 40 | 50 | 5 | 5 | 25 | 12.5 | 2.5 | 0 | 0 | 0 |
| India ¹⁴ | In vitro: clearing | 138 | 64.7 | 8 | 3.7 | 3.9 | 17.4 | 0.7 | 0 | 0 | 0 |
| India ²³ | In vitro : sectioning | 112 | 80 | 9 | 3 | 2 | 4 | 0 | 0 | 0 | 0 |
| China ²⁴ | In vitro: Micro-CT | 115 | 65.2 | 0 | 2.6 | 0 | 22.6 | 0 | 0.9 | 0 | 0 |
| Jordan ² | In vitro: clearing | 500 | 58.2 | 4.8 | 1.4 | 14.4 | 16.8 | 0.8 | 1 | 0 | 2.6 |
| Iran ²⁵ | In vitro: sectioning | 217 | 90 | 1.8 | 3.2 | 0.9 | 4.1 | 0 | 0 | 0 | 0 |
| Iran ¹⁸ | In vitro: clearing | 163 | 70.6 | 1.9 | 3.8 | 3.8 | 16.9 | 1.2 | 0.6 | 0 | 1.2 |
| Iran ²⁶ | CBCT | 577 | 90.8 | 1.9 | 3.4 | 1.6 | 2.3 | 0 | 0 | 0 | 0 |
| Turkey ³ | In vitro: clearing | 200 | 60.6 | 18.5 | 10.5 | 7 | 2.5 | 0 | 0 | 1 | 0 |
| Sri Lanka ⁸ | In vitro: clearing | 81 | 64.2 | 0 | 2.5 | 1.2 | 28.4 | 0 | 0 | 0 | 3.7 |
| Japan ⁸ | In vitro: clearing | 92 | 82.6 | 1.1 | 1.1 | 0 | 15.2 | 0 | 0 | 0 | 0 |
| Egypt ⁹ | In vitro: clearing | 250 | 61.2 | 5.6 | 2.8 | 13.2 | 16.4 | 0 | 0 | 0 | 0.4 |
| Saudi Arabia ²⁰ | In vitro: clearing | 100 | 69 | 0 | 8 | 4 | 16 | 0 | 0 | 0 | 2 |
| Nepal current study | In vitro: clearing | 150 | 72 | 2.6 | 3.3 | 2.6 | 18.6 | 0 | 0 | 0 | 0.66 |

SCT: Spiral computed tomography, Micro-CT: Micro computed tomography, CBCT: Cone beam computed tomography

CONCLUSION

Within the limitation of this study, it can be concluded that in a selected Nepalese population a higher incidence of type I configuration (72%) followed by type V configuration (18.6%) is observed. Since the success of endodontic therapy is influenced by complex and variable root canal anatomy, clinicians must be aware of such variations in mandibular first premolar during treatment to ensure proper treatment and better prognosis. Further studies are recommended with higher sample size with samples

segregated according to age, gender and caste to apply the result to specific group of Nepalese population.

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