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# Root canal morphology of mandibular first premolars in an Indian population: a laboratory study

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## Abstract

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**Aim** To determine the root canal morphology of mandibular first premolar teeth in an Indian population using a decalcification and clearing technique.

**Methodology** One hundred extracted adult mandibular first premolar teeth were studied following decalcification and clearing. The shape of the canal orifice, root canal pattern and length of the teeth were determined.

**Results** The mandibular first premolars were identified to have a round orifice (38%), oval orifice (44%), flattened orifice (17%) and C-shaped orifice (1%). The canal patterns were classified as Type I (72%), Type II (6%), Type III (3%), Type IV (10%) and Type V (8%) according to Vertucci's classification. C-shaped canals were identified in one tooth (1%). The average length of the teeth was 21.6 mm. Fourteen per cent of the teeth had mesial invaginations of the root.

**Conclusions** Type I canal patterns were the most frequently occurring in mandibular first premolars amongst the Indian population. 85.7% of the teeth with mesial invagination of the root had either two canals or division of canals.

**Keywords:** canal orifice, decalcification and clearing, length of the teeth, mandibular first premolar, mesial invagination.

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## Introduction

Understanding root canal morphology and its complexity is essential during endodontic therapy. Variation in the morphology of root canal systems occurs commonly and can be considered as normal (Cohen & Hargreaves 2006). Amongst the human permanent dentition, Brescia (1961) reported that the mandibular first premolar teeth had the most variable canal pattern. A study at the University of Washington assessed the failure rate of nonsurgical root canal therapy in all teeth. The mandibular first premolar had the highest failure rate and this may be attributed to the frequent variations in the root canal morphology and the inability to access extra canals (Ingle & Taintor 1985).

It is a well known fact that the root canal system varies with race (Trope *et al.* 1986, Ahmed *et al.* 2007), and gender (Sert & Bayirli 2004). Earlier studies on root canal systems were completed most commonly on teeth from Caucasian populations. Similar studies amongst the Indian population are rare (Reuben *et al.* 2008). The aim of this study was to determine the root canal morphology of mandibular first premolar teeth in an Indian population using a decalcification and clearing method.

## Materials and methods

One hundred extracted human adult mandibular first premolar teeth from an Indian population were collected. The age and gender of the patients were not known. Teeth with deep caries, metallic restorations,

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fracture, incompletely formed roots and those which were root filled were not included. Handling of the teeth was carried out according to Occupational Safety and Health Administration guidelines and regulations.

The teeth were preserved in 10% formalin (Western India Chemical, Udupi District, Karnataka, India). All attached soft tissue and calculus were removed using an ultrasonic scaler. The length of the teeth was measured using vernier caliper from the tip of the crown to the apex of the root. In case of a curved root, tangents were drawn to the curved portions of the tooth. The length was then measured by connecting the points of tangency.

The teeth were decalcified and rendered transparent using the technique reported by Robertson *et al.* (1980) to obtain a 3D view of the root canal system. Access cavities were prepared using a round bur (No. 2 round bur) and the shape of the canal orifice was observed with the naked eye. Following this, the teeth were placed in 3% sodium hypochlorite (Merck Limited, Mumbai, Maharashtra, India) for 48 h. The teeth were agitated manually to ensure complete removal of the pulp tissue. The teeth were then washed in running water for 2 h and then transferred to 5% nitric acid (Merck Limited) for decalcification. The teeth were placed in acid for 72 h, with the acid being changed every 24 h and stirred once every 8 h. The end-point of decalcification was determined by taking a radiograph of three sample teeth, which showed uniform decalcification of the teeth. The teeth were then washed in running water and dehydrated using ascending grades (70%, 80%, 90% and 100%) of isopropyl alcohol (Leonid Chemicals Pvt Ltd, Bangalore, Karnataka, India) for 2 days. Finally, they were rendered transparent by immersion in methyl salicylate (Sipali Chemicals, Chennai, Tamilnadu, India) and an oil-based dye was injected into the access cavity. The anatomy of the root canal was observed and classified based on the Vertucci's classification (Vertucci 1984). The supplementary canals present at the apical third were grouped as accessory canals and those in the middle third as lateral canals. Fourteen teeth in the study had invagination of the root surface on its mesial aspect. These teeth were analysed to check for any specific variations of the canal anatomy that could be associated with this feature.

## Results

### Canal orifice

The shape of the canal orifices were round in 38% of the teeth, oval in 44% of the teeth, flattened ribbon shaped in 17% of the teeth and C-shaped in 1% of the teeth. Two canal orifices were seen in 2% of the teeth.

### Canal type

Amongst the 100 mandibular first premolar teeth, 72% had a Type I canal pattern (Fig. 1a) with Type II, Type III, Type IV and Type V canals being identified in 6%, 3%, 10% and 8% of the teeth respectively (Fig. 1b–e, Table 1). One tooth had Category III c-shaped canal (1%) (Melton *et al.* 1991). Lateral canals were observed in 4% of the samples and another 4% of the samples had accessory canals. Intercanal communication was identified in only one tooth sample (1%).

### Position of the apical foramen

Amongst the teeth with a single canal at the apex ($n$ = 82), the apical foramen was located at the apex of the root in 83% teeth, 0.5 mm from the apex in 6%

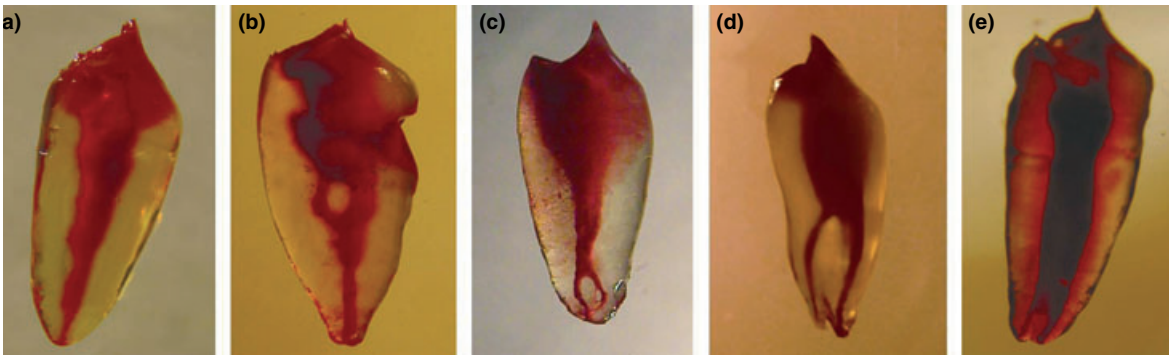


**Figure 1** Various canal patterns in mandibular first premolars. (a) Type I, (b) Type II, (c) Type III, (d) Type IV, (e) Type V.

**Table 1** Pattern and percentage of canals

| Type of canal | Canal pattern | % of Occurrence ($n$ = 100) |
|---|---|---|
| Type I[a] | 1 | 72 |
| Type II[a] | 2-1 | 6 |
| Type III[a] | 1-2-1 | 3 |
| Type IV[a] | 2 | 10 |
| Type V[a] | 1-2 | 8 |
| Type VI[a] | 2-1-2 | 0 |
| Type VII[a] | 1-2-1-2 | 0 |
| Type VIII[a] | 3 | 0 |
| C[b] | 1-3-1 | 1 |

[a]Vertucci (1984).
[b]Melton *et al.* (1991).

teeth, 1 mm from the apex in 9.7% teeth and 2 mm from the apex in 1.2% teeth.

### Length of teeth

The longest tooth in this study was 25.2 mm and the shortest was 17.7 mm. The average length of the mandibular first premolar teeth was 21.6 mm, the median and mode were 21.3 mm.

### Mesial invagination of the teeth

Mesial invagination of the root was found in 14% of the teeth. Amongst them, 7 teeth had Type IV canal pattern; 3 had Type V canal pattern and 2 had Type I canal pattern (Fig. 2 Table 2). One tooth with Type II and one tooth with Type III canal pattern were also identified. 85.7% of the teeth with mesial invagination had either two canals or division of canals. The mean distance from the cusp tip to the point of initiation of invagination was 14.6 mm.

## Discussion

This study analysed the canal morphology of mandibular first premolar teeth amongst an Indian population using a decalcification and clearing technique. Previous studies report a high occurrence of Type I canal pattern (Vertucci 1984). Studies on root canal anatomy have

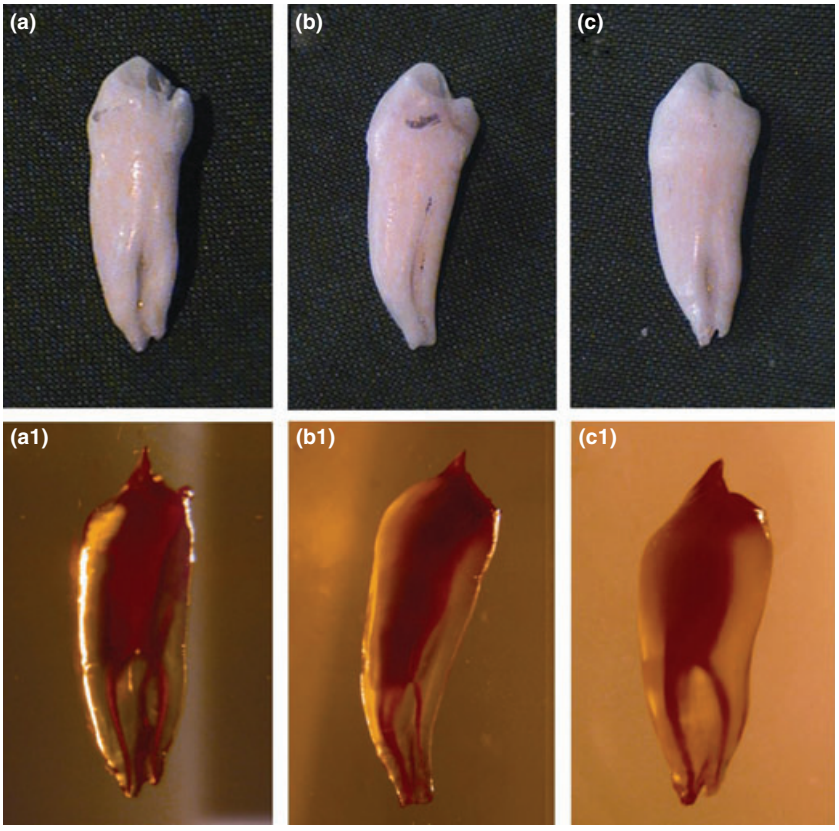


**Figure 2** Mandibular first premolars with mesial invagination of the root (a, b, c) and their root canal patterns (a1, b1, c1).

**Table 2** Mesial invagination of the teeth

| Canal type | No. of teeth | Average point of initiation of invagination (mm)[a] |
|---|---|---|
| Type I | 2 | 16.5 |
| Type II | 1 | 14.4 |
| Type III | 1 | 15.3 |
| Type IV | 7 | 13.8 |
| Type V | 3 | 15.1 |

[a]Point of initiation of invagination measured from the cusp tip. Average: 14.6 mm; median: 14.4 mm; mode: 15.3 mm; variance: 2.5; SD: 1.59.

been conducted using methods, such as radiography (Pineda & Kuttler 1972, Willershausen *et al.* 2006), decalcification and clearing (Caliskan *et al.* 1995, Rwenyonyi *et al.* 2007), direct observation with microscope (Sempire & Hartwell 2000), 3D reconstruction (Mikrogeorgis *et al.* 1999), computed tomography (Robinson *et al.* 2002, Reuben *et al.* 2008) and macroscopic sections (Baisden *et al.* 1992, Lu *et al.* 2006). It has been mentioned that the most detailed information can be obtained by demineralization and clearing technique (Vertucci 1984). Moreover, it is simple, acceptable and an inexpensive procedure (Rwenyonyi *et al.* 2007).

The most prevalent canal pattern in the present study was Type I occurring in 72% of the mandibular first premolars (Fig. 1a, Table 1). In an earlier study (Vertucci 1984) in Caucasian population, the prevalence was 70%, whereas other studies have reported a Type I canal pattern in 67.2% to 86.3% of teeth(Zillich & Dowson 1973, Trope *et al.* 1986). A Type II canal was encountered in 6% of the samples and Type V in 8% of the samples (Fig. 1, Table 1). Vertucci (1984) did not report any Type II canal patterns, but 24% of the teeth in his study had a Type V canal pattern. These variations may be attributed to the racial or genetic factors. Vertucci (1984) reported the occurrence of C-shaped canal in 0.5% of the samples, whereas in the present study, it was identified in one tooth (1%) (Table 1). Melton *et al.* (1991) classified C-shaped canals into three types. The C-shaped canal identified in this study was Category III sub division I, where the canal divided into three in the middle third and reunited at the apical region to exit through one foramen.

A previous study reported the average length of mandibular first premolar teeth to be 21.6 mm (Cohen & Hargreaves 2006). The average length of the teeth in the present study was also found to be 21.6 mm. In this study there were 14 teeth with a mesial invagination of the root. The point of initiation and the depth of the invagination varied. According to Ash (1999), these are deep developmental grooves found on the mesial surface of the root. Radiographic studies on canal anatomy have not reported on mesial invaginations of roots as it is impossible to identify its presence in clinical radiographs. The only *in vivo* study that reported their occurrence using spiral computed tomography concluded that 15% of mandibular premolars had invagination (Robinson *et al.* 2002). According to that study, the mesial invagination gave a false radiographic line that one can mistake for an extra canal. In this study, amongst the 14 teeth having mesial invagination of the root, 8 teeth had two canals, 4 teeth had bifurcation of canal and 2 teeth had a single canal. The teeth with two canals (Type II and Type IV) had the mesial invagination initiating from the cervical half of the tooth root. The teeth with canal bifurcation (Type III and Type V) and single canal (Type I) had the invagination in the apical half of the root, with the single canal specimen having the invagination apically. In these teeth, the lingual canal after bifurcation was smaller in diameter when compared with the buccal canal. The location of the canal bifurcation varied in accordance with the location of the point of initiation of invagination. There seems to be some anatomical correlation between mesial invagination of the root and canal pattern which requires further analysis.

## Conclusion

A Type I canal pattern was found to be the most prevalent in mandibular first premolar teeth amongst this Indian population. More than one canal was commonly found in the teeth with mesial invagination of the root.

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