Root canal morphology of South Asian Indian mandibular first, second, and third molar: A dye penetration and clearing study

Shishir Singh, Mansing Pawar¹, Rajesh Podar, Gaurav Kulkarni, Nikhil Bhanushali²

Department of Conservative Dentistry and Endodontics, Terna Dental College and Hospital, Navi Mumbai; ¹Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, St George Hospital Compound, Mumbai, Maharashtra; ²Department of Public Health Dentistry, Terna Dental College and Hospital, Navi Mumbai, Maharashtra, India

Abstract

Context: Studying in detail the root canal morphology specific to the Indian mandibular molars will help discern whether the root canal anatomy patterns resemble those reported internationally or are different from it.

Aim: The aim is to study the root canal anatomy of Indian permanent mandibular first, second, and third molar teeth using a tooth clearing technique.

Methods: The root canals of a total of 300 extracted Indian mandibular molars consisting of 100 first, second, and third molars each were accessed and injected with India ink, after which they were subjected to the clearing technique.

Statistical Analysis: Data was analyzed using descriptive statistics for the computation of percentages using SPSS version 21.

Results: Of the hundred first molars, 90% of teeth were two rooted with three canals, 79% had two apical foramina. 70% mesial roots of the three-rooted type showed Type I, whereas 100% distal roots and distolingual roots showed Type I Vertucci’s anatomy. About 70% mesial roots of two roots showed Type II and 90% distal canals showed Type I configuration. Among the second molars, five (5%) were single-rooted, ninety-one (91%) teeth were two rooted and four (4%) had three roots. Among the mandibular third molars, fifteen (15%) teeth had one root, sixty-three (63%) teeth had two roots, eighteen (18%) teeth had three roots, and four (4%) teeth had four roots.

Conclusions: The root canal anatomic features of mandibular molars showed differences in the frequency of particular anatomic types as compared to mandibular molars from other racial backgrounds. Further comparative studies on inter-racial anatomic characteristics from various geographic locations would be beneficial.

Keywords: Indian; mandibular molar; root canal anatomy

INTRODUCTION

The endodontic literature is replete with root canal anatomy studies done on various populations and teeth all over the world. Immense research has been done in this field, and the all-prevailing technique being; the dye penetration and clearing method is also the gold standard.¹,² Anatomical differences have long been linked to racial characteristics amongst the Caucasian, Mongoloid, and Negroid races.³

The ethnolinguistic composition of the population of South Asia that is, the nations of India, Pakistan, Afghanistan, Bangladesh, Nepal, Bhutan, Maldives, and Sri Lanka, is highly diverse. The majority of the population fall within two large linguistic groups; the Indo-Aryans and the...
Dravidians. Vertucci has established anatomical patterns and classified them with additional modifications making it easy for the dentist to imagine and communicate.

The aim of this study was to study the morphology of Indian mandibular first, second, and third molars with regard to: (i) number of roots and their morphology; (ii) number of root canals per tooth; (iii) root canal configuration in each root using Vertucci’s classification, with additional modifications; (iv) presence and location of lateral canals and intercanal communications using the dye penetration and clearing technique.

METHODS

A sample of 100 each of freshly extracted permanent mandibular first, second, and third molars from indigenous South Asian Indians were collected. Only extracted teeth with fully intact crowns and roots were the inclusion criteria. Severely carious, fractured, broken down or calcified teeth, and open apices was an exclusion criterion.

All the patients were screened before teeth extraction with proper family history and according to physical appearance and names to ensure that they were of Indian origin. Only teeth of patients of real Indian race constitutes the study. The specimens were processed as per the tooth clearing protocol by Gulabivala et al. and Singh and Pawar. The extracted teeth were cleaned ultrasonically, immersed in 2.5% sodium hypochlorite (Mumbai Healthcare Industries, India) for 30 min and then stored carefully in 2% thymol iodide solution.

After access preparation, 2% India Ink dye (Lobal Chemie Laboratory reagents and Fine Chemical, India) was injected into the canals with a 27G needle and a suction placed at the root apex to ensure complete dye penetration. After washing in water, the samples were decalcified in 10% Nitric acid (Fisher Scientific, Qualigens Fine Chemicals, India) and then dehydrated in 80%, 90%, and 100% methanol (Carbimol A. R. Himedia Laboratories, India) for 24 h, respectively, over 3 days. The samples were then dried on tissues and immersed in methyl salicylate (Oil of Wintergreen, Merck Specialties Pvt. Ltd.) for clearing. The transparent samples were viewed with the naked eye as well as under ×3 using special halogen lighting.

The root canal anatomy was classified using the Vertucci classification with additional types. The number of roots, root shape, apical foramen, lateral canals, and intercommunications were recorded as per Gulabivala’s classification, as mentioned in Tables 1 and 2. Figure 1 shows the specimens that were photographed using a Nikon D40 camera with a macro lens (Sigma AF105 mm1:2.8 EX DG Macro) under special halogen lighting. Descriptive statistics were used to determine the frequency for first, second and third molars using SPSS version 21 software package (SPSS Inc., Chicago, IL, USA).

RESULTS

Of the hundred Indian mandibular first molars, 90% of teeth were two rooted with three canals, and 10% teeth were three rooted with three canals. Seventy nine percent teeth had two apical foramina, 20% teeth showed three apical foramina, and 1% showed four apical foramina. Ten percent had three separate roots and 90% had two separate roots. In the group of ten teeth with three separate roots; the mesial roots showed 70% having a Vertucci Type I root canal anatomy, 20% having a Vertucci’s Type II anatomy, and 10% having a Type IV canal anatomy. One hundred percent distal roots and 100% distolingual roots showed a Type I root canal anatomy. In the group of ninety with two separate roots; for the mesial canals, 19% teeth had a Type I canal anatomy, 70% had a Type II, 10% had a Type IV, and 1% had a Type VI root canal anatomy. For the distal canals, 90% had a Type I, 8.9% had a Type II and 1.1% had a Type IV root canal anatomy. Among a total of 3% lateral canals, 1% of the them were observed in the apical third and 2% in the middle third of the mesial roots. Five percent canal intercommunications were seen.

Of the hundred mandibular second molars five (5%) were single-rooted, ninety-one (91%) teeth were two rooted and four (4%) had three roots. Five (5%) teeth had a single apical foramen, eighty-three (83%) teeth had two apical foramina, ten (10%) teeth had three apical foramen and two (2%) teeth exhibited four apical foramina. In the group of four teeth with three separate roots; all the mesial roots, distal roots, and distolingual roots (100%) had a Vertucci’s Type I root canal anatomy. In the group of ninety-one teeth with two
Table 1: The number of roots, root canals, root shape, apical foramina, lateral canals, and intercommunications in the mandibular first, second, and third molars

| Root numbers | First molars (n=100), % | Second molars (n=100), % | Third molars (n=100), % |
|--------------|-------------------------|--------------------------|------------------------|
| One          | 5                       | 15                       |                        |
| Two          | 90                      | 91                       | 63                     |
| Three        | 10                      | 4                        | 18                     |
| Four         |                         | -                        | 4                      |
| Root canal numbers |                  |                          |                        |
| One          | -                       | 5                        | 15                     |
| Two          | 90                      | 91                       | 63                     |
| Three        | 10                      | 4                        | 18                     |
| Four         | -                       | -                        | 4                      |
| Foramen numbers |                    |                          |                        |
| One          | -                       | 5                        | 12                     |
| Two          | 79                      | 83                       | 58                     |
| Three        | 20                      | 10                       | 25                     |
| Four         | 1                       | 2                        | 5                      |
| Root shape   |                          |                          |                        |
| Three roots: all separate | 10                  | 4                        | 18                     |
| Three roots: B roots fused | -                  | -                        | -                      |
| Three roots: DB and P roots fused | -                | -                        | -                      |
| Three roots: all fused | -                 | -                        | -                      |
| Two roots separate | 90                  | 91                       | 63                     |
| Two roots fused | -                   | -                        | -                      |
| One root: conical | -                  | -                        | -                      |
| One root: C shaped | -                  | -                        | -                      |
| Four roots: fused | -                 | -                        | -                      |
| Four roots: other | -                  | -                        | -                      |
| Lateral canals |                    |                          |                        |
| Coronal      | -                       | 1                        | -                      |
| Middle       | 1                       | 1                        | 1                      |
| Apical       | 2                       | -                        | 4                      |
| Intercommunications | 5                 | 3                        | 5                      |
| C shaped     | -                       | 5                        | -                      |

The root canal anatomy of human teeth is being studied globally for less than a century. The in vitro techniques used are sectioning, clearing, radiographic, microscopic, clinical, or a combination of two or more. The in vivo methods constitute clinical, radiographic, posttreatment records studies, which are less in number when compared to the in vitro techniques with the dye penetration and clearing being used most often, setting it as the gold standard. A clearing technique, as described by Okumara and Robertson et al., was used to study the root canal anatomy in the present study. The use of this dye penetration and clearing method has its advantages and is in use for a century now to examine the root canal anatomy of human teeth.

The benefits of the dye injection and clearing technique for studying the morphology and anatomy of root canals are many such as; retention of the original tooth form with the maintenance of the relationship between internal root surfaces and external tooth contour, clear visibility of minute structures, rare failure rate in the preparation of specimens, the possibility of the specimen preserved for a long time, the need for little equipment, space and the modest cost involved. The specimens can be viewed for its most intricate details with magnification, photographed easily, and reproduced for teaching purposes. None of the studies have studied the number of roots, root canal numbers, the number of apical foramina, lateral canals, intercommunications, and canal anatomy together. Since the parameters for various research studies were not the same drawing, a foolproof conclusion was a challenge in itself.
In the present study, 90% of the mandibular first molars had 2 roots. Five percent had 3 roots. This frequency is less than that reported in Japanese (22.7%),[11] Koreans (22.3%),[12] Hong Kong population (15.0%),[13] and by Zhang et al. (29%)[14] who reported a high prevalence of 3 roots in an Asian population. In this study, it was found that the mesial roots of 3 rooted mandibular teeth of the Indian population showed Vertucci’s Type I root canal anatomy predominantly (70%) followed by Type II (20%) and Type IV (10%) root canal anatomy. The distal roots of all three rooted mandibular first molars showed only Type I root canal anatomy. Among the 2 rooted mandibular first molars, the mesial roots demonstrated a higher prevalence of Type II root canal anatomy followed by Type I and Type IV. Only 1% of the mesial roots of the Indian population showed type VI root canal configuration. The distal roots mostly demonstrated Type I root canal anatomy, followed by Type II.

Chourasia et al. in 2012[15] did an in vitro clearing technique on 150 Indian mandibular first molars to present 5.3% with three roots. The mesial roots had 54% Type I and 38.8% Type II, while the distal canals had a 65.3% Type I and 20.6% Type II canal configuration. Although these findings emphasize the present results of Type I being the most prevalent canal configuration followed by Type II in distal roots, the incidence rate of this canal variation is lower than in our study. Zhang et al. in 2011[14] studied 389 Chinese mandibular first molars with a cone-beam computed tomography, wherein he found 29% mandibular first molars with three roots and mesial roots presenting Type IV canal systems followed by Type II and distal roots with a simple Type I root canal anatomical configuration. Many other studies have reported that in the mesial root, Type IV configuration was most prevalent, followed by Type II canal configuration, which differs from the findings in the present study.[16,19] An exception was reported by Al-Nazhan,[20] with Type II being the most prevalent, followed by Type IV. The diversity in the outcomes between studies might be explained by marked differences in sample sizes, case selection and methods used. Further investigation is necessary to clarify the issue.

C-shaped canals were found in 5% of the Indian mandibular second molars, which was consistent with Neelakantan et al.[9] but is noticeably lower than the populace of the far Eastern countries,[21] which consistently seem to have a higher incidence with 28% in Japanese,[22] 31% in Taiwanese,[23] 22% in Burmese,[3] 39% in Chinese,[24] and 40% in Korean.[25] Root canal intercommunications and lateral canals were present in the Indian population. They represent an important route for bacterial leakage that can lead to root canal treatment failure and the need for additional surgical intervention. Identification, preparation, and filing of Type I and IV canal systems are relatively straightforward because each of the canals is separate and distinct between the orifice and apex. Root canal treatment of Types II, III,
V, VI, and VII, where two canals join into one small canal at a sharp angle, is more difficult. The obturation of simple tubular and tapered canals may be achieved satisfactorily with the right techniques, adequate dental skills, sufficient instruments, and most importantly, timely diagnosis.\textsuperscript{[5,17]}

**CONCLUSIONS**

Root canal morphology of completely differentiated mandibular molars is complex. Although the distal root canals had simple pulpal structures, the mesial canals exhibited many complex configurations. The comparatively lower incidence of C-shaped canals in the mandibular second molars could be a racial characteristic. The Indian mandibular molars showed inter-canal communications and lateral canals, among other intricate pulpal structures. A wide range of anatomic and morphological variations can be encountered due to genetic and ethnic differences.

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**Conflicts of interest**

There are no conflicts of interest.

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