Original Article

Determination of root canal configuration and the prevalence of "C-shaped" canals in mandibular second molar in Central and South Gujarat population: An *in vitro* study

ABSTRACT

Aims: The aim of the present study was to determine the canal configuration and the prevalence of "C-shaped" canals in mandibular second molar in Central and South Gujarat population.

Materials and Methods: A total of 122 mandibular second molar teeth were collected and stored in 10% formalin. Identification of these teeth as mandibular second molar was confirmed by two independent observers. An endodontic access cavity was then prepared in each tooth. Then, they were injected with India ink and demineralized, they were made clear and transparent with methyl salicylate. Then, anatomy of their canals was studied.

Results: Out of 122 mandibular second molars, prevalence of "C-shaped" canals was 10.65% (13 teeth). These configurations were seen mostly in single-rooted mandibular second molars. Out of five categories of "C-shape," predominantly found category was (C1) – 46.15%.

Conclusion: Hard tissue of mandibular second molar contains dental pulp which can take a variety of configurations and shapes. The great differences reported among studies with regards to anatomy of the mandibular second molars and prevalence of "C-shaped" canals may be attributable to study methods and racial differences.

Keywords: C-shape canals, mandibular second molar, root canal anatomy, tooth-clearing technique

INTRODUCTION

The external morphological character of the crown differs according to size and shape of the head. Length of the crown of the tooth varies with the size and sex of the person. As external morphological features of the tooth differ from person to person so does the internal morphology of the crown and root. Practitioners must have knowledge of the internal anatomic relationships of teeth based on various racial groups and must be able to visualize these relationships before undertaking endodontic therapy, as such knowledge of anatomy can aid in the location of the canal orifices and negotiation of root canals, with their subsequent management.[1]

Endodontic textbooks state that "C-shaped" canal configuration is not rare; which is accepted in several studies with the prevalence ranges from 2.7% to 44.6%. Accepted prevalence includes 2.7%–8% for American,[2-4] 19.1% for Lebanese,[5] 10.6% for Saudi Arabians,[6] 31.5% for Chinese,[7] and 32.7% and 42.5% for Korean populations.[8,9] It is rarely seen in the fair people but has significantly high prevalence in mandibular second molars of Lebanese and Chinese populations. Hence, it is concluded that this anatomical

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configuration is more common in Asian population than in Fair peoples.[10]

"C-shaped" canal configuration was first documented in article by Cooke and Cox. It is found when fusion of either the buccal or lingual aspect of the mesial and distal roots occurs. Fusion may remain irregular throughout the root, and interradicular ribbon shape communication can be seen. The pulp chamber has a single ribbon-shaped orifice of 180° arc from the distal to mesial canal. The floor of the chamber is deep and has an unusual anatomical appearance. Beneath the orifice, an entire root canal may harbor a wide range of anatomical diversity. Two or three canals may be found in the "C-shaped" groove or continuous "C-shape" can be seen throughout the length of the root.[10]

Few studies are available in literature illustrating the canal anatomy of this particular tooth from Indian population which is hybrid of several ethnic groups with characteristics of Caucasian, Mongoloid, and Negroid races (Dravidian group).[1] Therefore, the present study evaluated the canal configuration and the prevalence of "C-shaped" canals in mandibular second molar in Central and South Gujarat population using clearing technique.

MATERIALS AND METHODS

After taking an ethical approval from the Institutional Ethics Committee (no-SVIEC/ON/Dent/SRP/16073), 122 mandibular second molars were collected from the Department of Oral and Maxillofacial Surgery as well as dental faculty, private dental clinics in Central and South Gujarat region. Samples were selected based on convenience sampling and by keeping 95% confidence interval and 90% power of the study. Identification of all the teeth was confirmed by two individual observers, using the criteria of Woelfel and Scheid.[11] Molars for which both investigators agreed were included in the present study. Molars with completely formed roots, with or without carious lesions, cracks and fracture lines not involving furcation areas were included in the study. Teeth with root resorption were excluded from the study. Gathered teeth were stored in 10% formalin. As an ample amount of following teeth had been extracted due to periodontal reasons, they were sound or had very little area affected by caries or fillings.

All the samples were cleaned of any attached bone fragments, soft tissues remnants, and calculus by scaling. Then, an access cavity was prepared, using #57 fissure carbide bur (Mani Inc.) and Endo Z (Dentsply Maillefer, Tulsa, OK). Then, floor of the pulp chamber was examined using DG16 endodontic explorer (Hu-Friedy, Chicago, IL, USA) to identify the canal orifices. Molars with calcification in the pulp chamber were discarded. After orifice location, all the samples were placed in 5.25% sodium hypochlorite solution for 48 h to remove pulp tissue remnant. After that, they were intensely rinsed in running tap water for 4 h to clean the root canals. After wash, India ink was injected into the canals and then all the samples were demineralized using 5% nitric acid at room temperature for 3 days. Five percentage nitric acid solution was replaced every day. After complete demineralization, samples were intensely rinsed in running tap water for 4 h. After that, dehydration process was carried out using a series of ethyl alcohol. Samples were kept in 80% ethyl alcohol overnight, followed by 90% ethyl alcohol for 1 h and then they were placed in 100% ethyl alcohol for 1 h. Dehydrated samples were then placed in methyl salicylate for 2 h to make them transparent and clear. Cleared samples were then examined under a PRIMA DNT (Labomed, America) dental operating microscope at ×25 magnification. Moreover, the root canal systems were classified based on the classification by modified Melton for "C-shape" and Vertucci.

RESULTS

Out of 122 samples, 13 (10.65%) molars were single rooted, a large number of molars, i.e. 105 (86.06%) had two roots and 4 (3.29%) teeth were three rooted. "C-shaped" canal configuration was most common in single-rooted molars (9 out of 13) and observed in 4 out of 105 two-rooted molars. In this study, incidence of "C-shaped" canal was 13 out of 122 (10.65%) [Table 1 and Figure 1].

Based on classification given by Vertucci, canal configurations found in the mesial roots of the two-rooted molars were Type I = 10 (9.90%), Type II = 50 (49.5%), Type IV = 38 (37.62%), Type V = 2 (1.98%), and Type VIII = 1 (0.99%). Moreover, canal configurations found in the distal roots of two-rooted molars were: Type I = 90 (89.10%), Type II = 3 (2.97%), Type III = 2 (1.98%), Type IV = 4 (3.96%), and Type V = 1 (0.99%). Out of this, one tooth had an unusual canal configuration which cannot be classified based on the Vertucci classification [Table 2 and Figure 2].

Out of five categories of "C-shape" predominantly found category was (C1) - 6 (46.15%) at the orifice. Followed by C4-3 (23.07%) and C2, C3-2 (15.38%) each.

Table 1: The number of canals and roots in the mandibular second molars and C-shaped canals

Number of teeth	Number of roots and percentage	C-shaped
13	One rooted 10.65	9
105	Two rooted 86.06	4
4	Three rooted 3.29	0

Table 2: Root canal configuration of the mandibular second molars for other than C-shape

Number of roots	Roots	Canal configuration of the roots									Total, *n* (%)
		I, *n* (%)	II, *n* (%)	III, *n* (%)	IV, *n* (%)	V, *n* (%)	VI, *n* (%)	VII, *n* (%)	VIII, *n* (%)	Unusual, *n* (%)	
Two-rooted teeth	Mesial	10 (9.90)	50 (49.50)	0	38 (37.62)	2 (1.98)	0	0	1 (0.99)	0	101 (100)
	Distal	90 (89.10)	3 (2.97)	2 (1.98)	4 (3.96)	1 (0.99)	0	0	0	1 (0.99)	101 (100)
Single-rooted teeth	Mesial	1 (25)	2 (0)	0	1 (25)	0	0	0	0	0	4 (100)
	Distal	4 (100)	0	0	0	0	0	0	0	0	4 (100)
Three-rooted teeth	Mesial	0	3 (75)	0	0	0	0	0	0	1 (25)	4 (100)
	Distal	1 (25)	0	0	3 (75)	0	0	0	0	0	4 (100)

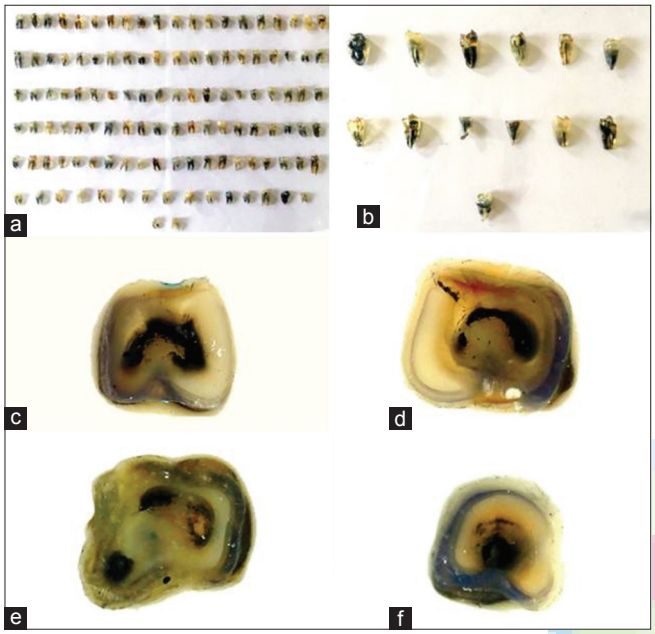

Figure 1: (a) cleared 122 samples. (b) 13 samples with c shape. (c) C-shaped mandibular second molars in cross-section, one C-formed canal throughout the root (d) two distinct canals. (e) Three distinct canals. (f) Only one round canal

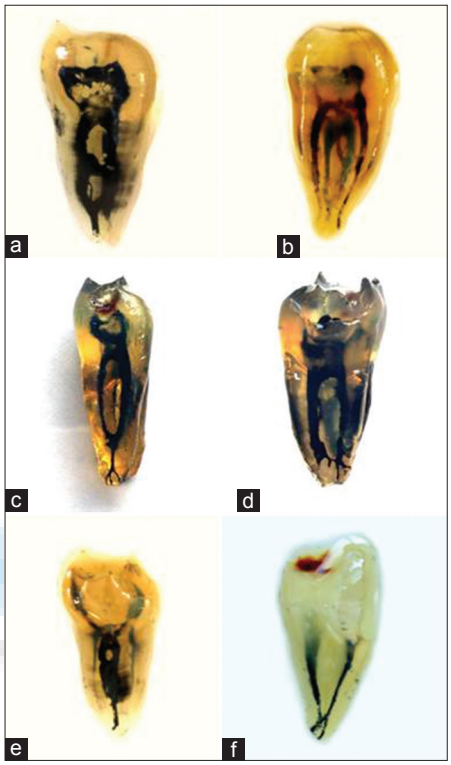

Figure 2: (a-f) Mandibular second molars with different canal configuration other than C-shape

DISCUSSION

Although mandibular second molars show this anatomical variant most commonly, mandibular first molar and premolar, maxillary first as well as second molar are the other tooth which can show this anatomical variation.[1] According to Cooke and Cox in 1979, 8% of endodontically treated mandibular second molars had the "C-shaped" configuration.[2] In 1988 Yang *et al*. used clearing technique and observed that 31.5% of mandibular second molars in Chinese people had "C-shaped" canals. Less than half of these had true "C-shaped" canals, and only one-fifth of the teeth (7.4%) had "C-shaped" canal orifices.[7]

Okumura recommended clearing technique in 1927 which shows superiority over other techniques for studying the root canal anatomy, as it gives 3D view of the pulpal cavity and entry to the pulp system can be done without instrumentation. Leading to preservation of the original canal anatomy and relationships of the canals are maintained. Even its minute structural details can be visible clearly with rare chance of sample distortion during preparation. Long-term preservation of specimens is possible with this technique.[4,12,13]

Ten percentage formalin was used as better storage medium for samples with minimal distortion of cell and tissue component. Indian ink is a neutral suspension of carbon particles (pH 7.5–8.5), with 10 μm in size which remains stable in demineralization process. Nitric acid decalcification was much faster and causes less clogging of canal than formic acid; nitric acid took 3–4 days while with formic acid it takes a longer duration of 7–8 days.[14] Ethyl alcohol with different concentrations was used as dehydrating agent. It removes aqueous fixatives and unbound water from tissue constituent. Wintergreen oil, i.e. methyl salicylate was used

as an organic solvent has superior properties which makes it better than both glycerol and other organic solvents. Its higher refractive index closely comparable with that of glass makes it better than glycerol.[15]

In this study, 10.65% of molars were single rooted and (86.06%) molars had two roots [Table 1], analogous to the results of Weine *et al*. (96%)[4] and Rahimi *et al*. (86.3%).[13] About 3.29% were three rooted, analogous to the result of Ingle *et al*. that is 2.2% and Rahimi *et al*. (4.3%).[13]

Based on classification given by Vertucci; in the mesial roots, the prevalence of teeth with the one canal at the apex of the root was 59.40% (Types I, II, and III) which was closely resembles to assessment given by Ingle *et al*., i.e., 60.3%.[16,17] Molars with two apical canals were 39.60% (Types IV, V) which is in close accordance with assessment given by Ingle *et al*., 39.7%[16] and 0.99% of molars had three apical canals. Commonly found configuration of the distal canal was Type I (89.10%) [Table 2]. The prevalence of two root canals in the distal root of two-rooted molars was 8.9% (Types II, III, and IV), which was very analogous to assessment given by Ingle *et al*., i.e. 8%.[16,17] Ninety-four percentage (Types I, II, and III) of the distal roots of two-rooted molars had one canal at the apex of the root, comparable to assessment given by Ingle's *et al*., i.e. 95%.[16,17] Moreover, 4.9% (Types IV, V, VI) had two canals at the apex of the root, which was very similar to the value given by Ingle *et al*., i.e. 5%.[16,17]

In the current study, "C-shaped" canal configuration was most commonly seen in the single-rooted molars (9 out of 13). It was also present in 4 out of 105 two-rooted molars. The total incidence of "C-shaped" canals was 13 out of 122 (10.65%) [Table 1], which is very similar to prevalence noted by Gulabivala *et al*. in Thai population using the injection of Indian ink, i.e. 10%[18] and was <19.14% noted by Haddad *et al*.,[5] 31.5% observed by Yang *et al*.,[7] 32.7% recorded by Seo and Park in 2004,[19] and 44.6% noted by Jin *et al*.[9] On the contrary, this is higher than the 2.7% frequency recorded by Weine[3] and 8% reported by Cooke and Cox.[2] This can be attributed to racial differences.[13]

In 2001 Gulabivala *et al*. studied Burmese patients for "C-shape" canal configuration using a tooth clearing and canal staining technique, noted the incidence of 22.4%. Inter canal communications were very common in these teeth.[20] Simultaneously, Lambrianidis *et al*. evaluated the periapical radiographs and correlated it with the clinical diagnosis and reported that 5% of treated teeth were "C-shaped."[21]

The prevalence of C-shaped canal obtained from the extracted teeth could not represent the real prevalence in the whole Gujarat as well as Indian population, nor could prevalence found in this study. As it is an observational study sample size is less.

Melton *et al*. in 1991 stated that "C-shaped" canals can vary in number and shape along the length of the root. Fan *et al*. in 2004 also showed the same result in their study.[23] Therefore, the clinical crown morphology or the appearance of the orifice of the canal may not be a good predictor of actual canal anatomy throughout the root canal length.[22] Hence, the cross-sectional canal shape has to be analyzed using more advance diagnostic tools like cone-beam computed tomography, 3D reconstruction and that has to be correlated with clinical data in further studies. More clinical studies are needed to confirm the results of this study.

CONCLUSION

Hard tissue of mandibular second molar contains dental pulp which can take a variety of configurations and shapes. C shape is one of them. The great differences reported in a variety of studies with regards to the anatomy and prevalence of "C-shaped" canals may be attributable to study methods and racial differences. Combination of nitric acid and methyl salicylate proved to be the best for the preparation of the transparent tooth model, as it is an inexpensive and excellent technique for demonstration of three-dimensional view of root canal morphology.

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Conflicts of interest

There are no conflicts of interest.

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