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Original

Root canal configuration and the prevalence of C-shaped canals in mandibular second molars in an Iranian population

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Abstract: A total of 139 extracted mandibular second molars were injected with India ink and demineralized. They were made clear and transparent with methyl salicylate, and the anatomy of their canals was studied. It was found that 86.3% of mandibular second molars had two roots, 9.3% had one root, and 4.3% had three roots. Ninety percent of the mesial roots of the mandibular second molars with two roots had two canals (predominantly with a type II or III configuration), and 77.5% of the distal roots of these teeth had one canal (predominantly with a type I configuration). Among the mandibular second molars, 7.2% had C-shaped canals and these configurations were seen mostly in single-rooted mandibular second molars. The results of this study indicate that mandibular second molar teeth have many variations in the number of roots and the morphology of their canals. Therefore it should not be assumed that all mandibular second molar teeth have two roots and three canals. (J. Oral Sci. 50, 9-13, 2008)

Keywords: mandibular second molar; canal configuration; clearing; C-shaped canal.

Introduction

The objective of endodontic therapy is restoration of a treated tooth to its proper healthy form and function in the masticatory apparatus (1). Knowledge of pulp anatomy is essential for success of endodontic treatment, and lack of such knowledge may lead to treatment failure. Knowledge of both the normal and unusual configurations of the pulp and possible variations is critical for success in endodontics. It is absolutely essential for an operator to form a mental picture of the pulp in cross-section and from the coronal aspect to the apical foramen. Each canal contains irregular and hidden regions that should be taken into account during endodontic treatment. Instruments must access these hidden regions and clean and shape them as maximally as possible to avoid or minimize treatment failure (2). Endodontic treatment is highly successful (86-98%) (3) for retaining natural teeth if it is combined with efficient restoration of the tooth involved.

Mandibular second molars are commonly more variable in shape than other molar teeth, but they usually resemble the mandibular first molars in possessing one (larger) distal canal and two mesial canals. There are always two canals in the mesial root of mandibular first molars, but mandibular second molars may have only one canal in the mesial root (1). The existence of single-rooted mandibular second molars with a continuous slit connecting two, three, or four canals was first described in the dental literature by Cooke and Cox (4) in 1979, although several clinicians had suggested its presence in lectures before this.

The C-shaped molar is so named because of the cross-sectional morphology of the root and root canal. Instead of having several discrete orifices, the pulp chamber of a C-shaped molar is a ribbon-shaped orifice with a 180-degree arc (or more), starting at the mesiolingual line angle and sweeping around to the buccal side (4) – although some

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C-shaped canals sweep lingually as well – to end at the distal aspect of the pulp chamber. Below the orifice level, the root structure of a C-shaped molar can harbor a wide range of anatomic variations. These can be classified into two basic groups: those with a single, ribbon-like, C-shaped canal from orifice to apex, and those with three or more distinct canals below the usual C-shaped orifice (Fig. 2A). More common is the second type, with discrete canals that take unusual forms (4). Other investigators have demonstrated that C-shaped canals in mandibular second molars vary in shape and number along the root length, making cleaning, shaping, obturation, and restoration of these teeth difficult (3). The mesiolingual canal is separate and distinct from the apex, although it may be significantly shorter than the mesiobuccal and distal canals. These canals are easily overinstrumented in C-shaped molars with a single apex. In these molars the mesiobuccal canal swings back and merges with the distal canal, and these exit onto the root surface through a single foramen (Fig. 2B). A few of these molars with C-shaped orifices have mesiobuccal and distal canals that do not merge, but have separate portals of exit (3). In the nineteenth century, dental anatomists and anthropologists described morphological variations and commented on their relative frequencies in different racial populations (5). There is significant ethnic variation in the incidence of C-shaped molars. Reported prevalances have included 2.7-8% for American (4,6,7), 31.5% for Chinese (8), 19.1% for Lebanese (9), 10.6% for Saudi Arabian (10), and 32.7% (11) and 44.5% (12) for Korean populations. The purpose of the present study was to determine the canal configuration and the prevalence of C-shaped canals in mandibular second molars in a North-Western Iranian population.

Materials and Methods

A total of 139 mandibular second molar teeth were collected from a dental faculty, clinics, and private offices

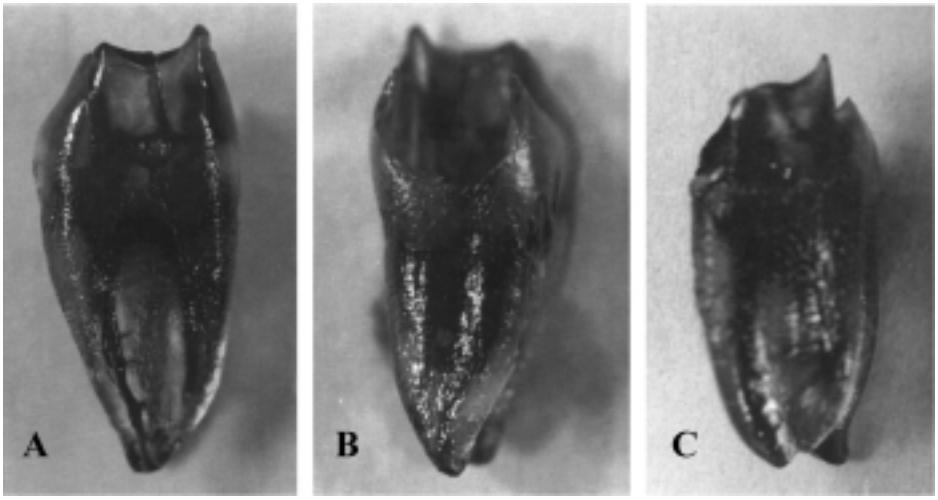

Fig .1 C-shaped mandibular second molars. A: Mesial view, B: Distal view, C: Proximal view.

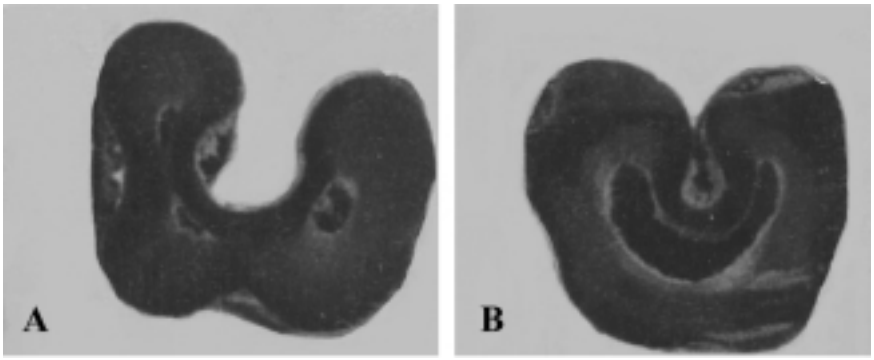

Fig. 2 C-shaped mandibular second molars in cross-section. A: Three distinct canals, B: One C-formed canal throughout the root.

in Tabriz, a city in north-western Iran. The identification of these teeth as mandibular second molars was confirmed by two independent observers using the accepted criteria of Woelfel (13). Only those teeth for which both investigators agreed were used in this study. The teeth were gathered during one year and stored in 10% formalin. Since a large number of these teeth had been extracted because of periodontal problems, they were intact or had small areas of caries or fillings in the coronal portions. The selected teeth were cleaned of any adherent soft tissues, bone fragments and calculus by scaling and polishing. An endodontic access cavity was then prepared in each tooth with diamond fissure burs (D&Z, Diamant, Germany). The floors of the pulp chambers were examined with a DG16 endodontic explorer (Hu Freiday, Chicago, IL, USA) to identify the root canal orifices. After locating the orifices, the teeth were placed in 5.25% sodium hypochlorite solution (Golrang, Tehran, Iran) for 48 h to dissolve debris and pulp remnants. All the specimens were then thoroughly rinsed in running water for 4 h to clean the root canals of any debris. Once washed, India ink was injected into the root canals and the teeth were demineralized for 3 days in 5% nitric acid at room temperature (20°C). The nitric acid solution was changed every day. After demineralization, the teeth were rinsed in running water for 4 h. The dehydration process consisted of a series of ethyl alcohol (Ararat, Tehran, Iran) rinses starting with 80% overnight, followed by 90% for 1 h and then 100% ethyl alcohol rinses for 1 h. The dehydrated teeth were placed in methyl salicylate (Merck, Darmstadt, Germany) for 2 h to make them clear and transparent. The cleared teeth were examined under a magnifying glass (Lumagny No.7540, Hong Kong) at ×5 magnification. The root canal systems were classified according to Vertucci (14).

Results

Out of 139 mandibular second molar teeth, 120 were two-rooted (86.3%), 13 were one-rooted (9.3%) and 6 were three-rooted (4.3%) (Table 1). According to Vertucci's classification (14), the shapes of the mesial roots of the two-rooted mandibular second molars were: type I = 9 (7.5%), type II = 51 (42.5%), type III = 3 (2.5%), type IV = 54 (45%), type V = 2 (1.6%) and type VIII = 1 (0.8%) (Table 2), and the shapes of the distal roots of mandibular two-rooted second molar teeth were: type I = 93 (77.5%), type II = 7 (5.8%), type III = 8 (6.7%), type IV = 6 (5%), type V = 4 (3.3%). Two of the teeth had an unusual form that could not be classified according to Vertucci (Table 2).

Out of 13 one-rooted mandibular second molars, 8 had one canal and 5 had three canals. Out of 6 three-rooted mandibular second molars, 5 had three canals (two canals in the mesial root and one canal in the distal root) and one had four canals (two in the mesial root and two in the distal root). The prevalence of C-shaped mandibular second molars in this study was 7.2% (10 teeth); 7 teeth had one root and 3 had two roots (Figs. 1, 2, and Table 1).

Discussion

Mandibular second molar teeth have more variants than any of the molars, even though the most common configuration is the same as that of the mandibular first

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

Number of teeth, roots and percent	Number of canals				C-shaped
	1	2	3	4	
13, One-rooted (9.3%)	13	0	5	0	7
120, Two-rooted (86.3%)	0	9	89	22	3
6, Three-rooted (4.3%)	0	0	5	1	0

Table 2 Root canal configuration of the mandibular second molars

Roots		Canal configurations of the roots									Total
		I	II	III	IV	V	VI	VII	VIII	Unusal	
Mesial	Number	9	51	3	54	2	0	0	1	0	120
	Percent (%)	7.5	42.5	2.5	45	1.7	0	0	0.8	0	100
Distal	Number	93	7	8	6	4	0	0	0	2	120
	Percent (%)	77.5	5.8	6.7	5	3.3	0	0	0	1.7	100

Table 3 The number and percentage of C-shaped mandibular second molars out of 139 teeth

	Total	One-rooted	Two-rooted	Three-rooted
Number	10	7	3	0
Percent	7.2%	5%	2.1%	0

molar: one distal canal and two mesial canals.

There are different methods for studying the morphology of human permanent teeth. These include the use of radiography (11), placing files in the canals to determine the canal configuration, cutting the teeth at different levels (7), making polyester resin cast replicas of the pulp space (15), and clearing and injection of dye (16). The clearing technique is advantageous for studying the root canal anatomy because it produces a 3D view of the pulp cavity (7), and instruments are not needed to enter the pulp system (14). Therefore, this technique helps to maintain the original form of the pulp system (17). Because of the accuracy of the clearing technique, this method was used in the present study. In this sample, a large number (86.3%) of mandibular second molars had two roots (Table 1), corresponding to the results of Weine et al. (96%) (7).

With regard to the number of canals in this study, two-rooted mandibular second molars had 3 canals in 89 teeth (74.2%), 4 canals in 22 teeth (18.3%), and 2 canals in 9 teeth (7.5%). Regardless of the number of the roots, 99 teeth (71.2%) had 3 canals and 23 teeth (16.5%) had 4 canals (Table 1).

The prevalence of mandibular second molar teeth with one mesial canal was 9.1% in this study, consistent with the reports of Weine et al. (4%) (7) and Ingle (13%) (18). When two mesial canals were present; a type II configuration was observed in 42.5% of cases and a type IV configuration was seen in 45%, unlike other studies (1,18). This can be attributed to racial differences.

According to Vertucci's classification (14), in the mesial roots of mandibular second molars the prevalence of teeth with one canal in the apex was 52.5% (types I, II, III), that of teeth with two apical canals was 46.7% (types IV, V), and that of teeth with three apical canals was 0.8%. The most common configuration of the distal canal was type I (77.5%) (Table 2). The prevalence of two canals in the distal root of two-rooted mandibular second molars was 17.5% (types II, III, IV), which was different from Ingle's value (8%) (18). Ninety percent (types I, II, III) of the distal roots of mandibular two-rooted second molars had one canal in the apex, and 8.3% (types IV, V, VI) had two canals in the apex (Table 2).

In this study, a C-shaped configuration was more common in one-rooted mandibular second molars (7 out of 10). C-shaped canals were observed in 3 out of 10 two-rooted mandibular second molars. The total incidence of C-shaped canals in this study was 10 out of 139 (7.2%) (Table 3), which was less than the 44.6% reported by Jin et al. (12), 31.5% reported by Yang et al. (8), 32.7% reported by Seo and Park (19), and 19.14% reported by Haddad et al. (9). On the other hand, this is higher than the 2.7% frequency reported by Weine (7) and similar to the frequency of 7.6% reported by Weine (6) and 8% reported by Cooke and Cox (4). In view of the significant differences among the results of studies on canal configuration and the prevalence of C-shaped canals in mandibular second molars in the different parts of the world (2.7-44.6%), future studies may reveal interesting information about the canal configuration and prevalence of C-shaped canals in mandibular second molars in different ethnic populations.

The present results demonstrate that mandibular second molar teeth have many variations in the number of roots and the morphology of the canals. Therefore, it should not be assumed that mandibular second molars always have two roots and three canals. The great differences evident among studies with regard to the anatomy of mandibular second molars and the prevalence of C-shaped canals may be attributable to racial differences and study methods.

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