Root and Canal Morphology of Permanent Mandibular Incisors

Morfología de Raíz y Canal de Incisivos Molares Permanentes

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ABSTRACT: There are no studies in the literature reporting the prevalence of root canal ramifications in samples of lower incisors in the population of northern Brazil. The knowledge of the usual endodontic morphology and its possible anatomical variations is important. The aim of this study was to evaluate the prevalence of canals in the lower incisors in the population of northern Brazil using the descaling and diaphanization method. In addition, external measurements were performed and the direction of the apical foramen was observed. One hundred teeth were used for this study, and 18 % of them had two canals, with type 3 being the most prevalent, and the lowest incidence was type 5. The average length of the teeth was 18.5 mm, with 76.31 % of the teeth having a foramen that coincided with the long axis of the tooth. Prior knowledge of such changes should be considered before endodontic therapy.

KEY WORDS: root canal; incisor; endodontics.

INTRODUCTION

Comprehension of the root canal system anatomy is an essential prerequisite for endodontic treatment success. Successful endodontic treatment requires an accurate knowledge of the root canal anatomy and morphology, and that the canals are instrumented, disinfected and properly filled (de Oliveira *et al.*, 2009; Al-Fouzan *et al.*, 2012).

A lack of anatomical knowledge, as well as possible changes, can lead to inappropriate treatment and may require endodontic retreatment or surgical intervention (Kabak & Abbot, 2007). This applies to dentists who have difficulty in detecting a second canal of the lower incisors (de Almeida-Gomes *et al.*, 2011; Al-Fouzan *et al.*).

Partial bifurcation of the root canal occurs when there is a separation followed by coalescence in the apical portion, forming only one foramen. The bifurcation involves the termination of the canals in

an independent manner, in other words, presenting independent foramina (Hwang & Min, 2005; de Oliveira *et al.*).

The bifurcation of the root canal has great clinical importance during endodontic treatment. Usually, teeth with partial bifurcation that are submitted to endodontic treatment have the filling of one of the canal's sealing the end of the other canal. In contrast, in teeth with full bifurcation, where there is the presence of two foramina, one canal without filling can lead to failure of the endodontic therapy (Al-Qudah & Awawdeh, 2006; de Oliveira *et al.*).

In the literature, there is some disagreement about the anatomical configuration of the pulp cavity, as well as the incidence of a second root canal in the lower incisors (Al-Fouzan *et al.*). Among the various studies, Vertucci & Williams (1974) analyzed 300 teeth and verified the presence of two canals in 40.5 % of

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the lower incisors. Kartal & Yanikoglu (1992), in a study of 100 incisors, observed the presence of two canals in 45 % of the teeth. Miyashita *et al.*, (1997) investigated the incidence of a second canal in 1085 incisors, finding such evidence in 12.4 % of the teeth. Gencoglu (2000) noted the presence of a second canal in 29 % of 70 incisors analyzed.

Aminsobhani *et al.* (2013), using a computed tomographic method, evaluated the average root length of the lateral (21.3 ± 0.10 mm) and lower central (21.9 ± 0.13 mm) incisors, observing that most of the central and lateral incisors had one canal (72.7 % and 70.6 %, respectively). Five types of canal configurations, as proposed by the classification of Vertucci *et al.*, were observed in the evaluated teeth. The configuration Vertucci Type 1 was the most prevalent configuration (72.3 % and 70.6 %, for the central and lateral incisors, respectively). The most frequent root curvature in these teeth was distal and vestibular. Rahimi *et al.* (2013), using the method of diaphanization with India ink, found a prevalence of 36.62 % of second canals in incisors.

In view of the high prevalence of lower anterior teeth with two canals, it would be prudent to assume that any mandibular anterior tooth being treated, has two canals until proven otherwise. Clinical success in teeth with an above-normal number of canals is linked to a correct diagnosis and careful clinical examination. Variations in their anatomy should be considered before an intervention (Al-Fouzan *et al.*; de Almeida-Gomes *et al.*). To evaluate the incidence of a second canal in mandibular incisors, an *in vitro* study was conducted using the technique of decalcification and diaphanization to analyse the internal anatomy of the root canal in mandibular incisors in northern Brazil.

MATERIAL AND METHOD

The study was approved by the Ethics Committee (102014/2013). One hundred lower incisors (central and lateral) were used. The teeth included in this study had complete root formation and the root portion was intact. After cleaning the teeth, radiographs were conducted to observe the absence of nodules and/or calcifications in the pulp chamber.

The access to pulp chamber was carried out on the palatal face of tooth, with a round carbide bur (KG Sorensen, São Paulo, Brazil) at high-speed rotation,

followed by the patency of the root canals with a Kerr file. External measurements were performed with a calliper (Mitutoyo Absolute Digimatic Series 500, accuracy ± 0.02 mm, Aurora, IL, USA). Maximum and minimum values were measured, and the average value of the length of the teeth was calculated (crown and root). The orientation of the peak was observed in accordance with the long axis of the tooth. After this process, we proceeded with the technique of decalcification and diaphanization.

The teeth were immersed in 2.5 % sodium hypochlorite for 2 days, with replacement of the solution every 24 hours, with the objective of dissolving possible pulp remains present within the canals, and promoting asepsis. After that, the samples were washed in running water for 4 hours and immersed in 5 % hydrochloric acid for demineralization of teeth, with replacement of the solution every 24 hours, for 2 days. Teeth were washed in running water for 12 hours and then dried naturally. The teeth were placed in an ascending ethanol gradient (70 %, 96 % and 100 %) for 5 hours in each concentration, and then naturally dried.

India ink was mixed with colourless gelatine, prepared according to the manufacturer's instructions. The mixture was placed in previously cleaned tubes of anaesthetics, with a dental carpule syringe and needle size 30 G, the India ink was inserted into the pulp chamber until leakage was observed at the apex. The excess dye was removed from the tooth surface with an alcohol swab.

The teeth were soaked in absolute ethanol for 4 hours and then dried naturally. Finally, teeth were immersed in methyl salicylate. The diaphanized samples underwent descriptive analysis, which assessed the presence of a second canal and the type of branching present. Initially, assessment was performed using the naked eye. The analysis was then performed with the aid of a stereoscopic microscope with 10x magnification. The teeth were photographed with a stereomicroscope and digital camera. All teeth were submitted to both analysis.

The types of observed branches were distributed according to the classification of Vertucci, as used by Al-Fouzan *et al.* In type 1, there is a single canal throughout the length of the pulp chamber and root. In type 2, there is the presence of two separate canals leaving the pulp chamber; however, they are combined to form a single foramen. In type 3, one canal goes out of the pulp chamber and divides into two at the root

portion; however, they join again, creating only one foramen. In type 4, there are two separate and distinct canals present from the pulp chamber, forming independent root foramina. In type 5, there is the presence of two canals, only in the root portion, each one with an independent root foramen.

RESULTS

The specimens were examined, and the number and type of root canals was recorded. The results are

Table I. Number and percentage of teeth with one and two canals in the total sample.

Number of canals		
	1	2
N (%)	72 (72)	18 (18)

summarized in Table I.

A second canal was observed in 18 (18 %) diaphanized specimens, and there was a higher prevalence of teeth with only one canal (Fig. 1). In the configurations of teeth with two canals, the most prevalent ramification was from type 3 (17 teeth, 94.45 %). Only one tooth presented type 5 ramification (5.55 %) (Figs. 2 and 3). Types 2 and 4 ramifications were not presented. All teeth had only a single root.

The average length of the teeth was 18.5 mm (range: 17–20.5 mm). The position of the foramen, in relation to the long axis of the tooth, was 73 % central and 27 % lateral for the analyzed specimens.

Fig 1. A selected canal (type 1) of the lower incisor showing the ink inside the ink canal diaphanized tooth image.

Fig. 2. Selected two canals (type 3) of the lower incisors. Images showing India ink inside the root canals of diaphanized teeth.

Fig. 3. A selected canal (type 5) of the lower incisor showing the ink inside the ink canal diaphanized tooth image.

DISCUSSION

The knowledge of the internal root anatomy, as well as their likely variations, is crucial in endodontic therapy. Based on this, various methodologies have been employed in the study of root canals. Barker *et al.* (1969), mentioned three methods of root canal research: longitudinal cuts in bucolingual and mesodistal ways, followed by the filling of the space with wax; pulp cavity filling with radiopaque material and radiographic analysis in bucolingual and mesodistal sides; cavity filling with epoxy red resin and subsequently perform diaphanization, obtaining a three-dimensional view (Green, 1955; Barker *et al.*; Gilles & Reader, 1990; Inojosa *et al.*, 1998).

Gilles & Reader conducted a study using scanning electron microscopy to assess the number of canals present in the roots of the upper first molars. Inojosa *et al.*, intending to observe the anatomical nuances of dental elements, performed radiographs in different positions, but this method is not complete because of the limitations of radiographic images.

Okumura (1927) used the technique of diaphanization and impregnation with India ink, being the first to classify canals according to their anatomical distribution, and several researchers have adopted this approach (Hwang & Min; Al-Quadah *et al.*; Kabak & Abbot; de Oliveira *et al.*; Scarlatescu *et al.*, 2010; Alemeida-Gomes *et al.*, 2011; Al-Fouzan *et al.*).

Among the techniques used in studies evaluating the canal morphology, it has been reported that more detailed information can be obtained by

demineralization and diaphanization (Fischer, 1907; Robertson *et al.*, 1980; Vertucci, 1984; Boruah & Bhuyan, 2011). This technique provides a three-dimensional view of pulp cavity towards the outside of the tooth, proving to be useful in assessing the morphology of the root canal, as well as being simple and faster (Al-Fouzan *et al.*; Sacarlatescu *et al.*, 2010), and hence was the method applied in this study.

The literature presents several studies regarding the internal and external anatomy of the teeth, with anatomical variations in all groups. Therefore, a thorough understanding of the complexity of the root canal system is essential (Al-Fouzan *et al.*). Studies are listed in Table II for the presence of a second canal in the lower incisors.

By the analysis of these studies, it appears that there is an average of about 30 % incidence for the appearance of a second canal in the lower incisors. This study found that 18 % of our specimens showed a second canal, agreeing with the mean incidence (de Oliveira *et al.*; al-Quadah *et al.*). For a good clinical examination, the access cavity should be extended in a cervical direction so that the presence of the orifice can be observed from lingual side. One of the main reasons for the lack of success in endodontic treatment is the failure to detect the second canal, which may cause the appearance of periapical lesions and/or endodontic lesions (Barrett *et al.*, 1925; Boruah & Bhuyan; Al-Fouzan *et al.*).

Despite the occurrence of the second canal, in many cases it merges with the apical foramen forming a single canal (Vertucci; Mauger *et al.*, 1998). In the analysis by Vertucci & Williams, the presence of a

Table II. Incidence of two canals in mandibular incisors in different studies.

Investigator	Number of specimens studied	Incidence (%)	
		Central	Lateral
Fischer (1907)	36	53	
Barrett (1925)	32 + 32	25	16
Green (1955)	200	20	
Vertucci <i>et al.</i> (1974)	100 + 100	30	25
Kartal & Yanikoglu (1992)	100	45	
Miyashita <i>et al.</i> (1997)	1085	12.4	
Genconglu (2000)	70	29	
Al-Quadah <i>et al.</i> (2006)	450	26.2	
Oliveira <i>et al.</i> (2009)	200	20	
Scarlatescu <i>et al.</i> (2010)	32	34.4	
Boruah & Bhuyan (2011)	480	36.25	
Al-Fouzan <i>et al.</i> (2012)	80	30	
Aminsobhani <i>et al.</i> (2013)	632 + 614	27.3	29.

second canal was verified in 27.5 % of the 300 lower incisors analysed. Miyashita *et al.* reported that 12.4 % of the observed specimens contained two canals, however, only 3 % had independent foramina. Mauger *et al.*, evaluated the canal morphology in the different thirds of the root portion of 100 lower incisors and noted that 98–100 % of the specimens had only one apical foramen. In this study, 94.44 % of the specimens with two canals had one foramen, type 3. The preparation and filling of the canals of type 1 and 4 is relatively simple, since each canal has a conduit and distinct apex. However, for types 2, 3 and 5, there is a higher level of difficulty because they have different characteristics, since there are areas where the two canals share the same space, and others in which they are separated. The type imposes a form of treatment, requiring an individualized procedure for instrumentation, cleaning and filling (Green *et al.*; Al-Fouzan *et al.*). Among the specimens evaluated, only one had a type 5 ramification (Fig. 1).

From the analysis of external morphological data, we noted that the average length of the teeth was similar to that reported by Aminsobhani *et al.* This finding has great clinical importance at the time of selection of appropriate instruments for the root canal in order to establish the working length.

Twenty-seven roots had their apex oriented to the mesial or distal parts, whereas 73 % had an apical foramen that was coincident with the long axis of the tooth. This data points to the importance of pre-bent instruments when gauging measurements and instrumentation (de Almeida-Gomes *et al.*; Boruah & Bhuyan).

CONCLUSION

The occurrence of a second canal in the lower incisors in northern Brazil is equivalent to approximately one-quarter of the sample, with no difference between the central and lateral incisors. The average length was equivalent to what is known in the literature, and a small variation was observed in the location of the apical foramen in relation to the long axis in a few specimens. The knowledge of these modifications needs to be considered before treatment. Furthermore, careful clinical examination and radiographs will be necessary to facilitate a correct diagnosis, since the internal root anatomy does not reproduce the simplicity of the exterior.

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RESUMEN: No hay estudios en la literatura que reporten la prevalencia de las ramificaciones del canal radicular en muestras de incisivos inferiores en la población del Norte de Brasil. El conocimiento de la morfología dentaria en endodoncia y sus posibles variaciones anatómicas es importante. El objetivo del estudio fue evaluar la prevalencia de canales en los incisivos inferiores en la población del Norte de Brasil utilizando el método de descalcificación y diafanización. Además, se realizaron mediciones externas y se observó la dirección del foramen apical. Cien dientes fueron utilizados en este estudio, 18 % tenían dos canales, siendo el tipo 3 el más prevalente, y solo un diente presentó el tipo 5. La longitud promedio de los dientes fue de 18,5 mm, de los cuales en el 76,31 % de éstos se observó un foramen que coincidió con el eje longitudinal del diente. El conocimiento previo de éstas variaciones debe ser considerado antes de la terapia endodóntica.

PALABRAS CLAVE: canal radicular, incisivo mandibular, morfología.

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