Morphology study of mandibular first molars by means of four methods

Humberto Ramah Menezes de **MATOS**[1]
Aldo Angelim **DIAS**[2]
Luanni Belmino **MATROIANNI**[3]
Luciana **CASTIGLIONI**[3]
Rodrigo Ferreira Lopes Arrais **NUNES**[3]

doi: http://dx.doi.org/10.14436/2178-3713.5.1.055-062.oar

ABSTRACT

Introduction: Knowing the morphology of the pulp chamber and root canals, as well as their diversity, is key to endodontic treatment success. Mandibular molars are a group of teeth with complex internal anatomy of which knowledge is paramount. **Objective:** The objective of this study was to assess, by means of four methods (radiographic, macroscopic, microscopic and anatomical), the amount and configuration of root canals present in mandibular first molars. **Methods:** This was a cross-sectional *ex vivo*, observational and descriptive study conducted with 50 permanent mandibular first molars. The following exclusion criteria were applied: teeth with completely destroyed crowns, incomplete root formation, resorption and/or perforation, including healthy and semi-healthy crowns. **Results:** A total of 24% mandibular first molars had three root canals, with a cross-section flattened mesiodistally and elongated buccolingually to the full extent of mesial (48.6%) and distal canals (52.2%) being the most prevalent. However, other possible configurations, such as circular morphology both in mesial (46.6%) and distal canals (38.1%), and cases of five root canals (16%) could also be seen. **Conclusion:** The methods adopted allowed us to find that, in mandibular first molars, there was a prevalence of root canals flattened mesiolingually and elongated buccolingually. Three root canals were prevalent; however, variations may occur.

Keywords: Pulp cavity. Molar. Anatomy.

How to cite this article: Matos HRM, Dias AA, Matroianni LB, Castiglioni L, Nunes RFLA. Morphology study of mandibular first molars by means of four methods. Dental Press Endod. 2015 Jan-Apr;5(1):55-62.
DOI: http://dx.doi.org/10.14436/2178-3713.5.1.055-062.oar

[1]Masters student in Endodontics, Universidade Estadual de Campinas (UNICAMP), School of Dentistry, Piracicaba, São Paulo, Brazil.

[2]Assistant professor, Universidade de Fortaleza (UNIFOR), Undergraduate program of Dentistry, Fortaleza, Ceará, Brazil.

[3]Undergraduate student of Dentistry, Universidade de Fortaleza (UNIFOR), Undergraduate program of Dentistry, Fortaleza, Ceará, Brazil.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Submitted: October 11, 2014. Revised and accepted: January 30, 2015.

Contact address: Humberto Ramah Menezes de Matos
Rua Bill Cartaxo 885, casa 16 – Água-Fria – Fortaleza/CE, Brazil
E-mail: beto_meneses@hotmail.com

Introduction

Knowing the internal anatomy of teeth as well as their diversity, is key to endodontic treatment success. Using appropriate instruments to identify and explore root canals is also important and avoids recurrent infections caused by poor instrumentation, shaping and filling.

One of the main means of identifying root canals is by radiographic analysis; however, overlapping images, calcification of conduits or atresic root canals are common and hinder identification by means of this exam. Another reliable method is pulp chamber access and further pulp chamber exploration floor with a straight probe explorer. More recently, new technologies have been used to assist endodontic procedures; one of these methods is surgical microscopy, which greatly helps root canal identification, especially atresic canals.

Morphology of mandibular first molars has been analyzed by different methods.[1] It has often been associated with two roots, one mesial and another distal, and three root canals: two in the mesial root and one in the distal root.[2,3,4] However, according to Vertucci et al,[5] variations can occur, among which the most common is the presence of four root canals, two in the mesial root and two in the distal root, in 14% of cases.

Borges et al[6] reported a case of left mandibular first molar with distolingual root; a clinical situation that, according to the authors, occurs in 10% of these teeth. Fachin et al[7] reported a clinical case of mandibular first molar with three canals in the mesial root. Chandra et al[8] reported a case of mandibular first molar with two root canals in the mesial root and three root canals in the distal root. Diagnosis was confirmed by computed tomography.

The objective of this study is to assess the amount and configuration of root canals present in mandibular first molars by means of radiographic, macroscopic, microscopic and anatomical methods.

Material and methods

This is an exploratory, descriptive, quantitative, cross-sectional study. All steps were performed in laboratory with samples comprising newly extracted teeth, that is, *ex vivo*. A total of 50 permanent mandibular first molars were removed by therapeutic indication of aggressive periodontitis with major loss of clinical attachment, or orthodontic and prosthetic reasons, which are part of the detailed records of the selected patients. Inclusion criteria were: healthy teeth or teeth with carious lesions. Conversely, exclusion criteria were: teeth without coronal structure due to severe destruction, regardless of the reason for such loss; teeth with previous endodontic treatment; incomplete root formation; internal or external resorption; and perforations. The research project was submitted to Universidade de Fortaleza Ethics Committee (Coética / UNIFOR) and approved under protocol #181.388/12.

After selection, all teeth were subjected to the criteria of the respective studies (radiographic, macroscopic, microscopic and anatomical).

Radiographic evaluation

Teeth were fixed to an intraoral periapical radiographic film (Kodak Insight, USA) using wax. Subsequently, a radiograph was taken for 0.22 seconds. In order to enable all root canals to be visualized, an angle of 20º, horizontally to the mesial surface of teeth, was used, simulating Clark's method. This method corresponds to a distortion in the horizontal angle of incidence of X-ray beams so as to reduce overlap of root canal images, thus improving observation.[9] This technique reproduces what is doable during clinical care, and provides better observation of root canals.

The radiographic films were developed in a darkroom after being immersed for two minutes in a developer solution. Subsequently, the films were removed and rinsed with water for 20 seconds, and then submerged in a fixer solution for five minutes. The radiographic films were cleaned in running water for five minutes and then dried before they were evaluated on a viewing box, measuring the number of canals in each tooth. Teeth of which film was not exposed correctly or which radiographic image did not allow correct distortion were exposed again so as to correct the error and provide proper visualization.

Macroscopic evaluation

The procedure of pulp chamber access and exploration was performed by the same operator, a dental-surgeon previously trained in a pilot study conducted with the same methods applied in the present study.

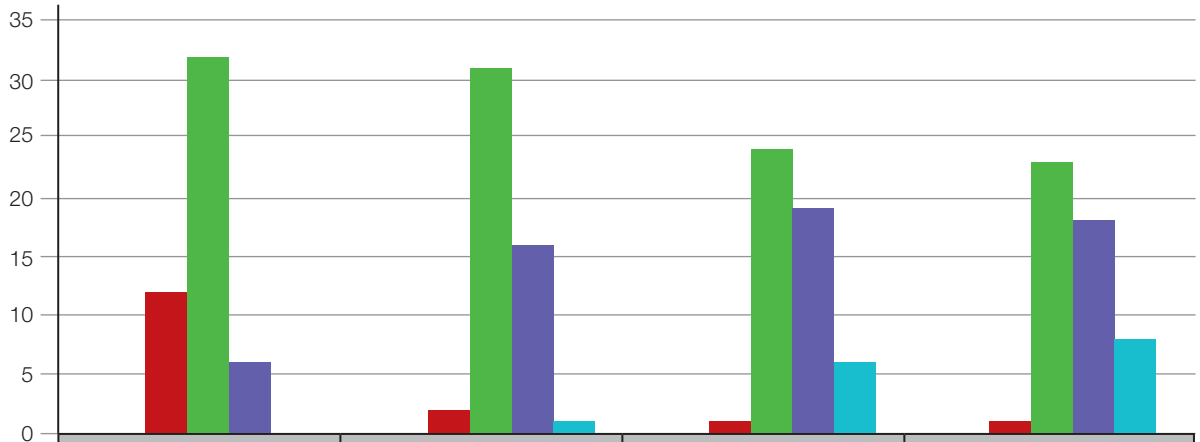
Access to pulp chamber was initially performed in healthy teeth by means of a spherical diamond tip drill #1013 (KG Sorensen Barueri, Brazil) coupled to a high-speed handpiece (Kavo Model 605C). The diamond tip was replaced for every 30 teeth so as to ensure the drill cut. An initial penetration was held in the center of the central sulcus with the drill parallel to the long axis of the tooth, giving it a contour shape according to the internal anatomy of the pulp chamber.[10] In teeth affected by carious lesion, the contour shape was determined according to the extent of caries which was removed with a spherical carbide low-speed drill (Sorensen Barueri, Brazil) compatible in size with the cavity. The drill was also replaced for every 30 teeth, and mounted on a low-speed air motor and low-speed handpiece (Kavo model 161 and model 2068, respectively).

After this procedure, the pulp chamber roof was removed and the surrounding walls rendered more occlusal with the aid of a high-speed Endo-Z bur (Dentsply Maillefer, Switzerland) in order to facilitate identification, lighting and access to the pulp chamber floor.

Once access was complete, a straight probe explorer was used on the pulp chamber floor to find all canal entries. In order to enhance visualization, a sequence of files was used to enlarge the entry of root canals, starting with files # 8 and #10 (Dentsply-Maillefer, Ballaigues, Switzerland), followed by file #15 Kerr (Dentsply Maillefer, Ballaigues, Switzerland) and then Flexofile files #20 and #25 (Dentsply Maillefer, Ballaigues, Switzerland). The files were replaced for each group of teeth. Solution of 2.5% sodium hypochlorite (Biodinâmica, Ibiporã, Brazil) was used throughout the exploration of root canals.

Microscopic evaluation

Visual magnification was performed by means of an optical microscope (DF Vasconcellos M900) which enhances visualization of the pulp chamber floor. All teeth were visualized under 16x visual magnification, which allowed root canals, which could not have been previously identified, to be viewed, and also to confirm the number of root canals more precisely.



	Radiographic examination	Clinical access	Microscopic examination	Anatomical section
One canal	0	0	0	0
Two canals	12	2	1	1
Three canals	32	31	24	23
Four canals	6	16	19	18
Five canals	0	1	6	8

Figure 1. Number of root canals in mandibular first molars.

Table 1. Percentage of root canals configuration in macroscopic evaluation of mandibular first molars.

Configuration	Mesial root n (%)	Distal root n (%)
Circular	59 (47.5%)	26 (40%)
Elliptical	5 (4%)	6 (9.2%)
Flattened	60 (48.3%)	33 (50.7%)
Total	124	65

Table 2. Percentage of the canals configuration on the phase of microscopic evaluation of mandibular first molars.

Configuration	Mesial root n (%)	Distal root n (%)
Circular	60 (46.1%)	28 (37.8%)
Elliptical	6 (4.6%)	7 (9.4%)
Flattened	64 (49.2%)	39 (52.7%)
Total	130	74

Table 3. Percentage of root canals configuration on the phase of anatomical visualization of mandibular first molars.

Configuration	Mesial root n (%)	Distal root n (%)
Circular	62 (46.6%)	29 (38.1%)
Elliptical	6 (4.5%)	7 (9.2%)
Flattened	65 (48.8%)	40 (52.6%)
Total	133	76

Microscopic evaluation without anatomic crown

In order to better identify the canals, since atresic canals are quite difficult to see, the tooth crowns were anatomically sectioned by the same operator.

The anatomical cuts of crowns were performed on the cemento-enamel junction by means of a diamond bur 2200 (KG Sorensen, Barueri Brazil) replaced for every set of teeth and mounted on a high-speed handpiece (Kavo Model 605C). After all teeth crowns had been sectioned, each tooth was stored in transparent plastic bags labeled according to the number of the tooth. Visualization and exploration with the straight probe explorer was performed under visual magnification (16x optical microscopy), thereby allowing identification of root canals that, at clinical access, could possibly not have been identified. Root canals found at this stage were subjected to exploration with the same aforementioned sequence of files.

Results

This study reveals that the number of root canals differed according to the method of evaluation (Fig 1).

Since radiographic evaluation does not assess the shape of root canals, their morphology was determined by subsequent assessments. The configuration with the highest percentage was that of root canal flattened mesiodistally and elongated buccolingually in both roots (Table 1, Fig 2).

In the third phase of study, during which visual magnification was used after accessing the pulp chamber, the percentages increased due to the higher number of canals found (Table 2).

During anatomical evaluation, some percentages remained, while others changed due to the fact that canals that could not have been viewed before ,were now found after the anatomic crown of teeth was removed (Table 3).

Discussion

The results of this study revealed a large variation involving permanent first mandibular molars, not only in the amount of root canals, but also in their configuration.

Çolak et al[11] analyzed 1,205 periapical radiographs so as to investigate the prevalence of mandibular first molars with three roots. The authors found 12 cases

Figure 2. Example of root canals flattened mesiodistally and elongated buccolingually present in most specimens studied.

(1%), only. Nevertheless, they also assert that conventional radiograph facilitates endodontic therapy, as it avoids root canals of being missed. Borges et al[6] and De Moor et al,[12] unlike the previous authors, stated that the presence of supernumerary root in mandibular first molars occurs in 10% of cases. Borges et al[6] also state that although more advanced methods, such as computed tomography, have been currently used, traditional radiographic examination is still used to detect variations. The present study corroborates the idea that radiographic examination should be complementary to clinical examination, since regardless of radiographic standardization, the images obtained hinder viewing of all root canals. Although this study did not analyze the external configuration of roots, supernumerary roots were not found.

Carvalho and Zuolo[13] conducted an *in vivo* study to assess the number of root canals in 93 mandibular first molars and 111 mandibular second molars. In the first session, pulp chamber exploration was performed with the naked eye and 641 canals were found. In the second session, visual magnification by means of optical microscopy was used and other 50 root canals were found (an increase of 7.8%). The authors concluded that the optical microscope helps one to identify root canals unseen by conventional clinical examination.

In our study, visual magnification by means of optical microscopy after clinical access and anatomical crown section also increased the amount of root canals identified in all groups. This is in agreement with previous authors, and proves that the optical microscope helps one to identify root canals unseen by conventional clinical examination.

Skidmore and Bjorndal[14] studied 45 extracted first molars and found that 93.3% had two canals in the mesial root while 28.9% had two canals in the distal root. The amount of teeth with four canals found in the present study after clinical access to the pulp chamber was 16. Magnification with the optical microscope revealed 19 mandibular first molars with four root canals. Anatomical section associated with optical microscopy revealed 18 mandibular first molars with four root canals. These findings reveal how optical microscopy helps to identify atresic and calcified root canals which could not have been revealed by traditional clinical examination alone.

Cunha et al[15] claim that most studies about the morphology of mandibular first molars do not report the possibility of presenting five canals. This is because the vast majority of researches study a small sample of teeth and present a low incidence of this variation. Fabra-Campos[16] conducted a study with 145 mandibular first molars and found four with five canals (2.75%). Baugh and Wallace[17] reported that the prevalence of mid-longitudinal canal in mandibular first molars is lower than 1-15%.

The literature reveals that the prevalence of mandibular first molars with three canals in the distal root is considered rare. Bueno et al,[18] in a case report of a mandibular first molar, stressed the importance of exploiting the region between mesiolingual and mesiobuccal canals, preferably by means of lighting, proper instruments and visual magnification, with a view to finding a fifth possible root canal. Lee et al[19] reported a case of a mandibular first molar with five root canals, in which reconstruction by computed tomography allowed more information about endodontic anatomy to be retrieved. Harris et al,[20] in a recent study on the morphology of mandibular first molars root canals carried out by means of micro computed tomography, found that 22.7% had two mesial canals while 81.8% had a single distal canal. Although the present study did not use the same methods

Figure 3. First molar with the presence of three canals in the distal root and two in the mesial root.

of the previous authors, results are similar, as this study shows a higher number of two root canals in the mesial root and of a single canal in the distal root.

In the present research, after clinical access to the pulp chamber, there was one single case of a mandibular first molar with five root canals. However, with anatomical crown section and optical microscopy, eight (16%) mandibular first molars with five root canals were found. Among the teeth with five canals, only one had two canals in the mesial root and three in the distal root (Fig 3); thus, this variation is rare.

Despite its limitations, radiographic examination should be used to assist identification of potential anatomical variations, in addition to adding the choice of resources and material used during endodontic therapy. Pulp chamber access should be accomplished so as to allow proper visualization of the pulp chamber floor in order to facilitate identification and configuration of root canals. Root canal exploration should be performed with appropriate instruments, since it is one of the most important phases of treatment. Knowing the anatomy is the result of such procedure.

Visual magnification by means of optical microscopy aids identification of atresic and calcified root canals, and is considered a tool that helps endodontic practice.

Conclusion

Based on the methods of this study it is reasonable to conclude that, in mandibular first molars, there was a prevalence of root canals flattened mesiolingually and elongated buccolingually, supposedly due to the shape of roots often flattened in the mesiodistal surface. The number of specimens with three canals was the most frequent; however, visual magnification by means of the optical microscope increased the number of four and five canals due to displaying the entry of atresic root canals.

We also highlight the importance of each examination complementing the others so as to allow general practitioners and endodontists not only to master the internal anatomy of this group of teeth, but also to identify potential variations, always with the aim of increasing endodontic treatment success rates.

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