

In vitro study of maxillary and mandibular premolars internal morphology by means of four methods

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ABSTRACT

The aim of this study was to assess, *in vitro*, and by means of four criteria (radiographic, macroscopic, microscopic and serial section), the amount and configuration of root canals in maxillary and mandibular premolars. It is a cross-sectional observational and descriptive study, in which 100 premolars were selected. Exclusion criteria comprised teeth destroyed by caries, presenting previous endodontic treatment, incomplete root formation, resorption and/or fractures. The teeth were divided into four groups ($n=25$): G1 = maxillary first premolars; G2 = maxillary second premolars; G3 = mandibular first premolars; and G4 = mandibular second premolars. Results showed that 100% in

G1 presented two root canals by macroscopic assessment, which were merged at various points of the root and had a higher prevalence of oval configuration (68%). G2 revealed 60% single root canals and oval shape (84%). The results obtained for G3 were single root and single canal (100%) and the incidence of oval configuration (72%). Finally, G4 had higher prevalence of a single root canal in single root (92%) with oval configuration (64%). Therefore, the methods used in this study revealed there was prevalence of oval root canals in all groups. Two root canals were predominant in maxillary first premolars, while in the other groups only a single root canal prevailed.

Keywords: Pulp cavity. Premolar. Endodontics.

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Introduction

Knowledge of internal anatomical variety of teeth is essential for a good endodontic treatment. The use of appropriate instruments in identifying and exploring root canals will also be an important factor for treatment success, avoiding recurrent infections due to root canals that were not instrumented, shaped and filled properly. It is noteworthy, therefore, the importance of adequate knowledge of internal morphology of the pulp chamber and root canals, and the correct operation of these to achieve success of the procedure.¹⁻³

The complexities of the internal morphology of teeth have been studied by various methods, such as diafanization, radiographs, and more recently micro-computed tomography, among other methods.⁷ The literature describes, through epidemiological studies carried out in different populations, which changes in the internal anatomy of teeth may be linked to genetic factors.⁸⁻¹⁵ Additionally, over the years, there is deposition of secondary dentine to the fullest extent of the pulp chamber and root canals, changing and hindering the mastery of the internal anatomy.¹⁵

The group of premolars has several anatomical variations such as the presence of additional root canals, deviations, longitudinal root depression, various configurations and difficulty in viewing the apical limit on radiographic examination.¹⁶ The internal anatomy of premolars usually presents with pulp chambers irregularly cubical and flat in mesiodistal direction.¹⁷

Maxillary first premolars have an incidence of 70-85% of two root canals.¹⁸ It is also found in the literature an 1-5% occurrence of three root canals.¹⁹ Maxillary second premolars present an incidence of 86.5% of only one root and can have two root canals in 47.5% of cases.²⁰

Regarding mandibular first premolars, 75% of them have a single root canal and 25% have two or more root canals.²¹ Mandibular second premolars, on the other hand, have an incidence of 58% of single root canals and 42% of two root canals.²²

The objective of this study was to assess the amount and configuration of root canals in maxillary and mandibular premolars, *in vitro*, by means of four methods.

Methods

This research is an *in vitro* cross-sectional, observational, descriptive and exploratory study. A total of 100 premolars were selected and divided into

four groups ($n = 25$): G1 = maxillary first premolars; G2 = maxillary second premolars; G3 = mandibular first premolars; and G4 = mandibular second premolars. All teeth were extracted and stored in saline solution until the time they were used. They were extracted due to therapeutic indication of aggressive periodontal disease with significant clinical attachment loss, or due to orthodontic or prosthetic reasons of which detailed history was part of patient's records.

Inclusion criteria were as follows: healthy teeth or teeth presenting minor restorations, patients of both genders, regardless of age or pathological condition or clinical reason that generated the extraction (periodontal, prosthetic or orthodontic indication).

Exclusion criteria were as follows: teeth without anatomical crown due to severe destruction, teeth with previous endodontic treatment, incomplete root formation, resorption and/or fractures.

The research project was submitted to the Ethics Committee for Research in Humans at *Universidade de Fortaleza* (UNIFOR) and was approved under registration #559 376 on March 11th, 2014.

Radiographic evaluation

The first criterion to which teeth were subjected was the radiographic one. Teeth were secured with utility wax to the periapical radiographic film (Kodak Insight). Subsequently, a radiograph was obtained during 0.24 seconds. To enable all root canals of teeth to be seen, a slight mesial distortion was used horizontally to simulate Clark's technique. The latter corresponds to a change in the horizontal angle on the incidence beam of x-rays to lessen the overlap of root canals images, thus improving visualization. This technique reproduces what it is possible to be done during clinical care, therefore, providing a better view of root canals present.

The development process of films was carried out in a darkroom, with film being sensitized for two minutes in the developer. After removal, a bath with water was performed and then the films were fixed for five minutes. Radiographs were bathed in running water and allowed to dry for only then be evaluated in a specific device (light box). The teeth of which film was not exposed correctly or of which radiographic image did not allow for correct distortion were exposed again in order to have the error corrected and provide adequate image view.

Macroscopic evaluation

Initially access to the pulp chamber of evaluated teeth was carried out using a diamond bur #1012 KG (Sorensen, Barueri, Brazil), coupled to a high-speed turbine. Initial entering was performed in the center of the central sulcus with the drill perpendicular to the long axis of the tooth, thus giving a contour shape according to the internal anatomy of the pulp chamber.

In teeth with carious lesion, the contour shape was associated with the extent of carious tissue, being removed with low speed KG spherical carbide drill (Sorensen, Barueri, Brazil), and mounted on the micromotor handpiece. After this procedure, pulp chamber roof was removed with the help of Endo-Z bur at high-speed (Dentsply Maillefer, Switzerland) in order to facilitate viewing, lighting and direct access to the pulp chamber floor. The entire access procedure and operation of the pulp chamber were run by the same operator.

After access, with the aid of a straight explorer probe, the floor of the chamber was assessed in order to find all root canals openings present. To improve visualization of root canals found, a sequence of files was used to enlarge the opening of root canals, starting with files of the special series #8 and #10 in narrow root canals, followed by K-file #15 (Dentsply Maillefer, Ballaigues, Switzerland) and then up to Flexofile #20 and #25 (Dentsply Maillefer, Ballaigues, Switzerland), with instruments changed for each group of teeth.

Microscopic evaluation

Visual magnification was conducted using a clinical optical microscope (DF Vasconcellos M900) which allowed for better visualization of pulp chamber floor. Therefore, all teeth were examined in the area of the pulp chamber floor under 16x magnification, so as root canals that were not identified could also be viewed, and also to confirm a more precise amount of root canals.

Serial sections

For the manufacturing of sections, a carborundum disk mounted on a straight piece mandril which, in turn, was coupled to the microengine at low speed, was used. The section was made below the crown-root junction of the tooth. After all teeth had been sectioned, visualization and operation with the straight probe were performed under visual magnification (optical microscopy under 16x magnification), allowing identification of root canals that could not possibly be seen during clinical access.

After sectioning of the cervical third, a section was made in the middle third of the root to check whether root canals remained separated or joined, in addition to checking the configuration they presented. Visual magnification was used with those purposes. The last operative stage was root canals assessment with files of the special series #8 and #10, using the microscope to check how many apical foramen each tooth had.

Results

According to the methods used, there was a difference in the amount of root canals found, as well as in their configuration depending on the stage carried out in the four groups of teeth examined (Tables 1, 2 and 3).

Table 1. Number of root canals in maxillary first premolars (1), maxillary second premolars (2), mandibular first premolars (3) and mandibular second premolars (4). Radiographic, macroscopic, microscopic, as well as serial section in the cervical third and middle third assessments.

	1		2		3		4	
Amount of root canals	1	2	1	2	1	2	1	2
Radiographic	36%	64%	96%	4%	100%	-	96%	4%
Macroscopic	-	100%	100%	-	92%	8%	100%	-
Microscopic	-	100%	92%	8%	88%	12%	96%	4%
Section in cervical 1/3	20%	80%	88%	12%	100%	-	92%	8%
Section in middle 1/3	-	100%	60%	40%	96%	4%	92%	8%

Table 2. Configurations of the root canals of maxillary first premolars (1), maxillary second premolars (2), mandibular first premolars (3) and mandibular second premolars (4). Macroscopic, microscopic, as well as serial section in the cervical third and middle third. Classification: circular canal (CC); oval canal (OC); flat canal (FC).

	1	2	3	4
Macroscopic	8% CC	32% CC	40% CC	44% CC
	64% OC	44% OC	44% OC	48% OC
	28% FC	24% FC	16% FC	8% FC
Microscopic	16% CC	28% CC	32% CC	40% CC
	44% OC	40% OC	56% OC	52% OC
	40% FC	32% FC	12% FC	8% FC
Section in cervical 1/3	0% CC	16% CC	28% CC	32% CC
	68% OC	84% OC	72% OC	64% OC
	32% FC	0% FC	0% FC	4% FC
Section in middle 1/3	64% CC	24% CC	32% CC	48% CC
	28% OC	68% OC	68% OC	52% OC
	8% FC	8% FC	0% FC	0% FC

Table 3. Number of foramina of maxillary first premolars (A), maxillary second premolars (B), mandibular first premolars (C) and mandibular second premolars (D).

	A		B		C		D	
Amount of foramina	1	2	1	2	1	2	1	2
	-	100%	68%	32%	92%	8%	92%	8%

Discussion

The methods used in this study revealed that during macroscopic evaluation 100% of maxillary first premolars were found with two root canals, with the same result confirmed by microscopic analysis. In radiographic evaluation, 64% of premolars presented with two root canals, while 36% presented with a single root canal, probably due to radiographic overlap.

With serial sections (sections carried out in cervical and middle thirds) some percentage of variations on the amount and configuration of root canals was observed, with predominance of two root canals with oval shape in the cervical third (68%) and with circular shape in the middle third (64%). This can be explained by the fact of maxillary first premolars presenting a mesiodistal flattening of the root in the cervical third, while in the middle and apical thirds the root is more rounded.^{19,23}

Similarly, Oliveira et al¹⁸ reported the existence of high incidence (50%) of maxillary first premolars with two root canals, when compared with studies conducted by different authors in different samples of different populations. They found on average 70% to 85% of maxillary first premolars with two root canals.

Regarding the results in maxillary second premolars, 96% and 100% of teeth had one root canal according to radiographic and macroscopic assessments, respectively. Cervical third sections revealed an incidence of only one root canal in 88% of cases and two root canals in 12% of cases. However, middle third section revealed only one root canal in 60% of cases and two root canals in 40% of teeth studied, suggesting that root canals may diverge in their path. There is a predominance of oval canals in 84% of teeth.

According to Yang et al,²⁰ in their study with 339 maxillary second premolars, 86.5% had only one root, and within this group, 54.3% had two root canals.

The present study showed that radiographic assessment revealed there was only one root canal in 100% of cases of mandibular premolars. Macroscopic assessment showed that 92% of mandibular first premolars had one root canal, but visual magnification (microscopic assessment) revealed this incidence decreased to 88%, thus confirming greater efficiency and better view of root canals when the optical microscope was used.

With cervical third section, 100% of teeth showed one root canal. Middle third section, on the other hand,

revealed 4% of teeth had two root canals, demonstrating this group of teeth has significant changes in the middle and apical thirds. In all evaluations, the oval shape of the root canals was predominant.

According to the literature, about 75% of mandibular first premolars have a single root canal and 25% have two or more.²¹

The last group of the present study consists of mandibular second premolars. In this group, there was a predominance of only one root canal (92%); however, 8% of teeth had two root canals after assessment with cervical third section. Oval root canals were predominant in all assessments of this group.

Singh and Pawar²² conducted a research with 100 mandibular second premolars and found that 92% had a single root, and 8% had separate or merged roots. On the number of root canals, they found 58% had a single root canal while 42% had two root canals. They also analyzed 100 maxillary first premolars and 100 maxillary second premolars, and found 82% had a single foramen and 16% had two foramina in the group of maxillary first premolars. In the group of maxillary second premolars, the authors found 88% of teeth had a single foramen and 12% had two foramina.²²

Knowing the conformation of root canals is important because during biomechanical preparation, oval and flattened root canals should be subjected to more thorough mechanical instrumentation. Brushing movements should be performed against the walls and bioactive solutions should be used for proper disinfection of the root canal system.^{24,25}

The present study also showed that two foramina were seen in 100% of maxillary first premolars. In the group of maxillary second premolars there was a decrease in the amount of two foramina, occurring in 68% of cases, and an increase in the existence of a single foramen, with a percentage of 32%. As for mandibular first and second premolars, the amount of foramina (92% with a single foramen; 8% with two foramina) was the same.

Conclusions

Based on results obtained, it was possible to conclude that the configuration and amount of root canals in maxillary and mandibular premolars varied in each assessment of this study.

Radiographic assessment revealed the most frequent number of root canals was found to be one canal in the group of mandibular first premolars (100%), and two root canals in maxillary first premolars (64%). There was a trend of increasing the number of root canals as assessments advanced, reaching all (100%) maxillary premolars with two root canals in macroscopic, microscopic and middle third section evaluations. However, a modest increase in the amount of root canals was also observed in other dental groups. Variation in the amount of root canals found by cervical and middle thirds section examination may be due to fusion or separation of root canals along the root.

The predominant configuration of root canals in the four groups was the oval conformation, probably due to flattening in the mesiodistal direction of these teeth. High rates of this configuration ranging between 64 and 84% were found in the cervical third section assessment. The group of maxillary first premolars showed the highest prevalence of root canals with flat conformation (40% in the microscopic phase) because of the presence of two roots, buccal and palatal, that can merge in any region of the root.

In the four groups studied, the presence of circular root canals was observed with the highest rates during analysis of middle third sectioning of the root.

The highest prevalence of teeth with root canals ending in two foramina was of maxillary first premolars, with 100% of cases; followed by the maxillary second premolar group, with 32% of studied teeth. In contrast, the mandibular premolars groups had similar percentages of 92% and 8% of root canals ending in one and two apical foramina, respectively.

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