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Original research

EVALUATION OF THE APICAL SEALING ASSOCIATED WITH MAXILLARY FIRST MOLARS RADICULAR MORPHOLOGY USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Objectives: To evaluate the grade of apical sealing associated with the root morphology of maxillary first molars with conventional endo-treatments using cone bean computed tomography (CBCT).

Materials and Methods: The sample included 47 CBCTs. Evaluations were performed independently by one previously trained and calibrated examiner. The grade of apical sealing was evaluated (total sealing, less than 2 mm of sealing, greater than 2 mm unsealed, unsealed and oversealed). Molar angulation according to the palatal plane and the longitudinal axis (vertical, vestibular and palatal), the number of canals, the presence or absence of a second mesiobuccal canal (MB2) and root shape (straight, curved, bayonet, angled, merged, bifurcated) were also assessed. Statistical analysis was performed using the Chi-square test.

Results: There were no differences in apical sealing according to root morphology, shape and molar root inclination ($p>0.05$). A significant association was reported between the presence of MB2 and a buccal inclination of the maxillary first molar ($p = 0.048$).

Conclusions: Root morphology and molar angulation did not affect the apical sealing of maxillary first molars. However, the presence of the MB2 was associated with a buccal inclination of the maxillary first molar.

Keywords: Cone-beam CT, root canal obturation, molar, dental pulp cavity.

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INTRODUCTION

Endodontic treatment success can be evaluated clinically and radiographically and by the remission of pathological processes.[1] The persistence of symptoms is often due to different causes such as the presence of non-located canals, or incompletely sealed canals, anatomical variations that determine a complicated morphology of root canals, or the presence of supplementary canals.[2] Adequate knowledge of root morphology is the main factor of success of conventional endodontic treatment. Baratto *et al.*[3] reported that first upper molars present three or four canals. With the use of cone beam computed tomography (CBCT), Pécora *et al.*[4] analysed the internal anatomy of maxillary first molars, reporting a frequency of 37% of four canals.

Many factors can affect the endodontic treatment success[5], the most crucial apical sealing.[6] Correct apical sealing is based on adequate root canal obturation to prevent the recurrence of bacterial infection.[7] Microleakage between the root canal and periapical tissues is hindered leading to death of any surviving microorganisms.[8] This should ensure optimal sealing in all dimensions blocking apical or lateral communication with the periodontium. Incomplete or nonexistent filling of a root canal by ignoring its presence is the main causes of endodontic treatment failure.[9]

Endodontic treatment success requires knowledge of the anatomy and morphology of the dental canalicular system, and clinicians must be prepared to identify all teeth showing an unusual anatomical configuration.[10] One aspect of canal configuration that has shown to have an important impact on instrumentation is canal curvature. The amount of curvature of a root canal affects access for instrumentation and also the risk of instrument separation. It is in this context that the high sensitivity and specificity of CBCT allows identification of the presence of additional canals, especially the second mesiobuccal canal (MB2) frequently present in maxillary first molars.[3,11]

The aim of this study was to evaluate the condition of apical sealing in relation to the root morphology of maxillary first molars with conventional endo-treatments using CBCT.

MATERIALS AND METHODS

The study was approved by the Ethics Committee of the Universidad Científica del Sur (Approval No. 000261). The material was selected from a series of records from a private Dental Imaging Center (CDI Diagnostic Imaging Center, Lima, Peru) between January 2018 and December 2019. The study population was composed of 47 CBCTs scans (32 women and 15 men) in which the condition of apical sealing in relation to root morphology (root divergence, root shape, root width, number of canals) were evaluated. The sample size was calculated using the Open Epi statistical software http://openepi.com/SampleSize/SSPropor.htm, automatically generated with a population size of 100, confidence level of 95%, frequency of outcome factor in the population of 25%, confidence limits d = 10%. We obtained a sample size of 43, however we obtained 47 CBCTs with endodontic treatment in the upper first molar. In addition, sex, molar angulation (vertical, vestibular, palatine) and the presence or absence of the MB2 canal were evaluated.

Inclusion criteria comprised CBCTs presenting conventional endo-treatments, excluding CBCTs of patients with radicular fractures, excessive destruction of tooth structure, pathological processes and CBCT images distorted by patient movement.

CBCT Data acquisition

All tomographic images were taken using a Picasso Master 3D, (Vatech Hwaseong, South Korea), with 8mA and 90 Kv. The field of view (FOV) was 20 x 19 cm and the voxel size was 0.4 mm with an exposure time of 20 seconds. The patient was positioned correctly with the teeth in maximum intercuspation. Digital Imaging and Communications in Medicine (DICOM) images were examined with a 3D imaging software (3D Viewer, EzImplant, version 1.5.8265.1, South Korea). Images were viewed in a dimly lit room on an 14-inch laptop screen (AMD E -300 APU Radeon ™, Lenovo, China) set at a screen resolution of 1366 × 768 pixels.

Measurements

Evaluation of apical sealing was performed using sagittal and coronal reconstruction for the mesial, distal and palatal root and considering five categories: complete sealing, sealed less than 2

mm; unsealed greater than 2 mm; unsealed and overfilled root canal treatment in relation to the apical foramen (Figure 1).

Figure 1. Linear measurement of apical sealing from the top of the endodontic material to the limit of the apex.

Molar inclination (vertical, vestibular and palatal) was evaluated by a coronal tomographic slice. This view allowed determining the direction drawing a line on the horizontal planes of the palatine bones with the apex toward the longitudinal axis of the tooth (Figure 2).

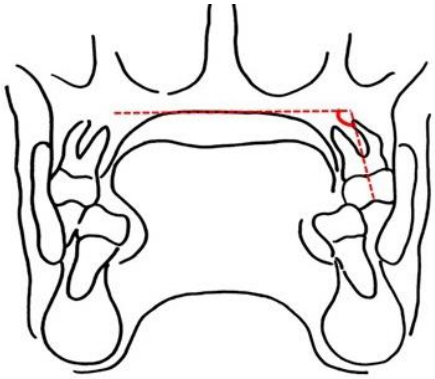

Figure 2. Coronal view of the measurement of the angle between the longitudinal axis of the tooth and the palatal plane.

The number of canals was determined in successive axial sections in the anoccluso-apical direction (Figure 3).

Figure 3. Axial view showing the presence of three canals at the cemento-enamel junction level. One of the canals has no endodontic treatment and the other two are completely sealed.

This allowed visualization of the MB2 (present/absent) (Figure 4).

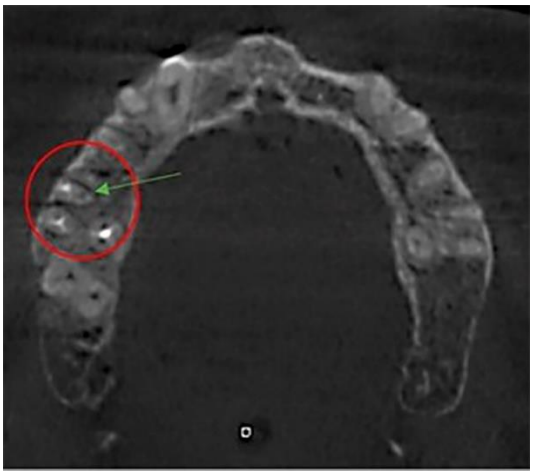

Figure 4. Axial view showing the presence of the MB2 without proper sealing at the cemento-enamel junction level.

The shape of the root structure was examined (straight, curved, bayonet, angled, merged and bifurcated). The mesial and distal root was assessed in the sagittal view. The palatal root was determined in a coronal section. All the evaluations were performed taking into account the longitudinal axis of the maxillary first molar.

Calibration

The intra-examiner calibration phase was analysed using the intra-class correlation coefficient (ICC) for quantitative variables (> 0.9). For qualitative variables such as apical sealing and molar inclination, the Kappa statistical test was used (0.722 –1). All measurements were performed over a two-week interval. A pilot study was performed to calculate the sample size using 15 CBCTs to evaluate the condition of the apical sealing of maxillary first molars and to determine root morphology, molar angulation and the presence or absence of MB2.

Statistical analysis

The statistical analyses were performed using SPSS for Windows (version 22.0; SPSS, Chicago III). Normality was evaluated by the Shapiro Wilk test. Two groups presented normality and the Student's t-test was used. When normality was not obtained for the other groups, the Mann Whitney U-test was used. When more than 3 groups obtained normality the ANOVA test was selected and non-parametric groups were analysed using the Kruskal-Wallis test. Associations were determined

with the Chi-square test. P <0.05 was considered to indicate statistical significance.

RESULTS

Apical sealing according to root morphology did not show any statistically significant differences (p>0.05). In most cases the apical sealing was found to be > 2 mm. The presence of MB2 versus root shape is described in Table 1.

Table 1. Association between the presence of the MB2 canal and shape of the mesial root

Root shape	Presence of MB2		Total n (%)
	Presence n (%)	Absence n (%)	
Straight	0 (0.0)	9 (100)	9 (100)
Curve	3 (7.9)	35 (92.1)	38 (100)
Total			47 (100)

Chi-square test p=0.384

Root morphology was straight in the group in which the MB2 was absent (100%). Furthermore, the performance of apical sealing associated with molar inclination is described in Table 2 showing that palatal molar inclination of the mesiobuccal and distobuccal canal was observed in 55.6% of the group sub-obturated > 2 mm.

Table 2. Association between sealed apical canal and maxillary first molar angulation

Canal	Molar angulation	Measurement	Complete sealing	Sealed < 2mm	Unsealed >2mm	Unsealed	Overfilled	Total	p
Mesiobuccal canal	Vertical	n	7	6	15	1	0	29	0.913 †
		%	24.1	20.7	51.7	3.4	0	100	
	Buccal	n	2	3	4	0	0	9	
		%	22.2	33.3	44.4	0	0	100	
	Palatal	n	3	1	5	0	0	9	
		%	33.3	11.1	55.6	0	0	100	
Distobuccal canal	Vertical	n	8	9	9	3	0	29	0.692 †
		%	27.6	31	10.3	0	0	100	
	Buccal	n	2	1	4	2	0	9	
		%	22.2	11.1	44.4	22.2	0	100	
	Palatal	n	1	2	5	1	0	9	
		%	11.1	22.2	55.6	11.1	0	100	
Patalal canal	Vertical	n	8	7	11	2	1	29	0.950 †
		%	27.6	24.1	37.9	6.9	3.4	100	
	Buccal	n	2	3	3	1	0	9	
		%	22.2	33.3	33.3	11.1	0	100	
	Palatal	n	4	2	3	0	0	9	
		%	44.4	22.2	33.3	0	0	100	

† Chi-square test

Total sealing of the palatal canal was obtained in 44.4%. The chi-square test showed no significant values in these associations (p>0.05). However, the presence of the MB2 showed a statistically significant association with maxillary first molar inclination (p = 0.048) between the presence of the MB2 and a vestibular molar inclination in 22.2% of the cases. The MB2 was absent in 77.8 % of the vestibular inclined molars (Table 3).

Table 3. Association between the presence of the MB2 canal and maxillary first molar inclination.

Molar Inclination	**Presence of MB2**		**Total n (%)**
	Presence n (%)	**Absence n (%)**	
Vertical	0 (0.0)	29 (100)	29 (100)
Buccal	2 (22.2)	7 (77.8)	9 (100)
Palatal	1 (11.1)	8 (88.9)	9 (100)
			47 (100)

Chi-square test p=0.048

DISCUSSION

The success of endodontic treatment is dependent on hermetically cleaning, shaping and filling the root canal system and achieving an adequate coronal seal.[12-13] Therefore, the technical quality of the root filling is an important factor in treatment success.[14] Root canal morphology evaluation is difficult, considering that the apical root canal is often conical, with multiple parallel walls or narrowing of apical sites.[15] This is why the use of CBCT is gaining importance in the diagnosis of root canal morphology. Intra- observer calibration was conducted over a period of two weeks, using kappa statistical analysis for each qualitative variable, and ICC for quantitative variables. Both methods obtained good results ensuring the reliability of the study.

This study evaluated morphological variation in order to determine associations between morphology and apical sealing. Although total sealing of the duct is ideal, it is common to find sealing less than 2 mm. While this sealing is allowed and guarantees the success of the treatment, the presence of unsealed ducts, sealing > 2 mm or oversealing results in ineffective treatment. Most of the cases in our sample presented an unsealed canal or an overfilled root canal treatment, leading to a high risk of endodontic treatment failure because bacteria can colonize the root canal. On radiographic examination, good root filling should ideally follow the continuous taper form of the prepared root canal from the coronal aspect to the apex, have no voids between the root filling and canal walls and have an optimal distance of 0.5 to 2 mm from the radiographic apex.[16] However, there is much discussion about the exact ending point of root canal treatment. Incomplete detection of all the root canals leading to untreated canals has been reported as a major cause of failure in root canal therapy. [17] According to Sjogren *et al*.[18] the apical sealing limit of root canals is more critical than the technique or sealant used. When the obturation reached 0 to 2 mm from the radiographic apex, 94% of clinical success was achieved while when the dimension was greater than 2 mm, the success this rate was reduced to 68% and 76% when the canal was overfilled. In addition, the success rate for retreatment therapy of properly sealed canals was 67%, whereas for deficient root canal sealing the percentage decreased to 31%. These findings reinforce the importance of correct apical endodontic sealing.

Other clinical studies have been conducted using magnification equipment, such as magnifying loupes and microscopes, and describing the presence of the MB2 canal in the maxillary first molar.[19] Although this is useful for locating the MB2 canal, magnication systems present limitations, such as a limited view, showing only the entrance foramen of the MB2 canal. In cases of inclined or rotated molars, magnification becomes less effective, since a severe to moderate angulation of the tooth prevents a good view of the cavity floor. Finally, equipment costs and operator training are important factors that limit the use of magnification. These limitations are currently overcome through the use of CBCT, a simple

diagnostic technique.

In relation to the MB2 and our findings, the literature reports a variety of information. Cleghorn *et al.*[20] reported that the incidence of two canals in the mesiobuccal root was 56.8%, being 43.1% for one canal, among the studies reviewed. Abuabara *et al.*[21] found a similar result reporting 62% of MB2. Another study that identified two MB2 in 48.2% of the maxillary first molars was performed in an Indian population.[22] Two similar studies conducted in Chinese populations detected MB2 canals in 52% of the teeth.[23,24] Other authors have compared the ability of CBCT to detect MB2 canals with clinical sectioning and reported no statistically significant differences.[25,26]

Shenoi *et al.*[27] analysed MB2 configuration by CBCT, reporting 80% of MB2 identification, of which 54.16 % were in the coronal third, 29.16% in the middle third and 16.66% were in the apical third. A significant association was found in our study between the presence of the MB2 and the buccal inclination of the maxillary first molar, while no other study has reported these results. This is a clinically important morphological finding that should be further investigated in larger samples in other types of populations.

CONCLUSIONS

Root morphology and molar inclination do not affect the apical sealing of maxillary first molars. However, we found that the presence of the MB2 was associated with the buccal inclination of the maxillary first molar.

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CONFLICTS OF INTEREST STATEMENT

None.

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