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Apical periodontitis in endodontically-treated teeth: association between missed canals and quality of endodontic treatment in a Colombian sub-population. A cross-sectional study

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ABSTRACT

A high prevalence of post-treatment apical periodontitis associated to variables such as endodontic treatment quality and missed canals has been reported. ***Aim:*** *The aim of this study was to evaluate the quality of endodontic treatment and the frequency of missed canals associated with teeth with apical periodontitis (AP) through CBCT in a Colombian sub-population.* ***Material and Method:*** *This was a cross-sectional study assessing 318 cone beam computed tomography (CBCT) scans of endodontically treated teeth from Colombian individuals. The scans were taken using J Morita X550 (J Morita Corporation, Osaka, Japan), with voxel size 0.125 to 0.20 mm. All endodontically treated teeth were assessed for quality of treatment, presence of missed canals and AP. All samples were analyzed by two endodontics specialists and an radiology specialist. Chi-square or Fisher's test and odds ratio were calculated to identify the association and risk relationship between the presence of AP and the study variables.* ***Results:*** *Missed canals were found in 18.61% (86/462), and 95.3% were associated with AP. The frequency of AP was 62.34% (288/462) for all the evaluated teeth. AP was found in 27.43 % (79/288) of the teeth with adequate endodontic treatment, in contrast to 72.57% (209/288) of the teeth with inadequate treatment (P<0.01). The frequency of missed canals was highest in maxillary molars, with 55.23% (58/105), with 96.55% presenting AP. The second mesiobuccal canal was the most frequently missed canal, 88.52% (54/61), with AP in 90.74% (49/54) of the cases.* ***Conclusion:*** *There was a high frequency of teeth with missed canals and PA. More than half of the teeth with missed canals were maxillary molars, with MB2 being the most common canal, commonly presenting apical periodontitis.*

Keywords: *apical periodontitis - cone-beam computed tomography - cross-sectional study - endodontically treated teeth.*

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Periodontite apical em dentes tratados endodonticamente: associação entre canais não localizados e qualidade do tratamento endodôntico em uma população colombiana: Um estudo transversal

RESUMO

Uma alta prevalência de periodontite apical pós-tratamento associada a variáveis como qualidade do tratamento endodôntico e fracasso do tratamento é relatada na literatura. O objetivo deste estudo foi avaliar a qualidade do tratamento endodôntico e a frequência e fracasso do tratamento associados a dentes com periodontite apical (PA) por meio de tomografia computadorizada de feixe cônico (TCFC) em uma subpopulação colombiana. ***Material e Método:*** *Este foi um estudo transversal que avaliou 318 tomografias computadorizadas de dentes tratados endodonticamente de indivíduos colombianos. Os exames foram realizados utilizando o tomógrafo J Morita X550, com tamanho de voxel de 0,125 a 0,20 mm. Todos os dentes tratados endodonticamente foram avaliados quanto à qualidade do tratamento, presença de canais não localizados e AP. Todas as amostras foram avaliadas por dois especialistas em endodontia e um especialista em radiologia. Foram calculados o teste qui-quadrado ou de Fisher e a razão de chances para identificar associação e relação de risco entre a presença de PA e as variáveis do estudo.* ***Resultados:*** *Foram encontrados canais não localizados em 18,61% (86/462) e 95,3% estavam associados à PA. A frequência de AP foi de 62,34% (288/462) para todos os dentes avaliados. AP foi encontrada em 27,43% (79/288) dos dentes com tratamento endodôntico adequado, em contraste com 72,57% (209/288) dos dentes com tratamento inadequado (P<0,01). A frequência de canais não localizados foi maior nos molares superiores, com 55,23% (58/105), sendo que 96,55% apresentavam PA. O canal mésio-palatino (MB2) apresentou maior frequência de canal não localizado (88,52% - 54/61), com PA em 90,74% (49/54) dos casos.* ***Conclusão:*** *Houve alta frequência de dentes com canais não localizados e com PA. Mais da metade dos dentes com canais não localizados eram molares superiores, sendo o MB2 é o canal com a maior frequência, comumente apresentando periodontite apical.*

Palavras-chave: *periodontite apical - tomografia computadorizada de feixe cônico - estudo transversal - dentes tratados endodonticamente.*

INTRODUCTION

Apical periodontitis (AP) is an inflammatory condition of periapical tissues, and one of the most common infectious diseases in the world[1-3]. When the root canal treatment fails, post-treatment AP may set in or persist and lead to tooth loss. Persistent, secondary, or extra-radicular infections are the leading causes of endodontic treatment failure[2,3].

Epidemiological studies have traditionally used periapical and panoramic radiographs to follow up endodontic treatment and determine possible variables associated with post-treatment AP. However, these radiographic examinations have limitations such as the superimposition of the overlying anatomy, the two-dimensional nature of the image, and the geometric distortion[4]. These deficiencies have been partly overcome by cone-beam computed tomography (CBCT) due to its high sensitivity to assess three-dimensional changes in dental tissues and supporting structures[5], the quality of endodontic fillings, and hypodense bone lesions. It can also be used to evaluate different visual planes with slices as thin as 0.5 mm or less[6].

Recent epidemiological studies using CBCT in Scotland, Brazil, France, Belgium, Germany, and Portugal confirmed the high prevalence of post-treatment AP, ranging from 40.8% to 55.5%[7-12]. In addition, a systematic review and meta-analysis of cross-sectional studies showed that 41.3% of endodontically treated teeth had post-treatment AP, on average. AP was significantly more frequent in teeth with both inadequate endodontic treatment and poor coronal restoration[13].

A risk factor for post-treatment AP is the inability of the clinician to locate all the root canals. Missed canals may harbor enough bacteria to maintain or lead to apical periodontitis. Even when initially uninfected, a missed canal becomes a susceptible site for infection[14]. Studies conducted in North America, Brazil, Portugal, and Saudi Arabia have reported a strong association between a missed canal and the presence of AP, with frequencies ranging from 12% to 23%, and 2.57 to 6.25 times more risk of presenting AP than teeth in which all canals have been treated[14-18]. However, these studies focused mainly on the missed canal variable, which could be considered a selection bias, given the greater number of teeth with AP in which all canals were treated[19].

It is not clear whether the presence of a missed canal would remain statistically significant in a multivariate analysis with a large set of variables, including those known to have a significant impact on treatment prognoses, tooth type, and quality of endodontic treatment[19]. Considering this context and the limited number of studies in the Latin American population, the present study evaluated the relation between the quality of endodontic treatment and the frequency of missed canals associated with teeth presenting AP through CBCT in a Colombian sub-population. The frequencies were determined for all tooth types.

MATERIALS AND METHOD

This research was conducted under the principles established by Resolution 08430 of the Government of Colombia and approved by the Ethics Committee of Santo Tomás University.

A cross-sectional study was conducted. A database of 1100 CBCT scans of Colombian individuals (n=318: 190 females and 128 males) was analyzed. Scans showing at least one endodontically treated tooth and voxel size between 0.125 and 0.20 mm were selected (594), while scans not showing endodontic treatment (472) or with voxel size greater than 0.20 mm (34) were excluded. Of the 594 selected scans, 276 were discarded due to artifacts, teeth without coronal restoration, or teeth with intra-radicular retainer, apical surgery, root fracture, perforations or resorption, leaving 318 CBCTs for study (Fig. 1). The CBCTs were obtained from two private radiology centers, one in Bucaramanga and another in Medellin. The scans were taken between June 2017 and June 2020, using two J Morita X550 CBCT Scanners (J Morita Corporation, Osaka, Japan): 127V, 50/60 Hz and 4 A panoramic X-ray,

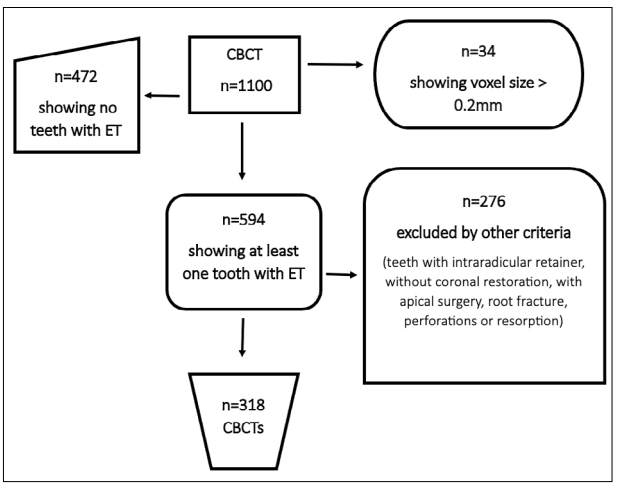

Fig. 1: Flowchart of the sample selection process.

and three different FOV sizes: small (up to 5 cm), single arc (5 to 7 cm), and inter-arc (7 to 10 cm)[20]. The I-Dixel One volume viewer software (J. Morita) was used. The tomographic images included in the database were requested for reasons beyond the scope of this research.

All dental types were evaluated. In multirooted teeth, each root was evaluated independently, centered, and aligned in sagittal and coronal planes, obtaining the most centered image to determine treatment quality based on the following criteria: Adequate Endodontic Treatment (AET), apical obturation limit between 0-2 mm from the root apex, and homogeneous compaction of filling mass; or Inadequate Endodontic Treatment (IET), apical obturation ending more than 2 mm from the apex or extruded gutta-percha, or poorly compacted root canal filling[21]. Missed canals were considered when there was a hypodense image, similar to a root canal, but without evidence of filling material, crossing the tooth root vertically, from the cervical region to the root apex[15], and they were also classified as IET[11].

AP was defined according to the cone-beam computed tomographic-endodontic radiolucency index (ERI), as a hypodense zone associated with the root apex greater than 0.5 mm in a coronal-sagittal view; length measured in millimeters in the vestibule-palatine or lingual direction and the mesial-distal direction, tracing a perpendicular from the root apex to the upper limit of the radiolucent area in its greatest extension[6].

Two endodontic specialists independently analyzed all samples. An oral and maxillofacial radiology specialist decided on discordant cases to identify the quality of the ET, the presence of missed canal, and the presence of AP. The observers' accuracy in detecting missed canals and AP was initially gauged with a pilot test of 100 images and using Cohen kappa intra and inter-evaluator reliability tests[22], the kappa concordance coefficient obtained was higher than 90% intra-evaluator and between 95.34 and 96.1% inter-evaluator for both evaluators, a satisfactory data reliability result.

Statistical analysis

The data were recorded using the Microsoft Excel software database (Microsoft Corp., LA, USA) and entered into the STATA 14.2 software (StataCorp LP, College Station, TX, USA). Absolute frequencies and percentages were calculated for qualitative variables. The proportion of AP in each group was calculated and expressed with a 95% confidence interval (CI). The presence of AP was related to the explanatory variables (quality of the filling, presence of missed canal, and tooth type) using the chi-square test or Fisher's exact test for proportions and analysis of group differences. P-value ≤ 0.05 was considered significant. The odds ratio (OR) was calculated to analyze the odds that AP occurs in teeth with missed canal or IET compared to teeth with all canals treated or AET, respectively.

RESULTS

The frequency of AP was 62.34% (288/462); 27.43% (n = 79) of teeth with AET, and 72.57% (n = 209) of teeth with IET, a statistically significant result ($p < 0.01$, Table 1).

The 288 teeth with AP and 174 without AP were distributed as follows: for teeth with IET, 60.76% had AP without missed canal, compared to 39.23% with AP and missed canal, with a statistically significant difference ($p < 0.01$, Table 2). In this study, 18.61% of endodontically treated teeth had a missed canal, of which 95.3% had AP compared to a prevalence of AP of 54.7% for teeth without a missed canal (Table 3). Concerning dental groups, multi-rooted teeth had the highest frequency of

Table 1. Frequency of apical periodontitis according to the quality of endodontic treatment.

Endodontic Treatment		Apical Periodontitis			
Quality	N (%)	Yes (n)	%	No (n)	%
Adequate (AET)	207(44.81)	79	**27.43**	128	**73.56**
Inadequate (IET)	**255(55,19)**	**209**	**72.57***	46	26.43
Total	462	288	62.34	174	37.66

**P-value* (≤ 0.05)

Table 2. Frequency of AP according to the presence or absence of missed canals in teeth with inadequate endodontic treatments (IET).

Sealing quality	N (%)	Presence of apical periodontitis			
		Yes (n)	%	No (n)	%
IET and missed canal	86	82	39.23	4	8.69
IET without missed canal	169	127	**60.76***	42	91.31
Total	255	209	100	46	100

**P-value* (≤ 0.05)

Table 3. Association between presence of missed canals and apical periodontitis (AP) in types of teeth.

	Sample	Missed canal	Missed canal		Without missed canal	Without missed canal	
Types of Teeth	**Teeth with ET**	**n (%)**	**With AP n (%)**	**Without AP n (%)**	**n (%)**	**With AP n (%)**	**Without AP n (%)**
Maxillary							
Central	48	1(2.12)	1(100)	-.-	47(97.87)	22(46.81)	25(53.19)
Lateral	49		-.-	-.-	49(100)	27(55.10)	22(44.90)
Canine	31		-.-	-.-	31(100)	13(41.94)	18(58.06)
Premolar	101	10(9.90)	8(80)	2(20)	91(90.10)	54(59.34)	37(40.65)
1st Molars	71	44(61.9)	42(95.4)	2(4.5)	27(38.1)	20(74)	7(26)
2nd Molars	34	14(41.1)	14(100)	-.-	20(58.82)	13(65)	7(35)
Mandibular				-.-			
Central	5		-.-	-.-	5(100)	2(40)	3(60)
Lateral	5		-.-	-.-	5(100)	3(60)	2(40)
Canine	4		-.-	-.-	4(100)	-.-	4(100)
Premolar	32	2(6.25)	2(100)	-.-	30(93.75)	9(30)	21(70)
1st Molars	53	10(18.8)	10(100)	-.-	43(81.13)	29(67.44)	14(32.55)
2nd Molars	29	5(17.24)	5(100)	-.-	24(82.75)	14(58.33)	10(41.66)
Total	**462**	**86(18.6)**	**82(95.3)**	4(4.7%)	**376(81.39)**	**206(54.7%)**	170(42.3%)

missed canal, with maxillary molars showing the highest percentage (55.23%, 58/105). The presence of AP in these teeth was 96.55% (56/58) (Table 3). In the mesiobuccal (MB) roots of maxillary molars, the MB2 canal was the most frequently missed canal (88.52%, 54/61), with 90.74% being associated with AP (49/54) (Table 4).

Teeth with endodontic treatment but with missed canals had a crude OR: 16.9 (95% CI, 6.07 - 47.10) to be associated with an AP, indicating a greater probability. In addition, according to the statistical significance found in the maxillary and mandibular molar teeth groups in the bivariate analysis, the logistic regression model adjusted for the variable type of tooth found an OR: 10.5 (95% CI 3.61- 30.86). Similarly, the groups of teeth with a statistically significant risk association were maxillary molars, OR :2.5 (95% CI 1.25-5.02), and mandibular molars, OR: 1.96 (95% CI 1.07-3.59), suggesting that a maxillary molar with missed canal had a 2.5-fold risk of having AP, and a mandibular molar with missed canal had a 1.96-fold risk of having AP when a missed canal was present (Table 5 and 6).

DISCUSSION

Several studies have investigated the prevalence of AP in teeth with endodontic treatment and its risk factors[23,24]; however, they have used 2D images, which have disadvantages compared to 3D images. Due to its high sensitivity, CBCT can more accurately evaluate the presence of AP[25], the quality of the endodontic treatment, and the presence of missed canals[14-16]. For example, a study conducted in Colombia in 2013 found an AP prevalence of 49% using 2D images for endodontic treatments[21], whereas the current study using CBCT found a higher prevalence of AP (62.34%), similar to recent CBCT studies that found AP between 51.8% and 88%[14-16].

A noteworthy aspect of the current study is the evaluation of a significant variable, the quality of endodontic treatment, in addition to the presence of missed canals. It was observed that 27.43% of teeth with Adequate Endodontic Treatment (AET) and 72.57% of teeth with Inadequate Endodontic Treatment (IET) presented Apical Periodontitis (AP). This suggests that the presence of missed canals is not the sole factor associated with AP. In fact, 60.76% of teeth with IET and all canals treated had AP, compared to 39.23% of teeth with IET and

Table 4. Association between presence of missed canal and apical periodontitis (AP) in the root and canals of maxillary and mandibular molars.

Root canals	Sample	With missed canal	With missed canal		Without missed canal	Without missed canal	
			AP			AP	
	N	n (%)	Yes n (%)	No n (%)	n (%)	Yes n (%)	No n (%)
Maxillary molars 1st molar							
Mesiobuccal root							
Mesiobuccal canal	71	1(1.40)	1(100)	-.-	70(98.59)	53(75.71)	17(24.28)
Mesiobuccal 2 canal	50	**43(86)**	**39(90.69)**	4(9.30)	7(14)	5(71.42)	2(28.57)
Distobuccal root							
Distobuccal canal	71	3(4.22)	2(80)	1(20)	68(95.77)	30(44.11)	38(55.88)
Palatal root							
Palatal canal	71	-.-	-.-	-.-	71(100)	32(45.07)	39(54.92)
2nd molar							
Mesiobuccal root							
Mesiobuccal canal	28	2(7.14)	2(100)	-.-	26(92.85)	19(73.07)	7(26.92)
Mesiobuccal 2 canal	11	11(100)	10(90.9)	1(9.1)	-.-	-.-	-.-
Distobuccal root							
Distobuccal canal	28	2(4.14)	2(100)	-.-	26(92.85)	13(50)	13(50)
Palatal root							
Palatal canal	28	-.-	-.-	-.-	28(100)	15(53.57)	13(46.42)
Mandibular molars 1st molar							
Mesial root							
Mesiobuccal canal	51	2(3.92)	2(100)	-.-	49(96.07)	28(57.14)	21(42.85)
Mesiolingual canal	51	2(3.92)	2(100)	-.-	49(96.07)	29(59.18)	20(40.81)
Distal root			-.-				
Distobuccal canal	14	6(42.85)	6(100)	-.-	8(57.14)	5(62.5)	3(37.5)
Distolingual canal	14	3(21.42)	3(100)	-.-	11(78.57)	8(72.72)	3(27.27)
2nd molar							
Mesial root							
Mesiobuccal canal	19	2(10.52)	2(100)	-.-	17(89.47)	10(58.82)	7(41.17)
Mesiolingual canal	19	4(21.05)	4(100)	-.-	15(78.94)	8(53.33)	7(46.66)
Distal root							
Distobuccal canal	2	-.-	-.-	-.-	2(100)	2(100)	-.-
Distolingual canal	2	-.-	-.-	-.-	2(100)	2(100)	-.-

missed canals. This finding could address the letter to the editor by Leprince & Nieuwenhuysen[19], who, after pooling data from the most relevant studies on missed canals[14-16], showed that 81.8% of all evaluated teeth presented AP and had all canals treated. Only 18.2% had presence of AP in teeth with missed canals. This corroborates the idea that multiple variables are associated with the presence of AP.

Furthermore, the current study found 18.61% of missed canals, similar to previous studies, which reported 12% to 23%[14-18]. Also, in the present study, 95.3% of missed canals had AP, comparable with previous studies[14-16], which found 82.8%, 82.6%, and 98%, respectively.

Maxillary molars were the teeth with the highest frequency of missed canals, with 55%, similar to prior reports of 40.1%[14,15]. Another study found

Table 5. Association between presence of apical periodontitis (AP) and quality of endodontic treatment in types of teeth.

Types of Teeth	Sample	Inadequate	Inadequate		Adequate	Adequate	
	Teeth with ET	n (%)	With AP n (%)	Without AP n (%)	n (%)	With AP n (%)	Without AP n (%)
Maxillary							
Central	48	9(18.75)	9(100)	-.-	39(81.25)	14(35.89)	25(64.10)
Lateral	49	17(34.6)	13(76.47)	4(23.52)	32(65.30)	14(43.75)	18(56.25)
Canine	31	7(22.58)	3(42.85)	4(57.14)	24(77.41)	10(41.66)	14(58.33)
Premolar	101	57(56.4)	43(75.43)	14(24.56)	44(43.6)	19(43.18)	25(56.81)
1st Molars	71	62(87.3)	58(93.5)	4(6.45)	9(12.6)	4(44.4)	5(55.5)
2nd Molars	34	26(76.4)	24(92.3)	2(7.69)	8(23.5)	3(37.5)	5(62.5)
Mandibular				-.-			
Central	5		-.-	-.-	5(100)	2(40)	3(60)
Lateral	5		-.-	-.-	5(100)	3(60)	2(40)
Canine	4		-.-	-.-	4(100)	-.-	4(100)
Premolar	32	17(53.1)	10(58.82)	7(41.17)	15(46.9)	1(6.66)	14(93.33)
1st Molar	53	40(75.4)	32(80)	8(20)	13(24.52)	7(53.84)	6(46.15)
2nd Molar	29	**20(68.9)**	**17(85)**	3(15)	9(31.03)	3(33.33)	6(66.66)
Total	462	255(55)	**209(81.96)**	46(18.03)	**207(45)**	**80(38.64)**	127(61.35)

59.55% and 40% missed canals in maxillary first and second molars, respectively[16], while the present study found similar results for the first and second maxillary molars, with 61.97% and 41.18%, respectively. The reason for the high percentage of missed canals may be the presence of a second mesial buccal (MB) canal in 88.5% of maxillary first molars and 83.4% of second molars[25]. The MB root has complex anatomy that usually presents Vertucci configurations type II (69.1%)[26] and type IV (48.7%)[27]. MB2 was also the most frequently missed canal in maxillary molars in previous studies, with prevalences of 65%[16], 93%[14], and 89% in the current study. This might be explained by the fact that the MB2 canal is usually narrow, significantly smaller than the MB1 canal, with its opening often covered by secondary dentin or calcifications[28,29], and the curvature in the mesial root is pronounced in the apical third of both canals and stronger in the MB2 canal. These anatomical features may make it more difficult to locate and achieve a straight course to the apex[29]. The presence of an MB2 canal should be considered the rule rather than the exception.

In the current study, mandibular molars had the second-highest frequency of missed canals, with 18%, similar to previous studies, which found 19.7%[15], 26%[14], and 10.42%[16]. All mandibular molars with missed canals were associated with AP in the present study. Other studies have reported similar frequencies, such as 94.1%[16] and 95.5%[14]. Another study found 62% of missed canals in the mandibular first molars, with the distolingual canal being the most frequently missed canal, although it did not specify the percentage of AP in mandibular first molars with missed canals[15].

In the current study, the most frequently missed canals were the distobuccal canal in mandibular first molars (42.85%), followed by the mesolingual canal in mandibular second molars (21.05%). This was similar to another study that found in mandibular first molars missed distolingual canals (21%) and mesolingual canals (29%), and in mandibular second molars, missed mesolingual canals (62%)[14]. These frequencies of missed canals in mandibular molars may occur due to variations in anatomy and location, which make it difficult to access and treat all root canals[14-16].

In the present study, the probability of a tooth with a missed canal having AP was 16.9 (crude OR) and 10.5 (OR adjusted to the tooth type variable). These findings could be considered higher than those of previous studies, which reported probabilities of 4.38[15], 6.25[14], and 4.4[16]. These differences may be related to the higher percentage of teeth with IET in this study.

Good quality endodontic treatment seems to

Table 6. Association between presence of quality of endodontic treatment and apical periodontitis (AP) in the root and canals of maxillary and mandibular molars.

Root canals	Sample	Inadequate	Inadequate		Adequate	Adequate	
			AP			AP	
	N	n (%)	Yes n (%)	No n (%)	n (%)	Yes n (%)	No n (%)
Maxillary molars 1st molar							
Mesiobuccal root							
Mesiobuccal canal	71	42(59.1)	36(85.71)	6(14.28)	29(40.8)	18(62.06)	11(37.93)
Mesiobuccal 2 canal	50	47(94)	**43(91.48)**	4(8.52)	3(6)	1(33.33)	2(66.66)
Distobuccal root							
Distobuccal canal	71	34(47.88)	21()	13()	37(52.1)	11(29.72)	26(70.27)
Palatal root							
Palatal canal	71	30(42.25)	19(63.33)	11(36.66)	41(57.74)	13(31.70)	28(68.29)
2nd molar							
Mesiobuccal root							
Mesiobuccal canal	28	18(64.28)	14(77.7)	4(22.2)	10(35.71)	7(70)	3(3)
Mesiobuccal 2 canal	11	11(100)	10(90.9)	1(9.1)	-.-	-.-	-.-
Distobuccal root							
Distobuccal canal	28	15(53.57)	10(66.66)	5(33.33)	13(46.42)	5(38.46)	8(61.53)
Palatal root							
Palatal canal	28	13(46.42)	9(69.23)	4(30.76)	15(53.58)	6(40)	9(60)
Mandibular molars 1st molar							
Mesial root							
Mesiobuccal canal	51	21(41.17)	15(71.42)	6(28.57)	30(58.83)	15(50)	15(50)
Mesiolingual canal	51	26(50.98)	17(65.38)	9(34.61)	25(49.01)	14(56)	11(44)
Distal root							
Distobuccal canal	14	10(71.42)	9(90)	1(10)	4(28.57)	2(50)	2(50)
Distolingual canal	14	10(71.42)	9(90)	1(10)	4(28.57)	2(50)	2(50)
2nd molar							
Mesial root							
Mesiobuccal canal	19	10(52.63)	7(70)	3(30)	9(47.36)	5(55.55)	4(44.44)
Mesiolingual canal	19	12(63.15)	10(83.33)	2(16.66)	7(36.84)	2(28.51)	5(71.42)
Distal root							
Distobuccal canal	2	2(100)	2(100)	-.-	-.-	-.-	-.-
Distolingual canal	2	2(100)	2(100)	-.-	-.-	-.-	-.-

decrease the prevalence of apical periodontitis in teeth with missed canals compared to teeth with IET and missed canals. However, further studies are needed to confirm this hypothesis.

Bivariate analysis of the results obtained in the current study was very similar to that reported in the studies mentioned above. Additionally, a wide confidence interval was observed for crude OR and OR adjusted for the tooth type variable. According to tooth type, an OR of 2.5 was observed for maxillary molars, similar to the 3.1 previously reported[16].

The major advantage of cross-sectional studies is that, with a large sample size, potential interpretation errors can be diluted[14]. However, the nature of cross-sectional studies may also be a limitation owing to the reliability of the observations. Moreover, it is difficult to establish the natural history of the disease, e.g., it is impossible to determine whether

AP is expanding, healing or stable[1]. Many of the images classified as AP at the time of analysis could be AP in the process of healing, reducing in size[30]. Another limitation was the CBCT method, which may show artifacts caused by high-density objects such as gutta-percha, which might generate false positives[14-16].

The diagnosis, histological and microbiological analysis of the small variations seen as areas of low density (0.5 mm radiolucent zone) around the apex in ET teeth when viewed in CBCT images is another crucial factor to consider. However, treatment need not be started immediately based on this finding because when the tooth in question is asymptomatic and functions normally, the clinician should evaluate subtle changes histologically or wait for a reasonable amount of time[31]. Future studies should also consider factors including lesion size and patient age.

CONCLUSION

The frequency of missed canals was 19%, with apical periodontitis being observed in 95,3% of these cases. More than half of the teeth with missed canals were maxillary molars, and the MB2 was the most frequently missed canal, with apical periodontitis being observed in 90.74%. Based on these results we conclude that there was a high frequency of teeth with missed canals and PA and more than half of the teeth with missed canals were maxillary molars, with MB2 being the most common canal, commonly presenting apical periodontitis.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

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