

ORIGINAL ARTICLE

The Prevalence of Second Distal Canals in the Mandibular First Molars: A Histological and Cone Beam Computed Tomography Study

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Abstract

Purpose: The prevalence of the Second Distal Canal (SDC) in the Mandibular First Molar (MFM) was assessed using histological and Cone Beam Computed Tomography (CBCT) studies.

Materials and Methods: This study included a total of 348 extracted MFM, which were divided into 6 groups according to gender and age. All the teeth were viewed by one CBCT device, and then the teeth were histologically examined. The images were evaluated, and the obtained results were analyzed by SPSS software using the Chi-square test. The comparison was considered statistically significant at $p < 0.05$.

Results: The prevalence rate of the canals was 171 (49.13%), males and females were 89 and 82, respectively, and according to the level of sectioning, they were found to be 43.94% of all the sections, with the lowest 16.11% and 15.62% at level 5 (coronal level) and level 1 (apical level) when viewed only histologically, being 110, while when viewed histologically and by CBCT, there were 61 teeth for the SDC, respectively, which was more in younger than older patients with no statistically significant difference.

Conclusion: The prevalence rate of the SDC seen by CBCT was 17.32%, while histologically it was 49.13%, respectively. Clinically, many canals cannot be detected because of their small size, which cannot be seen radiographically.

Keywords: Second Distal Canal; Histological Sectioning; Mandibular First Molar; Cone Beam Computed Tomography.

1. Introduction

Cleaning the whole root canal system mechanically and chemically, as well as creating the necessary room for intracanal filling materials, is the primary goal of root canal therapy. There are numerous and different variances and complexities in the architecture of the pulp space. Insufficient understanding of this anatomy can lead to errors in diagnosis and therapy planning, which ultimately lead to treatment failure [1-4]. Failure of root canal therapy can result from a variety of factors, including the existence of extra canals within the root, which may go undetected during treatment. Because it is not well known to exist and is rarely used during root canal therapy, the middle mesial or distal canal is one of the extra canals in the molars that are sometimes overlooked [5]. The initial tooth to erupt permanently is the mandibular first molar, which is the most susceptible to cavities and frequently requires root canal therapy [6, 7]. Mandibular molars typically contain three canals and two roots in the distal and mesial regions. Variations in the number of roots and the shape of the canals in these teeth are rather typical; the canal shape of these teeth is often complex [8, 9].

The most popular method of root canal diagnosis is periapical radiography because laboratory methods are not permitted in clinics. Moreover, the root canal cannot be accurately diagnosed with this technique. Thus, it appears necessary to use other techniques with better diagnostic accuracy, like CBCT [6, 10-18], clearing [19, 20], clinical assessment [21], and cross-section preparation [2]. The most popular method of root canal diagnosis is periapical radiography because laboratory methods are not permitted in Clinics. It is regarded as a crucial instrument for assessing the morphology of the root canal [22]. However, in the prepared images, distortion and superimposition are possible, so these radiographs are not entirely reliable [23]. The root canal can be observed with great accuracy using CBCT, which also enables the restoration and presentation of three-dimensional (3D) images [6, 15]. Many studies showed that various races had different canal morphologies [6, 10-18]. There are studies on the canal morphology of PMFM assessed by CBCT. Studies have been done on PMFM canal morphology as determined by CBCT [7, 11].

The current study was conducted to assess the prevalence of SDC in MFM using histological and CBCT techniques for the identification of sub-canals and additional canals that may affect the standard of care. No research has been conducted on this topic.

2. Materials and Methods

2.1. Sample Size

A total of 348 extracted MFM were chosen by simple random sampling at a 95% confidence level with 0.05 error rates and were divided into 6 groups. Each group has 58 teeth according to gender and age [24]. The sample was divided into three age groups (10-20, 21-40, and 41-60) and collected from November 15, 2022, to March 30, 2023.

2.2. Ethical Approval

The University of Baghdad's College of Dentistry's Research Ethics Committee accepted and reviewed the submitted research project (No. 711522) for ethical approval on 1/12/2022.

2.3. The Inclusion Criteria

1. Absence of root canal therapy for the specified tooth.
2. Fully formed teeth.
3. Teeth are not filled endodontically.
4. There is no external or internal resorption.

2.4. Cone Beam Computed Tomography Study

The teeth were cleaned with water as soon as they were extracted and placed in a bottle with a 10% formalin solution for at least 24 hours for fixation. The teeth were divided according to age and gender. The teeth were fixed in wax molds containing 1–10 teeth. Every tooth was given a number according to its group for age and gender. The CBCT device used in this study was a Carestream 8600 CBCT (France) with a detector pixel size of 75 mm. The teeth were mounted in wax and scanned with a CBCT device. The teeth were examined for the presence of the SDC at 5 different places, starting from 1 mm apical to the root canal orifice (Area 5) to 2 mm from the apex (Area 1)

for each root. The cross-sectional views of the restored images were chosen and examined, and they were shown on the screen. Lastly, an endodontist and radiologist evaluated the sections.

2.5. Histological Study

After taking CBCT, the teeth were washed out of formalin with tap water and soaked in 7% nitric acid for 7-9 days for decalcification [25]. The teeth were checked, and the solution was changed daily. Then the teeth were washed with water and saved in formalin until sectioning. The teeth were placed in wax and then sectioned cross-sectionally by the surgical blade size 11 every 2 millimeters (by digital caliper), starting at 2 millimeters from the root apex toward the orifice of the pulp canal. Then the sectioned samples were washed with water for one minute and kept to dry for 2–3 minutes. A stereomicroscope was used to examine the presence of SDC with magnification 20X with the eighth-generation iPhone cell phone. Then images of the CBCT were taken with the same dimensions and compared with microscopic images, and SDC's presence was recorded in each of the sectioned samples, whether microscopic or CBCT.

The data was analyzed by IBM SPSS Statistics Version 26 software. A Chi-square test was used for statistical analysis. The comparison was considered statistically significant at $p < 0.05$.

3. Results

Of the 348 teeth, 171 teeth (49.13%), respectively, revealed the presence of SDC. The ratio of the presence of SDC in both genders was 89/82, respectively, indicating no significant difference between the two genders. The teeth having SDC histologically without CBCT were 110 teeth (31.6%), respectively, but with the use of CBCT, the prevalence was 61 teeth (17.32%). In general, the age groups 10-21 and 21-40 years had a higher prevalence of SDC than the age group 41–60 years (Table 1, Figure 2).

Levels 5 (near orifice) and 1 (near apex) revealed the lowest prevalence among all levels of canal sections in SDC. The prevalence of SDC according to the level of sectioning from the apex to the orifice (five levels 1-5) ranged between 15.62 and 25.32% for SDC (Tables 2 and 3; Figure 3).

Statistically, SDC did show a significant difference between the examination method and gender except for the males and females ages 21-40 and the males of 10-20 years (Table 4).

Statistically, SDC did not show a significant difference between age and gender (Table 5).

Statistically, SDC did not show a significant difference between gender and examination method (Table 6).

This study revealed no significant difference between genders, age, or level of sectioning, as revealed by the Chi-square test (Table 7).

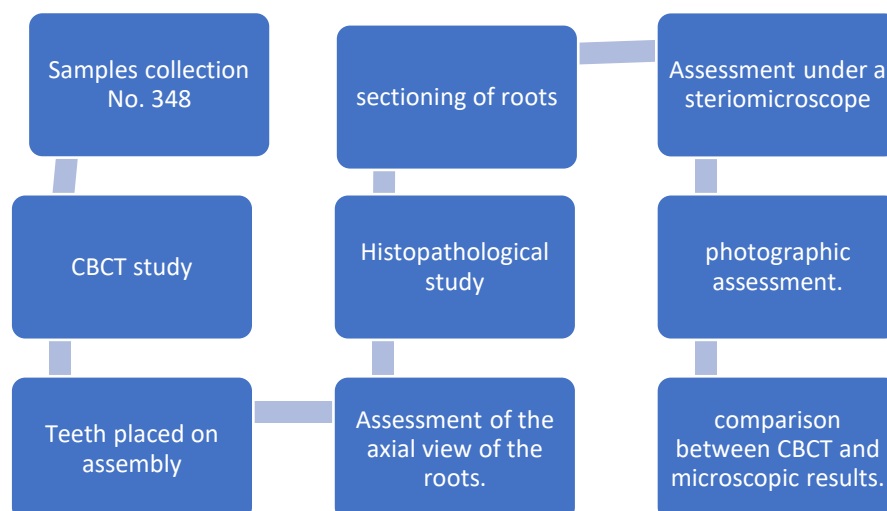
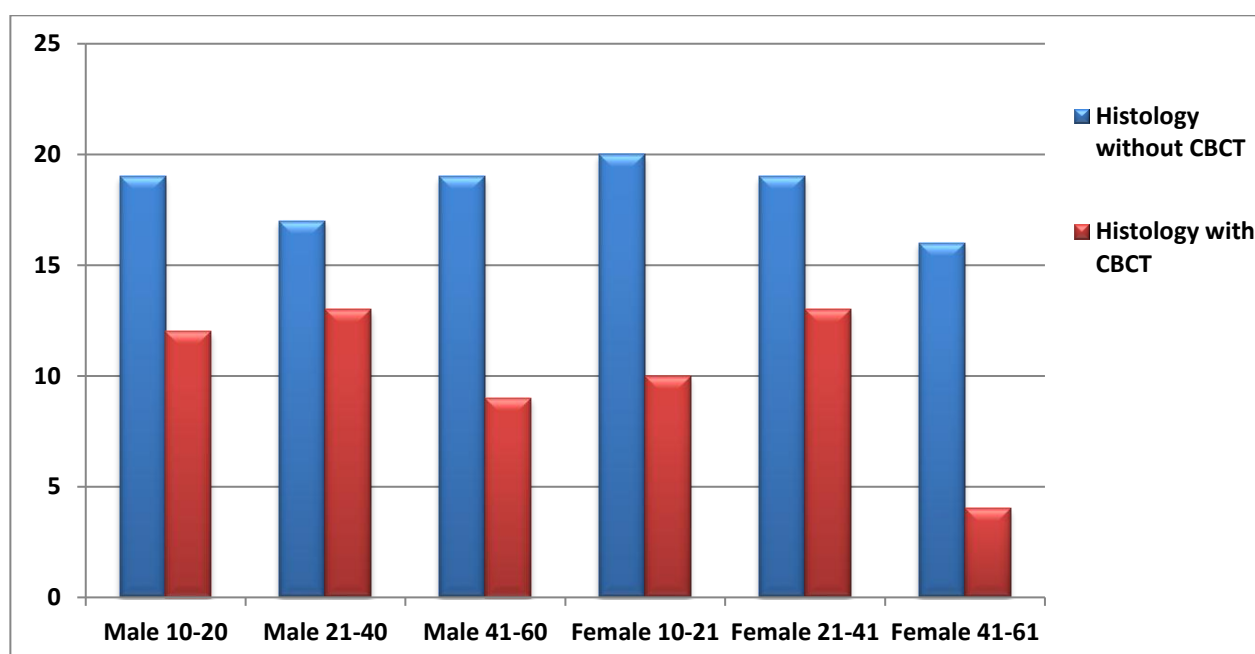


Figure 1. Flowchart of Methodology

Table 1. Descriptive statistics of the prevalence of the second distal canal according to age, gender, and examination method, which were represented in frequency (freq.) and percentage (perc.)

Examination method	Male			Female			Total age			Total gender		Total	%
	10-20Yrs	21-40Yrs	41-60Yrs	10-20Yrs	21-40Yrs	41-60Yrs	10-20Yrs	21-40Yrs	41-60Yrs	male	female		
SDC histology with CBCT	12	13	9	10	13	4	22	26	13	34	27	61	17.32
SDC histology without CBCT	19	17	19	20	19	16	39	36	35	55	35	110	31.6
Total samples with SDC	31	30	28	30	32	20	61	62	48	89	82	171	49.13
Total samples without SDC	27	28	30	28	26	38	55	54	68	85	92	177	50.86
Total samples	58	58	58	58	58	58	116	116	116	174	174	348	100

Yrs = years; SDC = second distal canal; CBCT = cone beam computed tomography

**Figure 2.** Descriptive statistics of the prevalence of the second distal canal in the mandibular first molar according to age, gender, histologically, and cone beam computed tomography, which were represented in frequency (freq.)**Table 2.** Descriptive statistics of the prevalence of the second distal canal according to age, gender, and level of sectioning histologically, which were represented in frequency (freq.) and percentage (perc.)

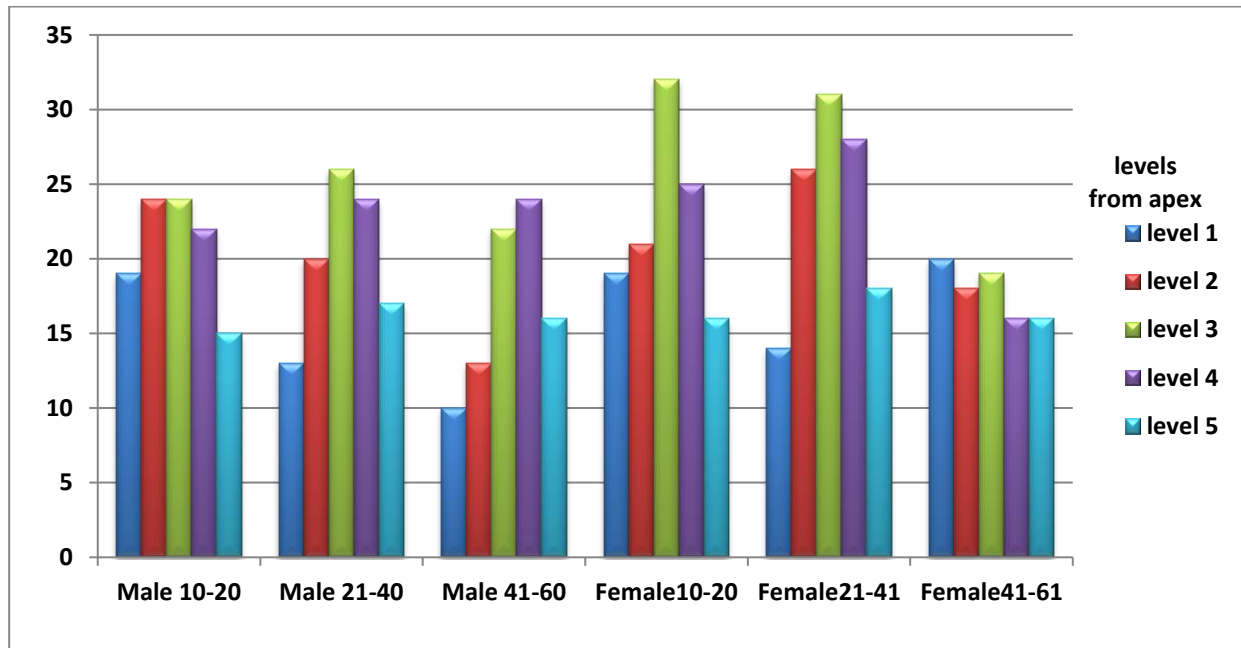
Levels	Male			Female			Total			Total	% According to levels
	10-20 Yrs	21-40Yrs	41-60Yrs	10-20 Yrs	21-40Yrs	41-60Yrs	10-20 Yrs	21-40Yrs	41-60Yrs		
1	19	13	10	19	14	20	38	27	30	95	15.62
2	24	20	13	21	26	18	45	46	31	122	20.06
3	24	26	22	32	31	19	56	57	41	154	25.32
4	22	24	24	25	28	16	47	52	40	139	22.86
5	15	17	16	16	18	16	31	35	32	98	16.11
Total	104	100	85	113	117	89	217	217	174	608	100

Yrs = years; SDC = second distal canal

Table 3. Descriptive statistics of the prevalence of the second distal canal according to the total level of sections of samples histologically, which was represented in frequency (freq.) and percentage (perc.)

	1	2	3	4	5	Total	% from sections having SDC
Presence of SDC	95	122	154	139	98	608	43.94
No presence of SDC	253	22.6	194	209	250	1132	65.05
Total	348	348	348	348	348	1740	100
% SDC total samples	27.29	35.05	44.25	39.94	28.16	34.94	

SDC = second distal canal

**Figure 3.** Descriptive statistics of the prevalence of the second distal canal in the mandibular first molar according to age, gender, and sectioning level histologically were represented in frequency (freq.)**Table 4.** Inferential statistics of the prevalence of SDC (Pearson Chi-Square test (χ^2)) were employed to find the relation between SDC number and study variables (age, gender, and examination method)

Age group	Gender	Z-score	p-value
10-20Yrs	Male	1.778	0.075
	Female	2.582	0.009
	Total	3.078	0.002
21-40Yrs	Male	1.033	0.303
	Female	1.5	0.134
	Total	1.796	0.072
41-60Yrs	Male	2.673	0.008
	Female	3.795	0.0002
	Total	4.491	0.0001

This study revealed no significant difference between genders and levels of sectioning, as revealed by the Chi-square test (Table 8).

Table 5. Inferential statistics of the prevalence of SDC (Pearson Chi-Square test (χ^2)) was employed to find the relation between SDC number and study variables (age and gender)

Age difference	Male	Female	Total
χ^2	0.773	2.374	2,607
d. f.	2	2	2
p-value	0.679	0.305	0.272

χ^2 = Chi-square test, d.f = degree of freedom, significance ($p \leq 0.05$).

Table 6. Inferential statistics of the prevalence of SDC (Pearson Chi-Square test (χ^2)) was employed to find the relation between SDC number and study variables (gender and method of examination)

Gender difference	Histology alone	Histology with CBCT
χ^2	0.394	1.319
d. f.	2	2
p-value	0.821	0.517

χ^2 = Chi-square test, d.f = degree of freedom, significance ($p \leq 0.05$)

Table 7. Inferential statistics of the prevalence of SDC (Pearson Chi-Square test (χ^2)) was employed to find the relation between SDC number and study variables (age, gender, and level of sectioning)

Age difference	Male	Female	Total
χ^2	4.802	6.044	4.391
d. f.	8	8	8
<i>p</i> -value	0.779	0.642	0.82

χ^2 = Chi-square test, d.f = degree of freedom, significance ($p \leq 0.05$).

Table 8. Inferential statistics of the prevalence of SDC (Pearson Chi-Square test (χ^2)) was employed to find the relation between SDC number and study variables (gender and level of sectioning)

Gender difference	1	2	3	4	5
χ^2	2.125	1.27	1.156	2.092	0.02
d. f.	2	2	2	2	2
<i>p</i> -value	0.346	0.529	0.561	0.351	0.99

χ^2 = Chi-square test; d.f = degree of freedom

Reliability. Twenty-four specimens were examined for inter-observer reliability using the Kappa test, and the results revealed perfect reliability (Kappa test = 1). The same specimens were examined by the same examiner twice, a week apart, to get rid of the memory bias and analyzed by the Kappa test to examine the intra-observer reliability, and the result indicated perfect reliability (kappa test = 1) (Figures 4, 5, 6, and 7).

4. Discussion

A great deal of research has been done on the shape and structure of the PMFM root canal [1-2, 9, 23, 26]. CBCT and microcomputed tomography have also

been used in a number of studies to identify the SDC and the morphology of MFM root canals [8, 27-31] and the middle distal canal [32-34]. However, as far as the investigators are aware, no study assessed the histological and CBCT prevalence of the SDC in Baghdad City, Iraq. Most of the time, every root includes a pulp canal, but in certain teeth, a single root contains more than one canal. The majority of research has made use of 3D imaging systems. By preparing various canal sections, CBCT, a 3D imaging system, can assist in finding more canals. Many studies have documented that the distal root frequently has two canals [8, 27, 28, 31, 35]. Furthermore, Hatipoğlu et al., 2023; Pan et al., 2019; Chen et al., 2009; Martins et al., 2022; and Shihab & Mahdee, 2021, found that 3-50%, 21.4 and 46, 16.4-60, and 28.24%, respectively, of SDC cases were prevalent in their study. These results using CBCT are higher than the results of the current study due to the procedure utilized to assess the extra canals, voxel size, filter type, machine learning of CBCT, and the variations in race between various populations, which appear to be the cause of this discrepancy [36, 37].

There are no published studies that used a histological study of SDC in MFM.

However, our study's findings did not reveal a statistically significant difference in the prevalence of the SDC between age, genders, and level of sectioning, but a statistically significant difference in methods of examination and gender groups.

The prevalence of SDC at the level of the root canal orifice is low, which poses additional difficulty in detecting them. There is a high possibility that the SDC will merge with the other canals and will be



Figure 4. This figure depicts images of the second distal canal in the cross section of the distal root of the endodontic-treated mandibular first molar (a) black-and-white cone beam computed tomography; (b) color histological images, male 10-20 years, level 4

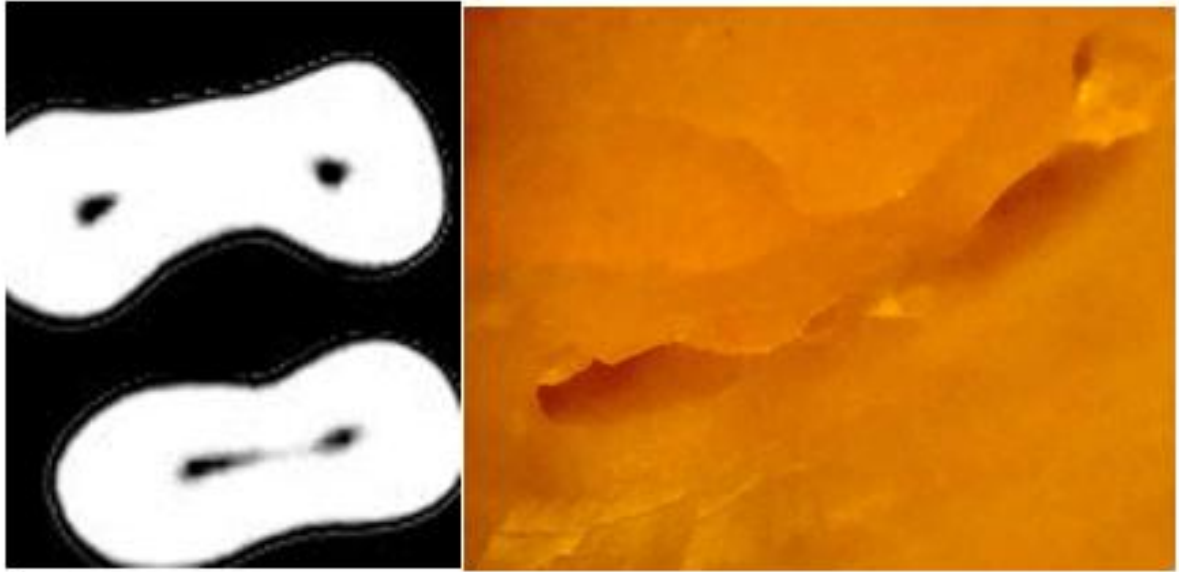


Figure 5. This figure depicts images of the second distal canal in the cross-section of the distal root of the endodontic-treated mandibular first molar (a) black-and-white cone beam computed tomography; (b) color histological images, male 21-40 years, level 5



Figure 6. This figure depicts images of the second distal canal in the cross-section of the distal root of the endodontic-treated mandibular first molar (a) black-and-white cone beam computed tomography; (b) color histological images, females 10-20 years, level 2

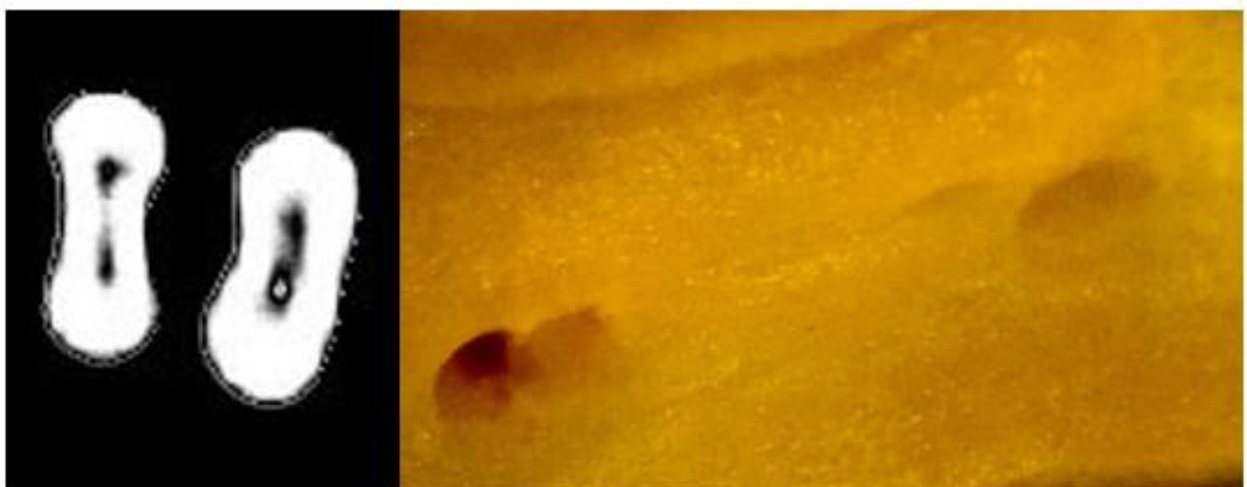


Figure 7. This figure depicts images of the second distal canal in the cross-section of the distal root of the endodontic-treated mandibular first molar (a) black-and-white cone beam computed tomography; (b) color histological images, females 41-60 years, level 3

undetected in the apical area. The middle levels of the root canal revealed a higher presence of the SDC, but they are still difficult to visualize and manage; therefore, three-dimensional agitated root canal irrigation is mandatory to clean these canals, and the thermoplasticized gutta percha technique with nanofilled filler sealer seems to be the only method to obturate these canals.

According to the histological study, it was concluded that many SDCs are undetected during root canal diagnosis and treatment. It is recommended that higher-resolution CBCT be used to detect these minute canals.

5. Conclusion

1. Despite the high prevalence of SDC in this study, histologically, about half of the SDC can be detected by CBCT. Therefore, in suspicious cases, further examinations are necessary to confirm the existence or absence of these canals.

2. Evaluating the histological and CBCT findings is very important clinically to find out how many canals are missed during treatment that can be detected only histologically.

3. The sample size is enough because of the use of G-Power, but if it were larger, it would be better.

4. Two-thirds of the cases can only be seen histologically, so they may be missed during treatment.

5. Older age shows less prevalence of the SDC, which may be due to dentin deposition and a decrease in canal width.

6. Most of the samples showed the SDC evident below the orifice region (Levels 2-4), or 68% of the samples

7. At level 5, at the orifice level, only 16.11% of the cases showed SDC, which may explain the clinical lack of the canal.

8. At the apex Level 1, the SDC is evident in only 15.62% of the cases which may indicate the merging of the canals to one apical foramen.

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