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The prevalence of undetected second distal canals in endodontic-treated mandibular first molars: A histological and cone beam computed tomography study

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Abstract

The mandibular first molar that has undergone endodontic treatment (ETMFM) may contain an additional canal that often goes unnoticed, known as the undetected second distal canal (USDC). While radiography is commonly used to identify the USDC in ETMFMs, its actual occurrence rate might differ when examined through histological methods. The prevalence of this canal was evaluated histologically through laboratory analysis and radiographically through cone beam computed tomography (CBCT). This study included 24 ETMFM from a total of 372 extracted mandibular first molars (MFM) from 372 Iraqi patients, which were collected from several private dental clinics in Baghdad city during 2022–2023. The extra canals, accounting for 6.45% of the total samples, is divided into two groups based on sex. All the teeth were examined using a single CBCT device, and then they were histologically prepared, sectioned, and observed under a stereomicroscope. The images were evaluated for the presence of the canals, and the results were statistically analyzed using the chi-square test and the Fisher exact test. The comparison was considered statistically significant at $p<0.05$. The prevalence rate of the canals was 13 teeth (54.16%) based on CBCT, while 18 teeth (75% histologically) had a sex distribution of 6/12 teeth (33.33% for males and 66.66% for females). In terms of the level of sectioning, 74.44% of all sections had USDC, with the lowest being 7.46% at level 1 (apical level) and 19.4% at level 2. The prevalence rates of the USDC were found to be high in ETMFM clinically, higher in the histological study than in the CBCT study, higher in females than in males, and higher in the middle sectioning levels than at the extremes, all of which showed no statistically significant difference. Consequently, in suspicious cases, additional examinations are required to confirm the existence or absence of these canals, as they are regarded as a contributing factor in the failure and tooth extraction after endodontic treatment in ETMFM.

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Keywords: Undetected second distal canal, histological sectioning, CBCT, Mandibular molars**.**

معدل وجود القناة الثانية البعيدة الغير مكتشفة في الاضراس السفلية الاولى المعالجة جذريا – باستخدام التقطيع النسيجي وجهاز التصوير المقطعي المحوسب ذو الشعاع المخروطي

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الخلاصة:

قد يحتوي الضرس الأول السفلي الذي خضع لعلاج لب الأسنان على قناة إضافية غالبًا ما تمر دون أن يلاحظها أحد، والمعروفة باسم القناة البعيدة الثانية غير المكتشفة في حين يتم استخدام التصوير الشعاعي بشكل شائع لتحديد هذه القناة في الاضراس الاولى السفلية التي خضعت لعلاج لب الاسنان فإن معدل حدوثه الفعلي قد يختلف عند فحصه من خلال الأساليب النسيجية لذلك تم تقييم انتشار هذه القناة نسيجيًا من خلال الفحص المخبري والتصوير الشعاعي من خلال التصوير المقطعي المخروطي. شملت هذه الدراسة 24 ضرسا اوليا سفليا معالج جذريا من مجموع 372 ضرسا اوليا سفليا مقلوعا تعود الى 272 من المرضى العراقيين تم جمعها من عدة عيادات خاصة لطب اسنان في مدينة بغداد للمدة من 2002 الى 2023 وقسمت هذه العينات الى مجموعتين ذكور و اناث , كانت القنوات الإضافية تمثل 6.45٪ من مجموع العينات. فحصت الاسنان المعالجة جذريا باستخدام جهاز تصوير مقطعي واحد ثم حضرت نسيجيا وقطعت جذورها الى خمسة مقاطع نسيجية من الاعلى الى الاسفل وبسمك 2 ملم لكل مقطع نسيجي مع عدم تضرر الانسجة اثناء التقطيع ثم فحصت جميع المقاطع النسيجية باستخدام المجهر التشريحي وتم تصويرها و تقييمها وثم تحليلها احصائيا باستخدام اختبار مربع كاي واختبار فيشر الدقيق وكانت نسبة وجود القناة الثانية البعيدة الغير مكتشفة في الاضراس المعالجة جذريا 54.16% بناء على التصوير المقطعي و 75% باستخدام التقطيع النسيجي, بينما كانت نسبة وجودها حسب المقاطع النسيجية الكلية للأسنان الحاوية عليها 74.4%,وكانت اقل نسبة لوجودها عند المقطع النسيجي الاول قرب قمة الجذر بنسبة 7.46% تليها في المقطع النسيجي الثاني بنسبة 19.4%, وكانت نسب الذكور منها 33.33% والاناث 66.66%. نسبة وجود هذه القناة عالية في الاسنان المعالجة جذريا ووجودها في الدراسة النسيجية اكثر من التصوير المقطعي وفي الاناث اكثر من الذكور وفي المستويات الوسطي من قناة الجذر اكثر من المستويات الطرفية وجميع هذه العوامل بدون تأثير معنوي احصائيا , وبالأخر, في الحالات المشتبه بها، مطلوب فحوصات إضافية للتأكد من وجود أو عدم وجود هذه القنوات حيث أنها تعتبر من العوامل المساهمة في فشل وخلع الأسنان بعد العلاج اللبي في الاضراس الاولى السفلية التي خضعت لعلاج لب الاسنان.

1. Introduction

The primary goal of root canal therapy is to clean the entire root canal system both mechanically and chemically, as well as to create the necessary space for intra-canal filling materials. The architecture of the pulp space is characterized by multiple variations and a high degree of complexity. Insufficient understanding of this anatomy can lead to errors in diagnosis and therapy planning, which ultimately result in treatment failure [1]. The failure of root canal therapy can arise from various factors, one of which is the presence of additional canals within the root that may remain undetected during treatment. Because it is not widely recognized and is seldom utilized during endodontic treatment, the middle mesial or distal canals are among the additional canals in molars that are occasionally undetected. The first tooth to erupt permanently is the mandibular first molar, which is most susceptible to cavities and often requires root canal therapy [2]. Mandibular molars generally possess three canals and two roots in the distal and mesial areas. It is quite common to observe variations in the number of roots and the shape of the canals in these teeth are quite typical, and the canal morphology of these teeth is often complex [3].

Due to its two-dimensional nature, periapical radiography has limitations when used as a diagnostic tool for root anatomy and treatment detection. Moreover, this technique cannot accurately diagnose the root canal and yet it is the most popular method for diagnosing root canals is periapical radiography, as laboratory methods are not allowed in clinics. Despite being an essential tool for evaluating root canal morphology, this technique can result in distortion and superimposition in the images, making these radiographs less than fully reliable [4].

It seems essential to employ other techniques with improved diagnostic accuracy to study the root canal morphology of the mandibular first molar, such as CBCT [5], operating dental microscopes [6], and ultrasonic devices [7] for clinical evaluation, as well as micro-computed tomography (M-CT) [8], clearing [9], and cross-section preparation for laboratory studies [10]. Many studies have been conducted on the canal morphology of the mandibular first molar as determined by CBCT. The distal root canal can be observed with great accuracy using CBCT, which also allows for the restoration and presentation of three-dimensional images [11].

The available information regarding the morphological characteristics of the distal root canal, especially the USDC characteristics of ETMFM within the Iraqi population, is completely lacking and requires continuous updating. The present study aims to use CBCT and histological sectioning to assess the prevalence of USDC in ETMFM and to correlate these findings with sex and various root cross-sectional levels. Additionally, it aimed to identify the sub- and extra-canals that could impact the quality of care, especially considering that no research has been conducted on this topic globally through histological sectioning, or CBCT, in Baghdad, Iraq.

2. Materials & methods

2.1 *Sample size*

This study included 24 ETMFM from a total of 372 extracted mandibular first molars from 372 Iraqi patients, collected between collected between November 15, 2022, to March 30, 2023, which were teeth extracted from different patients and collected from several private dental clinics in Baghdad city. The samples were divided into two groups: males and females. The age range was between 10 and 60 years old (Figure 1).

The inclusion criteria are: 1. Fully formed teeth. 2. Teeth were filled endodontically. 3. There is no external or internal resorption.

The exclusion criteria are: 1. Incompletely formed teeth. 2. Teeth were not treated endodontically. 3. There is external or internal resorption.

The strength of this research was studying an important topic, which is the failure to detect and treat all the root canals, leading to treatment failure and subsequent tooth loss.

The limitations of this research included the need for a large number of extracted teeth collected from dental clinics, the fact that histological sectioning is a destructive technique for verifying results, and the requirement for skilled and well-trained dentists to analyze the results and detect the USDC in both examination methods.

2.2 Cone beam computed tomography detection

The teeth were cleaned with water immediately after extraction and placed in a bottle containing a 10% formalin solution for at least 24 hours for fixation. They were categorized according to age and sex. The teeth were set in wax molds containing 1-10 teeth. Each tooth was assigned a number based on its group for age and gender. The CBCT device used in this study was the Carestream 8200 type, manufactured by Carestream, a French company. The teeth were secured with a wax mold and scanned using a CBCT device. The cross-sectional view began 2 mm from the root apex (level 1) and extended towards the canal orifice (level 5), with each level having a thickness of 2 mm. The cross-sectional views of the restored images were selected and analyzed, then displayed on the screen. Lastly, an endodontist and a radiologist assessed the section levels (Figure 2).

2.3 Histological detection

After taking CBCT, the teeth were rinsed with tap water to remove the 10% formalin solution and then soaked in 7% nitric acid for 7-9 days for decalcification [12]. The teeth

were examined, and the solution was changed daily. Then the teeth were cleaned with water and preserved in formalin until they could be sectioned. The teeth were embedded in wax and then cross-sectioned using a size 11 surgical blade every 2 millimeters with a digital caliper, beginning 2 millimeters from the tooth apex and moving toward the orifice of the pulp canal. Then the sectioned samples were washed with water for one minute and left to dry for 2–3 minutes. A stereomicroscope was utilized to investigate the presence of USDC at a magnification of 20x using an eighth-generation iPhone. Then images of the CBCT were taken with the same dimensions and compared with microscopic images, and the presence of USDC was recorded in each of the sectioned samples, whether microscopic or CBCT (Figure 2).

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

Statistical Analysis: Using a simple random sampling with a 95% confidence level and 0.05 error rates, the Chi-square test and Fischer exact test were employed to find the relation between USDC number and study variables, sex, and methods of examination (histological sectioning and radiographical detection).

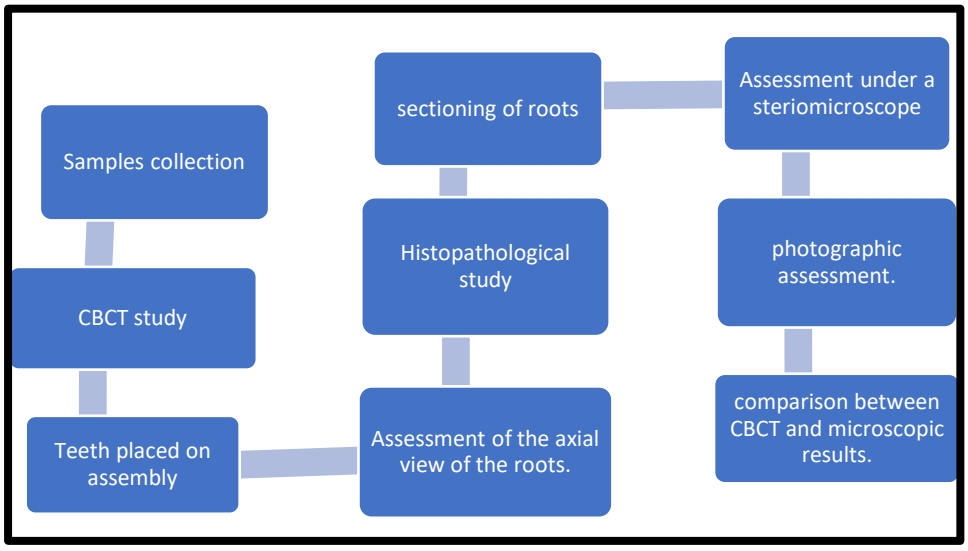

Figure 1: Flowchart of Methodology.

3. Results and discussion

3.1. Results

The prevalence rate of endodontically treated mandibular first molars was 6.45% (24 teeth) out of a total sample collection (372 teeth). On radiographic examination using CBCT, 13 teeth (54.16%) showed USDC, while histological examination revealed that 18 (75%) of the ETMFM had USDC, with 33.33% in males (6 teeth) and 66.66% in females (12 teeth) (Table 1).

Histological examination of endodontically treated mandibular first molars revealed a 74.44% prevalence of USDC. It was found that not all histological sections of the same tooth that contained USDC necessarily contained USDC. The lowest percentage was 7.46% at the first sectioning level (apical level), followed by 19.4% at the second level. The percentages varied between 7.46% and 26.86% for the five histological sectioning levels (Table 2).

This study showed that there was no significant difference between sex, method of examination, or level of sectioning, as indicated by the Fisher exact test and the Chi-square test (Tables 1, 2).

Table 1: study design teeth distribution.

Method examination	Male *n* (%)	Female *n* (%)	Total	%	
USDC CBCT	4 (30.8 %)	9(69.2 %)	13	54.16	Inferential statistics
USDC Histology	6(33.3 %)	12(66.7 %)	18	75	
USDC samples	6(33.33%)	12(66.7%)	18	75	
samples without USDC	2(33.33%)	4(66.7%)	6	25	
Inclusion: ETMFM samples	8(33.33%)	16(66.7%)	24	6.45	*P*=1.000 F NS
Exclusion: NETMFM	174(50%)	174(50%)	348	93.54	
Total MFM samples	182	190	372	100	

USDC: Undetected second distal canal; CBCT: cone beam computed tomography; Yrs = years; ETMFM: endodontically treated mandibular first molars; NETMFM: no endodontically treated mandibular first molars; MFM: mandibular first molars; F: Fisher exact test; NS: not significant; *P: p*-value.

Table 2: study design histological sections level distribution.

Levels of ETMFM	Levels not have USDC	USDC Levels	Male *n* = 22	Female *n* = 45	% USDC level to USDC total levels	Inferential statistics
level 1 n = 18	13 (72.22%)	5 (27.77%)	2 (40.0 %)	3 (60.0 %)	7.46%	*P*=1.000 F /NS
level 2 n =18	5 (27.77%)	13 (72.22%)	4 (30.8 %)	9 (69.2 %)	19.4%	*P*=1.000 F /NS
level 3 n =18	0 (0%)	18 (100%)	6 (33.3 %)	12 (66.7 %)	26.86%	*P*=0.958 C /NS
level 4 n =18	1 (5.55%)	17 (94.44%)	6 (35.3 %)	11 (64.7 %)	25.37%	*P*=0.803 C /NS
level 5 n =18	4 (22.22%)	14 (77.77%)	4 (28.6 %)	10 (72.4 %)	20.89%	*P*=1.000 F /NS
Total level =90	23 (25.55%)	67 (74.44%)	22 (32.83%)	45 (67.16%)	100%	NS

T: total; ETMFM: endodontic ally treated mandibular first molars; USDC: undetected second distal canal. F: Fisher's exact test; C: chi-square test; NS: not significant; *P*: *p*-value; CBCT: cone beam computed tomography; each tooth root is divided into 5 levels, 24 ETMFM results in 120 levels, and 18 EMFM-USDC results in 90 levels.

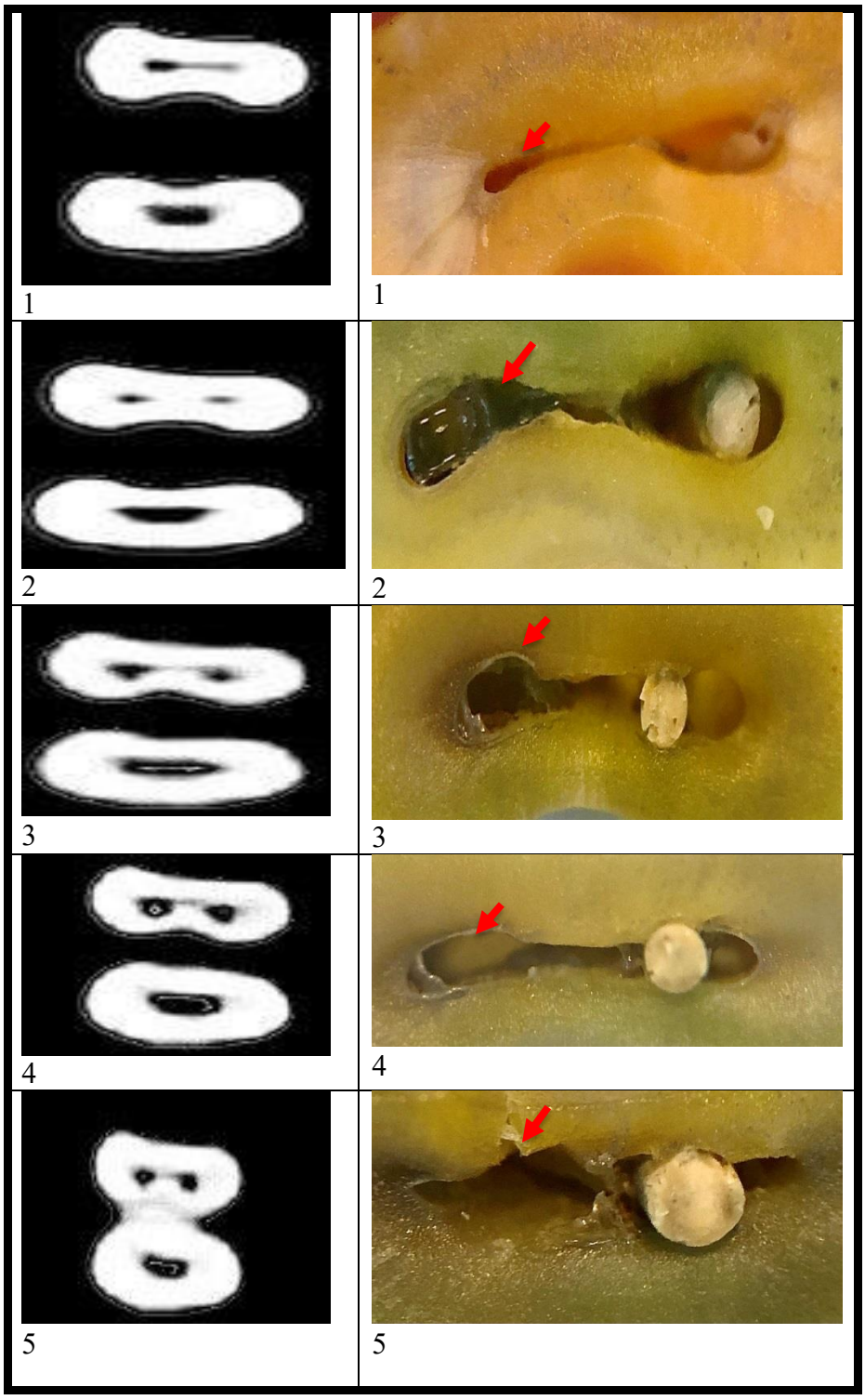

Figure 2: This figure shows images of an undetected second distal canal in cross-section: (a) black-and-white images from cone beam computed tomography and (b) color histological images, levels 1–5 (from the root apex at level 1 to the canal orifice at level 5), with a magnification power of 20x.

3.2. Discussion

The findings of the current study indicated that the prevalence of USDC was slightly higher than half of the samples using CBCT. Numerous studies have documented the fact that the distal root of the mandibular first molars often have two canals. Furthermore, Hatipoğlu et

al., 2023 (3-50%) [13]; Pan et al., 2019 (21.4%) [14]; Chen et al., 2009 (46%) [15]; Martins et al., 2022 (16.4-60%) [16]; and Shihab & Mahdee, 2023 (28.24%) [17]. The method employed to assess the additional canals, voxel size, filter type, machine learning in CBCT, sample size, and racial differences among various populations seem to be the reasons for this discrepancy [18.19]. CBCT, a 3D imaging system, can help in identifying additional canals, as cases of the second distal canal were common in their study.

To the best of our knowledge, there are no published studies that have employed histological sectioning to investigate the undetected second distal canal in ETMFM. The results of the current study showed that the prevalence of USDC reached three-quarters of the samples using histological sectioning and a stereomicroscope. Investigations utilizing magnification tools such as a microscope or lenses in the laboratory or during dental access for detection of the orifice of canals have shown a higher prevalence than radiographic studies due to magnification and direct viewing; there are no obstacles or barriers that prevent viewing the canals in the tooth root [20].

Nonetheless, the findings of our study indicated a higher prevalence of USDC in females than males, with sex distribution of teeth (33.33% for males and 66.66% for females). One of the reasons may be that more females than males underwent endodontically treated teeth in this study. Females are also more careful about their teeth and prefer to preserve them and have root canal fillings instead of extractions. However, failure to diagnose the number of canals or other problems ultimately leads to treatment failure and tooth extraction. Therefore, we find that more females than males had endodontically treated teeth extracted [21].

Interestingly, a quarter of levels of ETMFM that had USDC didn't have USDC, although the lowest percentage was at the first level (the apical level), followed by the second level. The prevalence of UDC at the level of the root canal orifice (level 5) is lower than at the middle levels, which account for more than a quarter of Level 5, posing additional difficulty in detecting it. There is a high possibility that the USDC will merge with the first canal in the last area at level 1, near the root apex. The middle levels of the canal system revealed a higher prevalence of USDC than the extreme levels, which were 71.64%, but they are still difficult to visualize and manage; therefore, three-dimensional agitated canal system irrigation is mandatory for preparing these canals, and the thermoplasticized gutta percha technique with nanofilled fillers and sealers seems to be the only method to obturate these canals. The histological study concluded that many second distal canals are undetected during root canal diagnosis and treatment. It is recommended that higher-resolution CBCT be used to detect these minute canals [22].

4. Conclusion

The prevalence rates of the USDC were found to be high in ETMFM clinically, with higher rates observed in the histological study than in the CBCT study, higher in females than in males, and higher in the middle sectioning levels than at the extremes, all of which showed no statistically significant difference. Therefore, in suspicious cases, further examinations, as using newer generation *CBCT*, micro-CT, operating dental microscopy, or ultrasound, are necessary to confirm the existence or absence of these canals, which are considered a causative factor in the failure and tooth extraction after endodontic treatment in ETMFM.

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Data availability: The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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