The Prevalence of Missed Canals and their Association with Apical Periodontitis in Medina Population: A CBCT Study

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Abstract

Background: The study examines the critical role of thorough root canal treatment (RCT) in preventing endodontic failure, often resulting from undetected canals. Missed canals can harbor persistent infections, leading to apical periodontitis—an inflammatory condition affecting the tissues surrounding the root. This research underscores the limitations of traditional radiographs in identifying these missed canals and emphasizes the advantages of cone beam computed tomography (CBCT), which offers a more precise, three-dimensional perspective of the root canal system. The study aims to evaluate the prevalence of missed canals and their association with apical periodontitis within the Medina population using CBCT. Methods: The materials and methods section of the study describes a cross-sectional analysis conducted on cone beam computed tomography (CBCT) scans collected retrospectively from multiple hospitals in

Medina between 2018 and 2023. The study included CBCT scans that featured at least one endodontically treated tooth, excluding those with no evidence of previous treatment, or with poor quality images. The scans were independently reviewed by two dentists to identify missed canals and the presence of apical periodontitis, with a third expert consulted in cases of uncertainty. Data collected included tooth number, the presence or absence of missed canals, the number of orifices, and the presence or absence of periapical radiolucency. The data were analyzed using SPSS software, with results presented as frequencies and percentages, and significance set at a p-value of less than 0.05. Results: The results of the study showed that the maxillary first molars (U6) had the highest prevalence of missed canals, accounting for 40.12% of the total missed canals, followed by the mandibular first molars (L6) at 18.83%. The second mesiobuccal (MB2) canals were the most commonly missed, comprising 35.8% of all missed canals. Additionally, 54% of the teeth with missed canals were associated with periapical lesions, indicating a strong link between missed canals and apical periodontitis. Teeth with multiple orifices had a significantly higher likelihood of missed canals, with 15.7% of such teeth showing missed canals, compared to 3.2% in teeth with single orifices. The study highlights the importance of thorough canal identification and advanced imaging techniques in preventing treatment failures in endodontics. Conclusion: In conclusion, this study reveals a notable prevalence of missed canals in endodontically treated teeth, particularly in maxillary and mandibular first molars among the Medina population. The findings show a strong link between missed canals and the occurrence of apical periodontitis, highlighting the crucial need for comprehensive canal identification during root canal procedures. Advanced imaging methods, such as CBCT, play an essential role in enhancing the detection of missed canals, thereby improving treatment outcomes and minimizing the risk of post-treatment complications. The study also underscores the importance of continuous education and specialized training for dental professionals to better manage complex canal anatomies and reduce the occurrence of missed canals. Future research should extend these findings to larger populations and examine additional factors, such as clinician experience, to further enhance endodontic success rates.

Keywords: Apical Periodontitis, Canals, CBCT.

1. Introduction

Root canal treatment (RCT) is aimed at performing adequate biomechanical shaping, cleaning, and filling in three dimensions (3D) of the entire root canal system. (1) The success of root canal treatment depends primarily on the reduction of microorganisms in the infected root canal system, in addition to the prevention of microorganisms from entering the root canal system. (1)(2) The reason for unsuccessful endodontic treatment is multifactorial and cannot be attributed to a single factor. (3)(4) There can be a variety of signs and symptoms associated with unsuccessful endodontic treatment, ranging from no clinical symptoms to acute apical abscess. (5)

Apical periodontitis is an inflammatory lesion that affects the periradicular tissues, caused by a persistent or secondary bacterial infection within the root canal system. (6)(7)(8) The occurrence of post-treatment apical periodontitis is frequently associated with a failure of endodontic

treatment. (7)(9) Various studies have been conducted to identify the potential risk factors of persistent apical periodontitis. Factors such as inadequate root filling, persistent bacterial infection, missing canals, improper coronal seal/restoration, and procedural errors have been correlated to apical periodontitis. (4)(10)(11)(12)(13)(14)

Missing canal is one of the most common factors contributing to post-treatment apical periodontitis, especially in teeth with necrotic pulps. (15) The persistent organic tissue in missing canals promotes the proliferation of microorganisms, a leading cause of persistent apical periodontitis, thereby adversely affecting the treatment outcome. (6)(16)(17)(18)

There is evidence that RCT failure is associated with untreated canals in various demographic groups, ranging from 12% to 42%. (5)(7)(19) According to the available literature, approximately 17% to 23% of apical periodontitis may be caused by missing canals, with molars constituting the majority of teeth affected, followed by premolars, incisors, and canines. (5)(7)(19)

All existing canals must be located within the root system to achieve optimal prognosis. Missing canals in endodontically treated teeth can be caused by complexities in canal configuration or operator error (such as inadequately designed access cavity) or limited knowledge of tooth anatomy. (5) Having a good understanding of dental anatomy combined with good endodontic planning and using magnification appropriately are essential for locating and treating all the existing canals effectively. (20) Also, there are various diagnostic aids for the purpose of locating all canals, including staining with 1% methylene blue dye, probing the floor of the pulp chamber with a sharp explorer, using ultrasonic tips and the sodium hypochlorite 'champagne bubble' test. (21)

In the practice of endodontics, treatment planning is based on clinical and imaging information. Cone beam computed tomography (CBCT) is becoming a more prevalent tool in planning endodontic treatment. CBCT is considered a valuable tool since it eliminates several limitations of conventional radiographs and increases the likelihood of achieving a successful outcome. (22) CBCT has improved the visualization of pulpal anatomy by providing a more accurate 3-dimensional representation, allowing for a more efficient and effective approach to the root canal system. (15)(23)(24)

Conventional radiographs, which have been used in prior studies of posttreatment apical periodontitis, have limitations when it comes to detecting missed canals due to their two-dimensional nature. (25)(26) However, with the advancement of the CBCT imaging technology, several studies have been conducted to assess the prevalence of missed canals in endodontically treated teeth and its correlation with periapical lesions in different populations. (7)(5)(19) By using CBCT, it was found that missed canals in endodontically treated teeth increased the prevalence of apical radiolucent lesions by as much as fourfold. (19) Thus, Karabucak et al recommended the examination of limited field-of-view CBCT before any endodontic retreatment to identify missed canals. (19)

Moreover, two studies have been conducted in Saudi Arabia, in Jeddah and Jazan, to assess missed canals and their association with apical periodontitis. (27)(28) In both studies, it was

determined that maxillary and mandibular first molars presented the highest number of untreated canals. In maxillary molars, the cause attributed primarily to missing the second mesiobuccal (MB2) canals. There are several factors that contribute to the high percentage of missed canals reported in the literature, such as the difficulty in locating and treating MB2 canals in maxillary molars. The access is typically narrow, curved, and frequently obscured by secondary dentin. (29)

The present research sheds light on a different region of Saudi Arabia, which is Medina. Thus, this study aims to assess the prevalence of missed canals in endodontically treated teeth and their association with apical periodontitis among Medina, Saudi Arabian population by using CBCT.

2. Materials and Methods

This cross-sectional study conducted on CBCT scans which were retrospectively collected from the archive of Taibah Dental hospital (multiple hospitals in Medina) between 2018 and 2023. These CBCTs were taken for other diagnostic and treatment purposes; no patient was exposed to radiography for the purpose of this study.

The study was approved by Taibah University, College of Dentistry Research Ethics Committee (TUCDREC/o2o424/AAlawfi)

A total of 1710 CBCT scans were randomly reviewed. Only those scans that included at least one anterior or posterior tooth with endodontic treatment were selected, resulting in 330 CBCT scans being included. Scans without evidence of prior root canal treatment, or those with artifacts and poor image quality, were excluded, accounting for 1380 CBCT scans.

CBCT scans of teeth with evidence of previous root canal treatment were analyzed independently by two dentists for the presence of missed canals and apical periodontitis using Blue Sky Plan.

The following data was collected for each tooth: tooth number, presence/absence of missed canal, single or multiple orifice and presence/absence of periapical radiolucency. The number of males and females in the study was not specified, as the presence of canals does not differ between genders. There was no specific limitation regarding nationality or ethnicity for participants in the study.

Missed canals were considered as those without any evidence of filling material whether from the coronal orifice of the canal or from separated orifice. Apical periodontitis were considered when the lamina dura continuity is disrupted and associated with a radiolucency around the root apex that was at least twice the thickness of the normal periodontal ligament space. (19) In cases where the two dentists were in doubt, a third expert endodontist evaluated the scan. For detecting missed canals, axial and sagittal planes were used, and for identifying periapical radiolucency, coronal planes were utilized.

The collected data were analyzed using a statistical software program (SPSS V26; IBM Corp., NY, USA). The results were presented as frequencies and percentages. The significance level set at P value <0.05.

3. Results

Tooth Number and Missed Canal

A detailed crosstabulation analysis was conducted to investigate the relationship between different tooth numbers and the occurrence of missed canals. The results, summarized in Table 1, show the distribution of missed canals across various tooth numbers. The analysis includes different types of missed canals such as buccal/labial (B/L), distolingual (DL), mesiobuccal (MB), and others.

Table 1 presents the crosstabulation of tooth number and missed canals, showing the distribution of various missed canal types across different teeth. Teeth L1 to L7 and U1 to U7 are analyzed, with U6 (upper first molar) exhibiting the highest number of missed canals, with 130 missed canals, representing 40.12% of all missed canals detected. Tooth L6 (lower first molar) had the second-highest occurrence of missed canals, totaling 61 missed canals. This was followed by tooth U5 (upper second premolar) and L7 (lower second molar) with 23 and 32 missed canals, respectively. The most common missed canal types include MB2 (116), DB (42), and MB (33). A significant association between tooth number and missed canals was found ($\chi^2(156) = 1370.794$, $p < .001$), indicating that certain teeth are more prone to having missed canals.

Tooth No.	B/L	D	DB	DL	M	MB	MB1	MB2	ML	MM	No Missing	P/L	RE	Total
L1	4	0	0	0	0	0	0	0	0	0	19	8	0	31
L2	3	0	0	0	0	0	0	0	0	0	22	8	0	33
L3	0	0	0	0	0	0	0	0	0	0	50	5	0	55
L4	1	0	0	0	0	0	0	0	0	0	77	6	0	84
L5	2	0	0	0	0	0	0	0	0	0	98	1	0	101
L6	0	0	12	20	0	12	0	0	15	1	151	0	1	212
L7	0	1	3	5	2	6	0	0	15	0	74	0	0	106
U1	0	0	0	0	0	0	0	0	0	0	153	0	0	153
U2	0	0	0	0	0	0	0	0	0	0	152	0	0	152
U3	1	0	0	0	0	0	0	0	0	0	125	0	0	126
U4	1	0	2	0	0	1	0	0	0	0	163	8	0	175
U5	9	0	2	0	0	1	0	0	0	0	143	11	0	166
U6	0	0	14	0	0	9	4	103	0	0	110	0	0	240
U7	0	0	9	0	0	4	1	13	0	0	49	0	0	76
Total	21	1	42	25	2	33	5	116	30	1	1386	47	1	1710

Table 1: Crosstabulation of Tooth Number and Missed Canals

The chi-square test for independence showed a statistically significant association between tooth number and missed canals ($\chi^2(156) = 1370.794$, $p < .001$),

Tooth Number and Periapical Lesion

Table 2 illustrates the relationship between tooth number and the presence of periapical (PA) lesions. The table includes counts of PA lesions categorized as "No," "No Missing," and "Yes" across different tooth numbers from L1 to U7. Notably, U6 shows the highest incidence of PA lesions with 75 cases, followed by L6 with 38 cases. Teeth such as U1 and U2 have no PA lesions. The chi-square test reveals a significant association between tooth number and the presence of PA lesions ($\chi^2(26) = 405.697$, $p < .001$). This finding suggests that certain teeth are more susceptible to developing PA lesions.

The relationship between tooth number and the presence of periapical (PA) lesions is illustrated in Table 2.

Table 2: Crosstabulation of Tooth Number and Periapical Lesions

Tooth No.	No	No Missing	Yes	Total
L1	1	19	11	31
L2	2	22	9	33
L3	3	50	2	55
L4	1	77	6	84
L5	0	98	3	101
L6	23	151	38	212
L7	13	74	19	106
U1	0	153	0	153
U2	0	152	0	152
U3	0	125	1	126
U4	3	163	9	175
U5	7	143	16	166
U6	55	110	75	240
U7	12	49	15	76
Total	120	1386	204	1710

The chi-square test confirmed a significant relationship between tooth number and the presence of PA lesions ($\chi^2(26) = 405.697$, $p < .001$).

Missed Canal and Periapical Lesion

Table 3 explores the association between missed canals and the presence of periapical (PA) lesions. The table categorizes PA lesions as "No," "No Missing," and "Yes" for various types of missed canals. Notably, MB2 has the highest incidence of PA lesions with 62 cases, followed by P/L with 36 cases and MB, DB with 36 cases. The "No Missing" category, with 1386 cases, indicates teeth without any missed canals. The chi-square test indicates a significant relationship between missed canals and the presence of PA lesions ($\chi^2(24) = 1791.678$, $p < .001$). This suggests that teeth with missed canals are more likely to develop PA lesions.

Table 3: Crosstabulation of Missed Canal and Periapical Lesions

Missed Canal	No	No Missing	Yes	Total
B/L	5	0	16	21
D	0	0	1	1
DB	20	0	22	42
DL	8	0	17	25
M	1	0	1	2
MB	11	0	22	33
MB1	1	0	4	5
MB2	54	0	62	116
ML	9	0	21	30
MM	0	0	1	1
No missing	0	1386	0	1386
P/L	11	0	36	47
RE	0	0	1	1
Total	120	1386	204	1710

The chi-square test showed a significant association between missed canals and PA lesions ($\chi^2(24) = 1791.678$, $p < .001$).

Orifice Number and Missed Canal

Table 4 examines the relationship between the number of orifices and the presence of missed canals. The table categorizes orifice numbers as "0," "Multiple," and "Single," and identifies various types of missed canals within these categories. Teeth with no orifices have no missed canals and are represented by the "No Missing" category with 1386 cases. The "Multiple" orifice category shows a significant number of missed canals, particularly MB2 (115 cases) and DB (35 cases). The chi-square test results show a significant association between orifice number and missed canals ($\chi^2(24) = 2329.037$, $p < .001$). This suggests that teeth with multiple orifices are more likely to have missed canals.

Table 4: Crosstabulation of Orifice Number and Missed Canals

Orifice No.	B/L	D	DB	DL	M	MB	MB1	MB2	ML	MM	No Missing	P/L	RE	Total
0	0	0	0	0	0	0	0	0	0	0	1386	0	0	1386
Multiple	8	0	35	21	1	31	5	115	30	1	0	21	1	269
Single	13	1	7	4	1	2	0	1	0	0	0	26	0	55
Total	21	1	42	25	2	33	5	116	30	1	1386	47	1	1710

The chi-square test for independence showed a significant association between orifice number and missed canals ($\chi^2(24) = 2329.037$, $p < .001$).

4. Discussion

The current study investigates the prevalence of missed canals and their association with apical periodontitis among the Medina population using Cone Beam Computed Tomography (CBCT). The findings provide valuable insights into the common challenges faced in endodontic treatment, particularly in the detection and management of missed canals, which are a significant risk factor for post-treatment apical periodontitis.

The prevalence of missed canals in the current study aligns with findings from previous research, yet also presents some notable differences. This study reveals a significant association between specific tooth numbers and the occurrence of missed canals, with certain teeth like U6 (maxillary first molars) and L6 (mandibular first molars) showing the highest incidences of missed canals, particularly in the second mesiobuccal canals (MB2) in U6, which were the most frequently missed canal type. The prevalence of missed canals in this study (130 missed canals in U6 and 61 in L6) underscores the complexity and anatomical challenges associated with these teeth, reflecting similar trends observed in previous studies.

In the study by Mashyakhy et al. (2021), the prevalence of missed canals was reported at 18%, with a notably higher prevalence in maxillary first molars (40.6%) (28). Alnowailaty and Alghamdi (2022) observed a slightly lower prevalence of untreated canals, at 12.46%, in the Saudi Arabian population (27). Rouhani et al. (2023) found a similar prevalence of missed canals at 13.3%, with the (MB2) canal in the maxillary first molars being the most commonly missed canal(30). Additionally, the analysis in our study revealed a significant association between

certain tooth types, particularly the (U6) and (L6), with the occurrence of missed canals, further emphasizing the variability in prevalence across different studies and populations.

However, this study's detailed crosstabulation analysis provides a more granular view of the distribution of missed canals across a broader range of teeth, highlighting not only the maxillary first molars but also significant occurrences in teeth like U5 (maxillary second premolars). The significant chi-square result further emphasizes that certain teeth are more prone to having missed canals, adding depth to the understanding of endodontic challenges in clinical practice. This finding reinforces the importance of targeted diagnostic and treatment strategies for these high-risk teeth to reduce the incidence of missed canals and subsequent treatment failures.

The association between missed canals and apical periodontitis is consistently significant across multiple studies. In the current study, missed canals were strongly associated with the presence of periapical lesions, with MB2 canals showing the highest incidence (54%), followed by P/L canals, indicating that teeth with missed canals are more likely to develop periapical lesions compared to those without missed canals ($\chi^2(24) = 1791.678$, $p < .001$). This finding aligns with the study by Mashyakhy et al., where 90% of teeth with missed canals exhibited apical periodontitis, particularly in maxillary and mandibular first molars, highlighting the critical role of thorough canal identification during root canal therapy to prevent treatment failures (28). Similarly, Ebrahimi et al. reported that 91.8% of teeth with untreated canals had periapical lesions, demonstrating an 11-fold increase in the likelihood of apical periodontitis in teeth with untreated canals, with the highest prevalence observed in the MB2 canals of maxillary molars (31). Together, these studies underscore the significant impact of missed canals on the development of apical periodontitis, emphasizing the necessity for advanced imaging techniques and meticulous endodontic procedures to ensure complete canal treatment.

The impact of tooth number and orifice number on missed canals has been consistently demonstrated across multiple studies, including the current document and previous research. The current study shows that teeth with multiple orifices, particularly in molars, have a significantly higher likelihood of missed canals, with the (MB2) canal being the most frequently missed, followed by (DB) canals. This finding is statistically significant, with a chi-square test showing a strong association between orifice number and missed canals ($p < .001$). This aligns with previous studies, which also identified maxillary molars, especially first molars with complex canal systems like MB2, as being highly susceptible to missed canals (32,33). The earlier studies further corroborate that the presence of multiple orifices complicates the detection process, leading to a higher prevalence of missed canals and subsequent apical periodontitis (32,33). These findings emphasize the need for careful examination and advanced imaging techniques in endodontic procedures to reduce the incidence of missed canals across teeth with multiple orifices.

The findings of this study highlight the critical role of advanced imaging techniques, such as CBCT, in endodontic diagnosis and treatment planning. The ability of CBCT to provide detailed 3D visualization of the root canal system allows for more accurate detection of missed canals, thereby reducing the risk of treatment failure and subsequent apical periodontitis. Clinicians are

encouraged to integrate CBCT into their routine practice, especially for complex cases involving molars with multiple canals.

Furthermore, the study underscores the importance of continuous education and training for dental professionals to enhance their understanding of root canal anatomy and improve their skills in canal detection and management. The high prevalence of missed canals in specific tooth types suggests that targeted training in the management of these challenging cases could significantly improve treatment outcomes.

While the study provides valuable insights, it is limited by its retrospective design and the specific population studied. The findings may not be generalizable to other populations with different demographic characteristics. Future research should consider prospective studies with larger, more diverse populations to validate the findings and explore additional factors that may influence the prevalence of missed canals and apical periodontitis.

Moreover, the study did not account for the impact of operator experience on the likelihood of missed canals, which could be an important variable to consider in future research. Understanding the role of operator expertise could further inform training programs and improve clinical practice.

this study provides significant insights into the prevalence of missed canals and their association with apical periodontitis in the Medina population, highlighting the complexity and challenges in endodontic treatment, particularly for specific teeth such as the maxillary and mandibular first molars. The findings emphasize the importance of advanced imaging techniques like CBCT for accurate diagnosis and treatment planning to reduce the incidence of missed canals and improve treatment outcomes. Additionally, the study underscores the need for ongoing education and targeted training for dental professionals to enhance their skills in detecting and managing root canal systems, especially in teeth with complex anatomies. While the study's retrospective design and specific population may limit generalizability, it lays the groundwork for future research to explore broader populations and additional factors influencing the prevalence of missed canals and apical periodontitis.

5. Conclusion:

this study underscores the importance of CBCT in improving the detection of missed canals and suggests that increased adoption of advanced imaging in endodontic practice, combined with enhanced education, can significantly enhance treatment outcomes. The findings lay the groundwork for further exploration into the complexities of root canal anatomy and the continued development of endodontic practices that prioritize comprehensive canal exploration.

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