Prevalence of Missed Canals in Previously Root Canal Treated, Symptomatic, Multirooted Teeth Diagnosed by Imaging Techniques: An In-Vivo Cone Beam Computed Tomography Study

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ABSTRACT

Background: Missed canals is one of the procedural errors that occurs during endodontic treatment. Untreated canal harbour microorganisms which leads to periapical pathology. RVG is a routinely used diagnostic tool in the root canal treatment and CBCT being the superior diagnostic imaging technique, which is preferred.

Aim: This study aimed to evaluate the prevalence of missed canal in previously treated root canal treatment, symptomatic, multi-rooted teeth with the help of imaging techniques.

Methods: 44 patients were selected which came with failed root canal treatment in maxillary and mandibular first and second molar teeth. The selected patient were divided into 2 separate groups - Group I (n=22) for maxillary and Group II (n=22) for mandibular molars. Both these groups were further subdivided into subgroup A (n=11) for patient with first molar and B (n=11) patient with second molar were placed. RVG with straight view, 15° mesial and 15° distal were taken and CBCT with sagittal, coronal, axial plane were taken. Presence or absence of missed canal was noted and tabulated by two independent evaluators on the basis of predetermined criteria. The consideration of R.C.T. teeth is define as if a R.C. filled contained with hyperdense or material. Untreated (missed) canals were identified as those completely unfilled from the cemento-enamel junction to the apex or canals disrupted from the main canals at any point. The presence of missed canal was recorded when it could be clearly seen in both the axial and coronal sections. The data was tabulated and statistically analysed using Chi square test ($P < 0.05$).

Results: The results showed overall prevalence of missed canal in molars was 54.5% (24 out of 44 teeth) which was higher in mandibular first molar followed by maxillary first molar and second molar and least in mandibular second molar teeth. In comparison between RVG and CBCT in identification of missed canal, CBCT demonstrated superior diagnostic accuracy with statistically significant difference ($P < 0.05$).

Conclusion: Prevalence of missed canal in one of cause of previously root canal treatment failure in molars. The prevalence missed canal was higher in mandibular first molar followed by maxillary first molar and second molar and least in mandibular second molar teeth. CBCT was found to be more effective in identifying the missed canal in comparison to RVG. So as to draw more conclusive results a wider clinical study needs to be undertaken.

Keywords: CBCT, Missed canal, RVG, Periapical.

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Introduction

The successful outcome of root canal treatment (R.C.T.) needs thorough understanding the morphology of root canal, proper cleaning and shaping, and filling with inert materials three dimensionally.[1]

However, the recurrence of clinical symptoms with radiolucency in periapical (PA) region after endodontic treatment leads to failure. Inadequate endodontic treatment is consistently identified as a major contribuiting factor. Among these inadequacies, missed canals (M.C.s) were the majority reasons for treatment breakdown. Negligence to locate the canals orifices during endodontic treatment often leads to missed canals providing a favourable space for the growth of microorganism which result in apical periododontitis.[2]

Anatomic variations within the root canal system are among the primary etiologic factors responsible for missed canal during the root canal treatment. Complex root canal (R.C.) morphology, narrow or calcified canals, additional root are the main etiologic factors that contribute to canals being missed.[3]

Missing a canal during root canal treatment can lead to several significant

complications that directly compromise the treatment success. Failure to identify or treat the complete root canal anatomy is the principal factor contribuiting to endodontic failure in molar teeth and represents the second most commom etiological factor in other tooth categories. The clinical outcome of such failures may vary widely, ranging from an absence of symptoms to severe periapical infections, including apical abscess formation.[2]

Attaining the ideal canal configuration will enchances the prognosis but it remains challenging. A range of diagnostic aids including conventional radiograph, 2 dimensional imaging, microscopes, bur or ultrasonic instrument can assist in locating canals but none can ensure indentification of all canals in every case.[4]

Radiology is an fundamental constitute of root canal treatment which aids a critical role in diagnosis, treatment planing and determining treatment success. Conventionally I.O.P.A. X ray or radiovisiography (R.V.G.) is the preferred radiographic method for identification of the defects / missed canals in root canal canal treated teeth. Cone beam computed tomography (C.B.C.T.) represents an advanced diagnostic modality that enables the 3 dimensional visualization of the maxillofacial hard tissue, involving a multi-slice view of the root canal system and facilitate the detection of iatrogenic errors.[1]

Despite the higher cost and relatively greater radiation exposure compared with conventional periapical radiography, studies have shown increased acceptance of C.B.C.T. among endodontists, as it allows precise assessment of root canal morphology and spatial localization.[1,2,5]

Therefore, this study aimed to identify the prevalence of missed canals in previously root canal treated teeth which had become symptomatic. C.B.C.T. was selected to confirm and it's effectiveness in identifying missed root canals was compared to R.V.G.

Materials and method

This study was conducted on patients who visited the Department of Conservative Dentistry & Endodontics with complaint of symptoms in previously R.C.T. mandibular & maxillary first & second molar. Ethical approval for the study was granted by the 'Ethical Committtee of TMDC&RC , Moradabad' and was carried out in a time period of 16 months.

These patients were shortlisted and further scrutinized on the basis of following inclusion and exclusion criteria. The considered inclusion criteria were previously R.C.T. teeth with radiopacity in the prepared R.C. space depicting radiopacity that was reflective of obturation, maxillary and mandibular first and second molar teeth, 18-55 years of age, presence of symptoms and patient who were ready to take part in the study. The exclusion criteria are premolars and third molars, anterior teeth, presence of resorption, age less than 18 years and more than 55 years, medically compromised patients, pregnancy, recent history of myocardial infarction, patient with debilitating disease, recent history of surgery, patient with split tooth syndrome, non restorable teeth.

Patient who fulfilled the above mentioned inclusion

and exclusion criteria was subjected to a R,V.G. examination of the selected tooth.

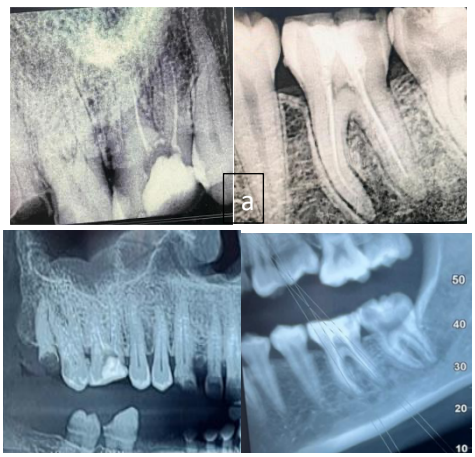
In this manner a total of 44 patients with one tooth each were selected and included in the study. These patients were equally & randomly distribuited in two groups. Group I consisted of 22 maxillary molars, further subdivided into first molars (n = 11) and second molars (n = 11). Group II consisted of 22 mandibular molars, similarly divided into first molars (n = 11) and second molars (n = 11) (table 1).

Each of these selected teeth in every patient underwent a R.V.G. examination comprising of 3 views; straight view , 15° mesial and 15° distal angulation. They further underwent a C.B.C.T. scan of the concerned tooth in axial-plane , coronal-plane , and sagittal-plane with 2-D multidirectional reconstructed slices. Reconstruction of aquired volumetric C.B.C.T. data was done using the manufacturer`s dedicated imaging software to create three-dimensional volume-rendered images. These 3D reconstructed images permit complete visualization of the tooth and its surrounding structures, to bring accurate estimation of the oburated canals in three dimentions views.

The presence or absence of missed canal was made on the basis of following criteria.

The consideration of R.C.T. teeth is define as if a R.C. filled contained with hyperdense or material. Untreated (missed) canals were identified as those completely unfilled from the cemento-enamel junction to the apex or canals disrupted from the main canals at any point. The presence of missed canal was recorded when it could be clearly seen in both the axial and coronal sections.

Based upon this criteria of each R.V.G. & C.B.C.T. scan was evaluaed, seperately by two independent evaluators.The data was tabulated and statistically analysed.



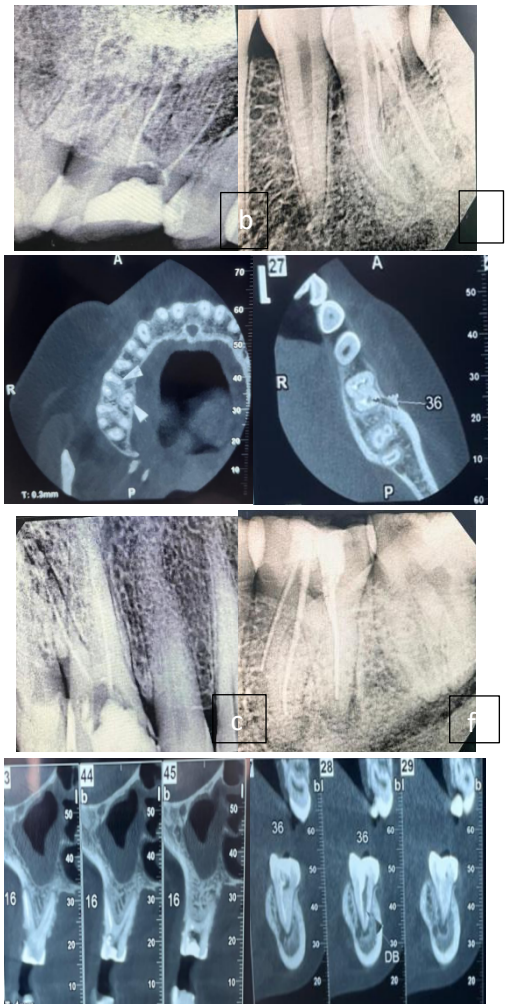


Fig 1 : Radiographs of maxillary and mandibular molars showing RVG views and missed canal detected by CBCT of those teeth. (a) and (d) RVG in straight view; (b) and (e) RVG in 15° mesial view; (c) and (f) RVG in 15° distal view; (g) and (i) CBCT in coronal plane; (h) and (k) CBCT in axial plane; (i) and (l) CBCT in sagittal plane.

STATISTICAL ANALYSIS

The collected data were entered into Microscope Excel and analysed using SPSS software. Descriptive statistics were used to express the data in terms of frequencies and percentages. The prevalemce of missed canals was calculated accordingly.

The Chi-square t-test was used to compare the effectiveness of radiovisiography (R.V.G.) & Cone Beam Computed Tomograph (C.B.C.T.) in detecting missed canals. Fisher's exact test was applied when expected cell frequencies were less than 5.

Sensitivity,specificity and Cohen's kappa coefficient were calculated to assess the diagnostic accuracy and agreement between

R.V.G. and C.B.C.T.

A p-value of < 0.05 was considered statistically significant.

Results and observations

Out of a total of 44 molar teeth examined, 24 teeth exhibited missed canals. Among the maxillary first molars, 7 out of 11 teeth exhibited missed canals, resulting in a prevalence of 63.6%. In maxillary second molars, missed canals were identified in 5 out of 11 teeth, corresponding to a prevalence of 45.5%.

A higher prevalence was observed in mandibular first molars, where 8 out of 11 teeth demonstrated missed canals, yielding the highest prevalence of 72.7% among all molar groups studied. In contrast, mandibular second molars showed missed canals in 4 out of 11 teeth, with a prevalence of 36.4%, representing the lowest occurrence among the evaluated teeth.(Table 1)

Among the conventional radiographic techniques, straight view R.V.G. identified missed canals in 6 cases (13.6%), while the 15° mesial angulated RVG detected missed canals in 7 cases (15.9%). The highest detection among the R.V.G. views was observed with the 15° distal angulation, which identified 9 missed canals (20.5%). Despite the slight improvement with angulation, the overall detection rate with R.V.G. remained relatively low, with more than three-fourths of cases being reported as not identified in all R.V.G. views.

In contrast, C.B.C.T. demonstrated a markedly higher detection rate, identifying missed canals in 24 out of 44 teeth (54.5%), while 20 cases (45.5%) were reported as not identified. Thus, CBCT detected more than half of the missed canals and substantially outperformed both straight and angulated RVG techniques.(Table 2)

Type of Teeth	Total Number of Teeth	Missed Canals	Prevalence (%)
Maxillary 1st Molars	11	7	63.6%
Maxillary 2nd Molars	11	5	45.5%
Mandibular 1st Molars	11	8	72.7%
Mandibular 2nd Molars	11	4	36.4%
Total Molars	**44**	**24**	**54.5%**

Table1 : Prevalence of missed canal in individual molar teeth

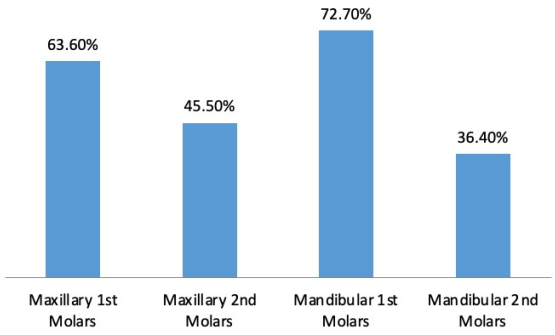


Figure 2: Graphically presentation of prevalence of missed canal in individual molar teeth

Imaging Method	Missed Canals n (%)	Not Identified n (%)	Total
Straight View RVG	6 (13.6%)	38 (86.4%)	44
RVG – 15° Mesial	7 (15.9%)	37 (84.1%)	44
RVG – 15° Distal	9 (20.5%)	35 (79.5%)	44
CBCT	24 (54.5%)	20 (45.5%)	44

Table 2: Detection of missed canals by different imaging modalities (overall)

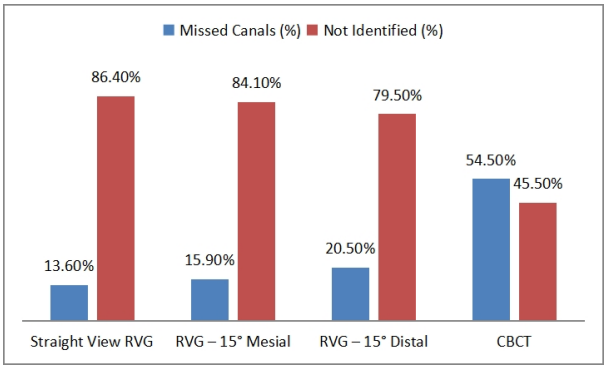


Figure 3 : Graphically presentation on detection of missed canals by different imaging modalities (overall)

Discussion

An inclusive idea of R.C. system is important successful endodontic procedures.[3,5,6,7] Teeth are characterized by intricate R.C. configuration, inadequate removal at all segment poses a potential growth of bacterias.[8,9] Identifying of R.C. anatomy can be challenging due to considerable variation among individuals and population**(Nair PN,Soğur E et al.,Cheng L et al.,Abd Latib AH et al.)**.[10,11,12,13] Inaccurate recognition of all pertinent anatomical features can result in predictable treatment failures.[14,15,16] Unaddressed anatomical complexities have been recognised as a significant factor contributing to endodontic failure. [17,18] Therefore, understanding the R.C.s configurations is essential, specially in multi-rooted teeth.[14,15,16]

The R.C. anatomy in mandibular & maxillary 1st & 2nd molars are different.[19] Maxillary molars usually have 3 roots (often with MB1 and MB2) while mandibular molars generally have two in no. of roots with variable canal number.[20] These additional canals can often be inaccessible or difficult to reach, leading to treatment failure, exacerbation of the symptoms and affect the prognosis .[21,22,23] Undetected R.C. anatomy contributes to endodontic treatment failure in 12% - 42% of cases.[24]

Dental radiography, including R.V.G. is widely used for diagnosis.[25,26,27] Multiple periapical views of radiographs are essential to identify the number of root canal, as they provide a 2-D representation of complex 3-D R.C. anatomy **(Rumon K et al.,Jain S et al.,Singla M et al.,Mohammadi Z et al.,Rouhani A et al.,Barati S et al., Tartuk GA)**.[28,29, 30,31,32, 33,34] Their diagnostic effectiveness is contingent upon angulations, anatomical superimposition, and individuals patients variables.[35]

C.B.C.T. offers three-dimensional images with multiple cross-sectional slices, improving detection of fine anatomical details**(Ahmad ZH et el.,Mashyakhy M et al.,Singla M et al.,Babu BV et al)**[22,24,30,36] It offers high resolution with relatively low radiation exposure and is more accurate than traditional and digital periapical radiographs in identifying R.C. systems.[37,38,39]

In this study the prevalence of missed canals iin previously R.C.T., symptomatic max. & mand. 1st & 2nd molars was 24 out of 44 molar teeth. Hence, the prevalence rate of M.Cs was found to be 54.5%. This finding is approximately similar to **Zargar N 2024** missed canals was found to be most common technical errors with (50.4%)[40], **Witherspoon et al 2013** in incidence of missed canal of previously treated molar 64 out of the 133 previously treated molar teeth (48%) were identified[14], **Hoen and Pink** detected (42%) of missed canal of overall teeth in which retreatment had performed nonsurgically[41], whereas prevalence of missed canal was less in **Karabucak et al** 23.04% (2016)[16] , **Rouhani A et al** 13.3% (2023) [32].

Missed canals in molars is often frequent, as these teeth didn't follow the one root canal pattern.[42] Due to variation in the R.C. anatomy, for multi-rooted teetth and R.C. orifice number. Frequency in this procedure error is most in posterior teeth, yet knowledge about them is poor and has highly involved R.C.T. teeth and two-dimensional radiographs.[43,44,45] According to **Valverde Haro HP et al** M.C.s are mainly related to pronounced curvature of canal, particularly in teeth exhibiting calcified canals.[46]

In this study distribuition of M.C. among individual molar, the mand. 1st molar exhibit high number of M.C., among all molar groups studied. Similarly, **Rumon K et al** frequency was highest in mand. 1st molar followed by max. 1st molar.[28] On the contrary **Mashyakhy M et al** found max. 1st molars were the high pre-valence of M.C.[24], **Do Carmo WD et al** found that max. 2nd molar were the high pre-valence of M.C..[47] The elevation of missed canals in mand. 1st molar may be attribuited to its anatomical difference, both in number of roots and canals, **(JC Bury et al, S Friedman et al,YL Ng et al).**[48,49,50] It is the most liable tooth in R.C.T. teeth.[34]

In this study the comparison for identification of missed canal by R.V.G. and C.B.C.T., C.B.C.T. demonstrated a significantly higher detection rate of missed canals. Missed canals were identified in 54.5**%** of cases using C.B.C.T. , whereas R.V.G. detected missed canals in only 20.5% of cases. This can be the angulation in RVG are static only one angulation at the time wherein C.B.C.T. is three-dimensional through all surfaces and planes for identification is possible. Study which exhibited similar is **Rumon K et al** R.V.G. didn't detect any missed canal out of 26 R.C.T. teeth whereas C.B.C.T. detected 5 missed canal.[28] A study by **Tira et al**, in comparison of C.B.C.T. with two C.C.D. & photostimulable phosphor plate which shown that in 40% cases conventional digital radiograph missed 1 R.C., this would compromised the treatment success.[3] Same findings were reported by **Subbarao et al,** were the supermacy of C.B.C.T. has been demonstrated, simultaneously with clearing technique and modified staining technique, upon digital radiography in excactly identification root canal morphology.[19]

Another finding in this study is that in angulated R.V.G., missed canals were identified in 13.6% of cases using straight R.V.G, compared with 15.9% and 20.5% using 15° mesial and 15° distal angulated R.V.G. views, respectively. This means distal view is slightly higher than straight view in identification of missed canal. Also, supported by **AR Siddique et al** radiographic images to see the additional canals, clinicians must employ 20°- 30° mesial-distal horizontal shifts to overcome the limitations of standard regular angulation.[51] Futhermore, the mesial angulation may not provide the exact anatomy of the root canal, **JI Ingle.**[52]

Overall, the results demonstrate a progressive improvement in missed canal detection from straight R.V.G. to angulated R.V.G., with C.B.C.T. providing the highest diagnostic yield, underscoring its value as

an advanced imaging modality in the assessment of previously treated molars.

According to European Society of Endodontology suggested that a teeth with difficult root canal structure, that will be going to nonsurgical Re-endodontic treatment, were allowed for C.B.C.T. with limited F.O.V. .[53,54] Small F.O.V. of about 40mm^3 - 50mm^3 is recommnended for edodontic purpose.[55]

Hence, C.B.C.T. serves as a baseline diagnostic tool for accurate identification of missed canals, root canal orifices, variation in root canal anatomy in retreatment endodontics. By providing a detailed three dimensional parameters such root length and numbers without distortion, C.B.C.T. overcomes superimposition and enhances diagnostic percision and support treatment planning.

Conclusion

On the basis of results obtained in our study it can be concluded that M.C. is one of the predominant etiologic reasons for failure of R.C. treatment. The prevalence of M.C. is relatively high in both maxillary & mandibular first molar compared to second molar. C.B.C.T. scan is more reliable with a higher specificity rate of identification of M.C. compared to R.V.G.

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