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Accuracy of Dental Operating Microscope in Detecting Number of Root Canals in Human Mandibular First Molars Obturated and Indicated for Retreatment: Diagnostic Accuracy Experimental Study

ALbaraa Alkady[1], Ahmed Abuelezz[2], Ahmed Ghobashy[3],
1: Teacher assistance of Endodontics Department, Faculty of Dentistry,Misr International University, Cairo, Egypt. Orcid: 0000-0002-7524-8188
2: Lecturer of Endodontics Department, Faculty of Dentistry,Misr International University, Cairo, Egypt. Orcid: 0000-0002-2251-5414
3: Professor of Endodontics Department, Faculty of Dentistry,Misr International University, Cairo, Egypt. Oricd : 0000-0002-8340-5649 . Scopus Author ID: 57194040342
Corresponding Author: Albaraa Alkady
Address: Endodontics Department, Faculty of Dentistry – Misr International University KM 28 Cairo – Ismailia Road Ahmed Orabi District, Cairo – Egypt

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KEYWORDS
number of canals, dental operating microscope, CBCT.

Abstract:

Background: Failure to disinfect and to locate all canals is a major reason for root canal primary and secondary failures, which may lead to periapical periodontitis. Cone beam computed tomography (CBCT) is considered the gold standard in canal detection although its use must be justified beforehand due to its high radiation dose. Using dental operating microscope may enhance canal detection and avoid error in interpreting CBCT images. **Aim:** To evaluate the accuracy of dental operating microscope in detecting root canals in mandibular first molars retreatment cases in comparison to CBCT imaging. **Materials and methods:** Thirty-five patients with obturated lower first molar(s) referred for retreatment will participate in this study. After a pre-treatment periapical x-ray to aid practitioner in access cavity formation a CBCT will be performed for all cases. **CBCT stage1:** CBCT scans performed to all participants will be randomly distributed and observed by the principle investigator and supervisors and the number of canals found will be recorded. **Clinical stage 2:** patients will be randomly distributed on 6 endodontic post graduate students* students enrolled in the endodontic master's program at MIU* students will then perform access cavity, the number of canals found will be recorded. Data collected will be compared. Between the stage 1and two

Results:

Kappa = 0.878 indicates that there was a very good agreement between the number of canals that were found by means of CBCT and the clinical examination that was performed using a dental operating microscope. The P-value for the two different approaches was 0.247, which indicates that there was no statistically significant difference between the number of canals that were found.

Conclusion: There was no significant difference between detected number of canals by the CBCT and dental operating microscope

Introduction

Ricucci & Siqueira in 2010 stated that apical periodontitis is a disease induced by bacterial contamination of the root canal system. Therefore, the success of final results of root canal treatment in tooth with no infected pulps relies upon on stopping root canal contamination, in tooth with non-vital necrotic pulps it is predicated on eradication or at the least decrease in bacterial counts to degrees like minded with periradicular tissue healing. Arnold et al. in 2013 stated that post-treatment apical periodontitis is a disease related to canal contamination. Tavares et al. in 2009 stated many factors to develop apical periodontitis, including missing canals, have been evaluated in

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maximum preceding studies. If the canal were missed and been infected and as such remained untreated may also harbor microorganism in enough numbers to preserve or purpose the apical periodontitis. If the canal were noninfected, untreated canals may also be characteristic as a probably susceptible for reinfection. (1)(2)(3)(4)(5)(6)

In lower mandibular molar the different canal can be seen, one of them is middle mesial which may be challenging for the dentist to locate, it has shown correlation of developing periapical periodontist and missed canal, the incidence of presence of middle mesial was tested by Mehrnaz Tahmasbi et al in 2017 in 122 teeth; the results show the prevalence of middle mesial in lower first molar was 26% and 8 % in lower second molars. (7)

Pomeranz et al in 2020, stated that middle mesial canal classified into: fin, confluent, and independent. Fin is defined when an instrument pass between the two canals the mesiobuccal canal and mesiolingual canal. The Confluent is defined as middle mesial canal originates as a separate orifice but in the apical area fuse with the mesio-buccal canal or the mesio-lingual canal (type II). independent is defined when middle mesial canal originates as a separate orifice and exit as a separate foramen.(8)

To obtain the most accurate data about root canal morphology and number of canals, CBCT is the optimum of choice. It provides 3D image rather than the traditional 2D x-ray that causes the anatomy to be superimposed and geometric distortion that may hide the area of interest, so CBCT overcomes this problem and gives a lot of information in all phases of treatment during and post treatment. The root canal morphology and number of canals cannot be detected by the traditional 2D x-ray, but CBCT enables the dentist to visualize the axial cut to determine the number of roots and root canals and where they divide. However, the use of CBCT is not a routine technique for assessing the canal anatomy. (9)

In retreatment cases clinicians face a lot of challenging situations that require special maneuver to overcome these problems. One of these maneuvers is to use CBCT for retreatment endodontic cases, but with care and following American Academy of Oral and Maxillofacial Radiology (AAOMR) and the American Association of Endodontists (AAE) to ensure safest dose for the patient using ALARA principles as low as reasonably achievable. According to a 2015 study by Nair MK et al, one of the recommendations for using CBCT according to (AAOMR) and (AAE) is in nonsurgical retreatment. CBCT should be considered the x-ray of choice, another recommendation is CBCT should be the imaging of choice for patients with nonspecific clinical signs and symptoms either untreated or previously treated teeth. So, patients referred for retreatment of previously treated lower molars are recommended for CBCT to detect missing canal or determine cause of failure. (10)

The aim of the study is to define the dental operating microscope for detecting root canals in mandibular first molars retreatment cases in comparison to CBCT imaging.

Materials and Methods

Materials

Table 1 : All material used in the study

Item	**Manufacturer**	**Country**	**Specifications**
Periapical Radiograph	Fona XDG X-ray	Italy	Digital exposure settings (0.21 MAs, 70 KVP, focal spot 0.4)
Sensor	Vista Scan PSP Sensor (Durr Dental)	Germany	Size 2 with resolution of 22 LP per mm and 16 bit greyscales.
Image Reading Software	VistaSoft 2.4.13/2022	Germany	Brightness and contrast will be standardized automatically.
Dental Operating Microscope	Leica M320D	Germany	Magnification 16X, using fully integrated 4K camera

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Hand Piece	NSK Pana-air	Japan	High Speed Contra-angle handpiece.
Bur	Mani	Japan	TR13 diamond stone
Rubber Dam	Sanctuary Dental Dam	Malaysia	Latex Free (6*6)- Heavy
Rubber Dam Clamp	Hygienic, Coltene	USA	Size 8 Winged Molar
Endodontic Probe	Dentsply Sirona	Germany	DG16
Manual File	Mani	Japan	#10 K- File
CBCT	Soredex Cranex 3D Dental Imaging System	Finland	XS FOV dimensions 61 x 41 mm (HxD) (XS FOV High resolution 90 kV / 4 - 12.5 mA / 6.1 s) 85 um voxel size
CBCT Software	OnDemand software	USA	DICOM Format
Randomization Software	Microsoft Office Excel	USA	.xlsx

Methodology

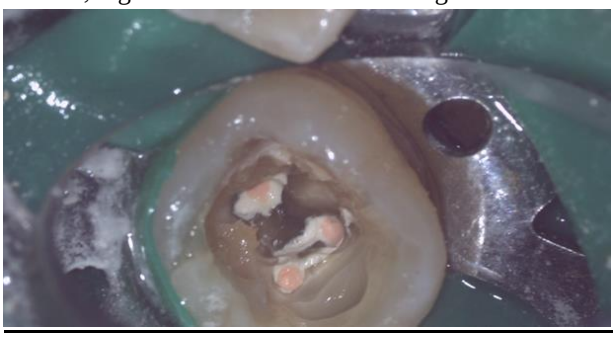
a. Methods

Thirty-five Patients with obturated lower first molar(s) referred for MIU dental clinic for retreatment. Informed consent will be obtained at first before a pre-treatment periapical x-ray to aid practitioner in access cavity formation a CBCT will be performed for all cases. Patients will be treated in a single visit as per the study methodology and then referred to the endodontic masters' program to finish endodontic retreatment with reference to the CBCT obtained.

1) CBCT exmanation stage: In this stage, CBCT scanning was done using Soredex Cranex 3D Dental Imaging System, FINLAND, with the following parameters ((XS FOV dimensions 61 x 41 mm (HxD)) (XS FOV High resolution 90 kV / 4 - 12.5 mA / 6.1 s)).

The samples will be randomized using randomization software (Microsoft Office Excel, USA) and will be assigned randomly to 2 endodontists who are unaware of the findings of stage 2. After interpreting and segmenting the CBCT scans in DICOM Format using OnDemand software (USA), the number of canals identified will be recorded on a pre-established information guide. (11)(12)(13)(14).

The samples are coded based on the patient's file number, and the codes were undisclosed so that the CBCT examiners could not identify the samples. All images were interpreted from the axial section in the analysis of the tomographic sections, the number of canals are identified by the corresponding radiolucent orifices, regardless of their location along the root



2) Clinical phase : This is a clinical stage where the thirty-five patients, as predetermined by power analysis, will be randomly distributed upon 6 Practitioners using randomization software (Microsoft Office Excel). Practitioners will then proceed in access formation under dental operating microscope, (Leica M320D using magnification 16X, using fully integrated 4K camera).

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Grouping of samples:
The acquired data will thereafter be categorized into two groups based on the approach used for canal detection.
Group 1 : CBCT: The quantity of root canals identified through the examination and analysis of CBCT images by endodontist (considered the most accurate method).
Group 2: Clinical: Number of root canals identified during clinical intervention through the process of access cavity preparation conducted by a postgraduate student.

Results

Statistical Analysis

Qualitative data were presented as frequencies and percentages. Friedman's test was used to compare between number of canals detected by the two methods. *Kappa* statistic was used to assess agreement between different methods. *K*appa values ranging from 0.6 to 0.8 indicate good agreement while values ranging from 0.8 to 0.99 indicate very good agreement. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. ROC (Receiver Operating Characteristic) curve was constructed to determine the diagnostic accuracy measures of clinical examination in relation to CBCT and. ROC curve analysis was performed with MedCalc® Statistical Software version 19.5.1 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2020).

Table 2 : Descriptive statistics and results of Friedman's test for comparisons between detected number of canals by the three methods

Number of canals	CBCT (n = 35)		Clinical examination (n = 35)		*P*-value
	n	%	n	%	
Three canals	14	40	12	34.3	0.247
Four canals	21	60	23	65.7	

**: Significant at P ≤ 0.05*

There was no statistically significant difference between detected number of canals by the two methods (*P*-value = 0.247). There was very good agreement between the number of canals detected by CBCT and clinical examination (*Kappa* = 0.878).

Diagnostic accuracy of clinical examination in relation to CBCT

ROC curve analysis of DOM for detection of number of canals utilizing CBCT as the Gold Standard is presented in Table (2) and Figure (1). ROC curve analysis showed that DOM has high sensitivity (85.7%), high specificity (85.7%) and high diagnostic accuracy (85.7%).

Table (3): Sensitivity, specificity, predictive values, diagnostic accuracy, Area Under the ROC curve (AUC) and 95% confidence interval (95% CI) of the (AUC) for DOM using CBCT as the Gold Standard

Sensitivity %	Specificity %	+PV %	-PV %	Diagnostic accuracy %	AUC	95% CI
95.7	95.7	90	80	95.7	0.857	0.697-0.952

+PV: Positive Predictive Value, -PV: Negative Predictive Value

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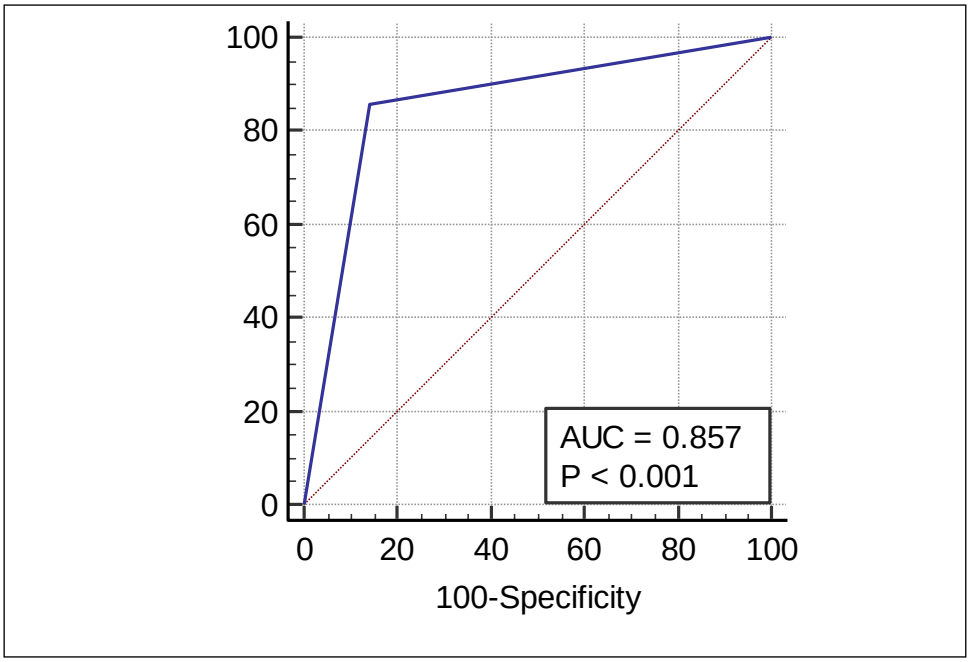

Figure (1). ROC curve of DOM accuracy of detecting number of canals using CBCT as the Gold Standard

Discussion

The correlation between untreated canals and the occurrence of periapical diseases in teeth that have had endodontic therapy. revealed that 82.6% of teeth with untreated canals were associated with periapical disease. Moreover, molars that possessed an unnoticed canal exhibited a 3.1-time higher probability of developing periapical disease in comparison to mandibular molars that had received treatment for all canals. The researchers established a statistically significant association between the existence of untreated canals and the development of apical periodontitis in teeth that have received endodontic therapy. [(15)]

To summarize. The incidence of apical periodontitis in root canal-treated teeth with undetected canals was found to be significant, approaching 90%. The majority of these unnoticed canals were identified in the first molars of both the upper and lower dental arches. [(16)]

Endodontics is limited to a tight working environment due to its focus on extremely small anatomical structures. Consequently, clinicians who handle complex situations seem to require a higher level of visual and high level of concentration to work in an efficient way and to detect all canal to prevent failure of root canal treatment. The eye can only perceive objects up to the level of the canal orifice. Additionally, the quality of natural eyesight would start to decline after an individual reaches the age of 40. This fact has been confirmed by employing reduced-scale visual charts positioned within teeth. The dental industry faces a dilemma due to a lack of awareness regarding this visual impairment.

This study use (CBCT) in identifying root canal structure with two specialists to determine the number of canals. The gold standard for canal detection was the utilization of Micro CT. The diagnostic precision for Periapical radiography and CBCT imaging was determined to be 55% and 89%, respectively. CBCT imaging demonstrated comparable efficacy to the gold standard. CBCT is presently considered the definitive method for identifying morphology, according to the scientists' findings. However, the disadvantages of using CBCT include increased radiation exposure and the practitioner's restricted ability to interpret the images. Artificial intelligence technology has the capacity to tackle these problems. [(17)]

The American Association of Endodontists (AAE) and the American Academy of Oral and Maxillofacial Radiology (AAOMR) released a Joint Position Statement. The purpose of the statement was to define precise criteria for the application of Cone Beam Computed Tomography (CBCT) in the field of endodontics. CBCT cannot be used as a routine method

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in endodontic treatment cases, as practitioners must follow the ALARA principle in their treatments. The American Academy of Oral and Maxillofacial Radiology (AAOMR) and the American Association of Endodontists (AAE) have established guidelines that emphasize the importance of adhering to the ALARA principle (as low as reasonably achievable) to minimize radiation exposure for patients. One of their recommendations is to use cone beam computed tomography (CBCT) specifically for nonsurgical retreatment. The use of CBCT is recommended for the detection of overlooked root canals or for determining the underlying cause of treatment failure. [10]

CBCT provides high-resolution three-dimensional images, enabling detailed visualization of the root canal system. The volumetric data obtained through CBCT offers a comprehensive view of tooth anatomy, contributing to precise canal identification . CBCT is renowned for its high clinical accuracy in canal detection, making it an indispensable tool in preoperative assessment and treatment planning. The detailed imaging capabilities of CBCT contribute to enhanced diagnostic confidence, especially in challenging cases. [18]

The precision of CBCT in identifying second canal anatomy is crucial for the clinical decision-making process of general dentistry practitioners and endodontists. The combined assessments of the precision of CBCT yielded a sensitivity of 94% and a specificity of 93.1% for the second distal canal of permanent teeth. CBCT is highly informative for detecting a additional canal. Clinicians should be aware that the accuracy of their findings may differ depending on the specific characteristics of the teeth, the prevalence of extra canals in various populations. [19]

In this study all access cavities were performed under the aid of dental operation microscope. The current use of magnification equipment in endodontics and clarify their potential for improving treatment results. the gradual decrease in visual sharpness experienced by professionals, which typically begins at approximately 40 years of age. The use of loupes and Dental operating microscope (DOM) as effective methods to address age-related vision impairment. Furthermore, the several magnification devices presently employed by practitioners, such as flip up loupes and through the lens loupes. Nevertheless, The DOM (Dental Operating Microscopes) are presently regarded as the most superior choice in endodontic therapy owing to their exceptional ergonomics, magnification, and documentation capabilities. Ultimately, the diverse uses of the Dental Operating Microscope (DOM), which encompass the identification of all canals. [20]

The DOM provides enhanced visualization during endodontic procedures, offering magnification and illumination that aids in the detection of intricate canal structures. This tool is particularly valuable in locating and negotiating canals with a higher degree of precision. The real-time observation facilitated by the DOM allows endodontists to visualize the entire canal system, aiding in the identification of additional canals or anatomical variations. This real-time feedback enhances diagnostic accuracy during the treatment process. [21]

In this study the use of dental operating microscope in retreatment cases in comparison with CBCT the result show no significant difference between the two method in canal detection which give the necessary to use high magnification in endodontics felid to prevent any missed canal .Although there is no significance different between the two methods in canal detection one of the cases show that it was missed in the CBCT while in the clinical stage it was found this is may due to the artifact that is associated with the presence gutta percha, also it may be due to the voxel size of the CBCT which affect the quality of the x ray.[22]

Conclusion

Under the circumstances of the current study, the following conclusions derived:

- The use of dental operating microscope is Nassery in endodontics felid.
- There is no difference between the CBCT and DOM in determine the number of canals.
- The voxel size and artifact presence in the CBCT may affect the interpretation of the Xray.

Clinical Relevance

- It is recommended to use the dental operating microscope in retreatment cases.
- Even if the CBCT did not show any extra canal a carful looks and examination under DOM could revel extra canal.

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