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Comparative evaluation of the efficiency of cone-beam computed tomography, clinical analysis, and dental loupes in detecting the MB2 canal in maxillary first molars. An in-vitro study

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ABSTRACT

Context: The success of an Endodontic treatment relies on the position and morphology of root canals. It is important for a clinician to be familiar with the canal morphology to negotiate and thereby filling the canals with an inert material. But, the possibility of negotiating the canals with the use of conventional technique alone is difficult. Hence, careful examination with the use of advanced techniques to enhance vision is required to minimize the rate of treatment failures.

Aims: To compare the efficiency of three methods Cone-Beam computed Tomography (CBCT), clinical analysis, AND Dental Loupes in detecting the MB2 canal in maxillary first molars.

Materials and Methods: One hundred and fifty extracted intact permanent molars were collected. Two examiners i.e., one Endodontist and a Radiologist examined CBCT images of teeth for the number and position of root canals. The first stage included unaided examination using an explorer and K- files. While those teeth that were failed to locate the canals were examined using dental loupes for better magnification.

Statistical Analysis used: The results were analyzed by McNemar's tests with Bonferroni correction, and Chi-square test using SPSS software v21.

Results: Among 150 extracted teeth that were compared, MB2 was detected using CBCT in around 68% of the teeth, while with the use of naked eye and dental loupes, it was found to be around 30% and 66% respectively and the difference in the detection rates was statistically significant.

Conclusions: With the view of the parameter under consideration, CBCT has high detection rates followed by dental loupes and naked eye vision.

Key Messages: The efficiency of CBCT scans and dental loupes in detecting a second mesio-buccal canal, thus making it more likely to be treated by the clinician.

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1. Introduction

One of the primary goals of endodontic treatment is adequate cleaning and shaping of all the pulp spaces and their complete filling with an inert material. The success of a case depends on the skill and expertise of the clinician with normal and anatomical variations of the root canal.¹

In early part of the 20th century, more interest is given in the maxillary first molar, with most attention being focused on the mesio-buccal root. Hess and Zurcher in the year 1925 proven that in the entire dentition mesio-buccal root of the maxillary first molar has the most complicated root canal system.² The maxillary first molars have a root canal anatomy with utmost complexity and thus the highest failure rate in endodontic treatment, and there is untreated second

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canal in the mesio-buccal root (MB2), which often being missed.^{3,4}

The incidence of MB2 canal has been reported to be as high as 95.2% in an in vitro study⁵ and as low as 18.6% in an in vivo study.⁵ In vivo, clinical studies included examinations of maxillary first molar during root canal treatment both with and without magnifications, and also with retrospective assessment of records and radiographs.⁶

Traditional means of exploring canals include clinical examination as well as conventional two-dimensional radiography. Iatrogenic errors including perforation mostly caused due to MB2 because of its smaller size and location often beneath overlying calcification.⁵

Periapical radiographs remained the gold standard for endodontic diagnosis but have several limitations, as it demonstrates only a two-dimensional image, the buccolingual dimension of the root cannot be appreciated and there is a superposition of the subjacent anatomy with the cortical density.^{7–9} The utilization of enhanced vision systems and the introduction of newer techniques such as dental computed Tomography (CT), CBCT, and scanning electron microscopy (SEM) changed the ability to visualize the canal anatomy and orifices.^{10,11}

Clinical studies with magnification include dental loupes which provide magnification of x 2.0 to x 6.0. Magnification helps the practitioner to have a clear and perfect view thus enabling the clinician to treat cases that have poor prognosis or are untreatable.^{12,13}

Cone-Beam computed Tomography (CBCT) generates three-dimensional images that allow inspection of the tooth much more perfect in all the planes. The axial plane is predominantly useful in helping the clinician to determine the number and location of root canals relative to one another.^{14,15}

The rationale of this study is to evaluate the detection of MB2 canals in maxillary permanent first molars using three different methods- CBCT, clinical analysis and dental loupes. This study may help clinicians in identifying, negotiating, and treating missed second canals in permanent maxillary first molar for a better prognosis.

2. Materials and Methods

One hundred and fifty extracted intact permanent maxillary molars with fully formed apices were collected from the Department of oral surgery, and private dental clinics. Teeth with external resorption, developmental anomalies, Vertical/horizontal root fracture, Calcified canals, and those with abrupt canal curvatures were excluded. Collected teeth were then cleaned of visible blood and gross debris and stored in 1% thymol solution for one week following occupational safety and health administration (OSHA) and the centre for disease control and prevention (CDC) guidelines. The teeth were then numbered from 1 to 150. Three teeth were placed in a wax slab. A gutta percha cone

was placed on the right side of the wax slab to identify in the CBCT image, later each slab was scanned with CBCT (KODAK, 9300c, U.S.A). The voxel of 0.2 mm was used with an exposure of 16 min. The record of the number of canals and their variations were recorded by two examiners, one endodontist, and one radiologist.

An access cavity was prepared under halogen bulbs using # 2 and #4 Endo Access bur (Maillefer, Dentsply, Switzerland). The point of entrance was made at the centre of the mesial pit, with the bur sloped palatally using a high-speed hand piece to the depth of dentin. After the larger palatal canal was located, Safe ended # 0152 Endo-Z bur (Maillefer, Dentsply, Switzerland) was used, keeping it in contact with the floor of the pulp chamber mesiobuccal and distobuccal canals were located simultaneously. Conventional triangular access was altered to a trapezoidal shape to get better access to the additional canals. Endo- Z fissure bur was used for the final finishing and funneling of the cavity walls. The contents of the pulp chamber were then removed using an endodontic excavator and subsequent irrigation with a 2.5% Sodium hypochlorite solution. The pulpal floor was explored using an endodontic explorer, DG-16 (Maillefer, Dentsply). The groove connecting the canal orifice was explored with the use of k-files #6, #8 or #10 (Mani, Japan). In the first stage, teeth were examined with the naked eye (unaided vision) for the second canal in the mesiobuccal root using an explorer followed by K-files #6 or #8 and EDTA. If the endodontist fails to locate the canal by the naked eye, samples will be subjected to the next stage where the teeth were examined with dental loupes x 3.5 magnification for the presence of MB2. Size 6,8,10 k file was inserted in MB and MB2 canals if located with or without magnification. The data were subjected to statistical analysis using IBM SPSS version 21. The McNemar's test with Bonferroni correction, and Chi-square tests were used to compare the canal detection rates among the three methods. A p value of <0.05 was considered statistically significant.

3. Results

We aimed to compare the second mesio-buccal canal detection rates of the three methods, in a sample of 150 extracted teeth. While CBCT could detect the canal in 102 teeth (68%), the number was lesser with 30(20%) and 99(66%) teeth using naked eye and dental loupes respectively. The difference in the detection rates was statistically significant (Table 1).

A pair-wise comparison of the CBCT and dental loupes each with naked eye also revealed significantly greater rate for the two techniques. Furthermore, CBCT could detect better than the dental loupes (Table 2).

The CBCT technique could detect the mesio-buccal canals in 14 additional teeth when compared to the dental loupes (Table 3).

Table 1: Comparison of the detection rate of mesio-buccal canals using the three methods

	Value		p-value
	Yes	No	
CBCT	102(68%)	48(32%)	<0.001
Naked eye	30(20%)	120(80%)	
Dental loupes	99(66%)	51(34%)	

* Statistically significant at $p < 0.001$

Table 2: Comparison of CBCT and dental loupes with naked eye clinical examination

		Naked eye		Total	Mc Nemar test
		Yes	No		
CBCT	Yes	27(26.4%)	75(73.5%)	102(68%)	<0.001*
	No	3(6.2%)	45(93.8%)	48(32%)	
	Total	30(25.0%)	120(75.0%)	150(100.0%)	
Dental Loupes	Yes	30(30.3%)	69(69.6%)	99(52.5%)	<0.001*
	No	0	51(47.5%)	51(47.5%)	
	Total	30(26.6%)	120(73.4%)	150(100.0%)	

* Statistically significant at $p < 0.001$

Table 3: Comparison of CBCT with dental loupes

		Dental Loupes		Total	Mc Nemar test
		Yes	No		
CBCT	Yes	88(86.2%)	14(13.8%)	102(68%)	<0.001*
	No	11(22.9%)	37(77.1%)	48(32%)	
	Total	99(66%)	51(34%)	150(100.0%)	

* Statistically significant at $p < 0.001$

4. Discussion

The Success in endodontic treatments is determined by an adequate cleaning, shaping and filling of the root canal system. The lack of a good knowledge about the morphological and anatomical features of a root canal makes it difficult to locate the canals which ultimately leads to a failure of root canal therapy.¹⁶ This is of particular significance in case of accessory canals.

An endodontist is supposed to have a prior understanding of the root curvatures and other anatomical variations often present in the teeth being treated, for this helps in a better treatment planning.

The first maxillary molar is quoted to be the most misunderstood tooth. It is frequently associated with anatomical variations concerning the number and disposition of the canals.¹⁷ The concept of a second mesio-buccal canal was suggested by Hess and Zurcher in 1925. A failure to detect the second canal in the mesio-buccal root affects the prognosis, though studies indicate its ease of identification in almost 70% of the cases.¹⁸

Maggiore et al found that the existence of MB2 canal in 63.59%, of the Korean population studied, with 88.10% mesio-buccal roots having bilaterally symmetrical morphology. Another study by Stropko¹⁹ showed a MB2 canal in as many as 93% of first molars.

Approaches like endodontic access, radiography (PINEDA), scanning electron microscope, ultrasonics, magnification loupes, dental operating microscope (alacam, tuncer), and CBCT have been used to detect MB2 canal.

CBCT is a newer diagnostic imaging modality which gives three dimensional inter-relational images in three orthogonal planes-axial, sagittal and coronal. It is being progressively used in endodontics. Its distinct features include lower cost and lower absorbed doses of radiation than conventional CT. They can be either adjusted to scan particular regions for diagnostic tasks or can also scan the entire craniofacial complex. They produce the best isotropic resolution ranging from 0.4 mm to as low as 0.125 mm. Additionally, scanning is rapid (10-70 seconds) and comparable with that of medical spiral CT systems. Reports indicate that the radiation dose is greatly reduced by up to 98% compared to conventional CT systems.

Zheng et al showed that, of the CBCT images of 775 maxillary first molars in a Chinese population, the prevalence of MB2 was 52.24%. In the present study, MB2 canal detection by CBCT imaging was almost similar, with the canal being found in 82 (68.3%) out of 120 extracted permanent first molars.²⁰

Baratto-Filho et al demonstrated an efficiency of 92.85% ex-vivo, 95.63% clinically, and 95.45% through CBCT. Blattner et al tested 20 completely intact maxillary first and second molars for presence of MB2 canal and concluded

that CBCT scanning is a reliable method to detect the MB2 canal.²¹

The use of optical instruments such as endoscopes, and loupes enables magnification of a specific area beyond that visible to a naked eye. Dental loupes help an endodontist in treating an otherwise poor prognosis tooth. They were proven to actually improve the success rate.³

In a study conducted by Iqbal, a MB2 canal was observed in 77 out of 300 extracted maxillary molars, through a naked eye. Whereas, with the use of dental loupes, the number increased to 223(88.3%).¹³

In another study, magnification was found to enhance the detection rate from 17.2% with the naked eye, to 62.5% with loupes and 71.1% using the surgical operating microscope.²² Our study findings match with this study, with a detection rate of 30% with naked eye that further rose to 66% with the use of dental loupes.

Coutinho Filho et al also showed increase in the rate of MB2 canal identification from 53.7% to 87.96% with use of magnification and opined that the identification of MB2 canal relies on a multitude of factors like- professional skill, good lighting, magnification and anatomical complexity.²³

5. Conclusion

Our study findings demonstrate the efficiency of CBCT scans and dental loupes in detecting a second mesio-buccal canal, thus making it more likely to be treated by the clinician. The better detection rates of the two techniques would suffice that determined by a naked eye, and improve the success rate of an endodontic treatment.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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