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Comparison between two CBCT systems in detection accuracy of second mesio-buccal root canal(s) in maxillary molars

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Background: Undetected second mesiobuccal canal (MB2) in maxillary molars (MMs) increases the failure rates of endodontic treatment.
Aim: The aim of this study is to compare between i-CAT classic (Imaging Sciences International, Hatfield, PA, USA) and Veraviewepocs 3D (J–MORITA, Kyoto, Jaban) CBCT systems in detection accuracy of MB2 canals in maxillary molars.
Materials and methods: 100 human MMs were collected mounted in the molar sockets of the skull and fixed by 3 layers of modeling wax. Teeth were scanned by 2 CBCT systems, the i-CAT and Verviewepocs 3D.
Results: From 100 MMs, MB2 was detected in the MB roots of 85 molars (85%). At the orifice level of MB roots, MB2 was detected in about 64 molars (64%). In the middle of the root, MB2 was detected in about 79 molars (79%). At the apex level, MB2 was detected in about 39 molars (39%). The differences between both CBCT systems were small & statistically non-significant. All the kappa coefficients were interpreted as adequate to good agreement.
Conclusion: The i-CAT and J-MORITA CBCT systems are reliable tools for MB2 canal detection in MMs when compared to gold standard sectioning technique and there is no significant statistical difference between them. The coding classification is simple, accurate and practical. MB2 is more prevalent in the middle of the root than the orifice level than the apex level. MB2 is more prevalent than MB3 and MB4

Keywords: second mesio-buccal canal, maxillary molars, coding classification system, cone beam computed tomography.

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Introduction

Maxillary molars are the most common teeth in endodontic failure because of the presence of undetected extra canal(s) (MB2) in their mesio-buccal roots (MB) [1,2]. According to Ingle's Endodontics, the incidence of MB2 was higher in laboratory studies (61.1%) than clinical studies (54.7%). According to Cohen's Pathway of the Pulp, MB1 incidence was 69%, MB2 29%, MB3 2.6% and MB4 1% [3,4].

Ideal classification of root canal system is needed for terms of diagnosis, communication and treatment planning. It must define the tooth in terms of root number, no. of canals in each root & canal course from orifice to apex. Also, can be applied in all root types and root canal configurations in all teeth groups. It must be reliable, accurate, simple, easy to communicate & can be used in clinical practice, training and research [5].

Many classifications were proposed but, additional types were reported in various studies that cannot be described by these classifications [6]. Also, it is not clear in which root the canals are encased in multi-rooted teeth [7]. Some root canal divisions have the same code & a same canal configuration has different codes in different classifications [5].

The coding classification considers the tooth type, the root encasing the canal configuration, the configuration from orifice to apex, the exit location of the canal and finally, anatomic variations e.g. radix molar, C shaped canal, etc., if present [8]. It includes codes like (TN) that indicates the tooth number and it can be written with any numbering system e.g. Palmer Notation or Universal numbering system or World Dental Federation System (FDI). If the tooth is not identified with any of the numbering systems i.e. extracted teeth, a suitable abbreviation can be used, e.g., upper molar is indicated by (UM) [8].

A superscript is added before the tooth number (^{R}TN) where (^{R}) indicates the roots number e.g. ^{1}TN indicates that tooth 'TN' is single rooted. Any root division is coded as two or more roots whether in the coronal, middle or apical third. Accordingly, the bifurcation and trifurcation are coded as ^{2}TN & ^{3}TN respectively and so on [8].

Root(s) details are added after the tooth number (^{R}TN Rn) where (Rn) indicates the root name e.g. mesial, distal, etc. The root canal configuration in each root is coded as a superscript number(s) right to the root name defining the whole root canal course from the orifice(s) (O), through the canal (C) to the foramen (F) [8] [Table 1].

Table 1: A summary of the codes allocated for single-, double and multi-rooted teeth, TN, Tooth number; R, Root; O, Orifice; C, Canal; F, Foramen.

Tooth type	Code
Single-rooted	^{1}TN $^{o-c-f}$
Double-rooted	^{2}TN R1^{o-c-f} R2^{o-c-f}
Multirooted	^{n}TN R1^{o-c-f} R2^{o-c-f} Rn^{o-c-f}

Certain factors contribute to the wide variations reported in the incidence of an MB2 canal in MMs. These include tooth position, race, age, and gender of the population studied [9,10], as well as the methods of research whether laboratory, clinical or radiographic methods [11]. Radiological methods include conventional & digital radiography, contrast medium enhanced digital radiography & CBCT [12]. CBCT plays an important role in endodontics as it provides 3D images without significant magnification or distortion that allows teeth inspection in all anatomical planes, specially, the axial plane which aids in detecting root canals [13].

Currently, there are many CBCT systems differing in their image quality and ability to show anatomic structures. This difference is most apparent in small and delicate structures such as periodontal ligament, trabecular bone, vertical root fractures and accessory root canals [14,15].The aim of this study was to compare the diagnostic accuracy of two CBCT systems, the i–CAT next generation (Imaging Sciences International, Hatfield, PA, USA) and the Veraviewepocs 3D (J–MORITA, Kyoto, Japan), in detection of second mesio-buccal canals in maxillary molar teeth.

Materials and methods

According to the sample size calculation of this study, 100 human MMs were collected from surgery department, faculty of dentistry, Ain Shams university then, cleaned and disinfected. Then, stabilized in a dry human skull and scanned with two CBCT systems, the i-CAT and the Veraviewepocs 3D CBCT systems using 0.125 mm voxel size. Badly decayed teeth fractured or erosed roots were excluded from our study.

All the scans were evaluated twice by 2 oral and maxillofacial radiologists of 5 years of experience, with one week interval on the axial view for the presence or absence, number & course of MB2 along MB roots with a slice thickness of 2 mm. They scored their results and gave each MB root a code according to the coding system. All MB roots were histologically sectioned with 2 mm interval at 3, 5, 7, etc. mms from the apex.

Every section was studied under stereomicroscope (gold standard) to prove presence or absence & number of MB2. All the scores and codes were tabulated, compared, and statistically analyzed.

Ethical consent

This study was expedited from review by the Ethical Committee affiliated to our institute.

Preparation of teeth

All teeth were immersed in 2% sodium hypochlorite solution (NaOCl) for 20 minutes then, properly washed & stored in distilled water. Teeth were numbered and mounted in the molar sockets of the skull and fixed by 3 layers of modeling wax.

Radiographic CBCT imaging

Teeth were scanned by 2 CBCT systems, the i-CAT (Imaging Sciences International, Hatfield, PA, USA) & Verviewepocs 3D (J. MORITA, Kyoto, Japan). The skull was stabilized using a small boxboard mounted on the chin holder of both machines then, adjusting the skull position using the laser guides of both machines so the vertical laser light was parallel to the sagittal plane of the skull and the horizontal laser light was parallel to the occlusal plane of the teeth [16].

Imaging parameters:

The smallest possible voxel size in both systems which was 0.125 mm and the possible FOV covering the whole area of maxillary arch were used. A preview scan was taken to assure that all the teeth were within the chosen FOV [Table 2].

Table 2: the imaging parameters used in this study.

Parameter	i-CAT	J-Morita
Voxel size	0.125	0.125
FOV	40 × 100	50 × 100
Kvp	120	90
mA	5	8
Scanning time	7 sec.	9.4 sec.

After scanning, the i-CAT and J-MORITA images were evaluated on the axial view [17,18] by two oral and maxillofacial radiologists using the inherent i-CAT Vision™ and J-MORITA i-Dixel one volume viewer software viewers. The observers investigated the axial sections of MB roots at the level of 3, 5, 7, etc. mm coronal from the apex to the orifice level of the root canal(s) [18] [Figures 1,2,3 &4].

Figure 1: Axial section of CBCT image (i-CAT system) showing root canals in maxillary molar roots.

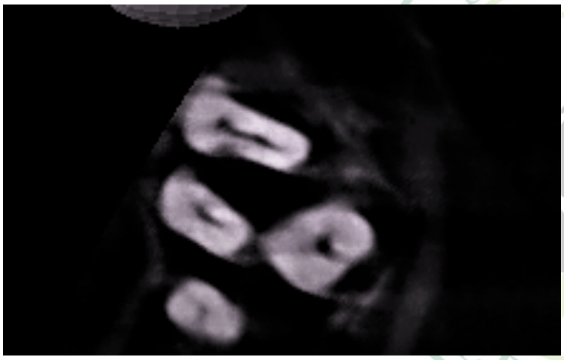

Figure 2: Axial section of CBCT image (J-MORITA system) showing root canals in maxillary molar roots.

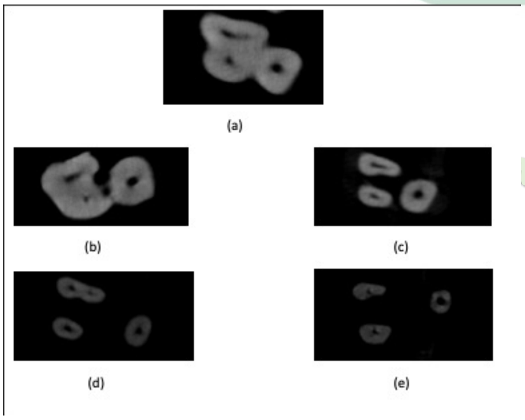

Figure 3: Axial section of CBCT image (J-MORITA system) showing root canals in mesio-buccal root of sample maxillary molar no. 14 at different levels, (a) at the orifice level, (b) at 2 mm from the orifice level "9 mm from the apex", (c) at 4 mm from the orifice level "7 mm from the apex", (d) at 6 mm from the orifice level "5 mm from the apex", (e) at 8 mm from the orifice level "3 mm from the apex".

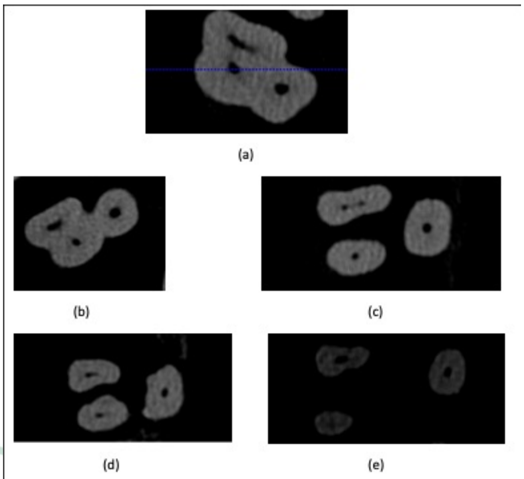

Figure 4: Axial section of CBCT image (i-CAT system) showing root canals in mesio-buccal root of sample maxillary molar no. 14 at different levels, (a) at the orifice level, (b) at 2 mm from the orifice level "9 mm from the apex", (c) at 4 mm from the orifice level "7 mm from the apex", (d) at 6 mm from the orifice level "5 mm from the apex", (e) at 8 mm from the orifice level "3 mm from the apex".

Coding Classification:

All the teeth used in this study were extracted human upper molars, so they all were given a (UM) code according to the coding system. The $(^3)$, $(^2)$ & $(^1)$ superscriptions were written left to the (*UM*) code for three rooted teeth, double rooted and single rooted tooth, respectively. In the three rooted teeth, the MB roots had the (MB) code while in the double rooted teeth, the mesial root had the (M) code and the single rooted tooth had the (R) code.

Number of root canal(s) in every section was written as a superscription right to the root code. About 4-5 superscription numbers were written according to the root length, while a single superscript number was written if the root had the same root canal number along its length. For example, ^{3}UM MB^2 represents a three rooted upper molar that has two orifices, two separate canals and two foramina in its mesio-buccal root [Table 3].

Table 3: A summary of the used codes in the evaluation, (^{o}) represents no. of root canals at the orifice level, (^{c}) represent no. of canals along middle of the root & (^{f}) represent no. of canals at the apical level.

Tooth type	Code
Single-rooted	^{1} R^{o-c-f}
Double-rooted	^{2} UM M^{o-c-f}
Three-rooted	^{3} UM MB^{o-c-f}

Histological Sectioning:

To prove the presence or absence of MB2 or extra canals and their number in our samples, multiple cross-sectioning of the scanned molars' roots were done using a diamond disk stone with a low-speed micro-motor (Strone 90 - Saeshin precision Co., LTO). Cross-sectioning of the scanned molars was done at apical 3mm then, at 2 mm interval along the root coronally. About 4 – 5 sections were obtained from each root according to the root length.

After sectioning, the roots sections were immersed in 2% sodium hypochloride (NaOCL) for 2 minutes to remove any debris resulted from the sectioning process. Then, these root sections were viewed under a stereomicroscope (Olympus TL3) using a lens size 40 and magnification x2, stabilized with a black dough material.

Photos of the stereomicroscope were captured using a digital camera (Canon DS126371), also, evaluated twice with one-week interval by the 2 observers independently. [Figure 5]. All the scores and codes were tabulated, compared, and statistically analyzed.

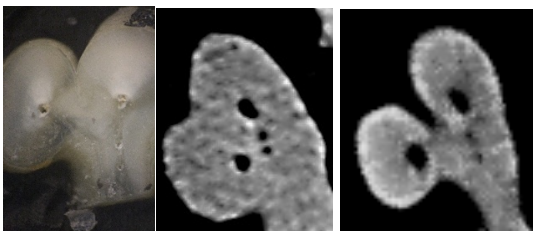

Figure 5: A stereomicroscope photograph showing a mesio-buccal root section fused to disto-buccal root section from no.11 with 3 canals in the MB root and one canal in the DB root and its corresponding J-Morita radiograph (on the left) and I-CAT radiograph (on the right) scans.

Results

From 100 MMs, 88 molars had 3 roots, 11 had 2 roots & one had single root. MB2 was detected in the MB roots of 85 molars (85%). At the orifice level of MB roots, MB2 was detected in about 64 molars (64%). In the middle of the root, MB2 was detected in about 79 molars (79%). At the apex level, MB2 was detected in about 39 molars (39%).

At the orifice level of MB roots, two canals were detected in about 56 - 57 molars while, three or more canals were detected in 9 - 7 molars by i-CAT & J-MORITA. At 2 mms depth from the orifice level "9 mm from the apex", two canals were detected in about 51 molars while, three or more canals were detected in 17 molars by i-CAT & J-MORITA.

At 4 mms depth from the orifice level "7 mm from the apex", two canals were detected in about 64 – 66 molars while, three or more canals were detected in 3 -4 molars by i-CAT & J-MORITA. At 6 mms depth from the orifice level "5 mm from the apex", two canals were detected in about 48 – 50 molars by i-CAT & J-MORITA while, three or more canals were detected in 3 – 5 molars by i-CAT & J-MORITA.

At 8 mm depth from the orifice level "3 mm from the apex", two or more canals were detected in about 32 molars by i-CAT & J-MORITA. The percentage of agreement (PA) of codes representing the root canal configuration of MB root was 61- 65 % & 55 -63 % by i-CAT & J-MORITA, respectively.

The comparison between i-CAT & J-MORITA systems in the PA showed that all the differences between PA of both observers were small and statistically non-significant (Table 4 & 5, Figures 6 & 7).

The comparison of PA between i-CAT & J-MORITA systems for inter-observer reliability showed high values of PA of interobserver reliability of both systems & the difference between both systems are small & statistically non-significant. The comparison between i-CAT & J-MORITA systems in the kappa coefficient (K) showed that the K of the two observers for the two systems can be interpreted as adequate to good agreement (Table 6 & 7, Figure 8 & 9). The comparison between i-CAT & J-MORITA systems for intra-observer reliability showed high values of PA of interobserver reliability of both systems & the difference between both systems are small & statistically non-significant (Table 8 & 9, Figure 10 & 11).

The comparison of K between i-CAT & J-MORITA systems for interobserver reliability showed that all K of the two systems can be interpreted as adequate to good agreement.

Table 4: Comparison between i-CAT & J-MORITA in PA of observer 1 & 2 showing non statistical significance between **PA** of both observers with i-CAT & J-MORITA.

	i – Cat		J - Morita	
	Observer 1	Observer 2	Observer 1	Observer 2
No. of roots	100%	100%	100%	100%
Presence of MB2	94%	95%	92%	92%
Course of MB2 along the MB root				
Orifice	93%	96%	91%	92%
Middle	91%	100%	94%	96%
Apex	94%	92%	90%	91%
No. of MB canals				
At the orifice level	89%	93%	90%	90%
At 2 mms depth	82%	87%	83%	87%
At 4 mms depth	85%	88%	84%	86%
At 6 mms depth	83%	83%	80%	79%
At 8 mms depth	92%	92%	89%	88%
Percentage Agreement of Codes	61%	65%	55%	63%

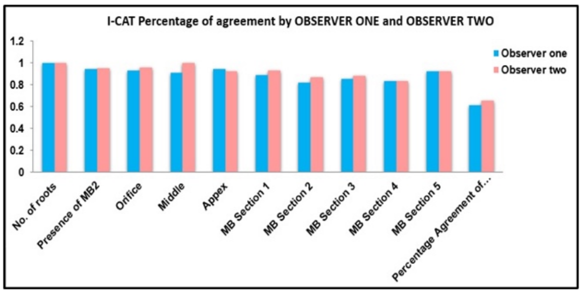

Figure 6: A comparative graph of **PA** between observer 1 & observer 2 for i-CAT showing non statistical significance between the two observers.

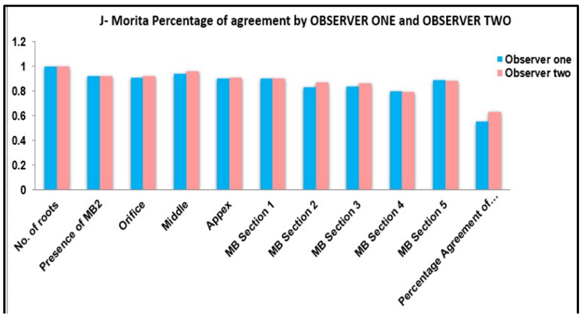

Figure 7: A comparative graph of **PA** between observer 1 & observer 2 for J-MORITA showing non statistical significance between the two observers.

Table 5: Comparison between i-CAT & J-MORITA in K of observer 1 & 2 showing that all k of the two observers for the two systems can be interpreted as adequate to good agreement.

	i – Cat		J - Morita	
	Observer 1	Observer 2	Observer 1	Observer 2
No. of roots	1.00	1.00	1.00	1.00
Presence of MB2	0.78	0.81	0.70	0.67
Course of MB2 along the MB root				
Orifice	0.85	0.91	0.85	0.82
Middle	0.73	1.00	0.82	0.88
Apex	0.88	0.83	0.79	0.81
No. of MB canals				
At the orifice level	0.80	0.87	0.82	0.82
At 2 mms depth	0.70	0.78	0.72	0.78
At 4 mms depth	0.71	0.77	0.68	0.72
At 6 mms depth	0.69	0.69	0.62	0.62
At 8 mms depth	0.88	0.88	0.84	0.82

Table 6: Comparison between i-CAT & J-MORITA systems in the PA for inter observer reliability showing non statistical significance between i-CAT & J-MORITA in PA for interobserver reliability evaluations.

	i – Cat	J - Morita
No. of roots	1.00	0.95
Presence of MB2	0.76	0.87
Course of MB2 along the MB root		
Orifice	0.91	0.96
Middle	0.73	0.88
Apex	0.90	0.92
No. of MB canals		
At the orifice level	0.93	0.96
At 2 mms depth	0.95	0.95
At 4 mms depth	0.91	0.89
At 6 mms depth	0.92	0.86
At 8 mms depth	0.94	0.83

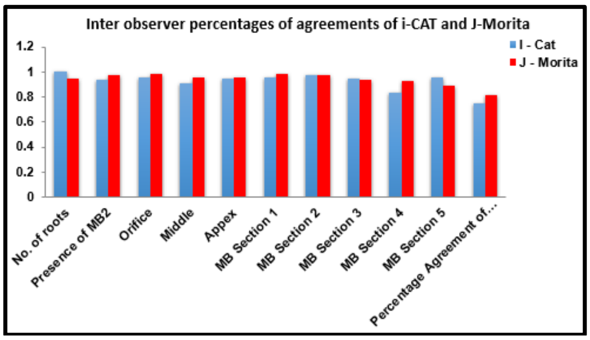

Figure 8: A comparative graph of PA between i-CAT & J-MORITA for interobserver reliability showing high values of PA of interobserver reliability of both systems. The differences between the two systems are statistically non-significant.

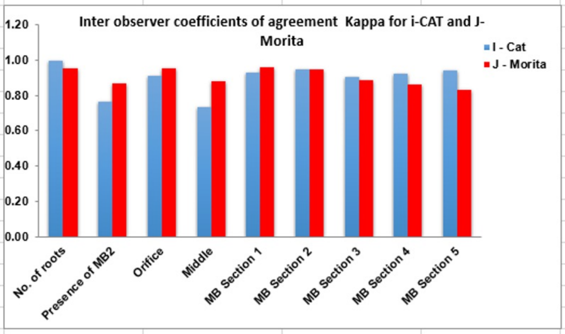

Figure 9: A comparative graph of K between i-CAT & J-MORITA for interobserver reliability showing all K of the two systems can be interpreted as good agreement.

Table 7: Comparison between i-CAT & J-MORITA in the K for interobserver reliability showing that all the K of the two observers for the two systems can be interpreted as adequate to good agreement.

	i – Cat	J - Morita
No. of roots	1.00	0.95
Presence of MB2	0.76	0.87
Course of MB2 along the MB root		
Orifice	0.91	0.96
Middle	0.73	0.88
Apex	0.90	0.92
No. of MB canals		
At the orifice level	0.93	0.96
At 2 mms depth	0.95	0.95
At 4 mms depth	0.91	0.89
At 6 mms depth	0.92	0.86
At 8 mms depth	0.94	0.83

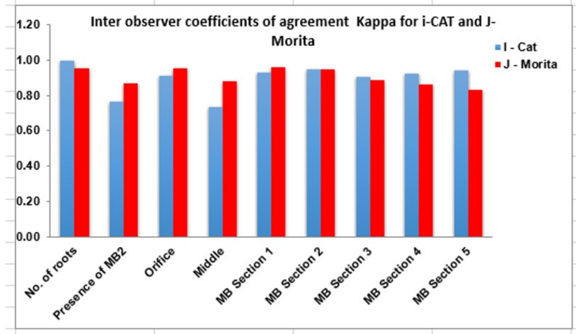

Figure 9: A comparative graph of K between i-CAT & J-MORITA for interobserver reliability showing all K of the two systems can be interpreted as good agreement.

Table 8: Comparison of the PA between i-CAT & J-MORITA for intraobserver reliability showing non statistical significance between i-CAT & J-MORITA in PA for intraobserver reliability evaluations.

	i - Cat	J - Morita
No. of roots	100%	99%
Presence of MB2	95%	99%
Course of MB2 along the MB root		
Orifice	94%	96%
Middle	95%	96%
Apex	97%	96%
No. of MB canals		
At the orifice level	93%	96%
At 2 mms depth	95%	98%
At 4 mms depth	94%	93%
At 6 mms depth	94%	92%
At 8 mms depth	96%	93%
Percentage Agreement of Codes		
	70%	82%

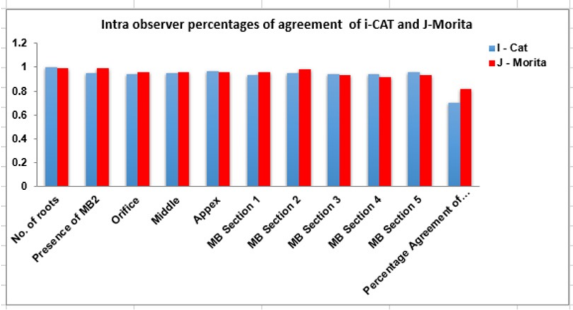

Figure 10: A comparative graph of PA between i-CAT & J-MORITA for intraobserver reliability showing high values of PA of intraobserver reliability of both systems. The differences between the two systems are statistically non-significant.

Table 9: Comparison between i-CAT & J-MORITA in K for intraobserver reliability showing that all the K of the two observations for the two systems can be interpreted as adequate to good agreement.

	i - Cat	J - Morita
No. of roots	1.00	0.95
Presence of MB2	0.80	0.96
Course of MB2 along the MB root		
Orifice	0.87	0.91
Middle	0.85	0.89
Apex	0.94	0.92
No. of MB canals		
At the orifice level	0.87	0.93
At 2 mms depth	0.91	0.97
At 4 mms depth	0.89	0.87
At 6 mms depth	0.89	0.84
At 8 mms depth	0.94	0.89

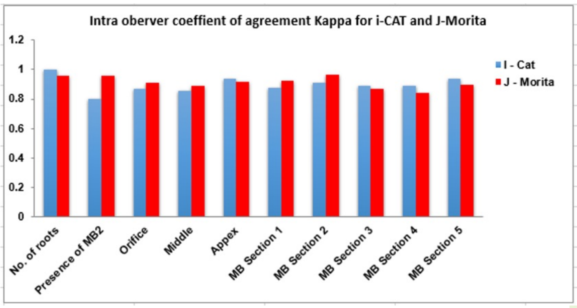

Figure 11: A comparative graph of K between i-CAT & J-MORITA for intraobserver reliability showing all K of the two systems can be interpreted as good agreement.

Discussion

Cone beam computer tomography (CBCT) is a very important method in determining the root canals' number and their location in relation to each other, particularly, when using the axial plane [13,19]. However, applicating CBCT in endodontics is better to be limited to evaluation and management of complex endodontic conditions due to its high effective dose of ionizing radiation compared to conventional radiographs [20].

Many studies investigated its ability in MB2 detection and concluded that it is an accurate & a reliable method in detecting & locating MB2 [2,10]. Others concluded that it increases the success rate of endodontic treatment [21,22], specially, when done pre-operatively [1] and in cases of retreatment [23].

Comparative studies between CBCT with conventional & digital radiographs were done concluding high specificity & sensibility of CBCT [23,24]. Others compared between different CBCT systems in their image quality & ability to show anatomic structures [25], specially, delicate anatomic structures such as periodontal ligament, trabecular bone [15], vertical root fractures (*VRFs*) [14] and root canals [26].

Comparisons done between Scanora and MORITA systems in visualization of endodontic structures concluding that both systems are convenient for depiction of endodontic structures in-vitro [26]. Studies compared different voxel sizes in i-CAT system in MB2 detection and concluded that the reliability was higher with improved resolution [27].

The present study aimed to investigate the accuracy of i-CAT next generation (Imaging Sciences International, Hatfield, PA, USA) and Verviewepocs 3D (J. MORITA, MFG.CORP., Kyoto, Japan) CBCT systems in the detection of MB2 in MMs and compared between them in reference to stereomicroscope (gold standard).

To the best of our knowledge, no previous study compared between the i–CAT and J–MORITA systems in the accuracy of second mesio–buccal root canal detection, so this study is a comparison between the i–CAT next generation (Imaging Sciences International, Hatfield, PA, USA) and the Veraviewepocs 3D (J–MORITA, Kyoto, Japan) CBCT machines.

The smallest voxel size in both systems, which was 0.125 mm, was used to improve the image resolution & detection reliability of MB2, according to Bauman R et. al.; 2011. Images were evaluated, mainly, for the presence, number & course of MB2 along MB roots on the axial view, as similar studies, at the levels of 3, 5, 7, etc. mms coronal from the apex. Then, all MB roots were sectioned at the levels of 3, 5, 7, etc. mms coronal from the apex [17,18].

In the present study, the apical third of the MB roots was not considered in the image observations, histological sectioning or stereomicroscope observations due to the difficulty in categorization of the main canal divisions in this part of the root [28].

Common classifications couldn't provide clear definitions for the apical root anatomy. Some considered those divisions as accessory canals, others considered them as small bifurcating canals which can't be negotiated clinically and only observed after root filling. To date, a standard categorization of the apical root anatomy has not yet been achieved [8].

However, CBCT is a valid clinical diagnostic tool, in comparison to μCT, CBCT does not usually allow detection of very fine details of the canal system e.g. small branches, intercanal communications & accessory canals, except for large accessory canals [29,30,31]. Also, the apex morphology, specially, the double apex may not be clearly identified in CBCT images due to their inherent limitations and the overlap of surrounding hard and soft tissues [28].

In present study, any division of a root whether in the coronal, middle or apical third was coded as two or more roots, according to the coding system.

The given code is used as a superscript on the left of the *TN* if the tooth is single rooted or on the left of a specific root if the tooth is double/multi rooted. To simplify, researchers can consider the root with a bifid tip or double apex as one group (single rooted) if this feature isn't relevant to the specific study [8].

In this study, the orifice level was located at the level of bi/trifurcation (the pulp chamber floor) according to the coding system. In cases where the bi/trifurcation was located in the middle or apical thirds and there was a common canal coronally, which starts from the *CEJ* level, this common canal is coded, similar to single-rooted teeth, as a superscript before the canal configuration codes of each root [28].

The pulp chamber is the portion of the pulp within the anatomic crown of the tooth but, this isn't accurate for double and multi-rooted teeth because their *CEJ* is not usually at the level of the pulp floor. Their pulp chamber is usually located at some distance apical to the *CEJ* corresponding to the root trunk [33,34].

Interpretation of the root canal configuration, including the pulp chamber and root canal accurately is a challenge as the transition from the pulp chamber to the root canal is not sharply detected macroscopically or microscopically [33,35].

Most studies, including common classifications of root and canal morphology, did not define the end of the pulp floor, and the beginning of the root canal orifice in order to define the canal configuration, accurately. In Weine's classification; 1969, the pulp floor was the reference for the root canal orifice in the *MB* root of *MMs* but, no information was given for the orifice location in single-rooted teeth [36].

Vertucci in 2005 suggested that a root canal starts as a funnel -shaped canal orifice which is present at or slightly apical to the cervical line, without a clear definition of the "slightly apical" position. The coding system states the location of the root canal orifice in single-rooted teeth at the level of the *CEJ* and in double and multi-rooted teeth at the level of bi/trifurcation "the pulp chamber floor" [28].

In the present study, from 100 *MMs*, *MB2* canals were detected in the *MB* roots of 85 molars (85%). *MB2* canals were detected in the middle of MB root in higher percentages (79 %) than at the orifice level (64 %) than at the apex level (39 %). At the orifice level, two canals were detected in about 56 (56%) & 57 (57%) molars by i-CAT & J-MORITA, respectively.

At 2 mms depth, in about 58 (58%) & 56 (56%) molars by i-CAT & J-MORITA, respectively. At 4 mms depth, in about 58 (58%) & 57 (57%) molars by i-CAT & J-MORITA, respectively. At 6 mms depth, in about 37 (37%) & 38 (38%) molars by i-CAT & J-MORITA, respectively. At 8 mms depth, 2 or more canals were detected in about 29 (29%) & 32 (32%) molars by i-CAT & J-MORITA, respectively.

At the orifice level, three or more canals were detected in 9 (9%) & 7 (7%) molars by i-CAT & J-MORITA, respectively. At 2 mms depth, in 18 (18%) & 19 (19%) molars by i-CAT & J-MORITA, respectively. At 4 mms depth, in 9 (9%) & 6 (6%) molars by i-CAT & J-MORITA, respectively. At 6 mms depth, in 5 (5%) molars by i-CAT & J-MORITA.

A study was done by Khalid Alfouzan et al.; 2019 on *MB2* detection in Saudi Arabian population using µCT scanning on 35 first maxillary molars (*MM1)* & 30 second maxillary molars (*MM2)*, *MB2* was found at the chamber floor in 70% & 61% of *MM1* & *MM2*, respectively.

At 2mms depth, it was found in 3% & 18% of MM1 & MM2, respectively. At levels deeper than 2mms, it was found in the remaining teeth. Two canals were present in 28 (80 %) & 24 (80%) *MM1* & *MM2*, respectively. Three canals were present in 6 (17 %) & 4 (13%) in *MM1* & *MM2*, respectively.

In the present study, the accuracy of i-CAT system in *MB2* detection was 94-95%, almost similar to Bauman et al.; 2011 study in which the i-CAT accuracy was 93.3%. The accuracy of J-MORITA system was 92%, while in Mirmohammadi H. et al.; 2015 study, the accuracy of MORITA system was 98%.

In the present study, there was no significant statistical difference between the two observers ($P = 0.0$) which means that both i-CAT & J-MORITA systems were reliable in the *MB2* canal detection. Also, all kappa coefficient (K) of the two observers for the two systems can be interpreted as adequate to good agreement.

The percentage of agreement of codes representing the MB root canal configuration, according to the coding system, was 61-65% by i-CAT % & 55-61% by J-MORITA. The interobserver & intraobserver reliability evaluations of both systems had high values of percentage of agreement suggesting that the differences between the two systems are small and statistically non-significant.

Recently, dental students and practitioners have supported the coding system application in teaching, research and clinical practice [40,41] as describes the roots' anatomical features in a consistent manner, However, the tooth is single or multi rooted [8,34]. Thus, it overcomes deficiencies in previous systems that couldn't describe teeth with complex canal systems [8,42].

Conclusion

Detection rates of MB2 using the i-CAT classic (Imaging Sciences International, Hatfield, PA, USA) and Verviewepocs 3D (J. MORITA, MFG.CORP., Kyoto, Japan) did not show any significant statistical difference. Both CBCT systems were found to be reliable tools for MB2 canal detection in MMs when compared to histological sectioning (gold standard) technique.

The coding classification provides detailed information about tooth number, root number and root canal configuration types. It is simple, accurate and practical that allows students, dental practitioners and researchers to classify root and root canal configurations.

MB2 prevalence in the MB roots of maxillary molars is high. MB2 canals are more prevalent in the middle of the root than at the orifice level than at the apex level.

Generally, MB2 is more prevalent than MB3 or MB4.

Limitations

The limitation of the present study is that the histological sectioning of the MB root samples at 3, 5, 7, etc. mms coronal from the apex may not have been exactly corresponding to the viewed axial sections. Moreover, this study didn't assess extra canals in other roots of MMs so, further studies should be performed to detect extra canals in distobuccal and palatal roots of maxillary molars.

Abbreviations

MB2: second mesiobuccal canal, MMs: maxillary molars, MB3: third mesiobuccal canal, MB4: forth mesiobuccal canal, TN: tooth number, UM: upper molar, Rn: root name, O: orifice, C: canal, F: foramen, CBCT: cone beam computed tomography, UM: upper molar, MB: mesiobuccal, M: mesial, R: single root, K: kappa coefficient, PA: percentage of agreement, CEJ: cementoenamel junction.

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Declarations

Ethics approval and consent to participate

This study was expedited from review by the Ethical Committee affiliated to our institute.

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Availability of data and materials

The datasets used during the current study are available from the
corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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