ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 5, Issue – 1, February - 2022, Page No. : 346 - 356

Endodontic management of three different aberrant root canal anatomies in maxillary second molar: A case series

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Citation of this Article: Dr. Soham Datta, Dr. Debaprasad Das, Dr. Anirban Bhattacharyya, Dr. Asim Bikash Maity, Dr. Gayatri Majumder, Dr. Abhisek Guria, "Endodontic management of three different aberrant root canal anatomies in maxillary second molar: A case series", IJDSIR- February - 2022, Vol. – 5, Issue - 1, P. No. 346 – 356.

Type of Publication: Case Report

Conflicts of Interest: Nil

Abstract

A thorough knowledge related to root canal morphology and its possible variations is the key to successful endodontic treatment. Usually, the maxillary second molar has three roots and three canals. The presence of a second canal in the mesio-buccal root (MB2) of maxillary molars is well documented in the literature but this condition is less in cases with maxillary second molar than that in maxillary first molars. Failure to locate these extra canals may result in endodontic failure. Many studies, where various cases of maxillary second molars with more number of roots and root canals were mentioned, but only very few cases were reported with less number of roots and root canals**.** Diagnosing these uncommon cases is of high importance for successful endodontic treatment of these teeth. This case report documents a total four cases of successful endodontic management of three different aberrant root canal anatomies in the maxillary second molar.

Keywords: Maxillary Second Molar, Single Root, Two roots, Single Canal, Two canals, MB2 Root Canal,

Introduction

The variations in root canal anatomy of multirooted teeth are a constant challenge for diagnosis and successful endodontic management. Thus, it is necessary for a clinician to have a thorough knowledge of the variation in root canal anatomy of multirooted teeth.[1] Traditionally, the maxillary second molar has been described to have 3 roots with 3 or 4 root canals, with the fourth canal commonly being found in the mesio-buccal root (MB2).[2] Fava et al.[3]have reported a study on morphologic variation in maxillary and mandibular molars. They have reported variations in the root canal system having a single root and single canal in maxillary and mandibular molars. However, it was reported to be most frequent with the mandibular molar. The majority of variations seen in the maxillary molar are seen with the maxillary first molar. Variations in root canal anatomy of the maxillary second molar are quite rare.

Kim et al. [4] in their study using Cone Beam Computed Tomography (CBCT) found the incidence of a single-rooted maxillary second molar to be 10.7% in the Korean population, and Zhang et al.[5] found the incidence to be 10% in the Chinese population. However, study on the Indian population by Neelakantan et al.[6] reported 0.9% of maxillary second molars with a single root but none with a single root canal. Other researchers have found only 0%–3.1% incidence of occurrence of single root and single canal in maxillary second molar.[7]

Stropko[8] in 1999 examined 611 maxillary second molars over eight years. He found an incidence of MB2 canals present in 310 (50.7%) cases. It occurred as a separate canal in 119 (45.6%) cases and joined the MB1 in 142 (54.4%) cases. Schwarze,[9] confirmed in his study that there was a high number of second canals in the mesiobuccal roots (i.e.) 48% of maxillary second molars. Endodontically retreated teeth were found to contain more undetected MB2 canals than first-time treated teeth suggesting that failure to treat existing MB2 canals leads to a poorer prognosis.[10] Use of multiple angled radiographs and advanced radiographic diagnostic methods such as cone beam computed tomography (CBCT) or the use of magnifying loupes or operating microscope can lead to appropriate diagnosis and management of such complex root canal anatomy. The present paper aimed to report three different aberrant root canal anatomies with the maxillary second molar.

Case report 1

A 30-year-old male patient reported to the Department of Conservative Dentistry & Endodontics with the chief complaint of pain in his left upper back teeth region while chewing food for the last 2 days. The patient's medical history was noncontributory. Clinical examination revealed that a faulty tooth color restoration was present at the disto-occlusal aspect of the maxillary left second molar. The tooth was tender on vertical percussion with delayed response to the electric pulp test. Radiographic examination showed the presence of secondary caries (radiolucency) in between the faulty restoration and the tooth surface approaching the pulp. Clinically diagnosis of symptomatic apical periodontitis was established.

Under local anesthesia, first, the faulty restoration and secondary caries were removed completely and pre-endodontic build-up **(**Tetric N-Ceram, Ivoclar Vivadent, Germany) was performed followed by root canal therapy under rubber dam isolation. Access cavity was prepared by achiving a bur drops with a no.4 round bur (SS White, USA) after which, the roof of the chamber was removed completely with the help of an Endo Z bur (Dentsply Maillefer, Switzerland). Once the pulp

chamber was completely deroofed, initially a triangular-shaped access opening was obtained. A dentinal map connecting three orifices only was explored with the help of an Endo explorer (Dentsply Maillefer, Switzerland) probe. One orifice was present in the Mesio buccal aspect, another two were present in the disto buccal and palatal aspect. The dentinal map showed a long groove between the palatal and the mesiobuccal orifices. Careful examination and exploration with endo explorer (Dentsply Maillefer, Switzerland) of the groove resulted in the detection of an extra mesiobuccal canal roughly about 2-3 mm away from the MB1orifice and present mesially to the imaginary line connecting the first mesiobuccal and palatal orifices. After detection of the second mesiobuccal canal, the mesial wall further extends mesially which altered the shape of the access cavity from triangular to rhomboidal. Initial negotiation into these canals was done using small size No. 6,8,10, hand K files (Mani, Japan). Working length was determined with an apex locator (Canal pro, Coltene, Switzerland) and confirmed radiographically. Initial preflaring was made up to 20k hand files in all canals (Mani, Japan). Biomechanical preparation was made with Neoendo Flex rotary Files (Orikam, France) till #25/4% in first mesiobuccal and distobuccal canals, #20/4% in Second mesiobuccal canal, and #25/6% in the palatal canal using single length technique. 17% EDTA gel was used as a lubricant during shaping and 5.25% sodium hypochlorite and 17% EDTA liquid were used as an irrigant. After drying the canals with paper points (Orikam, France), Single cone obturation was made in all canals with their corresponding gutta-percha cones (Orikam, France) and Seal apex used as a sealer (Kerr, USA). The access cavity was permanently restored with Amalgam (DPI, India). The patient was Clinically asymptomatic during the entire treatment procedure.

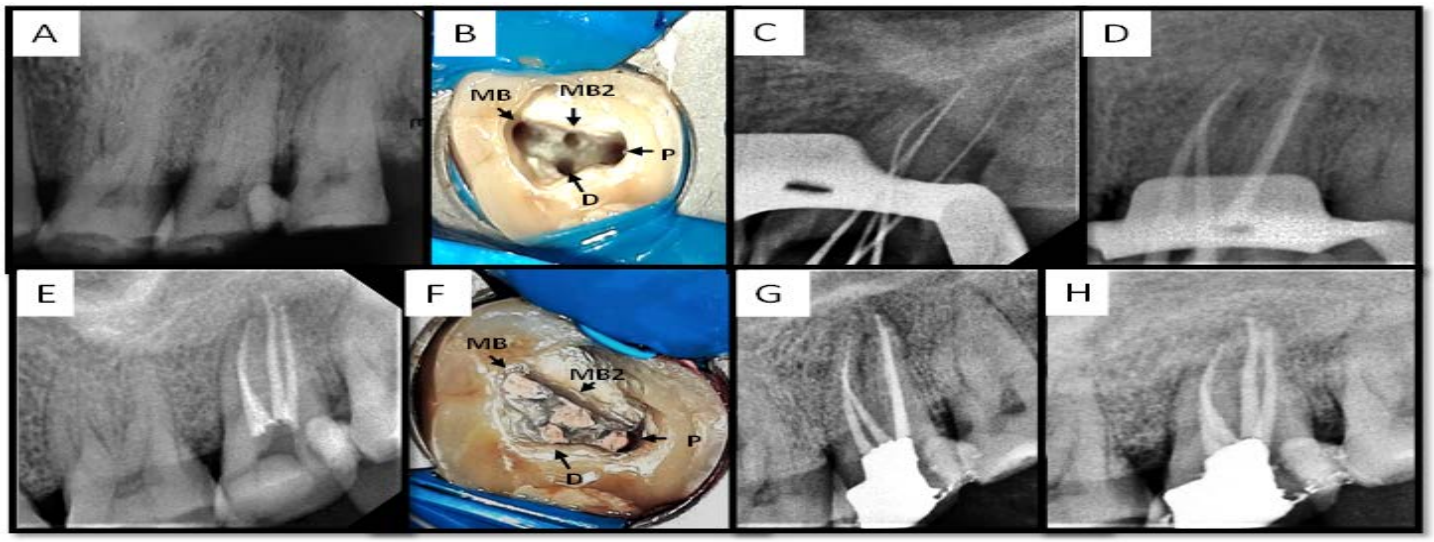

Figure 1: A) Preoperative Radiograph. B) Access Cavity Preparation. C)Working Length Radiograph. D)Master Cone Radiograph. E&F) Radiograph & Clinical picture After Obturation. G & H) Radiograph after Post Endodontic Restoration. (Different angulation)

Case Report 2

A 46-year-old female patient reported to the Department of Conservative Dentistry & Endodontics with the chief complaint of pain in her left upper back teeth region while chewing food for the last few days. The patient's medical history was noncontributory. Clinical examination revealed disto-occlusal caries of the maxillary left second molar. The tooth gave a delayed

response to the electric pulp test. Preoperative IOPAR (Intra Oral Periapical Radiograph) showed carious process (radiolucency) at the disto-occlusal aspect approaching the distal pulp horn & apical widening of PDL (Periodontal Ligament) space. Clinically diagnosis of symptomatic apical periodontitis was established and root canal treatment was planned. As Preoperative radiographic examination gave the suspicion of the presence of two roots and two canals, a cone-beam computed tomography (CBCT) was done to confirm the canal anatomy and to identify any other canal if present. CBCT images confirmed the presence of two roots directed on the buccal & palatal side with one canal in each root.

Under local anesthesia,the caries were removed completely and pre-endodontic build-up was performed (Tetric N-Ceram, Ivoclar Vivadent, Germany) followed by root canal therapy under rubber dam isolation. Access cavity was prepared by achiving a bur drop with a no.4 round bur (SS White, USA) after which the roof of the chamber was removed completely with the help of an Endo Z bur (Dentsply Maillefer, Switzerland). The access opening revealed two orifices directed buccally & palatally. Initial negotiation into these canals was done using No. 10 hand K files (Mani, Japan). Working length was determined with an apex locator (Canal pro, Coltene, Switzerland) and confirmed radiographically. Initial Preflaring was made up to 20k hand files in the canal (Mani, Japan). Biomechanical preparation was made with Neohybrid (Orikam, France) rotary Files till up to #25/4% in the buccal canal and #25/6% in the palatal canal using single length technique. 17% EDTA gel was used as a lubricant during shaping and 5.25% sodium hypochlorite and 17% EDTA liquid were used as an irrigant. After drying the canals with paper points (Orikam, France), single cone obturation were made in all canals with the corresponding gutta-percha cones (#25/4% in buccal canal and #25/6% in palatal canal, Orikam, France) & using Sealapex as a sealer (Kerr, USA). The access cavity was permanently restored with core build-up material. The patient was clinically asymptomatic during the entire treatment procedure.

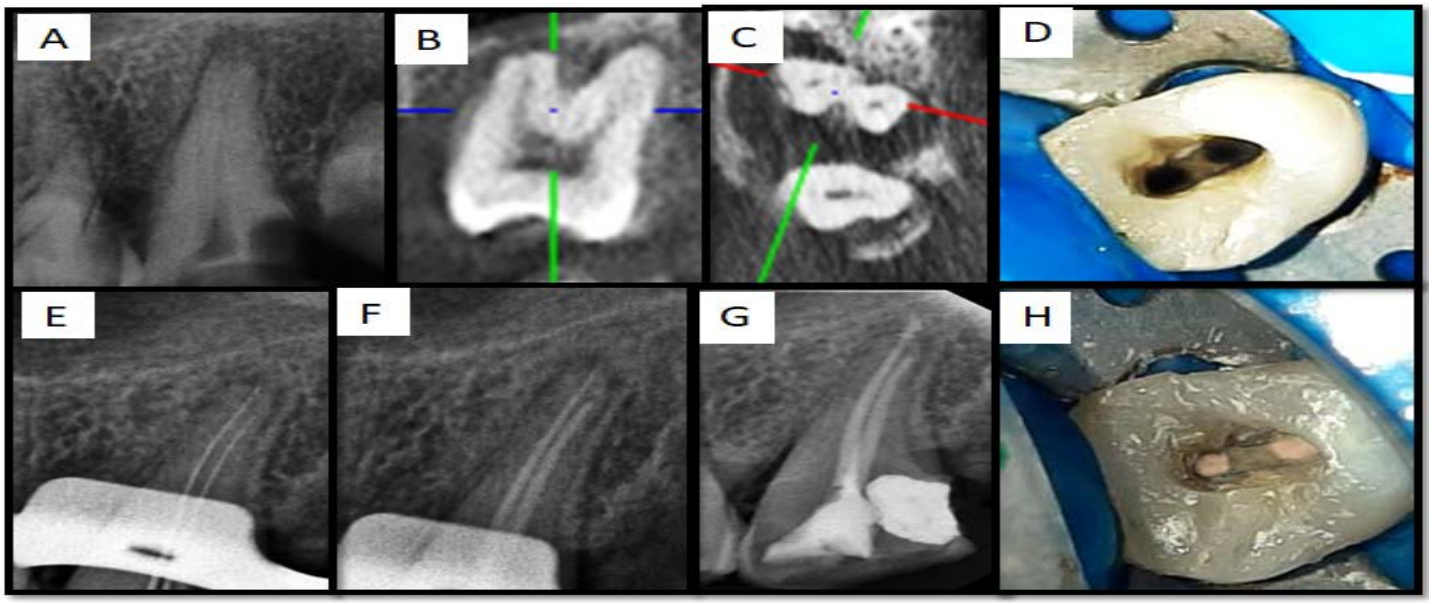

Figure 2: A) Preoperative Radiograph. B& C) Preoperative Coronal & Horizontal sections of CBCT Showing presence of two (Buccal & Palatal) roots of maxillary second molar. D) Access Cavity Preparation. E) Working Length Radiograph. F) Master Cone Radiograph. G) Post obturation radiograph. H) Post obturation Clinical Picture

Case Report 3

A 44-year-old female patient reported to the Department of Conservative Dentistry & Endodontics with the chief complaint of pain in his right upper back teeth region while taking hot beverages for the last few days. The patient's medical history was noncontributory. Clinical examination revealed disto-occlusal caries of the maxillary right second molar. The tooth gave a delayed response to the electric pulp test. Radiographic examination showed a carious process (radiolucency) at the disto-occlusal aspect approaching the distal pulp horn. On preoperative radiograph, only a single large canal could be traced at the center of the single conical root. Clinically diagnosis of symptomatic irreversible pulpitis was established and root canal treatment was planned.

Under local anesthesia, first caries were removed completely and pre-endodontic build-up was performed (Tetric N-Ceram, Ivoclar Vivadent, Germany) followed by root canal therapy under rubber dam isolation. Access cavity was prepared by achiving a bur drop with a no.4 round bur (SS White, USA) after which the roof of the chamber was removed completely with the help of an Endo Z bur (Dentsply Maillefer, Switzerland). The access opening revealed a large single orifice and one single-wide root buccolingually extending toward the root apex. No further dentin was removed in search of any other canal. Initial negotiation into these canals was done using No. 15 hand K files (Mani, Japan). Working length was determined with an apex locator (Canal pro, Coltene, Switzerland) and confirmed radiographically. Initial Preflaring was made up to 20k hand files in the canal (Mani, Japan). Biomechanical preparation was made with Protaper Gold rotary Files (Dentsply Maillefer, Switzerland) till up to F2 using crown down technique. 17% EDTA gel was used as a lubricant during shaping and 5.25% sodium hypochlorite and 17% EDTA liquid were used as an irrigant. After drying the canals with paper points (Dentsply Maillefer, Switzerland), Single cone obturation were made in all canals with the corresponding gutta-percha cone (F2, Dentsply Maillefer, Switzerland) using Sealapex as a sealer (Kerr, USA). The access cavity was permanently restored with core build-up material. The patient was clinically asymptomatic during the entire treatment procedure.

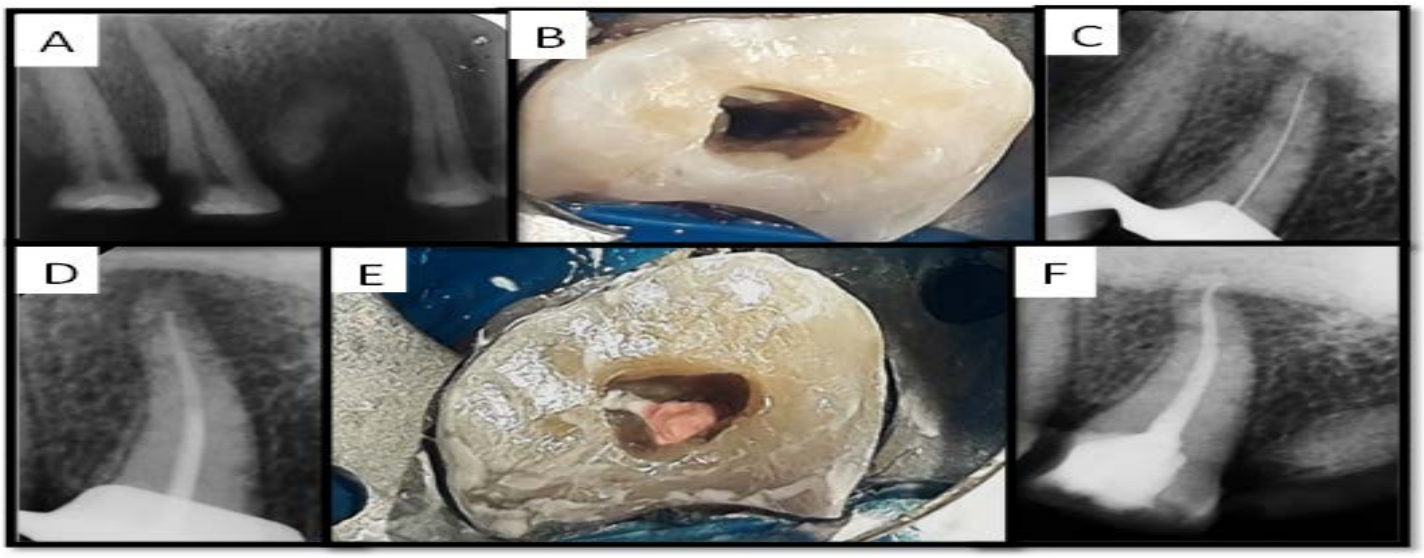

Figure 3: A) Preoperative Radiograph. B) Access Cavity Preparation. C) Working Length Radiograph. D) Master Cone Radiograph. E&F) Clinical & Radiographical picture After Obturation.

Discussion

An inability to locate Mesio-buccal 2(MB2) root canal in mesio-buccal root of maxillary molars may be a major cause of the failure of root canal treatment. Maxillary second molar usually contains three roots and three canals. Usual anatomical variation encountered is the presence of extra canal in thr mesiobuccal root (MB2) & more incidence of finding this extra canal were in retreatment cases compared to initial treatment indicating the main reason for endodontic treatment failure.[11] According to studies done by James Wolcott[12] et al 35% of maxillary 2nd molars had MB2 canal. According to Weine[13] one of the causes of endodontic failures in maxillary second molars is the lack of incidence of locating the second mesiobuccal canal and the subsequent absence of its debridement and obturation.

There are multiple concepts, armamentaria, and instruments that are useful to find missed canals & are as follows.[11,14,15]

Anatomic familiarity

The form, configuration, and number of root orifices and canals should be kept in mind before beginning an endodontic procedure. Many a time the MB2 canal of the maxillary molars is not searched for, as it has become a habit and practice to believe that the maxillary molars have three canals. However, the prevalence of these teeth having an extra canal is high, and the operator should use all the armamentaria at his disposal to locate a missed canal.

Beer and Bauman's geometrical techniques to identify missed canals

Suggested geometrical techniques to identify missed canals in maxillary molars. They proposed three lines. The first line connected the mesiobuccal canal to the palatal canal. The second line was drawn perpendicular to line one, at a point one-third the inter-canal distance from the palatal canal, such that, this line passed over the distobuccal canal. The distobuccal canal might be somewhere along line 2. A fourth canal lay somewhere along line 3, which deviated approximately 10°.

Krasner and Rankow's (2004), proposal of anatomic laws to identify missed canals

A. Law of centrality — The floor of the pulp chamber is always located in the center of the tooth at the level of the cementoenamel junction (CEJ).

B. Law of concentricity — The walls of the pulp chamber are concentric to the external outline of the tooth at the level of the CEJ.

C. Law of the CEJ — CEJ is the most consistent, repeatable landmark for locating the position of the pulp chamber.

D. Symmetry: (Except for maxillary molars).

D1.If a line is drawn in a mesial-distal direction across the center of the floor of the pulp chamber, the orifices of the canals on either side of the line are equidistant.

D2. If a line is drawn in a mesial-distal direction across the center of the floor of the pulp chamber, the orifices of the canals on either side are perpendicular to it.

E. **Law of orifice detection**

E1. The orifices of the root canals are always located at the junction of the walls and the floor.

E2. The orifices of the root canals are located at the vertices of the floor-wall junction.

E3. The orifices of the root canals are located at the terminus of the root developmental fusion Lines.

F. Law of Color change

Orifices appear in a darker color than the surrounding area and can be differentiated and followed to locate the missed canals.

Radiographic analysis

Periapical films should be taken with the cone directed in at least two different angulations. Straight angulation of the radiograph produces superimposition of the tissues on the resulting image and leads to a false interpretation. A mesiodistal angulation (buccal object rule) leads to separation of the roots and canals. The SLOB rule is an acronym for Same Lingual Opposite Buccal. In this method, one radiograph is taken straight on at a 90-degree angle to the tooth and a second radiograph is taken with the tube head shifted either mesially or distally. The rule says that the object imaged will move in the same direction as the tube head is moved if it is located on the lingual (Same Lingual). Conversely, the object being imaged will move opposite the tube head movement if it is located on the buccal (Opposite Buccal).

Digital radiography, computed tomography (CT), and Cone Beam Computed Tomography (CBCT), significantly enhance the radiographic diagnostics in identifying hidden, calcified, or untreated canals.

Vision

The use of magnification glasses, headlamps, and transilluminating devices improves the vision of the access cavity, thereby, identifying the missed canals. A dental operating microscope (DOM) provides an easier and more accurate outcome of endodontic treatment. Long shank burs are used not because they can reach deeper in the access cavity, but because they enhance direct vision by importantly moving the head of the handpiece further away from the occlusal table, and improving the line of sight along the shaft of the bur.

Most of the MB2 canals, however, can be best identified utilizing an operating microscope. It was found that 33.3% of cases with MB2 were identified using a 3.5 X magnifying loupe, whereas 95.8% were identified using an operating microscope.

Access cavities

Access cavities should be expanded and finished to enhance vision, improve diagnostics, and provide straight-line access to the orifice. The isthmus area and/or developmental grooves should be probed with an explorer, in order to find a 'catch.' Luebke has made an important point that an entire wall need not be extended in the event that an instrument impingement occurs owing to a severely curved root or an extra canal. By extending only that portion of the wall needed to free the instrument, a cloverleaf appearance may evolve as the outline form. Hence, Luebke has termed this a 'shamrock preparation'.

Piezoelectric ultrasonics

These help in exploring and identifying calcified and missed canals, avoiding the bulky heads of the handpieces. Thereby, they improve vision by illuminating the operating field unlike the handpieces, which block the light. The abrasive coatings on their working end help in efficiently removing the calcifications and dentinal obstruction to the missed canals.

Micro-openers (Dentsply International)

Combine the canal finding capabilities of an explorer with the instrumentation capabilities of a K-file. They are ISO-sized hand instruments with 7 mm k-type flutes. The Micro-Openers are available in sizes 10 and 15 with .04 and .06 tapers. The exaggerated taper enhances the instruments' tensile strength. This makes it easier to locate, penetrate, and initially instrument even the most difficult or calcified canals. These instruments provide unobstructed vision when operating on difficult teeth, with limited access.

Dyes

Various dyes, such as iodine in potassium iodide, ophthalmic dye, or 1% methylene blue can be irrigated into the pulp chambers of the teeth and rinsed thoroughly with water, dried, and visualized. The dye will be absorbed into the orifices, fins, and isthmus areas, and serves to 'roadmap' the anatomy, aiding in the identification of missed canals and fractures

Bubble test/champagne test

Sodium hypochlorite flooded into the chamber reacts with the organic tissue or the chelator used. This indicates a positive 'bubble test or champagne test'. This helps in clearing the pulp chamber and improving visibility in the hidden orifices and missed canals.

Transillumination

In this procedure, the light is shone through the gingival tissue to the root and pulp chamber. The canal's light transmission differs from the rest of the tooth, as it is hollow, and appears as a dark spot in an otherwise bright structure.

Endo Explorer

An endodontic probe (e.g., DG16, CK17) is a double-ended long probe, which helps in identifying missed canals. It is used to punch through the secondary dentin and calcifications to expose hidden orifices.

White line test

In necrotic teeth, if we use ultrasonics, the byproduct is dust and this dust can go into anatomical space, like a groove, and it will leave a characteristic "white line". So, we can use the white line test to help us roadmap to another orifice.

Red line test

In vital cases, after the hemorrhage was under control by amputating the vital pulp tissue all the levels of the orifices. in furcated teeth sometimes little bead of blood emanating out of a groove. This can be another indicator that there's more anatomy to be found.

Restorative disassembly

It provides a better orientation to the underlying tooth structure and improves safe access to the pulp chamber.

Perio probing

Probing the sulcus can provide important information as to the relationship between the long axis of the clinical crown and the underlying root, as well as indicate a possible root fracture.

Weine's classification has been used to describe four common configurations of the maxillary MB root. Type I is a single canal from orifice to apex, Type II has two orifices that converge to one, Type III has separate and distinct canals from orifice to apex, and Type IV begins as one canal and diverges into two separate canals.[13] Here in the 1st case report weine's type II configuration of the MB root was found.Most of the cases of maxillary second molars have been reported with a greater number of roots and/or root canals, but only very few cases have been reported with less number of roots and root canals. A thorough knowledge related to the root canal morphology and their possible variations is the key for successful endodontic treatment as failure to identify such configuration may lead to poor prognosis due to excessive removal of the dentin in search of canals.[16]Peikoff *et al.*[7] conducted a retrospective study of 520 endodontically treated maxillary second molars and have classified the anatomical root and canal variations found in maxillary second molar into six variants: (1) Three separate roots (MB, DB, and P-palatal) with one canal in each root; (2) Three separate roots (MB, DB, and P) and four canals (two in the MB root); (3) Three roots but MB and DB canals combine to form a common buccal (B) with a separate P canal;(4) One B and one P canal with a single canal in each; (5) Single canal in a

single conical root; and (6) four separate roots – MB and DB and two palatal roots – a mesiopalatal and a distopalatal root. This study revealed that the occurrence of the "standard" configuration in maxillary second molars, i.e. three roots with three canals was most frequent (56.9%) Followed by three roots and four canals (Variant 2) which were found in 22.7% cases. According to this study, it was concluded that 6.9% of maxillary second molars had two roots with one canal in each root (Variant 4) & 3.1% of maxillary second molars had one root and one canal (Variant 5). According to Peikoff 's categorization of the morphology of the root canal system, the variants identified in our cases would be considered as variant1(Case 1), Variant 4 (Case 2) & Variant 5 (Case 3).

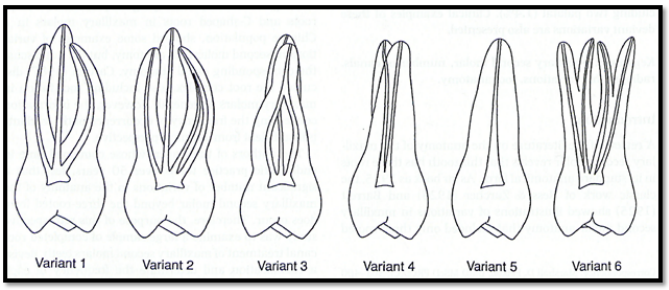

Figure 4: Peikoff's classification of different anatomical root and canal variations found in maxillary second molars.[7]

Such variation in the maxillary molar having two roots with one single canal in each root & a single root and single canal can be detected in the routine radiograph. However, multiple preoperative radiographs can help us differentiate if two canals are present superimposing each other buccolingually.

The use of an advanced diagnostic method such as CBCT can help rule out complex root canal anatomies where radiographs will be inconclusive. In the second case, a Preoperative radiographic examination gave the suspicion of the presence of two roots and two canals.[16] Therefore, CBCT was done to confirm the canal anatomy and to identify any other canal, if present. CBCT images confirmed the presence of two roots directed on the buccal & palatal side with one canal in each root.

Neelakantan et al[6] in 2010 performed an in vitro study of 220 maxillary first & 202 maxillary second molars to investigate the root and canal morphology of maxillary first and second molars in an Indian population by using cone-beam computed tomography and reported that two rooted maxillary second molar were found in 5.8% of the teeth studied (n=12) & single-rooted maxillary second molar were found in only 0.9% studied Indian population. According to this study among the 0.9% (n=2) of studied teeth that have a single root, all teeth (n=2) had Vertucci type III (1-2-1) root canal configuration and none with Vertucci type I (1-1). Among the 5.8% (n=12) of studied teeth that have two roots (Buccal & Palatal), Vertucci type 1 canal configuration present in 1.9% buccal (n=4) & 4.9% palatal (n=10) roots.

Various other studies have also been done in vivo and in vitro about the variations in root canal anatomy of the maxillary and mandibular molars. Libfeld and Rotstein[17] in their in-vivo study reported an incidence of 0.5% out of 200 radiographs of patients treated with endodontic treatment having a single root and a single canal in maxillary second molars. Rwenyonyi et al.[18] also found a single root in a maxillary molar; however, the roots were found to be fused. Wang et al.[19] in their study reported that the incidence of maxillary second molar with a single root and a single canal is very rare. Ng et al.[20] and Alavi et al. [21] failed to find a case in their 77 maxillary second molars with a presence of a single root and a single canal.

Although the inability to search for an extra canal can lead to endodontic failure but it is also a fact that

overenthusiastic search for finding extra canal leads to common iatrogenic mishaps such as perforation or excessive tooth removal. Therefore, a proper idea of the variations present in the root canal systems along with advanced radiographic techniques (such as CBCT, Compute Tomography) & enhanced vision (Dental loups, Dental operating microscope) helps the clinician to avoid such errors and perform ideal root canal treatment.[13]

Conclusion

Knowledge of variations in root canal anatomy guides in designing the therapy to be implemented in a particular case and can also affect the possibility of success with that therapy. Even though the occurrence of maxillary second molar with a second mesiobuccal canal is well documented in the literature. This condition is less encountered in cases with maxillary second molars than in maxillary first molars. The prevalence of maxillary second molar with two roots along with two canals and a single root with a single canal is also not high. Diagnosing these unusual cases is of tremendous importance for successful endodontic treatment of these teeth.

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