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Case Report

Maxillary second molar with morphologic variations in number of roots & canals: Literature review & report of two cases

Mohit Zarekar[1]*, **Apurva Satpute**[2], **Mohini Zarekar**[3]

[1]*Private Practitioner, Maharashtra, India*
[2]*Govt. Dental College & Hospital, Chhatrapati Sambhajinagar, Maharashtra, India*
[3]*Charité – Universitätsmedizin Berlin, Germany*

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ABSTRACT

The root canal and root morphologies of maxillary second molars might vary. This article details the endodontic treatment of two cases involving unusual root canal morphology in a maxillary second molar. The first case involved a single root and a single canal, whereas the second case had a single root with two separate canals. A literature review was conducted to clarify the prevalence of anatomical changes in the number of roots and canals in the maxillary second molar. The utilisation of a dental operating microscope facilitated the detection of the canal orifices in both cases. The objective of this study is to increase the knowledge of clinicians regarding the atypical structure of root canals by examining the complex differences found in maxillary second molars.

1. Introduction

Anatomical variations can occur in any tooth and maxillary second molars are not exempt from the possibility of such anatomical variations. Understanding root canal structure and the existence of any anatomical variations is essential to increase the success of endodontic treatment.[1] While the maxillary second molar can vary, it commonly presents three roots and three distinct canals structure. In 14–94% of cases, a second mesiobuccal canal (MB2) is present.[2] Prevalence of maxillary molars having a single canal reported to be 0.5-0.6%.[3] In their CBCT-based investigation, H.M. Alamri et al.[4]Table 1 discovered 0.3% of Saudi subpopulation had a single-rooted maxillary second molar. They reached the conclusion that the majority of the second maxillary molars are more prone to have three and two roots. Additionally, they found that males are more inclined to have three roots, while females are more inclined to have two roots. Christie et al.[5] documented 16 instances of maxillary molars having two palatal roots that were discovered over a span of 40 years of regular clinical practise. The authors categorised these teeth based on their morphology and the degree of root separation, classifying them as type I, II, and III. Maxillary molars of Type I have two widely divergent palatal roots, frequently characterised by their elongated and convoluted nature. The buccal roots frequently exhibit a morphology resembling that of a cow's horn and display less divergence. The radiograph displays four distinct root apices. Maxillary molars of type II exhibit a quadrifurcated root structure, with the roots frequently being of reduced length, aligned in a parallel manner, displaying both facial and lingual root morphology, and possessing blunt root at the apex. The root morphology of Type III maxillary molars is characterised by a constriction, where the mesiobuccal, mesiopalatal, and distopalatal canals are enclosed inside a network of dentin in the root. In some circumstances, the distobuccal root can

* *Corresponding author.*
E-mail address: zarekarmohit@gmail.com (M. Zarekar).

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be observed as distinct and might even deviate towards the distobuccal direction.

This paper describes two clinical case reports demonstrating successful endodontic therapy of maxillary second molars with distinct morphological variations in root form and canals. The first scenario consists of a solitary root with only one canal, while the second case consists of a single root with two distinct canals and different exit terminals. The root canal system of human teeth has undergone thorough investigation, However, there is still a dearth of study on the root canals in single-rooted, permanent maxillary second molars. This study seeks to address this deficiency by offering a methodical examination of these root canals. The objective of this study was to record and characterise the significant macroscopic characteristics of the root canal number and their location in the maxillary second molar containing single root.

2. Case Presentation

2.1. Case 1

A 30-year-old female presented to our clinic with a primary concern of experiencing heightened discomfort in the upper right posterior tooth. The pain intensifies during biting and after consuming hot or cold food products. The patient also presented with unremarkable medical history. During the clinical examination, it was observed that there was extensive occlusal caries in the upper right second molar. The tooth was stationary, and periodontal probing was also within the normal range. Tooth 17 was found to have deep occlusal caries during the radiographic examination. As a result, it was recommended to have root canal therapy for the affected teeth. The radiographic examination also indicated that tooth 17 had considerable anatomic change in its root structure, indicating the existence of a single root and a singular canal (Figure 1A). After injecting 1 ml of local anaesthesia containing 40mg articaine hydrochloride and 0.005 mg epinephrine (Septodont, Saint-Maur-des-Fossés, France) and rubber dam isolation, access cavity was prepared with the aid of an endodontic microscope (Carl Zeiss OPMI® pico Munich, Germany) of tooth 17 which revealed a big single opening and a single wide root extending from the buccal to the lingual side, reaching towards the root apex. The Root ZX mini (J. Morita, Kyoto, Japan) apex locator was used to measure the working length and confirmed with the radiograph (Figure 1B). The canal was first equipped with #15 nickel-titanium files (Dentsply Maillefer). The biomechanical preparation was performed employing crown-down technique, utilising rotary ProTaper Gold files (Dentsply sirona Charlotte NC, USA). The apical preparation was expanded to a ProTaper size F2. The root canal was frequently flushed with a solution of 5.25% sodium hypochlorite (Hypochlor, SafeEndo, India). The intracanal medicament of calcium hydroxide paste (RC Cal; Prime Dental Products, India) was then administered. The patient was summoned for a follow-up appointment after 1 week, and the tooth showed no symptoms.

The root canals were cleaned in the next session using a 5.25% sodium hypochlorite solution, and they were then dried with sterile paper points. Subsequently, the canals were sealed with MTA Fillapex (Angelus, Brazil) and protaper gutta-percha (Figure 1C). The tooth was then rebuilt using a resin composite restoration (MultiCore Flow, Ivoclar Vivadent). follow up radiograph was taken after 6 months (Figure 1D).

*2.2. Case **2***

The primary complaint of a 45-year-old male patient who came to our clinic was a sudden ache in his left upper molar tooth. The tooth exhibited sensitivity to vertical percussion, cold stimuli, and warm stimuli. The occurrence of pain was more common during the night, lasting for a duration of 2 to 3 hours, with intermittent moments of relief. Intraoral examination revealed proximal caries associated with tooth no. 27. The radiographic examination revealed significant proximal caries and notable anatomical variation in the root structure, indicating that the tooth had a single root (Figure 2A). Consequently, the patient received local anaesthetic containing 40mg articaine hydrochloride and 0.005 mg epinephrine (Septodont, Saint-Maur-des-Fossés, France). Following complete isolation, the endodontic access procedure was carried out with the aid of an endodontic microscope. The canals were initially negotiated with #15 nickel-titanium files (Dentsply Maillefer). Two canal orifices were discovered, one located buccally and one located lingually, reflecting the morphology of the maxillary premolar. The canals were thoroughly prepped with manual hand k-files (Dentsply, Maileffer, USA) and RaCe NiTi (FKG Dentaire SA, Switzerland) rotary files. Apical preparation was carried out till the size of 25/4%. The root canals were cleansed with a 2.5% solution of sodium hypochlorite after each usage of the instruments, and a 17% solution of ethylenediamine tetraacetic acid (EDTA) was utilised for the final flush. Following the drying of the root canals, calcium hydroxide was administered as an intracanal medicament. The patient was scheduled for an appointment one week later. The patient had no symptoms one week later. Mastercone radiograph was obtained (Figure 2B) followed by obturation with appropriate gutta-percha cones and MTA fillapex (Angelus, Brazil), and a final periapical radiograph was obtained to verify the root canal filling (Figure 2C). After that, the patient was recalled for his final composite restoration. Follow up radiograph was recorded after 8 months (Figure 2D).

Table 1: Variations in no. of roots of maxillary second molar in previous studies

Authors	No. of samples	Study type	Country	1 root	2 roots	3 roots	4 roots
Rweuyonyi et al.[6]	221	Clearing	Uganda			86%	
Zhang et al.[7]	210	CBCT	China	10%	8%	81%	
Ng et al.[8]	77	Clearing	London			100%	
Gu Y et al.[9]	1226	CBCT	China				0.98%
Rouhani et al.[10]	125	CBCT	Iran				1.6%
Georgia et al.[11]	402	CBCT	Greece	5.4%	8.25%	85.07%	1.2%
Silva et al.[12]	306	CBCT	Brazil			45.09%	
Libfeld et al.[13]	1200	Radiograph/ RCT	Israel	3%, 0.5%	6%, 12%	90.6%, 87%	0.4%
Kim et al.[14]	821	CBCT	Korea	4.63%			
Perez-Heredia et al.[15]	142	CBCT	Spain	16.9%	4.2%	78.9%	
Afzal et al.[16]	70	CBCT	India			85.7%	
Ghoncheh et al.[17]	423	CBCT	Iran	11.3%		86%	
Martins JN et al.[18]	240, 802	CBCT	Portugal	10%, 13.3%	11.3%, 13.2%	77.1%, 72.9%	1.7%, 0.5%
Xia Y. et al.[19]	400	CBCT	China	9.75%	12.25%	78.0%	
Ghobashy et al.[20]	610	CBCT	Egypt	1.6%	10.7%	87.7%	
Neelakantan et al.[21]	205	CBCT	India	0.9%	5.8%	93.1%	
Nikoloudaki GE[22]	402	CBCT	Greece	5.47%	8.21%	85.07%	1.24%
Ratanajirasut et al.[23]	457	CBCT	Thailand	3.5%	9.2%	87.1%	0.2%
H.M. Alamri et al.[4]	351	CBCT	Saudi A.	0.3%	6.6%	92%	1.1%

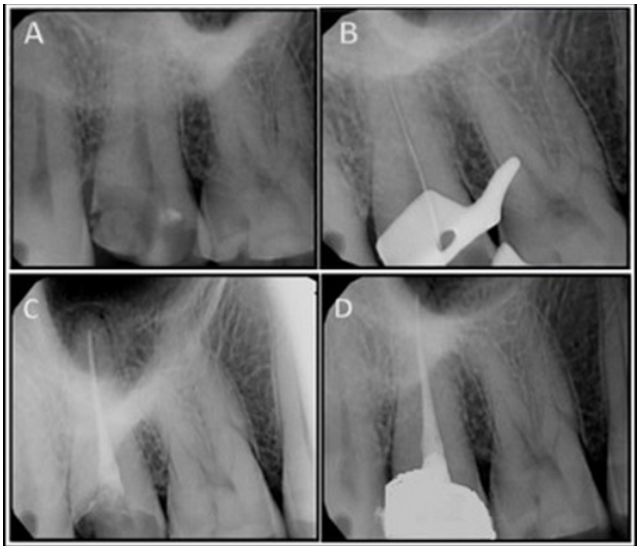

Figure 1: Case 1.**A:** Preoperative radiograph; **B:** Working length confirmation; **C:** Immediate post-obturation radiograph; **D:** Follow up radiograph after 6 months.

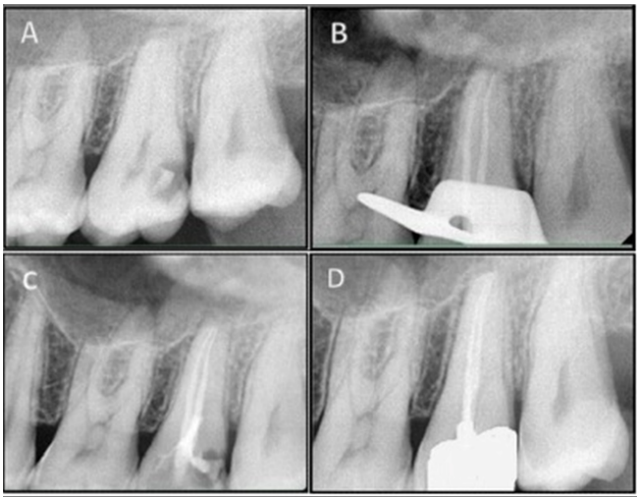

Figure 2: Case 2: **A:** Preoperative radiograph; **B:** Mastercone radiograph; **C:** Immediate post-operative radiograph; **D:** Follow up radiograph after 8 months.

3. Literature Review

3.1. Search methodology

The MEDLINE database, Google Scholar and DOAJ databases were searched to find research on the morphology of maxillary second molars. The search was conducted using the following keywords: Anatomic variation OR Morphologic variation OR root canal configuration OR maxillary second molar.

Articles that satisfied the subsequent criteria were incorporated into the ultimate review:

1. Full-text papers.
2. Articles written in English language.
3. Root canal anatomy of maxillary second molars were assessed.

Following studies were included in this article: Cone beam computed tomographic studies, clinical studies incorporating periapical radiography, clearing studies, in-vitro studies

Carlsen O et al.[24] examined 104 maxillary second molars which had a single root at the midroot and apical levels using a stereomicroscope. Within the middle part of the tooth, a single root canal was identified in 25.96% of the teeth tested. In 34.62% of the teeth, two canals were observed. In 37.49% of the cases, two canals were detected. Libfeld H et al.[13] (Table 1) conducted a study on a sample of 1,200 teeth to investigate the occurrence of four rooted maxillary second molars. A total of 1,000 teeth that had not received any treatment were analysed using radiographic examination. A total of 200 teeth underwent radiographic evaluation after receiving endodontic therapy. The findings indicated that 3% of the subjects had a single root, with 0.5% of them having a single root canal. The majority, 90.6%, had three roots, while 6% had two roots, and only 0.5% had four roots. M.D. Peikoff et al.[25] performed a retrospective analysis on 520 maxillary second molar teeth that had endodontic treatments done. The treatments were selected from a specialised endodontic clinic and included radiographic evaluation. Their analysis revealed 6.9% of the samples had two unique roots and one canal, 3.1% had one primary root and one canal, and 1.4% had four distinct roots and four distinct canals. Rwenyonyi et al.[6] (Table 1) conducted a clearing study on the maxillary molars. They found that root fusion variations were much more frequent in the maxillary second molar compared to the first molar. Zhang et al.[7]Table 1 conducted a morphological assessment of maxillary molars in the Chinese population. Among a total of 210 maxillary second molars, 10% exhibited a single root, whereas 8% possessed two roots. Ng et al.[8] (Table 1) conducted a study on the canal morphology in maxillary molars of Burmese individuals. They found that inter-canal contacts were more commonly observed in the mesio-buccal canals of molars with three distinct roots. This is comparable to prior morphological investigations on maxillary molars, which typically concentrated on the existence of the MB2 canal in the mesiobuccal roots, also the complex canal structures in the fused roots. In a study by Gu Y et al.[9] (Table 1) the incidence and anatomic characteristics of 4-rooted permanent maxillary molars were observed in a community of northwest Chinese people. They discovered that 12 out of 1226 maxillary second molar teeth had an extra root. In their CBCT analysis of maxillary first and second molars, Rouhani A et al.[10] (Table 1) discovered that 1.6% of maxillary second molars had four roots. The existence of one root and a one canal in upper first molars and second molars seem to be rather rare, consistent with findings from prior investigations. According to Georgia et al.'s[11] (Table 1) CBCT study on the Greek population, the majority of first and second molars had three roots and three canals, along with other morphological variations including the fusion of a maxillary second molar with a supernumerary tooth. Additionally, Silva et al.[12] (Table 1) in their CBCT analysis on maxillary molar teeth discovered that second molars had a greater frequency of three distinct roots. Kim et al.[14] (Table 1) examined the root and canal morphology of first and second maxillary molars in a Korean population. Their findings revealed that a mere 4.63% of the second molars exhibited a single root. In 79% of cases, Pérez-Heredia et al.[15] (Table 1) observed that maxillary second molars possessed three roots. Afzal N et al.[16] (Table 1) also did a study specifically on maxillary second molars and found that the majority of these teeth had three roots. In their investigation, Ghoncheh et al.[17] (Table 1) aimed to evaluate the root morphology of the maxillary first and second molars in an Iranian population. They found that 11.3% of the second molars had a single root. As a result, they concluded that the root canal configuration of the maxillary second molars exhibited greater diversity compared to that of the first molars. In their study, Martins JNR et al.[18] (Table 1) aimed to compare the root and root canal configurations between Asian and white subpopulations. They discovered that the Asian ethnic group had a higher occurrence of Vertucci type I configuration in maxillay molars, while the white group exhibited a greater variety of morphologies in the multiple root canal system. Xia Y et al.[19] (Table 1) analysed CBCT imaging data of 400 permanent molars in the upper jaws. They found that 78.0% of second molars had three roots, and fused roots were identified in 31.5% of the teeth. Ghobashy AM et al.[20] (Table 1) also conducted a study on the root number and canal structure of maxillary permanent molars in a population from Egypt. The study's findings were conclusive. All maxillary first molars exhibited a three-root configuration, while maxillary second molars displayed three, two, and single-root morphologies. Neelakantan P et al.[21] (Table 1) conducted a CBCT evaluation to examine the root and canal structures of maxillary first and second molars in an Indian population. They discovered that second molars with two roots exhibited significant variations in canal anatomy. Consequentially, they concluded that the root number, morphology, and canal structure of Indian maxillary molars displayed distinct characteristics that differed from both Caucasian and Mongoloid traits. The name is Nikoloudaki GE et al.[22] (Table 1) in their CBCT evaluation assessed the number of roots and root canals in the first and second maxillary molars. The researchers reported that most second molars include three roots, and there are also instances of fusion between a maxillary second molar and a supernumerary tooth. Ratanajirasut R et al.[23] (Table 1) examined the roots and root canal anatomy of maxillary first and second permanent molars in a Thai population. They reported that the most often observed configuration consisted of three roots in both first and

second molars. Currently, there is limited research available regarding maxillary second molars that possess either single root or two roots or two palatal roots.

4. Discussion

The second maxillary molar sometimes possess an intricate root canal system, because the inability to precisely identify and properly clean the whole root canal system is one of the reasons endodontic therapy fails.[12] Several studies have examined the shape of root canals using different research methodologies. Maxillary second molars often possess a tri-radicular configuration, with three distinct roots and three corresponding root canals. In the initial periapical radiograph, a clinician should be able to clearly detect the entire canal, beginning at the orifice to the apical third.[14]

Operating microscopes and traditional radiography are the primary techniques used in clinical practice to assess tooth anatomy. Lately CBCT imaging offers valuable insights into the features of the root canal. However, routine usage of this method should be avoided due to its higher cost and the need to justify the exposure to ionising radiation on an individual basis.[15,16] Utilising a dental microscope or surgical loupes aids in the diagnosis. These gadgets enhance the visibility of the surgical area, hence improving the chances of identifying hidden canals.[17,18] The occurrence of a second maxillary molar with a single root along with single canal, as well as a single root with two canals, is extremely uncommon. The different types of variations can be readily identified using radiographic imaging. However, it is important to use caution when comparing the position of the root with the image obtained from radiography.[19] Occasionally, it might be challenging to understand morphologic differences on a radiograph. Therefore, it is crucial to prioritise the use of an endodontic microscope, and use an electronic apex locator.[20] Existing literature indicates that Maxillary second molars have a higher degree of variability in terms of root numbers and morphology when compared to first molars.[23]

Regarding the study's clinical implications, the results indicate a significant advancement in the harmonisation of narrow and standardised concepts pertaining to the number of roots and canals. This is because, sometimes the inability to identify unnoticed additional roots or root canals with distinct morphology is the reason endodontic therapy fails.

5. Conclusion

The management of a maxillary second molar with a single root, as outlined in our example, begins with an accurate diagnosis and subsequent adjustment of the treatment plan as necessary. This understanding is crucial in order to execute accurate root canal therapy while considering the potential difficulties posed by the anatomy of the pulp space. In conclusion, the current study's description of a unique variation in the morphology of a maxillary molar with single root and single canal as well as single root with two canals has great didactic value because these instances are rarely found in textbooks.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Mohit Zarekar, Head Dentist, Private Practitioner https://orcid.org/0000-0002-5101-896X

Apurva Satpute, Post Graduate Resident https://orcid.org/0009-0000-7011-5581

Mohini Zarekar, Master's Student https://orcid.org/0009-0001-3425-8240

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