

Case Report

Unusual anatomy of a maxillary second molar: a second mesiobuccal canal or a second palatal canal?

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Abstract: This study presents a maxillary second molar (MSM) with an unusual root canal morphology confirmed by cone-beam computed tomography (CBCT). The tooth had two fused mesiobuccal (MB) roots with 2 separate canals, 1 normal distobuccal (DB) root with 1 canal, and 1 bulky palatal root with 1 canal. The second mesiobuccal (MB2) canal orifice, located in the mesiopalatal (MP) corner, was considered a second palatal (P2) canal when the chamber floor was examined, but it was verified as an MB2 based on CBCT. The described case reveals the complexity of MSM variations and emphasizes the importance of using advanced imaging modalities such as CBCT to confirm the 3-dimensional (3D) anatomy of teeth during endodontic treatments. Additionally, an in-depth evaluation of this case based on CBCT could provide new insights into the definition of MB2.

Keywords: Canal morphology, cone-beam computed tomography, second mesiobuccal canal

Introduction

Thorough knowledge of tooth anatomy and root canal morphology is essential for successful root canal treatment. If any portion of the root canal is missed, it cannot be properly cleaned, shaped and sealed, inducing endodontic failure. Therefore, the clinician must be aware of typical anatomical morphologies and certain unique variations during diagnosis and treatment [1].

Previous studies have indicated that the maxillary molars have the most complicated root canal configurations, especially the second maxillary molars, given their diverse root numbers and shapes [2, 3]. Several studies, including in vivo and in vitro studies, have investigated the configuration of the root canal systems of these teeth [4-6], which typically have the following three roots: (1) mesiobuccal (MB), (2) distobuccal (DB) and (3) palatal (P). However, the MB root often has many variations. Kulild and Peters stated that the presence of an MB2 canal in the maxillary first and second molars is fairly common [7]. Some case reports have

described other maxillary second molar (MSM) variations, such as an MSM with additional palatal canals and/or roots; however, most of these reports were based on radiographs taken both pre- and postoperatively [8-12].

A radiograph is only a two-dimensional (2D) image. When used to evaluate 3D teeth, radiography consistently results in the superimposition of images. The ideal method for precisely determining a tooth's root canal morphology is serial sectioning; however, this method cannot be achieved in clinical practice. In recent years, notable advances in noninvasive imaging technology for dental structures to guide endodontic treatment have been introduced, such as cone-beam computed tomography (CBCT) [13]. Compared with conventional radiography, this new diagnostic method greatly facilitates visualization of the internal root canal morphology as the data represent a volume rather than a slice and provide 3D information [14]. Therefore, this technology can reproduce every detail, thus improving the diagnosis, location determination, and treatment of unusual root canals.

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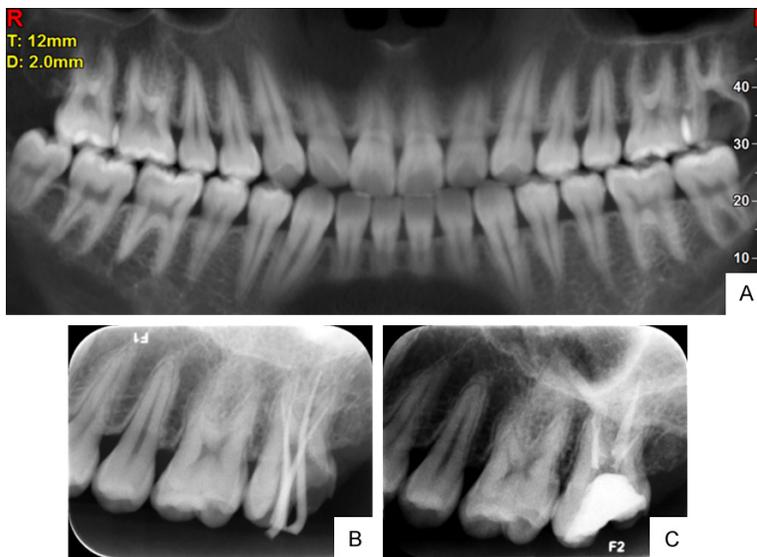


Figure 1. A. Preoperative panoramic radiograph of tooth No. 27. B. Working length determination. C. After root canal obturation.

This paper reports a case of an MSM with four root canals and reviews the literature on MB2 and P2 root canals in MSMs. The vagueness of the morphology of the extra root canal in this case contributes to the difficulties associated with its definition. Clinicians should consider CBCT imaging when such anatomical differences are encountered during treatment.

Case report

A 22-year-old male patient was directed to the Department of Caries and Endodontics at Nanjing Stomatological Hospital and presented with a history of spontaneous pain in the maxillary left second molar. The spontaneous pain had steadily increased in intensity from moderate to acute over the preceding few days. The patient's medical history was noncontributory. Clinical inspection revealed deep occlusal caries with severe pain upon probing with an explorer. These findings and sensitivity tests led to a diagnosis of acute irreversible pulpitis requiring root canal therapy. A preoperative panoramic radiograph was taken, and the overlapping images of the roots alerted us to the existence of a morphological variation (**Figure 1A**).

To completely understand this complex canal system, a preoperative CBCT image was obtained and analyzed. The CBCT images were obtained using a NewTom VG scanner (QR SRL,

Verona, Italy) according to the manufacturer's recommended protocol with a tube voltage of 110 KV and a tube current of 10 mA. CBCT images were analyzed with the inbuilt software NNT 2.19 using a 29.7-inch RadiForce MX300 W screen with a 2,560 × 1,600-pixel resolution. The involved tooth was identified, and its morphology was determined through coronal, axial, and sagittal sections with a thickness of 0.125 mm. A horizontal cross section (axial view) at the levels of the coronal, middle and apical thirds of the roots was obtained; it revealed four independent canals (MB1, MB2, DB and P; type I

Vertucci) (**Figure 2**). The geometric location of the MB2 canal was found in relation to the MB1 and P canals. The central points of each canal were located (PMB1, PMB2 and PP), and straight lines were projected between them (PMB1-PP and PMB1-PMB2). A third line was drawn (PMB2-PT) perpendicular to the PMB1-PP line (PT point) according to the protocol described by Betancourt *et al.* [4]. The distances between the points were measured in millimeters (**Figure 3B**).

The root shape characteristics of the involved tooth were represented in detail using a 3D reconstructed image (**Figure 4**). The image revealed the presence of two mesiobuccal (MB) roots fused from the coronal segment to the apical segment; however, the canals were separate (type I Vertucci). Consequently, two different canal orifices for the MB roots (one located mesiobuccally and the other located adjacent to the P orifice), two separate foramina in the apical part, and a small apical furcation in the fused root were present.

The patient received 2% lidocaine with 1:100,000 epinephrine for local anesthesia, and the maxillary left second molar was isolated under a rubber dam (Hygenic Coltene, Ohio, USA). After carefully analyzing the CBCT images, a modified trapezoidal endodontic access opening was created using a low-speed diamond round bur with the assistance of an oper-

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Figure 2. A-C: The different CBCT scanning levels of tooth No. 27 before root canal treatment.

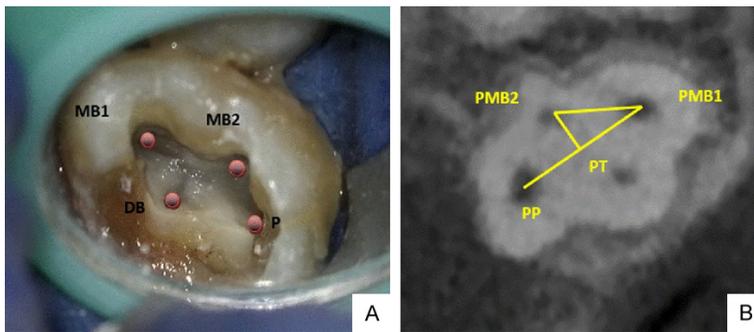


Figure 3. A. The chamber floor revealed 4 root canal orifices: MB1, MB2, DB and P. B. Axial view of tooth No. 27. PMB1 (center of the mesiobuccal canal), PMB2 (center of the MB2 canal), and PP (center of the palatal canal).

ating microscope (OPMI Pico, Zeiss, Oberkochen, Germany) to expose all the canals. Clinical examination of the chamber floor with an endodontic explorer (DG-16, Ash Instruments, Dentsply, Gloucester, UK) revealed four root canal orifices, including two on the buccal side and two on the palatal side (**Figure 3A**).

The working lengths of each canal were estimated with an electronic apex locator (Root ZX, Morita, Tokyo, Japan) and confirmed with a periapical radiograph. Coronal flares were performed using Gates-Glidden burs No. 2 and 3 (Dentsply Maillefer, Ballaigues, Switzerland). The root canals were cleaned and shaped using NiTi rotary protapers (Dentsply Maillefer, Ballaigues, Switzerland) with the crown-down technique and were enlarged to the size of a No. 25 file.

The canals were irrigated with 5% and 2.5% sodium hypochlorite between each file during instrumentation. Calcium hydroxide-based intracanal dressing was applied to all the canals,

and a sterile cotton pellet was placed in the pulp chamber. The tooth was then fitted with a temporary Cavit filling (ESPE, Seefeld, Germany).

One week later, the canals were obturated using AH Plus (Dentsply DeTrey, Konstanz, Germany) as a sealer; a warm vertical technique was performed thereafter. A postoperative radiograph was obtained to confirm the quality of the obturation (**Figure 1**).

After completing the root canal treatment, the tooth was restored with a posterior composite filling (Z350; 3M Dental Products, St. Paul, MN).

Discussion

Maxillary molars, particularly second molars, have the most complicated root and canal morphologies [5]. Zhang *et al.* reported that among MSMs, 10% had one root, 8% had two roots, and 81% had three roots. Of the MB roots, 22% had two canals and the others had one [14]. This illustrates that the most common MSM morphology is three roots (MB, DB, and P), with one canal in each root. However, many studies have reported abnormal maxillary molars with additional root canals, and the most common anatomic variation is related to the root canal configuration of the MB root. Pablo Betancourt used CBCT to study 225 permanent MSMs and reported that the MB root MB2 canal was present in 48% of the cases [4]. However, various studies have reported large differences in the detection of the MB2 canal in the MSM accord-

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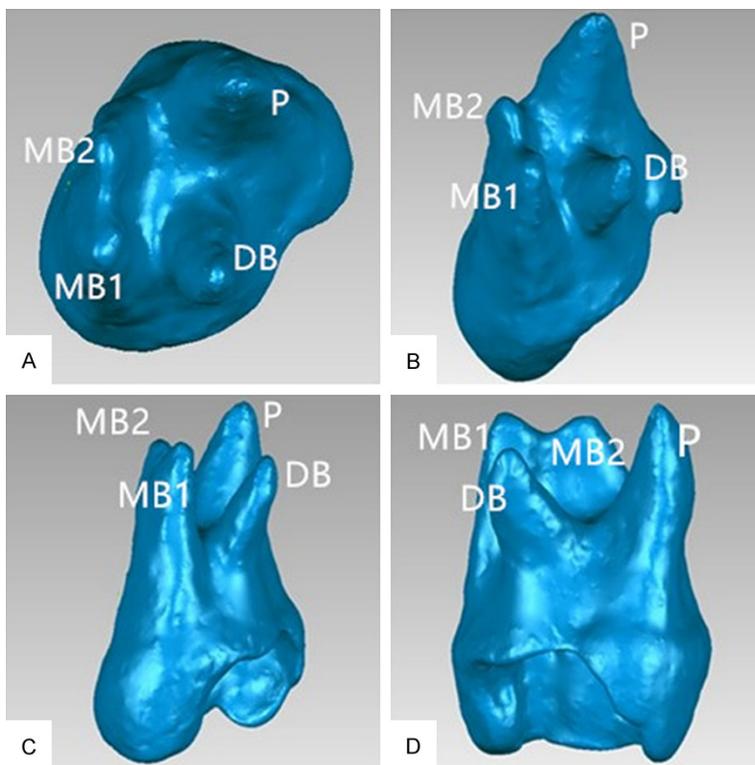


Figure 4. A-D: 3D reconstructed image of tooth No. 27. This tooth had 4 roots: 2 fused MB roots, 1 DB root, and 1 palatal root.

ing to the technique used; the in vivo prevalence may range from 19.7% to 73% [15, 16]. The substantial discrepancies in the results among these studies are mostly due to the interpretation of morphological variations using different methods.

Methods used to examine root and canal morphologies include canal staining and tooth clearing, serial sectioning, conventional and digital radiography, microscopic evaluation, CT, spiral CT, and CBCT [17-21]. Neelakantan *et al.* compared five methods (the modified canal staining and clearing technique, CBCT, peripheral quantitative CT, spiral CT, and plain and contrast medium-enhanced digital radiography) to investigate their accuracy in studying root canal morphology and found that CBCT imaging was a useful diagnostic tool for this purpose [21]. CBCT uses a cone-shaped beam and multiple exposures around an object to reveal its internal structure. This method has many advantages, including low radiation exposure, faster image acquisition without requiring chemicals, and high-resolution images in multiple planes of space while eliminating superimposition of surrounding structures. CBCT has

improved clinical success with respect to diagnosing, locating, and treating complex root canals. However, in daily clinical practice, the application of CBCT is limited due to its high cost and relatively complex operation. Conventional radiographs, from periapical and panoramic radiography, remain the best method for helping dentists understand the main problems associated with teeth, periodontal tissue, and the jaw. CBCT can be recommended only when these 2D images are insufficient to evaluate unusual anatomic variations.

In the present case report, four canals were identified with the assistance of a microscope, including two canals on the buccal side and two canals on the palatal side (**Figure 3A**). The extra canal located in the mesiopalatal

(MP) corner was considered a P2 canal from the coronal view under direct vision; however, CBCT scanning revealed that it was an MB2 canal. The tooth had four roots and four canals, including two fused MB roots with one canal in each, a DB root with one canal, and a bulky palatal root with one canal (**Figures 2 and 4**). For a better understanding, 24 cases of MSMs with unusual root canal anatomy reported in the literature were compared, as shown in **Table 1**. Most previous studies used radiography, whereas more recent studies tended to use CT or CBCT to improve the accuracy of investigation. Among these studies, 14 papers were related to the palatal root, where the presence of two canals has most often been reported. Nevertheless, the majority P2 cases were inspected by 2-dimensional radiographs, which cannot provide exact information about the extra root canal. Whether the “claimed P2 root canals” of the reported cases were truly P2 root canals or the same variation as in our case is uncertain.

The geometric location of the MB2 canal in the present case is shown in **Figure 3B**. The length of the PMB1-PP line was 6.76 mm. The length

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Table 1. Review of cases reports on maxillary second molars with unusual canal morphology

Reference	Study type	Description	Year of publication
Suresh <i>et al.</i> [22]	In vivo (PA radiographs and CBCT)	3 MB, 2 DB and 1 P root canal	2017
Zeng <i>et al.</i> [3]	In vivo (PA radiographs and CBCT)	C-shaped MB root with 2 canals, 2 fused DB roots with 2 canals and 1 P root canal	2016
Nabavizadeh <i>et al.</i> [9]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2015
Beshkenadze and Chipashvili [23]	In vivo (PA radiographs)	1 buccal and 1 P root canal	2015
Fakhari and Shokranezh [24]	In vitro (PA radiographs)	1 MB, 1 DB and 2 P root canals	2013
Simsek <i>et al.</i> [25]	In vivo (CBCT)	1 mesial root and 1 distal root with 2 canals in each root	2013
Arora <i>et al.</i> [26]	In vivo (PA radiographs and MDCT)	3 MB, 1 DB and 1 P root canal	2013
Shojaeian <i>et al.</i> [27]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals, Enamel pearl	2013
Badole <i>et al.</i> [28]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2012
Patel and Patel [11]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2012
Ioannidis <i>et al.</i> [29]	In vivo (CBCT)	1 root, 1 canal	2011
Eskandarinekhad and Ghasemi [30]	In vivo (PA radiographies and microscope)	1 MB, 1 DB and 2 P root canals	2011
Zhao <i>et al.</i> [31]	In vivo (PA radiographs and CT)	3 MB, 1 DB and 1 P root canal	2011
Singla and Aggarwal [32]	In vivo (spiral CT)	C-shaped P Canal	2010
Weinstein <i>et al.</i> [33]	In vivo (PA radiographs and Endoscope)	2 MB, 1 DB, 1 P and geminated buccal canal	2010
Prashanth <i>et al.</i> [34]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2010
Kottoor <i>et al.</i> [35]	In vivo (PA radiographs and CBCT)	2 MB, 1 DB and 2 P root canals	2010
Aggarwal <i>et al.</i> [36]	In vivo (PA radiographs and spiral CT)	1 MB, 1 DB and 2 P root canals	2009
Holderrieth and Gernhardt [37]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2009
Ozcan <i>et al.</i> [38]	In vivo (PA radiographs)	3 MB, 1 DB and 1 P root canal	2009
Ulusoy and Görgül [39]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2007
Barbizam <i>et al.</i> [1]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2004
Baratto-Filho <i>et al.</i> [40]	In vivo (PA radiographs)	1 MB, 1 DB and 2 P root canals	2002
Carlsen and Alexandersen [41]	In vitro (stereo-microscope)	Ligual supernumerary roots	2000

MDCT: multidetector computed tomography.

of PMB1-PMB2 was 4.29 mm, and the length of PMB2-PT was 1.58 mm. This result is quite different from those of previous studies. In an *in vitro* study, Grduysus *et al.* observed that the MB2 canal was located mesially to the MB1 canal and 1.81 mm from the MSM using an operating microscope, and Degerness & Bowles located this canal 1.78 ± 0.6 mm from the MB1 canal using a stereomicroscope [42, 43]. In an *in vivo* study, Pablo Betancourt *et al.*

reported that the MSM MB2 canal was located 2.41 ± 0.64 mm palatally and 0.98 ± 0.33 mm mesially to the MB1 canal using CBCT [44]; using the same technique, Betancourt *et al.* reported that the canal was 2.2 ± 0.54 mm palatally and 0.98 ± 0.32 mm mesially to the MB1 canal [4]. This discrepancy between *in vivo* and *in vitro* studies may be explained by the loss of the anatomical relations in the *in vitro* studies or the use of various magnification tools with

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microscopy that distort the images. With CBCT, the resolution of the resulting image is isotropic on every spatial axis. Consequently, we selected the more efficient and accurate method, CBCT, to identify the location of the MB2 canal. However, a discrepancy between our result and those of other CBCT studies remains, possibly due to sample limitations in previous reports. Assisted by CBCT, our results expand upon previous knowledge of the MB2 location and suggest that the MB2 canal may be located more palatally to the MB1 canal.

A recent study on the anatomy of four-rooted MSMs classified 25 molars into three types (I-III) according to their root divergence considering that fusion may occur at the different levels of all roots [45]. In type I molars, the palatal roots were widely divergent and were often longer and more tortuous than the buccal roots, which were less divergent and often “cow-horn” shaped. In type II molars, the roots had blunt apices, ran almost parallel to one another and were often shorter than those in type I teeth. In type III molars, the palatal roots were less divergent and were often shorter than the buccal roots, which were widely divergent. In the present study, CBCT scanning and 3D reconstruction indicated that the two MB roots and the DB root were shorter, ran in parallel, and exhibited blunt root apices (**Figure 4**). The two MB roots were fused together and leaned towards the mesiobuccal area. The P root revealed a pronounced elongated shape that stood alone and diverged from the other roots. This type of root morphology did not belong to any of the three previously described classifications.

In addition to the variation in the number or morphology of the root/canal, fusion is a common deviation observed in maxillary molars. However, no uniform definition of fusion is currently available, and researchers have widely divergent viewpoints on fusion. Some consider fusion to be full roots fusing together, whereas others define fusion as one-third or less of the roots fusing together. Some researchers do not even provide a definition for fusion [46]. Fusion occurs more frequently in MSMs than in MFMs, which may explain the increased variation in MSMs. According to a previous study, 42.25% of MSMs had fused roots. Of the 42.25% of MSMs with fused roots, 27.85% and 7.59%

exhibited partial and complete canal merging, respectively [47]. Marco Aurelio Versiani et al. examined the anatomy of four-rooted MSMs using CBCT and reported that root fusion was evident in 44% of the samples [45]. Sabala et al. studied 500 dental records and found that root fusion occurred more often in MB roots, with a 0.4% prevalence and 100% bilateral presence [48]. These studies demonstrated that the four-rooted MSM with two fused MB2 roots identified in the present case is not a rare phenomenon. The main reason for the limited reports on this type of morphological variation may be the variability in the definition of MB2/P2 or limitations due to the examining methods.

Conclusion

The current study challenges previous studies claiming the existence of two P roots or canals without any CBCT analysis and provides new data regarding the location of MB2. Our study emphasizes that an accurate radiographic technique and proper interpretation are essential for sound diagnosis and treatment.

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Disclosure of conflict of interest

None.

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