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CASE REPORT

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Rare root canal morphology of maxillary second molars: A report of three cases

Takayoshi Nagahara[1,2] | **Katsuhiro Takeda**[2] | **Keinoshin Wada**[3] | **Tomoya Naruse**[2] | **Hideki Shiba**[2]

[1]Nippon Kokan Fukuyama Hospital, Hiroshima, Japan

[2]Department of Biological Endodontics, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan

[3]Wada Dental Clinic, Hiroshima, Japan

Correspondence
Katsuhiro Takeda, Department of Biological Endodontics, Graduate School of Biomedical and Health Sciences, Hiroshima University, 1-2-3 Kasumi, Minami-ku, Hiroshima 734-8553, Japan.
Email: takepon@hiroshima-u.ac.jp

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Key Clinical Message

Endodontists should be aware that some maxillary second molars can have more than three roots. If any unusual anatomical features are detected during dental radiography or endodontic procedures, it is necessary to conduct cone-beam computed tomography (CBCT) scanning to prevent procedural mishaps.

Abstract

CBCT can provide three-dimensional reconstructed images of the root canal system. With the help of CBCT, variations in tooth root number and root canal morphology, such as extra canals, apical ramifications, apical deltas, and lateral canals, can be identified. Knowledge of the variations is very important for the success of endodontic treatment. This report suggests that endodontists must not assume that a MSM has only three tooth roots, which is the most prevalent number.

KEYWORDS

case report, cone-beam computed tomography, maxillary second molar, root canal morphology

1 | INTRODUCTION

Adequate knowledge about the root canal system and meticulous radiographic interpretation is essential for successful endodontic treatment. Ignorance of maxillary molar anatomic variation leads to a higher failure rate.[1] The limitations of instruments and the high variation of the root canal systems of a maxillary second molar (MSM) are the major reasons for the difficulties in endodontic therapy. The MSM has, in general, a three-rooted configuration with three or four root canals (one or two root canals in a mesiobuccal root, one root canal in a distobuccal root, and one root canal in a palatal root).[2–5] The prevalence of a second mesiobuccal root canal (MBC 2) ranges from 14.0% to 83.4%.[3] Root fusion occurs more frequently in a MSM than in a maxillary first molar.[3,6,7]

The anatomy of MSM roots has been thoroughly investigated with sectioning technique and analysis of three-dimensional radiographical images using micro-computed tomography and cone-beam computed tomography (CBCT) which are tools for understanding tooth anatomy and root canal morphology.[3,4,8] CBCT has become an indispensable tool for understanding the structure of tooth roots and root canals. This report presents three cases of MSMs with atypical roots and canal numbers: Case 1 with five roots and five root canals, Case 2 with four roots and four root canals, and Case 3 with four roots and four root canals.

2 | ENDODONTIC TREATMENT

Cases 1 and 2 had endodontic treatment as follows. After removal of dental restorative materials and infected dentin under local anesthesia (Xylocaine®, DENTSPLY-Sankin Co., Ltd.), the pre-endodontic build-up using flowable light-cured composites (Unifil® Flow; GC Dental Industrial Corp.) was performed to place the rubber dam. After an access cavity was prepared under the rubber dam, the pulp chamber was examined under high magnification using a surgical operating microscope (ManiScope Z®, Mani). After locating the orifices, the root canals were negotiated using a #10 hand file (Dentsply Maillefer). Coronal flaring was done with a Gates Glidden drill (Mani). The working length was determined with an electronic apex locator (Root ZX®; J Morita). Root canal preparation was continued by K-files (Mani). The root canal was irrigated with 10% sodium hypochlorite (Neo Cleaner®, Neo Dental) and ethylenediaminetetraacetic acid (EDTA) (Smear Clean®, Nippon Shika Yakuhin Co., Ltd.). Calcium hydroxide (Calcipex II®, Nippon Shika Yakuhin Co., Ltd.) was then used as an intracanal medication. The access cavity was then temporarily double-sealed with temporary stopping (Temporary stopping®, GC Dental Industrial Corp.) and glass ionomer cement (Base cement®, Shofu Inc.). All root canals in the two teeth were obturated by the lateral condensation technique with gutta-percha (GC, GC Dental Industrial Corp.) and sealers (NISHIKA CANAL SEALER BG®, Nippon Shika Yakuhin Co., Ltd.).

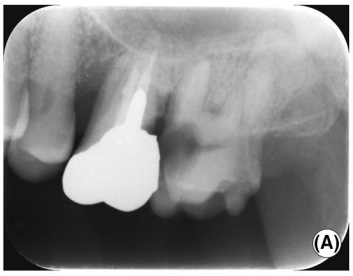
2.1 | Case 1

A 64-year-old Japanese man visited Nippon Kokan Fukuyama Hospital with a chief complaint of persistent pain on his left MSM for 3 days. He also had spontaneous pain on the right maxillofacial side. A radiographic image of tooth 27 showed mesial cervical caries approaching the pulp chamber. There was no obvious periapical lesion (Figure 1A). Tooth 27 was diagnosed as having symptomatic irreversible pulpitis with normal apical tissues. Since the anatomy of the root canals in the initial dental radiograph was unclear, CBCT (3DX Multi-Image Micro CT FPD8, J Morita) scans were performed to confirm its anatomical structure. CBCT images (Figure 1B–D) and 3D reconstruction images (Figure 1G–I) were obtained. MBC 2 is commonly located mesiopalatally to the first mesiobuccal root canal (MBC 1).[9] The location of MBC 2 has been studied in both in vitro and in vivo studies.[10–14] The in vivo analysis of the MSM using CBCT by Betancourt et al. showed that the average distance between the central points of MBC 1 (a) and of MBC 2 (b) was 2.41 ± 0.64 mm[11] and 2.2 ± 0.54 mm[10] (Figure 1E) on the axial slice apically 1 mm from the floor of the pulp chamber. The (c) is a central point of a palatal canal (PC) (Figure 1E). They also reported that the average distance between b and d (a point which is one corresponding to a perpendicular line between b and the a–c line)[11,12] was 0.98 ± 0.33 mm[12] and 0.98 ± 0.35 mm[11] (Figure 1 E). In the present case, the distances between a and b and between b and d on CBCT were 4.83 and 3.72 mm, respectively, in Figure 1F (Figure 1B where the three red lines are drawn). These lengths were quite different from those of the averages reported by Betancourt et al.[10,11] Thus, point b was assumed to be the central point of the mesiopalatal root canal (MPC), but not of MBC 2. CBCT images showed that a mesiobuccal root (MBR) and a mesiopalatal root (MPR) were fused (Figure 1B–D,G–I). The orifice located in the mesiopalatal corner was a MPC (Figure 1J,K). The CBCT images also showed a second distobuccal root canal (DBC 2) and root (DBR 2) (Figure 1B–D,G–I). Tooth 27 was found to have five root canals (MBC, MPC, DBC 1, DBC 2, and distopalatal canal [DPC]) and five roots (MBR, MPR, DBR 1, DBR 2, and distopalatal root [DPR]). After the five root canals had been shaped and cleaned (Figure 1J,K), obturation was carried out (Figure 1L). No obvious abnormalities were observed at 1-year follow-up (Figure 1M).

2.2 | Case 2

A 39-year-old Japanese woman was referred from a private dental clinic to Nippon Kokan Fukuyama Hospital.

FIGURE 1 Case 1. (A) Dental radiograph of tooth 27. (B–D) Different CBCT scanning levels of axial slices of tooth 27 before obturation. Coronal slice apically 1 mm from the pulp chamber floor (B). Middle slice (C). Apical slice (D). M: mesial side, D: distal side, B: buccal side, P: palatal side. Red arrow: second distobuccal canal (DBC 2) in the second distobuccal root (DBR 2). (E) This looks like an axial slice 1 mm apical from the floor of the pulp chamber of MSM with MBC 2. a (central point of MBC 1), b (central point of MBC 2), and c (central point of PC). Two straight lines projected: a–c line and a–b line. d point: point corresponding to a perpendicular line between b and the a–c line. M: mesial side, D: distal side, B: buccal side, P: palatal side. (F) Axial view ([B] where the three red lines are drawn) of tooth 27. The distance of the lines drawn between the points was measured in millimeters. a–b line: 4.83 mm, b–d line: 3.72 mm. M: mesial side, D: distal side, B: buccal side, P: palatal side. (G–I) The 3D reconstruction of tooth 27. It has five roots: mesiobuccal root (MBR), mesiopalatal root (MPR), two distobuccal roots (first distobuccal root [DBR 1] and DBR 2), and a distopalatal root (DPR). MBR is fused with MPR. (J, K) Microscopic images of the five orifices of the root canals: mesiobuccal canal (MBC), mesiopalatal canal (MPC), first distobuccal canal (DBC 1), DBC 2, and distopalatal canal (DPC). (L) After obturation. (M) One-year follow-up. No obvious abnormalities are observed.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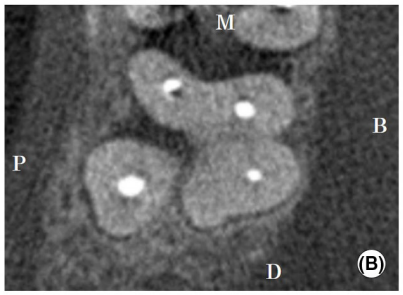
M
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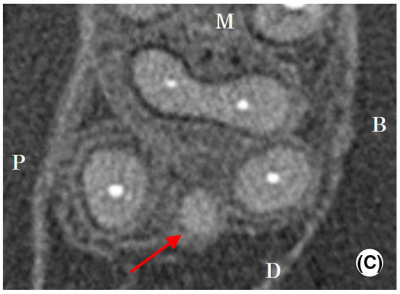
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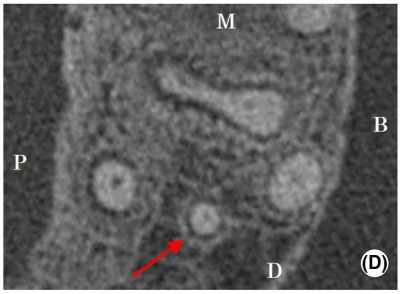
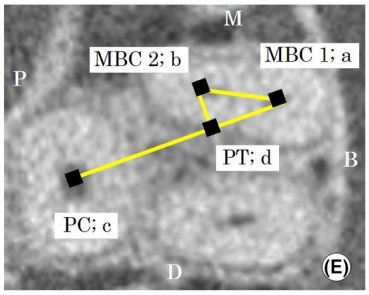
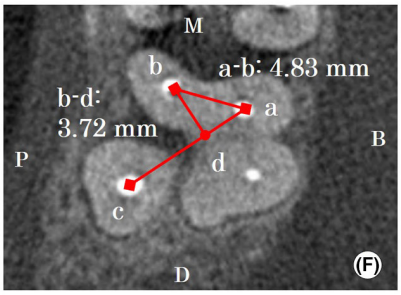
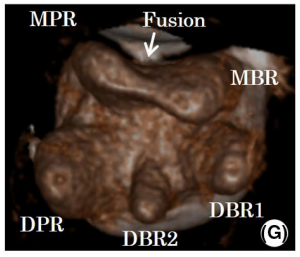
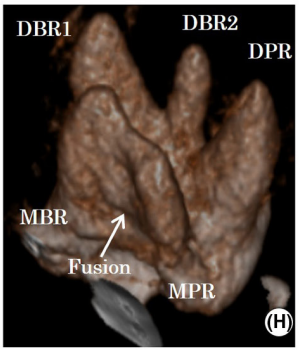
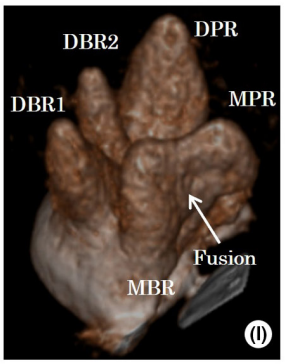

M
B
P
D
(D)

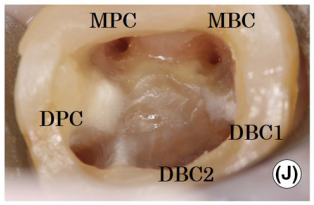

M
MBC 2; b
MBC 1; a
P
PT; d
B
PC; c
D
(E)

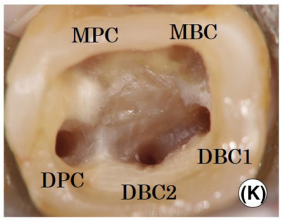

M
b
a-b: 4.83 mm
b-d:
3.72 mm
a
B
P
d
c
D
(F)


MPR
Fusion
MBR
DPR
DBR1
DBR2
(G)


DBR1
DBR2
DPR
MBR
Fusion
MPR
(H)


DBR2
DPR
DBR1
MPR
Fusion
MBR
(I)


MPC
MBC
DPC
DBC1
DBC2
(J)


MPC
MBC
DBC1
DPC
DBC2
(K)


(L)


(M)

Her chief complaint was a persistent spontaneous pain following caries treatment with glass ionomer cement on tooth 17. Radiographic examination showed no obvious periapical lesion and no obvious root canal abnormality of tooth 17 (Figure 2A). This was diagnosed as symptomatic irreversible pulpitis with normal apical tissues.

After pulp chamber opening, it was found that the position of root canal orifices was abnormal. CBCT was used to assess the complexity of canal anatomy and identify the potential presence of accessory canals or morphological features that may impede the procedure. CBCT scans of tooth 17 were performed to observe the details of the anatomical structure. CBCT images (Figure 2B–D) and 3D reconstruction images (Figure 2F–I) were obtained. In Figure 2E (Figure 2B where the three red lines are drawn), the distances between a–b and b–d were 5.67 and 4.18 mm, respectively. These lengths were quite different from those of the averages reported by Betancourt et al.[10,11] (Figure 1E). Thus, the root canal located in the mesiopalatal corner was considered MPC, not MBC 2 (Figure 2B–D). Tooth 17 was found to have four root canals (MBC, MPC, DBC, and DPC) (Figure 2B–D) and four roots (MBR, MPR, DBR, and DPR) (Figure 2F–I). The orifice located in the mesiopalatal corner was an MPC (Figure 2J). CBCT images showed that MBR and MPR were fused (Figure 2B–D,F–I). The radiograph after obturation (Figure 2K) also showed four root canals. No obvious abnormities were observed at 1-year follow-up (Figure 2L).

2.3 | Case 3

A 73-year-old Japanese woman was referred from a private dental clinic to Nippon Kokan Fukuyama Hospital for a second opinion about root canal treatment on tooth 27 (Figure 3A). The chief complaint was swelling and pain on biting. The medical referral letter from the referring dental clinic stated that these symptoms remained unimproved even though the tooth had received endodontic treatment. The pocket probing depth on tooth 27 was within normal limits except for probings of 8 mm in the buccal and palatal furcations. CBCT was taken to confirm the extent of the perforation and to determine whether perforation repair was possible. The CBCT images showed four root canals and perforation (Figure 3B–D). This case was diagnosed as previously treated, perforation and acute apical abscess. The distances between a–b and b–d were 3.12 and 2.40 mm, respectively (Figure 3E) (Figure 3B where the three red lines are drawn). These lengths were quite different from those of the averages reported by Betancourt et al.[10,11] (Figure 1E). Thus, the root canal located in the mesiopalatal corner was considered MPC, not MBC 2 (Figure 3B–D). Tooth 27 was extracted with the patient's consent due to a large perforation that extended from the furcation area to the floor of the pulp chamber. The tooth was found to have four roots (Figure 3F–J).

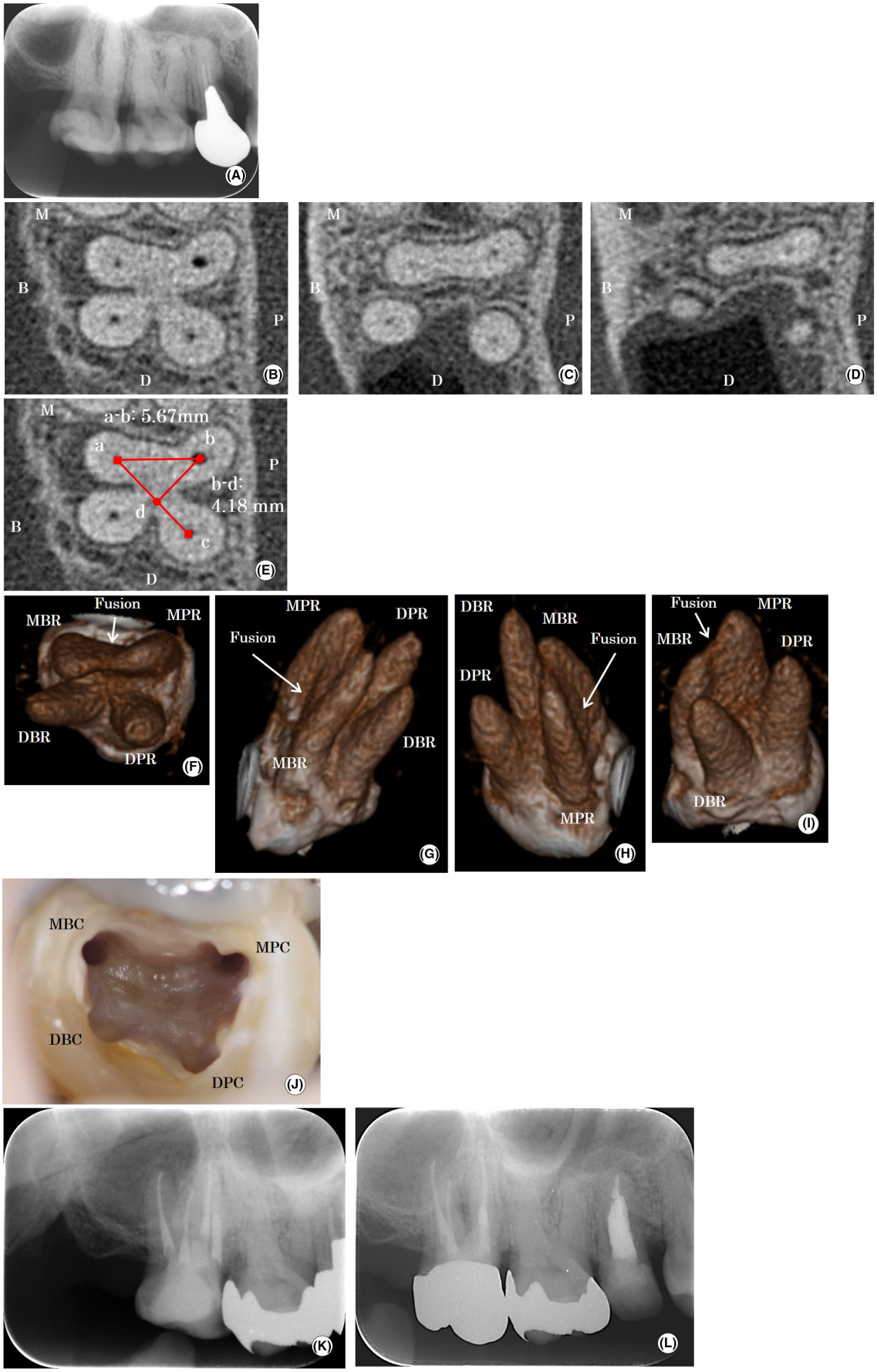
3 | DISCUSSION

A significant challenge of endodontic therapy is completing thorough treatment of the entire root canal system. There is anatomic variation based on sex, ethnicity, and population group.[3,15,16]

The MSM has been recognized to be, in general, a three-rooted tooth with three or four root canals.[2–5] Kato et al. recently reported the root numbers of Japanese MSMs; the percentages of one root, two roots, and three roots were 20%, 24.3%, and 65.7%, respectively.[17] In a systematic review, Martins et al. reported that 0.3%–1.7% of MSMs have four roots.[3] The literature review showed that the incidence of two palatal roots and two palatal root canals in maxillary molars was reported to be less than 2%.[18] Zeng et al. showed a MSM with four roots (C-shaped MB root, two root-fused DB root, and one bulky palatal root) and five root canals (MBC 1, MBC 2, DBC 1, DBC 2, and PC).[19] According to Tian's classification,[20] which considers fusion as a separate root, this case report identified a MSM in case 1 with five root canals (MBC, MPC, DBC 1, DBC 2, and DPC) and five roots (MBR, MPR, DBR 1, DBR 2, and DPR). Unlike Zeng's case, in this paper, MBC2 was considered as MPC from the distances between a–b and b–d by Betancourt et al.[10,11] Further discussion may be needed regarding naming, such as MBC2 or MPC.

We present findings of a MSM with five roots and two MSMs with four roots, all of which featured fused roots. Regarding fusion of the MSM with three roots, the prevalence of root fusion ranges from 5.9% to 42.25%.[7,20–29] Martins et al.[7] reported that the most frequent type was MBR fused with a palatal root (PR), followed by PR fused with MBR and DBR. Zhang et al.[28] and Tian et al[20] reported that fusion of MBR and DBR was the most common,

FIGURE 2 Case 2. (A) Dental radiograph of tooth 17. (B–D) Different CBCT scanning levels of tooth 17 before obturation. Coronal slice apically 1 mm from the pulp chamber floor (B). Middle slice (C). Apical slice (D). M: mesial side, D: distal side, B: buccal side, P: palatal side. (E) Axial view ([B] where the three red lines are drawn) of tooth 17. Straight lines are projected. The distance of the lines drawn between the points was measured in millimeters. a–b line: 5.67 mm, b–d line: 4.18 mm. M: mesial side, D: distal side, B: buccal side, P: palatal side. (F–I) The 3D reconstruction of tooth 17. It has four roots: MBR, MPR, DBR, and DPR. MBR is fused with MPR. (J) Microscopic images of the four orifices of the root canals: MBC, MPC, DBC, and DPC. (K) After obturation. (L) One-year follow-up. No obvious abnormalities are observed.


(A)
M
B
P
D
(B)
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(D)
a-b: 5.67mm
a
b
b-d:
4.18 mm
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(E)
MBR
Fusion
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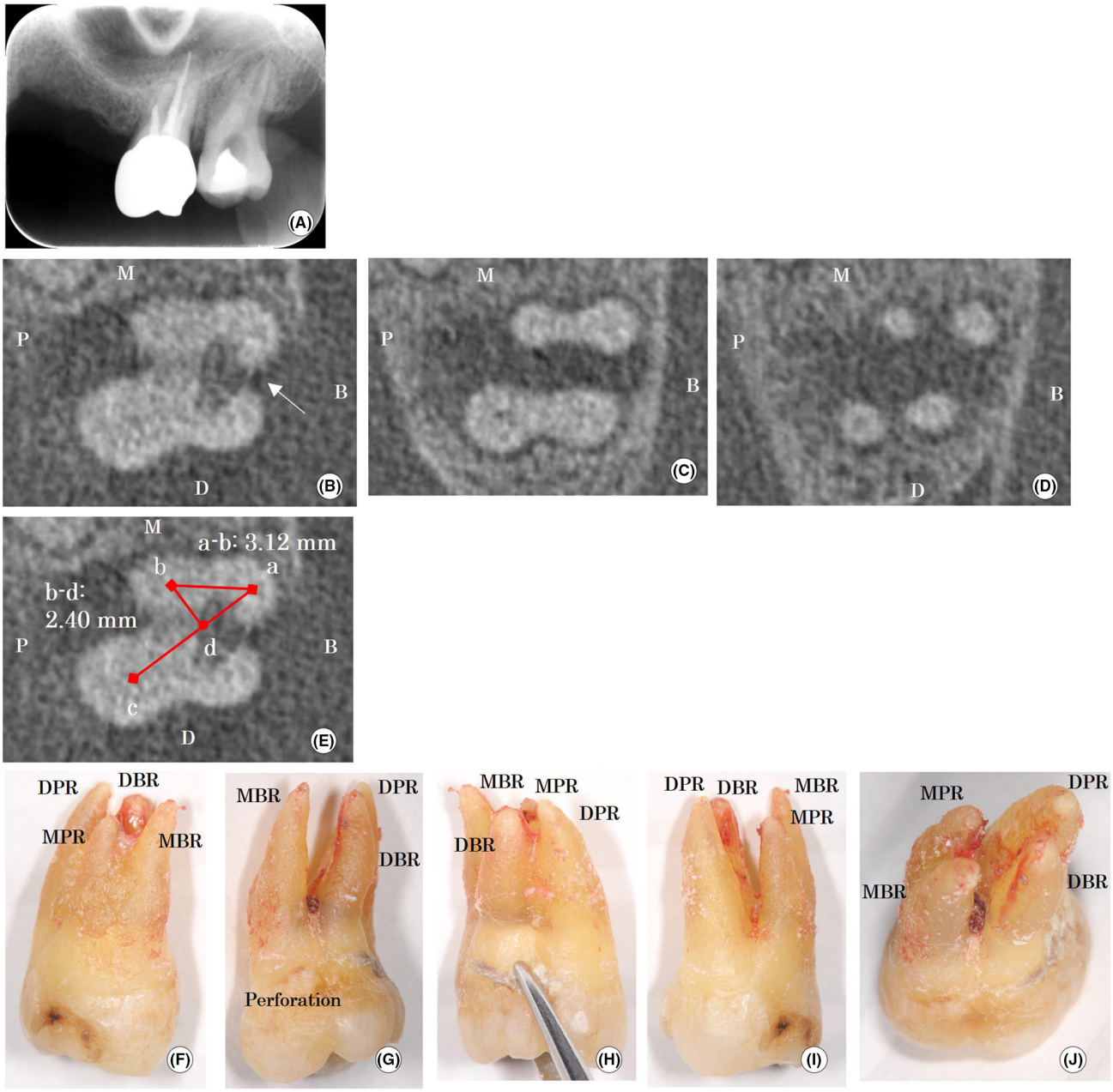

FIGURE 3 Case 3. (A) Dental radiograph of tooth 27. (B–D) The different CBCT scanning levels of tooth 17 before obturation. Coronal slice apically 1 mm from the pulp chamber floor (B). Middle slice (C). Apical slice (D). M: mesial side, D: distal side, B: buccal side, P: palatal side. White arrow: perforation. (E) Axial view ([B] where the three red lines are drawn) of tooth 27. The distance of the lines drawn between the points was measured in millimeters. a–b line: 3.12 mm, b–d line: 2.40 mm. M: mesial side, D: distal side, B: buccal side, P: palatal side. (F–J) The extracted tooth 27. The tooth has four roots: MBR, MPR, DBR, and DPR. MBR is fused with MPR. DBR is fused with DPR.

followed by fusion of MBR with PR. Zapata et al.[8] found that fusion of MBR and DBR was the most common, followed by fusion of DBR with PR. In the present study, Cases 1 and 2 showed fusion of MBR and MPR. Case 3 showed fusion of MBR and MPR, and fusion of DBR and DPR, similar to the root morphology of the mandibular molar. Since knowledge of the occurrence of root fusion in the MSM has an impact on endodontic treatment,[6,7,19] further epidemiological studies of the root fusion of MSM are necessary.

4 | CONCLUSION

This case report emphasizes that endodontists should know the MSM. In rare cases, it has more than three roots

and accurate radiographic technique and proper interpretation of tooth root morphology are essential for appropriate diagnosis and successful endodontic treatment. It is not usual to obtain CBCT images for every case of MSM. However, if unusual anatomical features are detected during dental radiography or endodontic procedures, it is necessary to conduct CBCT scanning to prevent perforation or other procedural mishaps.

AUTHOR CONTRIBUTIONS

Takayoshi Nagahara: Data curation; investigation. **Katsuhiro Takeda:** Writing – original draft. **Keinoshin Wada:** Investigation. **Tomoya Naruse:** Writing – review and editing. **Hideki Shiba:** Writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

ORCID

Takayoshi Nagahara https://orcid.org/0000-0001-6896-1404
Katsuhiro Takeda https://orcid.org/0000-0002-2416-6692

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