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CASE REPORT

Detection, characterisation and management of complex root canal configurations in the mesiobuccal roots of maxillary first molars: A case series

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Abstract

This report presents the detection, characterisation, instrumentation and filling of complex canal configurations in the mesiobuccal (MB) root of maxillary first molars. Three patients were referred for root canal treatment in first maxillary molars. Medical history, age, sex and clinical findings were recorded. Intraoral periapical radiographs and cone beam computed tomography (CBCT) were used for diagnosis and pre-operative assessment. Using Ahmed et al. (2017) classification system, codes ^{3}MaxM MB$^{3\text{-}5\text{-}4\text{-}2}$ DB$^{1\text{-}2\text{-}1}$ P^{1} (case 1), ^{3}MaxM MB$^{2\text{-}5\text{-}3\text{-}2}$ DB^{1} P^{1} (case 2) and ^{3}MaxM MB$^{1\text{-}4\text{-}2\text{-}1\text{-}2}$ DB^{1} P^{1} (case 3) were identified. Using the dental operating microscope, CBCT (if indicated) and troughing up to 3 mm allowed identification of more than three canals in the MB root of maxillary first molars. The coding system proposed by Ahmed et al. (2017) allows the classification of MB roots with highly complex canal configurations.

KEYWORDS

Ahmed classification, CBCT, dental operating microscope, maxillary first molars, root canal system, Vertucci classification

INTRODUCTION

The aim of root canal treatment (RCT) is to remove the irreversibly inflamed or necrotic pulp tissue, eradicate microbial irritants and prevent reinfection from the complex root canal system [1, 2]. The successful RCT of infected root canals requires adequate knowledge of the regular and unusual anatomy of the teeth to be treated [1]. Untreated microbially infected root canals may compromise the outcome of RCT, allowing inflammation to persist [2, 3]. Untreated root canals are most frequently reported in the mesiobuccal (MB) roots of maxillary first molars reaching up to 74% [4, 5].

In clinical practice, the use of a dental operating microscope (DOM) and cone beam computed tomography (CBCT) (if indicated) help to identify root canals at different levels of the root [6, 7]. Reports found 20%–50% additionally detected root canals in the MB root of maxillary molars using the DOM compared to dental loupes [8–10].

The number of root canals can vary greatly in maxillary first molars ranging from 1 to up to 8 root canals [11, 12]. Literature shows a high frequency of a second MB root canal (MB2) in maxillary first molars ranging from 19% [13], 52% in a Chinese population [14], 80% in an Italian population [15], to more than 90% [8]. The prevalence of three MB root canals in the MB root ranges from 1.1% to 12% [16–18], with configuration type 3-2 being the most common [19]. Other more complex anatomical variations have been reported in micro-CT studies [18].

For many years, the classification of tooth anatomy suggested by Vertucci [20] has been the most frequently used system to categorise root canal configurations using

a small range of Roman numerals, for example, I–VIII. However, the morphological characteristics of root canal systems are highly complex, and many canal configurations had to be described as 'non-classifiable' when using that system [17, 18]. In 2017, Ahmed and colleagues proposed a new coding system for classification of root and root canal anatomy, which provides information on tooth notation, number of roots and additional details on root canal configuration in a single code [21]. The system has been reported in both laboratory and clinical studies as well as in routine clinical practice to be accurate when classifying root and canal anatomy [22].

While high-resolution micro-CT studies have shown a wide range of complex anatomy in the MB root of maxillary first molars, with up to 3 or even more root canals [18], so far no clinical report has documented the occurrence of this high level of complexity in the MB root of maxillary first molars. This report aims to present three clinical cases in which the MB roots in maxillary first molars present with more than three root canals using two classification systems [20, 21, 23].

CASE SERIES

This case series has been written according to Preferred Reporting Items for Case reports in Endodontics (PRICE) 2020 guidelines [24] (Figures S1–S3). The three patients of Caucasian ethnicity were referred to the dental office limited to endodontics because the root canals could not be completely located. The three cases were examined and treated under identical conditions. After reviewing the risks, benefits and treatment options with the patient, written informed consent was obtained for investigation and RCT.

Medical and dental history were non-contributory for all three patients, and the teeth scheduled for RCT were examined clinically and radiographically. The teeth reacted negatively to the pulp sensitivity testing using cold spray (Miracold plus, Hager & Werken, Duisburg, Germany) and an electrical pulp test (Digitest, Parkell, Edgewood, NY, USA). Probing depths, axial and horizontal percussion stimulus, and tooth mobility were recorded. Radiographical examination was performed intraorally with Trophy IRIX 70 and the RVG Sensor 6200 (Carestream Dental LLC, Atlanta, GA, USA); tube voltage 70 kV, tube current 7 mA, exposure time 0.3 s. A CBCT scan (Veraviewpox 3D R100, Morita Co., Kyoto, Japan) with a field of view (FOV) 4 × 4 cm, tube voltage 80 kV, tube current 7 mA, voxel size 125 µm and exposure time 17 secs was obtained. The axial CBCT sections were viewed and interpreted by a specialised endodontist with more than 20 years of experience (M.A.), and the findings were confirmed by a specialised endodontist with more than 20 years of experience (A.HMA.). Images were assessed on a 27″-LCD screen, where image brightness and contrast could be modified using i-Dixel software (Morita Co., Kyoto, Japan). When the number of visible root canals changed, screenshots were taken and saved as an image. The teeth were locally anaesthetised and isolated using rubber dam (DermaDam, Ultradent, Köln, Germany). The teeth were treated by an experienced operator (Endodontic Specialist) with an experience of more than 20 years (M.A.).

The endodontic access cavity was prepared under visualisation with a DOM (PROergo; Carl Zeiss Meditec AG, Jena, Germany). Endo Access Burs in sizes 012 to 005 (Hager & Meisinger, Neuss, Germany) in descending size were used to expose the root canal orifices. During troughing preparation of the MB root canals, digital photographs were taken with maximum magnification by the DOM and a digital camera (Alpha 7, Sony Europe, Berlin, Germany) whenever the number of root canals changed, and this was possible during the clinical procedure.

Coronal preflaring with ProFile sizes 15.04 and 20.04 (Dentsply Maillefer, Ballaigues, Switzerland) was carried out before initial determination of the working length. The electronic measurement was carried out with the EndoPilot (Schlumbohm, Brokstedt, Germany). For mechanical instrumentation of the root canals, ProFile 04 instruments sizes 15–45 in crown-down technique were used (Dentsply Maillefer, Ballaigues, Switzerland) under continuous irrigation with 1% NaOCl. For extended cleaning and disinfection, citric acid 10%, ethanol 70% and chlorhexidine digluconate 2% (lege artis, Dettenhausen, Germany) were used separately with passive ultrasonic agitation for 20 s per root canal (VDW.ULTRA, Munich, Germany). The root canals were dried with sterile paper tips in 4% conicity (VDW, Munich, Germany). Vertical compaction of gutta-percha and Sealer (2Seal, VDW, Munich, Germany) were used for root canal obturation. Downpack was performed using the System B Heat Source (Obtura Spartan Endodontics, Young Specialities, IL, USA) and the backfill using Obtura III (Obtura Spartan Endodontics, Young Specialities, IL, USA). The gutta-percha was compacted with NiTi hand pluggers in sizes ISO 25-60.

After applying the acid-etch technique for 5 s and conditioning the dentine with OptiBond FL (Kerr, Herzogenrath, Germany), the root canals were sealed 1–2 mm below the root canal orifice with flowable resin composite Tetric EvoFlow (Ivoclar Vivadent, Ellwangen, Germany). The core was restored in layers with Tetric Power resin composite (Ivocar Vivadent). The treated teeth were asymptomatic and in function during the 5- and 10-year follow-up.

Case 1

History

A 48-year-old male patient was referred to continue root canal therapy on tooth 16. The patient described increasing persistent pain over a period of 2 years and repeated loss of fillings on affected tooth. In the last few days, the stabbing pain intensified and radiated over the entire half of the face. With the diagnosis of acute pulpitis, initial RCT was performed by the referring dentist, who failed in locating the MB and disto-buccal (DB) root canals.

Pre-operative assessment

With the vertical percussion test, slight pain was elicited compared to teeth 14, 15 and 17. No pathological findings were present apically on tooth 16 on the intraoral radiograph. Radiographically, the root canals were visible, but appeared narrow. At the bottom of the pulp chamber, a radiopaque structure overlapped the root canal orifices (Figure 1a). A double periodontal ligament space at the MB root apex suggested an unusual anatomy. A slightly widened periodontal ligament space was evident at the MB root apex (Figure 1a). Intracoronally, a pulp stone was suspected (red arrow). Accordingly, a CBCT was considered to provide additional information for access cavity preparation in this case of extremely complex root canal anatomy. The axial view of the MB root confirmed the suspicion of a root canal system with a type 2-1-2 configuration (Figure 1b). The CBCT images confirmed the presence of severe pulp canal calcification but no apical periodontitis. Tooth 16 with a pulp stone was diagnosed with pulp necrosis.

Clinical management

After removing the occlusal filling material under the DOM at 8× magnification, amorphous, mineralised tissue was identified at the floor of the pulp chamber. The MB and DB root canals were not detectable due to deposition of dentine covering the orifices (Figure 1c). The initial access cavity was enlarged in the MB direction with a flame-shaped diamond (KP6863.314.012, Komet, Lemgo, Germany). The dentine was removed with Endo Access Burs (EAB) in size 012 (Hager&Meisinger, Neuss, Germany) so that the root canal orifices could be completely exposed. Three root canal orifices were initially visible mesiobuccally at 8× magnification (Figure 1d). The pulp tissue was necrotic. After a 2–3 mm troughing preparation under 16× magnification, three MB root canals splitting into five separate canals were identified (Figure 1e). During further troughing preparation with the long shank round drill size 005, MB1 and the adjacent canal merged, so that four root canals were subsequently enlarged with rotary NiTi files (Figure 1f,g). The outer two root canals of the MB root merged in the apical third of the root into two root canals. In the DB root, the initially crescent-shaped root canal divided into two separate and apically merging root canals (Figure 1h).

The buccal root canals were enlarged to an apical size ISO 30 and the palatal canals to ISO 45 in a crown-down technique using ProFile 04. After cleaning and disinfection, vertical compaction was performed with gutta-percha and 2 Seal (Figure 1i). An apical delta was identified in the palatal root canal. The tooth was classified as Vertucci non-classifiable for the MB root, types III and I for the DB and palatal (P) roots, respectively. According to the Ahmed et al. coding system, the tooth was classified as $^{3}16$ $MB^{3\text{-}5\text{-}4\text{-}2}$ $DB^{1\text{-}2\text{-}1}$ $P^{1(D)}$. Further follow-up examinations were performed at the referring dentist. According to the dentist, 5 and 10 years after the RCT the tooth is asymptomatic and radiographically without pathological findings.

Case 2

History

A 51-year-old male patient presented with pain on tooth 16. The patient was referred because the root canals could not be located, and the patient had a severe gagging reflex. The clinical examination revealed the presence of a small fluctuant swelling related to tooth 16. The tooth was tender to vertical percussion. Bleeding on probing was present distally with a pocket depth of 4 mm.

The pre-operative radiograph taken during the emergency visit showed a radiolucent area related to the P root of tooth 16 (Figure 2a). The root canals appeared calcified. Due to the strong gagging reflex, an intraoral radiograph with an altered projection was not taken. On the CBCT scan, narrow root canals with extremely complex root canal anatomy could be identified in all three roots (Figure 2b–d). Apically, the presence of an apical radiolucency was evident around all three root tips.

Pre-operative assessment

After rubber dam isolation, the intracoronal exploration was performed at 8× magnification with the DOM. Preparation of the access cavity was performed in MB

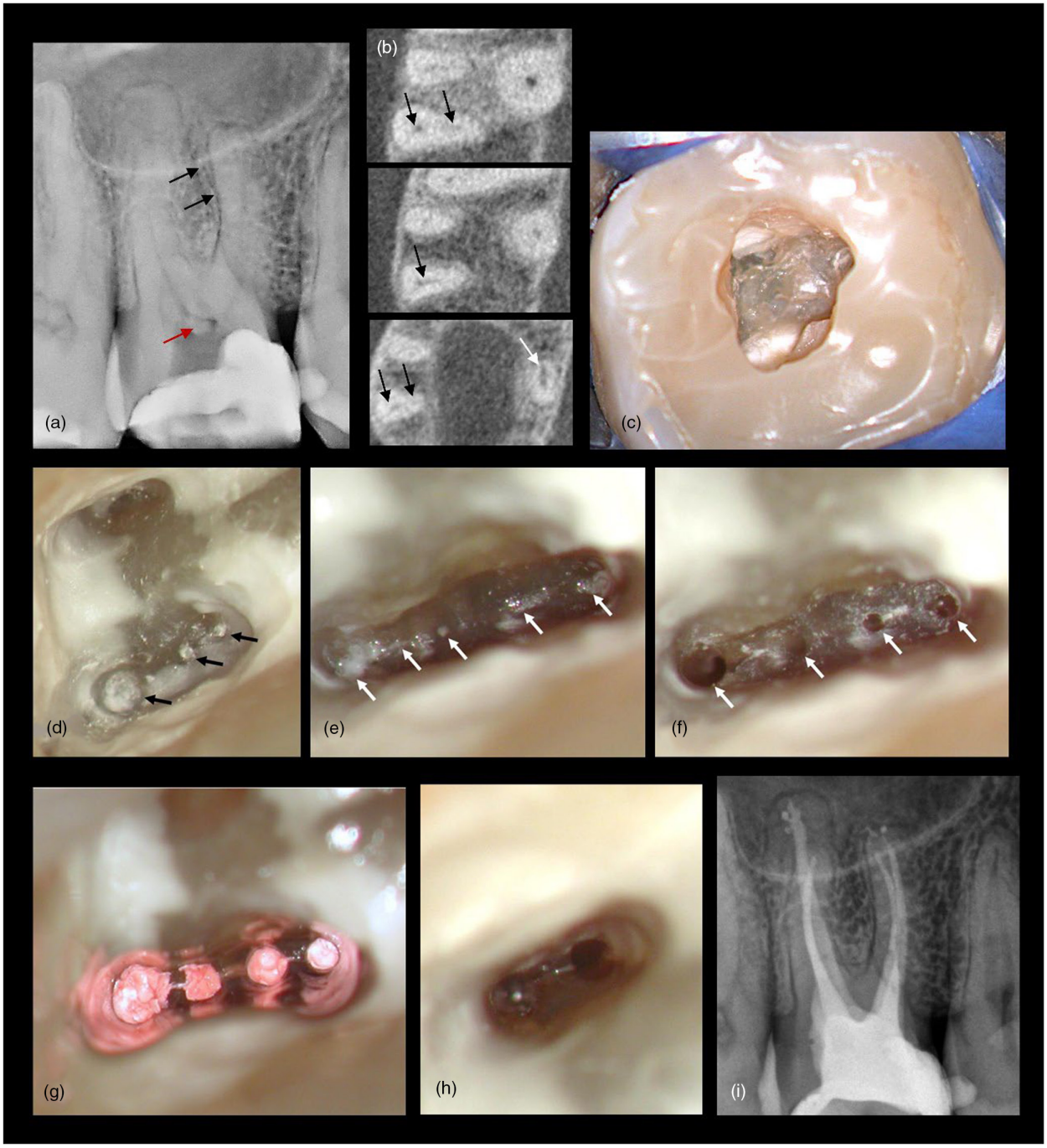

FIGURE 1 Case 1 presenting a 48-year-old male patient with Caucasian ethnicity (a) Pre-operative radiograph showing tooth 16 with initial preparation of endodontic access cavity. Calcification or a pulp stone is visible at the bottom of the pulp chamber (red arrow). The double periodontal ligament indicates two root canals in the MB root (black arrows). (b) Axial CBCT views in the coronal, middle and apical root third. The identified root canals are marked (black arrows). An accessory canal was identified in the P root (white arrow). (c) Initial access cavity required enlargement (magnification 8×). A pulp stone superimposed the MB root canals orifices. (d) Three root canals and (16×) were identified (black arrows). (e) After 3 mm troughing preparation, five root canals were identified (20×) (white arrows). (f) Two enlarged root canals merged apically into two separate canals with a total of four canals (20×) (white arrows). (g) MB root canals after thermoplastic filling (20×). (h) The DB root showed two root canals of type 2-1 which were prepared and filled (20×). (i) Post-operative radiograph showing the filled MB root and an apical delta in the P root.

direction. A pulp stone was identified at the floor of the pulp chamber in which the root canals could not be probed (Figure 2e). The pulp stone was successfully removed using EAB size 012 (Hager&Meisinger, Neuss, Germany) at 8–16× magnification. The DB and P root canals with necrotic pulp tissue could be located.

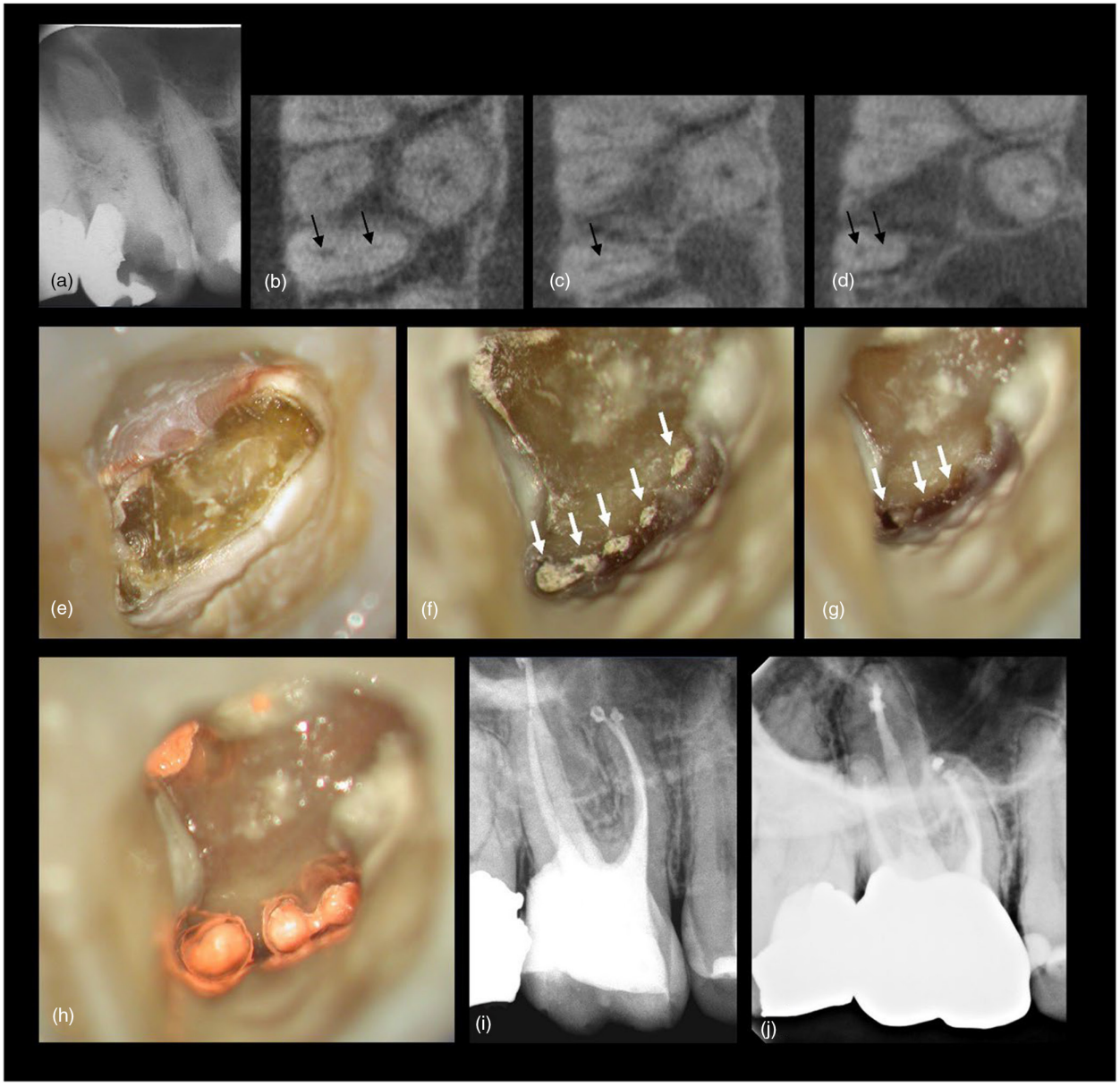

FIGURE 2 Case 2 presenting a 51-year-old male patient with Caucasian ethnicity (a) Pre-operative radiograph of tooth 16 with an apical radiolucency. Root canals could not be detected. Axial CBCT views of tooth 16 in (b) coronal, (c) middle and (d) apical root third with a type 2-1-2 in MB root (black arrows). (e) A pulp stone filled the pulp cavity completely (Magnification 8×). (f) After removing the pulp stone, five root canals were detected (16×) (white arrows). (g) Troughing preparation revealed merging of the 5 MB root canals into 3 (16×) (white arrows). (h) Three MB root canals were filled (16×). (i) The post-operative radiograph shows adequate root canal obturation with two apical foramina in the MB root. (j) Ten years post-operative follow-up.

Based on the clinical, radiographic and intracoronal findings, a diagnosis of infected pulp necrosis associated with an acute apical abscess was made and the RCT was performed subsequently.

Clinical management

With the troughing preparation in the MB root, five root canals were initially identified which merged into 3 (Figure 2f,g). The root canals MB2 and MB3 were only confluent in the apical third of the root. The root canals were enlarged to size 35 up to the working length, while the P canal was enlarged to size 45. The canals were disinfected using 1% NaOCl, calcium hydroxide (UltraCal, Ultradent, Cologne, Germany) was applied, and the cavity was temporised with Cavit (ESPE, Seefeld, Germany) and resin composite.

After 1 week, the patient was symptom-free, and the tooth was further cleaned and irrigated with 10% citric

acid, 70% ethanol and 2% CHX (lege artis, Dettenhausen, Germany) for 20 s per canal using a self-adjusting file (ReDent Nova, Berlin, Germany) with a diameter of 1.5 mm. Finally, three root canals in the MB root were obturated with warm vertically compacted gutta-percha and sealer (Figure 2h). A periapical radiograph was taken to check the root canal filling (Figure 2i). On the distal-shift projection, two root canals and two separate apical foramina are visible mesiobuccally, which leads to a classification of Vertucci non-classifiable for the MB root, type I for each of DB and P roots. Using the Ahmed et al. coding system, the code $^{3}16\ MB^{5\text{-}3\text{-}2}\ DB^{1}\ P^{1}$ describes the root canal configuration of the tooth. At the 10 years post-operative follow-up, the patient was free of symptoms and radiographically without pathological findings (Figure 2j).

Case 3

History

The 55-year-old male patient was referred with infected pulp necrosis and an expected difficult root and root canal anatomy in a curved MB root in an asymptomatic tooth 16.

Pre-operative assessment

The periodontal probing depth was 5 mm distally accompanied with bleeding. Intraoral radiography showed secondary caries distally at the restoration margin. Inside the pulp chamber, the dentine-dense structure indicated the presence of a pulp stone (Figure 3a). The CBCT image suggested a complex multiple subdivision of type VII according to Vertucci in the coronal view of the mesial root (Figure 3b–g). Tooth 16 with pulp stone and deep caries was diagnosed with pulp necrosis with chronic apical abscess.

Clinical management

Inspection of the pulp chamber with the DOM at 16× magnification confirmed the presence of distal caries, a pulp stone and a necrotic pulp (Figure 3h). The resin composite restoration and caries were completely removed. After dentine-adhesive temporary resin composite restoration and surface disinfection of the rubber dam and access cavity, the pulp stone was removed with a rose bur. The DB root canal had a crescent-shaped and the P root canal an oval cross-section, filled with partially mineralised pulp tissue. Mesiobuccally, the MB1 and MB2 merged to form a wide band-shaped root canal, which split up into four root canals after a troughing preparation of approximately 2 mm (Figure 3i,j). During initial exploration of the root canals, suppurating fluid was discharged from the MB root canal (Figure 3k). Mechanical enlargement and shaping of the MB and DB root canals were performed using a combination of rotary NiTi instruments FlexMaster (VDW, Munich, Germany) in sizes 15.02 and 20.02 and ProFile sizes 15.04–25.04 (Maillefer, Ballaigues, Switzerland). The DB and P root canals were enlarged to working length up to ISO sizes 25 and 40, respectively, with irrigation using 1% NaOCl. Calcium hydroxide UltraCal (Ultradent, Cologne, Germany) was applied and the cavity sealed with Cavit (Espe, Seefeld, Germany) and resin composite (Tetric EvoFlow, Ivocar Vivadent, Ellwangen, Germany). After 1 week, the patient appeared asymptomatic, and the root canals were finally cleaned and disinfected using an SAF file 1.5 mm with 1% NaOCl, 10% citric acid, 70% ethanol and 2% CHX. After completing thermoplastic root canal obturation, an accessory root canal was detected radiographically in the middle third of the root (Figure 3l). The tooth was classified as Vertucci non-classifiable for the MB root, type I for each of the DB and P root. According to the Ahmed et al. coding system, $^{3}16\ MB^{1\text{-}4\text{-}2\text{-}1\text{-}2(M1)}\ DB^{1}\ P^{1}$ was used to describe the root canal configuration of the tooth in addition to accessory canals. Ten years after RCT, the tooth is in function without pathological findings (Figure 3m).

DISCUSSION

The occurrence of three root canals in the MB root of maxillary first molars has been documented in earlier studies and case reports [12, 19]. Results from high-resolution micro-CT studies show a more complex anatomy in the MB root compared to CBCT and 2D radiographic imaging [15, 17, 18]. In two cases, it was even possible to detect more than three root canals in the MB root. Thus, it seems that the improved imaging of the radiographic technique has an important impact on the detection of additional root canals. However, small canals may not be identified if the size of the canal is below the range of the voxel size of a given CBCT device. Therefore, troughing between canal orifices and the use of small stainless-steel hand files is important for the detection of additional canals. This may explain why the frequency of MB2 in maxillary three-rooted maxillary first molars decreases with age [25]. For example, CBCT was able to detect MB2 in 69% of cases, whereas it was detected by using a microscope in 78% of cases [26].

The design of the endodontic access cavity from a primarily triangular to a rhomboid shape usually facilitate the location of the MB2 canal [13, 27]. The same principle was applied in all cases with three or more MB canals.

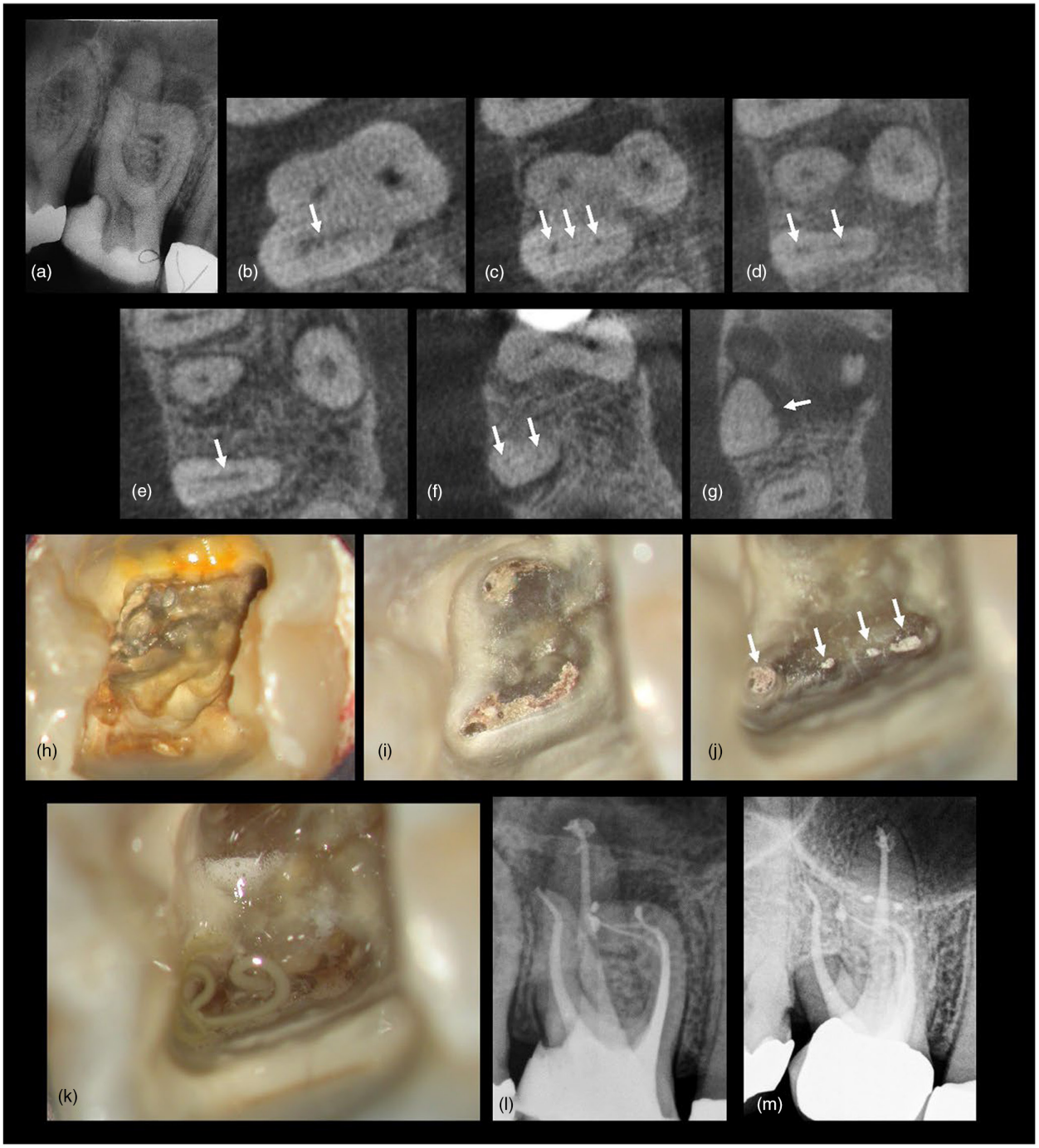

FIGURE 3 Case 3 presenting a 55-year-old male patient with Caucasian ethnicity (a) Pre-operative radiograph shows tooth 16 with unusual root canal anatomy, and an apical radiolucency. (b–g) The CBCT axial views show a complex root canal system (white arrows). (b) MB starts with one canal, which divides (c) into three root canals. In the middle third of root the MB system (d) these merged into 2 and then (e) into an isthmus. (f) Apically the MB canal splits up into two apical foramina and (g) one accessory canal (white arrow). (h) The pulp chamber was filled with a pulp stone and sclerotic dentin. Discoloured secondary/tertiary dentin covered the MB root canals (Magnification 8×). (i) After troughing, one root canal was identified (8×). (j) 2 mm deeper 4 root canals were detected (16×) (white arrows). (k) Following mechanical exploration, purulent fluid discharged was noted (16×). (l) The post-operative radiograph shows a complete root canal filling and confirms an accessory canal in the apical third of the MB root. (m) Ten years follow-up after root canal treatment.

For the troughing preparation of the MB root canals, the straight-line access is crucial. The cavity was, therefore, extended to the MB cusp tip and to the mesial marginal ridge. With the use of DOM, the colour perception could be used for location of the canal orifice in the pulp chamber floor [28]. Currently, whenever indicated, the use of CBCT and DOM is recommended for accurate detection of root canals in multi-rooted teeth [7].

TABLE 1 The use of Ahmed et al. classification system [32] at different phases of RCT.

	Pre-operative		Intra-operative	Post-operative
	Intraoral X-ray	**CBCT**	**After enlargement**	**After root canal filling**
Case 1	$^{3}16\ MB^{2}\ DB^{1}\ P^{1}$	$^{3}16\ MB^{2\text{-}1\text{-}2}\ DB^{1\text{-}2\text{-}1}\ P^{1(A1)}$	$^{3}16\ MB^{3\text{-}5\text{-}4\text{-}2}\ DB^{1\text{-}2\text{-}1}\ P^{1(A1)}$	$^{3}16\ MB^{3\text{-}5\text{-}4\text{-}2}\ DB^{1\text{-}2\text{-}1}\ P^{1(D)}$
Case 2	$^{3}16\ MB^{1}\ DB^{1}\ P^{1}$	$^{3}16\ MB^{2\text{-}1\text{-}2}\ DB^{2\text{-}1}\ P^{1}$	$^{3}16\ MB^{5\text{-}3\text{-}2}\ DB^{2\text{-}1}\ P^{1}$	$^{3}16\ MB^{5\text{-}3\text{-}2}\ DB^{2\text{-}1}\ P^{1}$
Case 3	$^{3}16\ MB^{1}\ DB^{1}\ P^{1}$	$^{3}16\ MB^{1\text{-}3\text{-}2\text{-}1\text{-}2(M1)}\ DB^{1}\ P^{1}$	$^{3}16\ MB^{1\text{-}4\text{-}2\text{-}1\text{-}2(M1)}\ DB^{1}\ P^{1}$	$^{3}16\ MB^{1\text{-}4\text{-}2\text{-}1\text{-}2(M1)}\ DB^{1}\ P^{1}$

Note: In case 1, the root canal configuration in the MB and DB roots appeared more complex in CBCT compared to 2D. A more complex canal anatomy in the MB root was identified under DOM and after troughing. One accessory canal was identified in the apical third of the P root; however, after root canal filling, it is obvious that there are additional accessory canals forming an apical delta (D). Similar findings have been identified in the second and third cases. The flexibility in using the codes allows more detailed interpretation of the canal configuration types along different phases of RCT.

The cases presented were inspected and treated using a DOM at 8–30× magnification. The troughing preparation and minimally invasive removal of the secondary/tertiary dentine allowed accurate detection of the root canals and facilitated reopening and enlargement [27]. In a recent study, it was shown that in the coronal root third, the number of root canals increases in the MB root [29], as shown in the first and third cases. Only in the second case, five root canals could be visualised immediately after removal of the pulp stone.

The colour variations at the pulp chamber floor were used for locating the root canal orifices. In this manner, sclerosed dentin could be differentiated from the normal root dentine due to different light reflection. Under magnification, it was possible to identify structural characteristics in dentin, thus avoiding procedural errors including perforations. After completing this troughing preparation of the root canal orifices of 1–3 mm, it was possible to open the severely narrow root canals for further preparation using ProFile 0.4 instruments. With this procedure, even apparently obstructed root canals can be opened up and enlarged [30].

The detection of root canal bifurcations is limited to straight root canals with DOM. The presence of deep bifurcations was, therefore, evaluated before starting treatment with CBCT to better plan the minimally invasive procedure for enlargement of deep splits. In particular, the anatomical shape and cross-section of the root allow further assessment of the root canals locations. In the axial plane, the presence of two or more root canals could be determined from the corono-apical dimension (Figures 1b, 2b–d and 3b–f). The coronal view was used to evaluate the splitting and merging levels of root canals in the MB root and to identify accessory canals (Figure 3g). The evaluation is carried out in a dynamic observation. By determining the location and extent of the apical radiolucency, it was possible to use the portals of entry and exit as additional predictors for the presence of accessory canal.

This report showed that the coding system introduced by Ahmed et al. [21] for root and canal anatomy, as well as accessory canals [23] was able to classify the complex anatomical variations presented in this report compared to Vertucci's classification. This is in agreement with a recent systematic review [22]. It is worth mentioning that the initial coding given to the cases, based on the intraoral radiographic images, could be updated with the information from the CBCT and clinical exploration. This means that the coding system is flexible enough to address the root and canal anatomy before and after treatment. By using the DOM, it was possible to reproduce the radiological information on the tooth and use it for an adequate minimally invasive intervention. During different steps of the RCT procedures, the classification of the respective root canal system could be further addressed in which the codes can be changed along the RCT procedures from the simple configurations identified in the pre-operative 2D imaging to the more complex anatomical presentations identified in CBCT, under the DOM, after troughing procedures and root canal filling (Table 1) [31]. Indeed, the high complexity of the root canal configuration usually results in teeth with long codes [22].

It has to be noted that apart from the main root canal, the microbial biofilm may also reside in complex branching extending laterally from the main canal, isthmuses connecting adjacent root canals in the same root [32]. Current literature emphasises the important role of advanced root canal irrigation techniques for proper disinfection of complex communications of the root canals [32].

CONCLUSIONS

The root canal anatomy in the MB root of maxillary first molars can be highly complex. The use of CBCT (whenever indicated) and the DOM are beneficial for locating additional canals. A troughing preparation up to 3 mm is helpful in identification and root canal enlargement. Based on the current Ahmed et al. classification for root canals, it is possible to characterise the complex anatomical variations of maxillary first three-rooted molars in clinical settings.

CONFLICT OF INTEREST STATEMENT

The authors deny any conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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