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Endodontic Management of a Maxillary Central Incisor with two Roots: A Case Report and Literature Review

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Maxillary incisors are typically straightforward cases for root canal therapy. While it is commonly assumed that maxillary central incisors have a single root canal, they may occasionally exhibit variations in their root canal system anatomy. In this report, we present a case of a maxillary central incisor with multiple root canals and provide a review of relevant literature on this anatomical variation. A 13-year-old female with deep carious lesion in tooth 11 was admitted in Department of Endodontics. Following a precise clinical and radiographic examination, a maxillary central incisor with necrotic pulp and chronic apical periodontitis along with unusual root anatomy was found and considered for non-surgical root canal treatment. Successful treatment results depend on various factors and awareness of root canal system anatomy is one of them. Due to an increasing number of reported cases of maxillary central incisors with different anatomy, it is imperative to consider anatomical variations even in the most routine cases.

Keywords: Anatomic Variation; Maxillary Central Incisor; Root Canal

Introduction

The objectives of endodontic treatment are to eliminate infection and inflammation, relieve pain, and save the tooth. However, the root canal system can be complex and diverse, and a lack of awareness of this complexity can lead to residual infectious tissue and toxic products used in root canal treatment, ultimately reducing the long-term prognosis for the tooth. It is commonly believed that maxillary central incisors have a single root and canal [1, 2]. But recent reports have revealed additional anatomical variations in the maxillary central incisor beyond this belief [3-6]. This report aims to provide a detailed account of endodontic treatment for a maxillary central incisor with two roots, as well as review literature on this anatomical variation.

Case Report

A 13-year-old female patient with no significant medical history, presented to the Department of Endodontics at the School of Dentistry, Mashhad University of Medical Sciences, Iran. Intraoral examination revealed a deep carious lesion in tooth 11 with no response to electrical (Parkell digital EPT, New York, USA) and thermal (Frisco spray, Arztbedarf, Frenchen, Germany) pulp tests while adjacent teeth responded within the normal ranges. The patient reported slight pain on palpation and percussion, and periodontal examination showed no probing or abnormal mobility. Crown morphology was normal and identical to tooth 21. Periapical radiograph displayed bifurcated roots in the mesiodistal direction with slight apical radiolucency and periodontal ligament (PDL) widening (Figure 1A). Cone-beam computed tomography (CBCT) using Planmeca ProMax 3D (Planmeca, Helsinki, Finland) was performed to improve assessment and revealed a two-rooted tooth with one orifice and two foramina (Figure 1B-1E). With the diagnosis of necrosis and chronic apical periodontitis, the tooth was considered for root canal treatment.

After administration a local infiltration with 2% lidocaine and 1:80000 epinephrine (Darupakhsh, Tehran, Iran), the tooth was isolated with rubber dam and disinfected. Under a dental operating microscope (Carl Zeiss Meditec Inc., Dublin, CA, USA), the access cavity was prepared with a high-speed

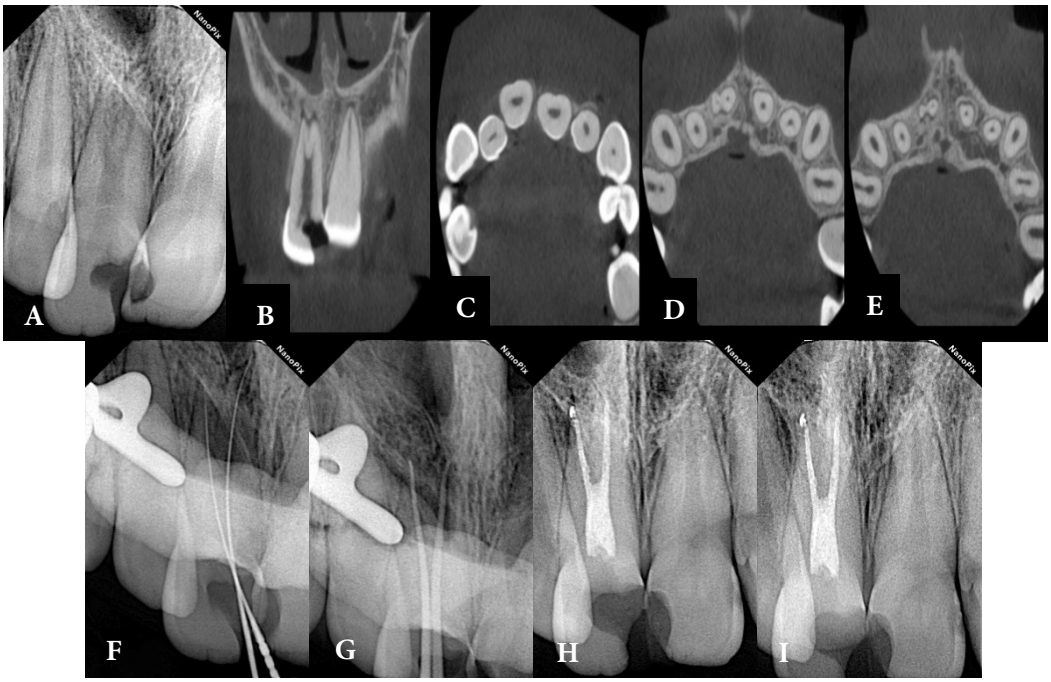

Figure 1. *A*) Preoperative intraoral radiograph; Preoperative CBCT view; *B*) Frontal view; *C*) Coronal third axial view; *D*) Middle third axial view; *E*) Apical third axial view; *F*) Working length confirmation radiograph; *G*) Master cone confirmation radiograph; *H*) Postoperative intraoral radiograph; *I*) Six months follow-up radiograph

long shank diamond No. 2 round bur (Jota AG, Rüthi, Switzerland) with continuous water spray. Canals were negotiated with #10 K-file (Mani Inc., Utsunomiya, Japan), and working length was determined as 20 mm for the mesial canal and 19 mm for the distal one by an electronic apex locator (E-Pex Pro; Eighteeth, Changzhou, China) and then confirmed with radiography (Figure 1F). Chemo-mechanical cleaning and shaping was performed by crown-down technique with M3 Pro Gold rotary files (United Dental, Sichuan, China), up to size 25/04 for both canals under copious irrigation with 5.25% sodium hypochlorite and normal saline alternately. Canals were dried with paper points (META, Chugbuk, South Korea), and master cone 30/04 (META, Chugbuk, South Korea) fit was checked with a periapical X-ray (Figure 1G). The obturation was performed with the warm vertical technique by FastFill (Fast Fill Obturation System; Eighteeth, ChangZhou, China) using gutta-percha and AH-26 sealer (Dentsply, Ballaigues, Switzerland). After the operation, the quality of the filling was evaluated on a periapical radiograph (Figure 1H). Finally, Cavit (Cavisol, Tehran, Iran) was applied as a temporary restoration and the patient was referred to the department of restorative dentistry for permanent restoration. At the 6-month follow-up, the tooth was clinically and radiographically asymptomatic (Figure 1I).

Review of Literature

Search strategy

An electronic survey was conducted using the following internet websites:

http://www.x-mol.com

http://pubmed.ncbi.nlm.nih.gov

http://researchgate.net

to identify case reports of maxillary central incisors with multiple roots/canals. Keywords were “maxillary central incisor”, “case report”, “type V”, “anatomic variation”, “root canal”. Relevant reports were manually checked by reviewing the references of found articles. A total of 40 case reports in English language that reported maxillary central incisors with multiple roots/canals without developmental anomalies (fusion, gemination, dens invaginatus) and had full texts available were included in our study.

Prevalence and etiology

As mentioned earlier, the majority of maxillary central incisors have a single root and canal, with almost 100% exhibiting this morphology [2]. In a study by da Silva *et al.* [7], 98% of maxillary anterior teeth were found to have a consistent root canal morphology with a single canal. Iqbal *et al.* [8] reported a prevalence of 97.89% for Vertucci’s type I root canal morphology

in a population with diverse ethnic backgrounds. While various factors such as ethnicity, gender, age, diseases and developmental anomalies have been proposed for multiple roots/canals in anterior teeth [9-11], dental trauma, particularly intrusive luxation to deciduous teeth, can lead to cervical loop division and formation of two roots in mesiodistal direction in the successor tooth [12].

In current review, 23 (57.5%) of the patients were female and 17 articles reported multiple roots/canals in male patients (42.5%). Gender was not reported in one study [13]. The age range of the patients was 8-65 years. Al-Nazhan *et al.* [14] reported a case of severe maternal infection with rubella and scarlet fever during the patient's fetal period, as well as constant illness during the first two years of life, which could be associated with abnormal tooth morphogenesis. Candeiro *et al.* [15] reported a case of cleft lip and palate as another developmental anomaly that can alter the anatomy of involved teeth. In addition to these two cases, 12 articles specifically mentioned a history of dental trauma [3, 5, 12, 16-24]. Crown discoloration, calcific metamorphosis, hypoplastic enamel, 180-degree rotation, and a history of orthodontic treatment were also reported in literature as potential signs of previous dental trauma that adult patients may not remember [25-29].

Anatomic and morphologic features

Various dental anomalies, such as fusion, gemination, dens invaginatus, and talon cusp, can lead to noticeable changes in the shape of the clinical crown. However, even teeth with normal crowns may exhibit exceptional anatomy in their root canal system. In current survey, 26 articles reported normal crown morphology identical to the adjacent tooth. Shivakumar *et al.* [28], Shokouhinejad *et al.* [29] and Al-Nazhan [14] found cases of discoloration and hypoplastic enamel despite normal-sized crowns. Imperfect amelogenesis and altered crown morphology was also identified by Candeiro *et al.* [15]. In five studies, crowns could not be identified due to fractures, previous restorations or caries [17, 20, 30-32], and only four cases had abnormally large crowns [16, 33-35].

Root bifurcation can occur in either the mesiodistal or buccolingual direction, with our review identifying 23 cases in the former and 17 cases in the latter.

Sabala *et al.* stated that aberrant anatomy occurs bilaterally in 90% of cases [36]. But in contrast to their finding, 30 out of 41 case reports included in this review were reported as unilateral. Seven articles did not specify whether cases were unilateral or bilateral [20, 29, 30, 37-40] and bilateral aberration was reported in only four cases [14, 18, 23, 27].

Radiographic and clinical diagnosis

Pre-operative clinical assessment is crucial in detecting accessory roots/canals. Deviations in the shape and size of the clinical crown can provide an indication of potential variations in the root canal system. However, some teeth, like maxillary central incisors, may exhibit ordinary crown morphology despite having multiple roots/canals. Therefore, it is always necessary to assess the root structure via pre-operative radiographs. Fast break, narrowing or changes in radiographic density of the root canal can signal the presence of accessory canals or canal branching [41]. Nonetheless, 2D intraoral radiographs have their own limitations. Mesiodistally root/canal bifurcation can be easily detected in 2D radiographs, yet angulated images will be required to identify roots bifurcated buccolingually. However, angulation is not always useful as it can cause distortion and superimposition of other anatomical structures. In such instances where anatomical variations are suspected, 3D imaging would be more beneficial.

Bifurcation can also be identified by probing, particularly when it occurs close to the cervical level of the root. However, it should be noted that probing maxillary incisors requires cautiousness due to the risk of causing a combined endodontic-periodontal lesion that has a poor prognosis, as noted by Gondim *et al.* [42].

To increase the chances of identifying accessory orifices during the procedure, it is recommended to remove the pulp chamber roof and lingual dentinal shelf completely and to extend the access cavity carefully under magnification and illumination. Furthermore, using ultrasonic tips can enable the safe visualization of small calcified orifices on the pulp chamber floor [31].

Root canal system preparation and obturation

Crown-down, step-back and passive step-back techniques were mostly employed in root canal cleaning and shaping of maxillary central incisors with more than one canal. Among these, a crown-down approach offers several advantages including: 1) early removal of bacterial contamination, 2) facilitation of irrigating solutions flow to the apical region, 3) the creation of a straight line access to the apical region in curved canals, and 4) the preservation of precise working length and apical size [43]. An electronic apex locator can also be helpful in working length determination, especially in buccolingually bifurcated roots [42].

In terms of obturation techniques, the lateral condensation and warm vertical techniques were most commonly used in cases of multiple roots/canals in maxillary central incisors. Bessa *et al.* [16], Jain *et al.* [25] and Sponchiado *et al.* [44] utilized the hybrid thermo-mechanic technique. Coelho *et al.* [31] and de Almeida-Gomes *et al.* [45] adopted Tagger's technique for root canal system obturation. Rao Genovese *et al.* [46] and Aznar Portoles *et al.* [47] used thermoplastic injection and continuous wave techniques, respectively. However, Cabo-Valle *et al.* [33] and Mahadevan *et al.* [32] did not specify the obturation technique utilized in their studies.

Table 1. Case reports of maxillary central incisor with multiple roots/canals

	Author	Canals/ Roots	Canals Location	Sex	Bi/Uni-lateral	Preparation technique	Obturation technique
1	Michanowicz *et al.* [35]	2/2	1 mesial 1 distal	Female	Unilateral	Apical surgery	
2	Al-Nazhan [14]	2/1	1 mesial 1 distal	Female	Bilateral	-	Lateral condensation
3	Lambruschini *et al.* [48]	2/2	1 mesial 1 distal	Male	Unilateral	Manual instrumentation	Warm vertical compaction
4	Mangani *et al.* [49]	4/1	2 mesial 2 distal	Female	Unilateral	-	Warm vertical compaction
5	Cabo-Valle *et al.* [33]	2/1	1 mesial 1 distal	Female	Unilateral	-	-
6	Cimili *et al.* [34]	2/2	1 mesial 1 distal	Male	Unilateral	Step-back technique	Lateral condensation
7	Rao Genovese *et al.* [46]	2/2	1 buccal 1 palatal	Female	Unilateral	Rotary instrumentation	Thermoplastic injection
8	Gonzalez-Plata-R *et al.* [17]	2/2	1 mesial 1 distal	Female	Unilateral	Crown-down technique	Lateral condensation
9	Khojastehpour *et al.* [26]	2/2	1 mesial 1 distal	Female	Unilateral	Manual instrumentation	Lateral condensation
10	Lin *et al.* [20]	2/2	1 buccal 1 palatal	Female	-	Passive step-back technique	Lateral condensation
11	Sponchiado *et al.* [44]	2/2	1 mesial 1 distal	Female	Unilateral	Crown-down technique	Hybrid thermo-mechanic technique
12	Sheikh-Nezami *et al.* [23]	3/1	2 buccal 1 palatal	Male	Bilateral	Step-back technique	Lateral condensation
13	Gondim *et al.* [42]	3/2	2 buccal 1 palatal	Male	Unilateral	Rotary instrumentation	Warm vertical compaction
14	Rodrigues *et al.* [39]	2/2	1 buccal 1 palatal	Female	-	Crown-down technique	Lateral condensation
15	Shokouhinejad *et al.* [29]	2/2	1 buccal 1 palatal	Female	-	Passive step-back technique	Lateral condensation
16	Nabavizadeh *et al.* [21]	2/2	1 buccal 1 palatal	Male	Unilateral	Rotary instrumentation	Warm vertical compaction
17	De Almeida-Gomes *et al.* [50]	2/1	1 buccal 1 palatal	Female	Unilateral	Crown-down technique	Lateral condensation
18	Krishnamurti *et al.* [27]	2/1	1 buccal 1 palatal	Female	Bilateral	Step-back technique	Lateral condensation
19	De Almeida-Gomes *et al.* [45]	4/1	-	Female	Unilateral	Rotary instrumentation	Tagger's technique
20	Shivakumar *et al.* [28]	2/2	1 buccal 1 palatal	Male	Unilateral	Passive step-back technique	Lateral condensation
21	Maghsoudlou *et al.* [12]	2/2	1 mesial 1 distal	Male	Unilateral	Step-back technique	Lateral condensation
22	Coelho *et al.* [31]	2/2	1 buccal 1 palatal	Female	Unilateral	Rotary instrumentation	Tagger's technique
23	Jain *et al.* [25]	2/1	1 mesial 1 distal	Male	Unilateral	-	Thermo mechanical technique
24	Calvert [30]	2/1	1 mesial 1 distal	Male	-	Rotary instrumentation	Warm vertical compaction
25	Garlapati *et al.* [38]	2/2	1 buccal 1 palatal	Male	-	Step-back technique	Lateral condensation
26	Kavitha *et al.* [18]	2/1	1 mesial 1 distal	Female	Bilateral	Rotary instrumentation	-

27	Kirilova *et al.* [13]	2/1	1 mesial 1 distal	-	Unilateral	Crown-down technique	Warm vertical compaction & Thermoplastic injection
28	Sharma *et al.* [22]	2/1	1 buccal 1 palatal	Male	Unilateral	Step-back technique	Lateral condensation
29	Syed *et al.* [40]	2/1	1 buccal 1 palatal	Male	-	Passive step-back technique	Lateral condensation
30	Kumar Gupta *et al.* [51]	2/2	1 mesial 1 distal	Female	Unilateral	Rotary instrumentation	-
31	Levin *et al.* [19]	2/2	1 mesial 1 distal	Male	Unilateral	Rotary instrumentation	Lateral condensation
32	Aznar Portoles *et al.* [47]	4/1	3 buccal 1 palatal	Female	Unilateral	Rotary instrumentation	Continuous wave technique
33	Bessa *et al.* [16]	2/1	1 mesial 1 distal	Female	Unilateral	Rotary instrumentation	Hybrid thermo-mechanic technique
34	Candeiro *et al.* [15]	2/2	1 buccal 1 palatal	Male	Unilateral	Crown-down technique	Lateral condensation
35	Yadav *et al.* [6]	1/2	1 mesial 1 distal	Female	Unilateral	Rotary instrumentation	Warm vertical compaction
36	Al-mahdi [37]	2/2	1 mesial 1 distal	Female	-	Rotary instrumentation	Continuous wave technique
37	Wang *et al.* [24]	3/3	2 buccal 1 palatal	Male	Unilateral	Rotary instrumentation	Warm vertical compaction
38	Zhang *et al.* [3]	1/2	1 mesial 1 distal	Female	Unilateral	Rotary instrumentation	Vertical compaction
39	Jafari *et al.* [52]	2/2	1 mesial 1 distal	Male	Unilateral	Rotary instrumentation	Warm vertical compaction
40	Mahadevan *et al.* [32]	2/2	1 mesiolabial 1 distopalatal	Male	Unilateral	Rotary instrumentation	-
41	Present case	2/2	1 mesial 1 distal	Female	Unilateral	Crown-down technique	Warm vertical compaction

Discussion

Complexity and diversity of the root canal system can lead to missed canal(s) and weakened treatment prognosis in the long-term. The majority of studies have reported maxillary central incisor as a single-rooted tooth with one root canal. However, over time, there have been increasing reports of maxillary central incisors with different anatomies, underlining the importance of more detailed investigations pre-operatively even in the most routine cases. Table 1 summarizes the case reports of maxillary central incisors with different anatomies.

Gemination, fusion, dens in dent and palatogingival groove are the most common anomalies reported for maxillary central incisors [26], all of which were ruled out in our case after radiographic and clinical examination. A possible reason for this anomaly can be intrusive luxation of the corresponding deciduous tooth, leading to cervical loop division and the formation of two roots in the mesiodistal direction in its successor tooth [12]. Since these traumatic injuries are relatively common in deciduous teeth, clinicians should be more careful in diagnosing possible resulting anomalies in their permanent successors. Detailed radiographic examination and using novel imaging modalities such as CBCT pre-operatively can be useful in diagnosing these cases [53]. Besides the correct diagnosis, cleaning and shaping the root canal system of these teeth can be challenging. Canals bifurcation in areas deeper than the coronal third of the root or severe angle of extra canal/root separation can reduce visibility and access. The use of illumination and magnification, together with proper access cavity extension and using ultrasonic tips can be helpful in safely discovering orifices, negotiation, disinfection and preparation of canals up to the apical end.

Conclusion

In summary, the effective management of aberrant cases in modern endodontics relies on two key factors:

1) A precise understanding of the root canal system anatomy and any possible variations even in routine cases.

2) The utilization of advanced technology such as dental operating microscope, 3D imaging techniques, ultrasonic and electronic apex locators in identification and management of these variations.

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