



Endodontic Management of a C-shaped Mandibular Second Premolar with Four Canals and Four Apical Foramina: A Case Report

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Abstract

A thorough understanding of root canal morphology is critical for achieving predictable outcomes in endodontic therapy. Anatomical variations in mandibular second premolars are uncommon compared to other teeth, and the coexistence of a C-shaped root canal configuration with four independent canals and four separate apical foramina is exceptionally rare. This case report describes the nonsurgical endodontic management of a mandibular second premolar exhibiting this unique morphology, confirmed through cone-beam computed tomography (CBCT) and magnification. A 52-year-old male was referred by a prosthodontist for elective root canal treatment before post placement. CBCT imaging revealed a C-shaped root in the coronal third that bifurcated into four separate canals at the midroot level, each terminating in an independent apical foramen. Nonsurgical treatment was performed over two visits, using meticulous chemo-mechanical preparation, intracanal calcium hydroxide dressing, and warm vertical compaction obturation. At the 9-month follow-up, the tooth was functional, asymptomatic, and radiographically stable. This case underscores the importance of preoperative assessment with advanced imaging and magnification in identifying and successfully treating rare endodontic anatomies.

Keywords: Anatomy; Cone-beam Computed Tomography; Endodontic Treatment; Mandibular Premolar

Introduction

Detection of all canals of the tooth and adequate cleaning and shaping of them is necessary for a successful root canal treatment [1-3]. According to the literature, the root canal morphology of mandibular premolars has wide diversity [4]. Although many reports have been published about the presence of two and three canals in mandibular premolars [5, 6], reports of four canals and C-shaped anatomy in mandibular premolars are rare [7, 8].

Due to limitations of conventional intraoral periapical views [9], it is important to use advanced imaging techniques and magnification in teeth with potential complex anatomy [10, 11].

This article presents a nonsurgical endodontic management of a mandibular second premolar with a C-shaped root canal and four apical foramina, wherein cone-beam computed tomography (CBCT) and dental loupe were used as confirmatory diagnostic tools.

Case Report

A 52-year-old male with a noncontributory medical history presented to the Endodontic Department of Shahed University, Tehran, Iran, following referral from a prosthodontist for elective root canal treatment of tooth #20. The indication for treatment was preparation for an intracanal post to support a prosthetic restoration. The patient reported no history of pain or swelling associated with the tooth.

Extraoral examination was unremarkable. Intraoral examination revealed tooth #20 with a normal crown morphology and an orthodontic bracket bonded to its buccal surface. The tooth was in slight infraocclusion, but no caries, fractures, or crown discoloration were observed. The periodontal tissues were healthy, and no sinus tracts were present.

Pulp sensibility testing with cold spray and electric pulp testing elicited no response, indicating pulp necrosis. Percussion and palpation tests were negative, and the tooth exhibited no mobility.



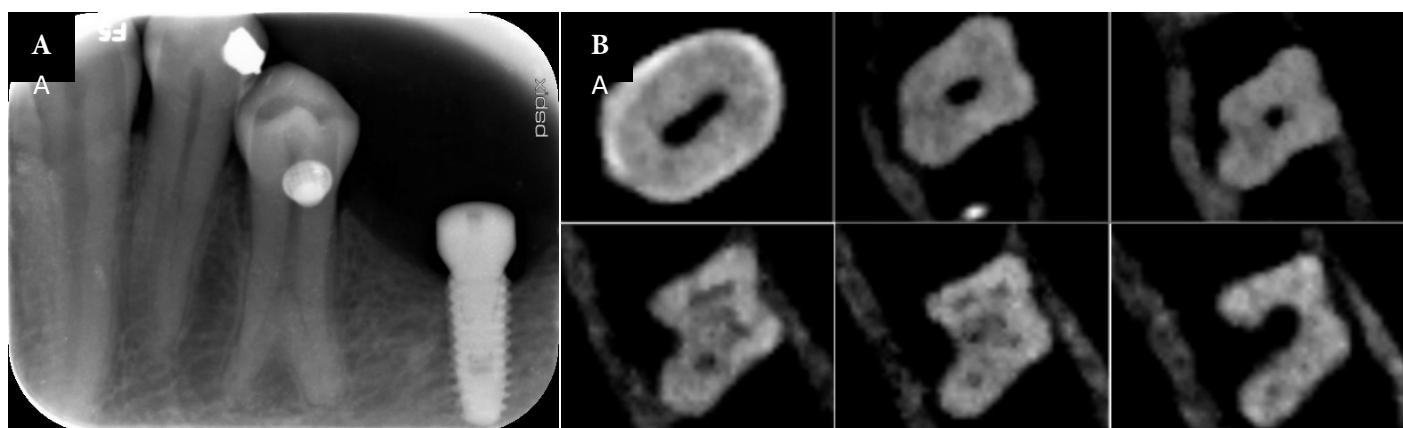


Figure 1. A) Preoperative periapical radiograph; B) Axial sections of the CBCT scan of tooth #20

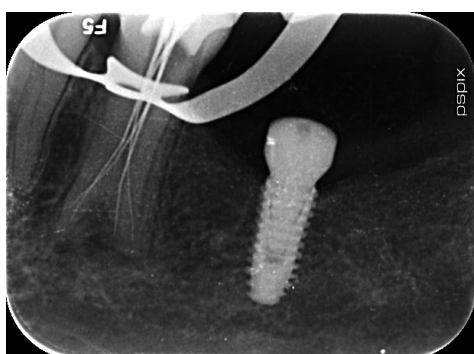


Figure 2. Working length determination radiograph

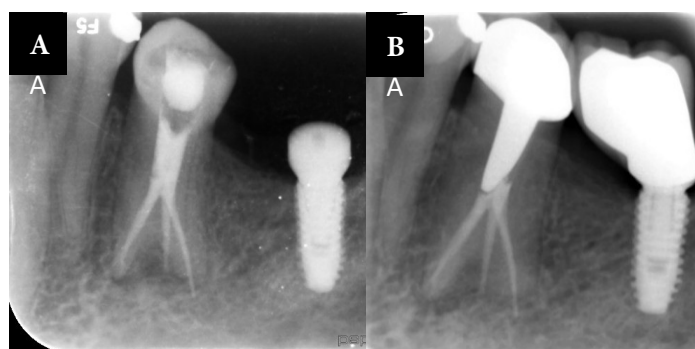


Figure 3. A) Postoperative radiograph; B) 9-month follow-up

A periapical radiograph suggested an atypical root morphology, raising suspicion of additional roots (**Fig. 1A**). Given the complexity suggested radiographically, CBCT images from a previously acquired limited field-of-view scan (taken for implant planning in the adjacent region) were evaluated. Axial CBCT sections revealed a single C-shaped canal at the pulp chamber level. At the midroot level, the canal divided into four discrete canals, positioned mesiobuccally (MB), mesiolingually (ML), distobuccally (DB), and distolingually (DL), each with a separate apical foramen (**Fig. 1B**).

After obtaining written informed consent, local anesthesia was achieved with 2% lidocaine containing 1:100,000 epinephrine. The tooth was isolated with a rubber dam, and the access cavity was prepared using a #13 long-shank fissure diamond bur under copious water spray. Magnification with 3.5× dental loupes (Zumax Medical, Jiangsu, China) was used to aid in locating canal orifices.

The canals were initially negotiated with size #10 K-files, confirming their patency. Working lengths were determined using an electronic apex locator (Root ZX; Morita, Tokyo, Japan) and verified radiographically (**Fig. 2**). The glide path was

established up to size #25 stainless steel K-files, followed by rotary instrumentation using ProTaper Universal files to size F2 (25/0.08 taper) for all canals. Irrigation was performed with 2.5% sodium hypochlorite (NaOCl) delivered with a side-vented needle after each file, with a final rinse of saline.

Given the complex anatomy and necrotic pulp status, an inter-appointment dressing of aqueous calcium hydroxide paste was placed in all canals, and the access cavity was sealed with Caltosol temporary restorative material (AriaDent, Tehran, Iran).

At the second visit, the tooth was re-isolated, and calcium hydroxide was removed using saline irrigation and gentle instrumentation. Obturation was carried out using the warm vertical compaction technique with gutta-percha cones and Neo Sealer (Avalon Biomed, Houston, USA) (**Fig. 3A**). Postoperative radiography confirmed dense obturation of all canals. The access cavity was sealed with a temporary restoration, and the patient was referred back to the prosthodontist for definitive full-coverage restoration.

At the 9-month follow-up, clinical and radiographic evaluations revealed no symptoms, normal periapical status, and full function (**Fig. 3B**).

Discussion

The present case report documents an extremely rare anatomical presentation: a mandibular second premolar with a C-shaped root canal configuration that bifurcated into four separate canals, each terminating in an independent apical foramen. While multi-canal mandibular premolars have been reported in the literature [4, 7, 11], the coexistence of a C-shaped configuration and four distinct foramina in this tooth type appears to be virtually undocumented. Such a combination represents an exceptional deviation from conventional anatomy and poses significant diagnostic and therapeutic challenges.

Epidemiological data confirm that mandibular second premolars usually have a single canal configuration, though variations do occur and are often influenced by ethnicity. In the Iranian population, a systematic review by Hosseinpour *et al.* [12] encompassing 1,268 mandibular second premolars across eight provinces found that 82.86% presented with Vertucci's Type I configuration, followed by 6.25% Type III, 5.32% Type II, 4.27% Type IV, and only 0.69% Type V. The overwhelming predominance of Type I underscores the rarity of multi-canal configurations in this ethnic group. Against this backdrop, the C-shaped configuration with four independent canals and four apical foramina observed in the present case is an extreme anatomical outlier. These findings reinforce the clinical imperative for heightened suspicion when radiographic or clinical cues suggest unusual morphology and highlight the indispensable role of advanced imaging modalities such as CBCT in detecting atypical root canal anatomy that might otherwise remain undiagnosed.

Traditional two-dimensional periapical radiographs, while useful for routine endodontic diagnosis, are inherently limited in visualizing complex three-dimensional structures due to superimposition and geometric distortion [14]. In contrast, CBCT offers high-resolution, multiplanar reconstructions that allow precise assessment of root canal bifurcations, accessory canals, and apical foramina [13-15]. In this case, CBCT imaging was pivotal in confirming the intricate canal configuration and informing the treatment strategy, thereby minimizing the risk of missed canals and procedural errors.

C-shaped canal systems, regardless of tooth type, present substantial challenges for chemo-mechanical debridement. Their irregular cross-sections, fins, and isthmuses harbor

debris and microorganisms that are difficult to eliminate with standard instrumentation [16]. In multi-canal variants, such as this case, complete negotiation and cleaning of each canal are essential. The creation of a reproducible glide path to size #25 before rotary shaping helped preserve the original canal trajectory and minimize transportation [17]. Sodium hypochlorite remains the irrigant of choice for necrotic pulp cases due to its antimicrobial and tissue-dissolving properties; however, activation techniques (sonic, ultrasonic, or negative pressure) could further enhance irrigant penetration into complex spaces [18].

Obturation of teeth with multiple apical foramina demands techniques that can adapt filling materials three-dimensionally to intricate apical anatomy. Warm vertical compaction was employed in this case to maximize adaptation of gutta-percha to the canal walls and irregularities [19]. The initial referral for post placement added another layer of complexity, as aggressive post space preparation in such teeth risks weakening already thin radicular dentin walls. At the 9-month follow-up, the tooth remained asymptomatic and functional, but long-term prognosis will depend on maintaining an intact coronal seal and preventing structural compromise.

Conclusion

This case highlights the necessity of considering uncommon root canal anatomies in mandibular premolars and demonstrates the critical role of CBCT and magnification in their detection and management. Successful nonsurgical endodontic treatment was achieved through meticulous canal negotiation, careful chemo-mechanical preparation, and three-dimensional obturation. Clinicians should be vigilant for such anatomical variations to avoid missed canals, which can compromise long-term outcomes.

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Conflict of interest

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Authors' contributions

Methodology: ZJ/AK, Formal analysis and investigation: ZJ/MR, Writing review and editing: ZJ/AK/MR, Supervision: MR. All authors read and approved the final manuscript.

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