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Non-surgical Management of a C-shaped Mandibular Second Molar with Apical Periodontitis and External Root Resorption: A Case Report

Sorour Saeidi [a], **Ali Hamedi** [b], **Zakie Kheradmand** [a *]

a Department of Restorative Dentistry, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran; b Endodontist, Private Practice, Mashhad, Iran

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Corresponding author: Zakie Kheradmand, School of Dentistry, Mashhad University of Medical Sciences, Vakil Abad Blvd., Mashhad, Iran.

E-mail: kheradmandmahshid73@gmail.com

Abstract

This case report describes the successful nonsurgical endodontic management of a mandibular second molar with a confirmed C-shaped canal configuration complicated by chronic apical periodontitis and active external inflammatory root resorption in a 16-year-old female patient. The patient presented with pain on biting, deep localized periodontal probing, and radiographic evidence of a large periapical radiolucency and resorptive changes in the distal root. Diagnostic tests confirmed pulpal necrosis and an endodontic–periodontal communication. Following access under magnification, the complex C-shaped canal system was negotiated and disinfected using 5.25% sodium hypochlorite, activated irrigation, and calcium hydroxide dressing. Because of apical resorption and an open apex, a 4–5 mm mineral trioxide aggregate apical plug was placed, followed by warm vertical obturation of the remaining canal system. The tooth was restored and monitored clinically/radiographically. At the 8-month follow-up, the patient was asymptomatic, probing depths had normalized, and radiographs demonstrated complete resolution of the periapical lesion with arrest of external root resorption. This case highlights that conservative endodontic therapy, supported by modern materials and careful disinfection, can achieve predictable healing even in teeth with complex morphology and resorptive defects. Early diagnosis and meticulous management are essential for a favorable outcome.

Keywords: Apical Periodontitis; C-shaped Canal; External Root Resorption; Mineral Trioxide Aggregate; Thermoplastic Obturation

Introduction

Endodontic treatment success depends on the effective elimination of intracanal infection and thorough obturation of the root canal system [1]. Variations in root canal morphology, such as the C-shaped canal configuration, can significantly complicate diagnosis and treatment [2]. A C-shaped canal is an anatomical variant most often seen in mandibular second molars, resulting from failure of Hertwig's epithelial root sheath to fuse during root development [3]. C-shaped canals, first described by Cooke and Cox in 1979, are characterized by a single ribbon-shaped orifice with an arc of 180 degrees or more, typically found in mandibular second molars [4, 5]. The prevalence of C-shaped canals varies widely, from ~7–10% in some populations to over 40% in others, with a higher incidence reported in certain Asian groups [6]. Cleaning and shaping during endodontic therapy, as well as surgical treatment of a C-shaped canal, is a treatment challenge due to the thinness of the root and the presence of concavities in that area. Another potential mishap is improper root canal preparation, which could lead to a strip perforation. Comprehensive knowledge of root canal morphology using cone-beam computed tomography (CBCT) can lead to true diagnosis and management [7, 8].

Although C-shaped canal configurations in mandibular second molars are well documented, the simultaneous presence of a C-shaped anatomy, active external inflammatory root resorption, and a large chronic apical periodontitis is exceedingly

uncommon. Most published reports describe either intact root structures or isolated periapical disease and do not address cases where complex morphology and resorptive pathology occur together. To our knowledge, no previous case has demonstrated complete nonsurgical healing of both a substantial periapical lesion and ongoing external inflammatory resorption in a confirmed C-shaped canal system. This case, therefore, provides new evidence by demonstrating that conservative endodontic treatment, supported by meticulous disinfection and a mineral trioxide aggregate (MTA) apical plug, can arrest resorptive activity and promote full periapical regeneration, even in a tooth with significant anatomical and biological compromise. The favorable outcome also highlights the robust healing capacity of periapical tissues in young, systemically healthy patients, reinforcing that nonsurgical endodontic therapy remains a predictable option despite multiple complicating factors.

Case Presentation

A 16-year-old female patient presented to the dental clinic of Mashhad Dental School with the chief complaint of persistent pain in the right mandibular posterior region. The pain had been moderate in intensity for about two weeks and was exacerbated by chewing or biting on the affected area. The patient's medical history was non-contributory; she was generally healthy with no known systemic conditions. Her dental history included routine restorative treatments and one prior root canal therapy in a different tooth, with no history of trauma to the mandibular region.

On clinical examination, the mandibular right second molar (tooth #47) was found to have a large carious lesion on the occlusal surface extending deep toward the pulp. The tooth was tender to percussion, reproducing the patient's chief complaint of pain upon biting pressure. There was no visible swelling of the adjacent gingiva or face, and no sinus tract was observed on the gingival surface. Periodontal examination revealed a localized deep probing depth (~7 mm) in the mid-buccal sulcus of tooth #47, whereas other probing sites around the tooth were within normal limits. This isolated deep pocket suggested a possible drainage pathway of the infection through the periodontal ligament space. The tooth exhibited slight mobility (Grade I), likely due to inflammation in the periapical area; neighboring teeth were normal and not tender. The patient was diagnosed provisionally with a pulpal necrosis of tooth #47 leading to symptomatic apical periodontitis.

A series of diagnostic tests was performed to confirm the pulpal and periapical status of tooth #47 (Table 1). Thermal pulp tests, including cold test (Roeko Endo-Frost; Coltene, Whaledent, Germany) and heat test (using a heated gutta-percha stick applied to the buccal surface of the tooth) yielded no response from #47, in contrast to adjacent teeth, which responded normally, consistent with a necrotic pulp. Similarly, response to an electric pulp test (Parkell Inc, Edgewood, NY, USA) was negative for #47. The tooth was percussion positive, and palpation of the buccal mucosa over the root apex elicited mild tenderness. These findings indicated inflammation extending to the periapical tissues. The isolated deep periodontal probing on the buccal aspect was suggestive of an endodontic-periodontal communication. Further cold/heat tests showed no reaction from the patient, indicating a necrosis in pulpal tissue. There were no signs of pulpal calcification or crown discoloration (Fig. 1A). Sensibility test and periodontal findings on the contralateral and adjacent teeth were within normal limits, helping to localize the problem to tooth #47.

The pre-operative radiograph (Fig. 1A) revealed an extensive chronic apical periodontitis around tooth #47, extending from the apex of the fused roots. The radiolucent area indicated chronic apical periodontitis. The two mesial and distal roots of #47 were fused with a thin radiographic separation line, and the canal system was not distinctly separable into individual canals, raising suspicion of a C-shaped root canal morphology. No root fractures were visible on the radiograph. Based on the clinical assessment, the final diagnosis for tooth #47 was pulpal necrosis and symptomatic apical periodontitis. The external inflammatory resorption of the distal root was identified as a consequence of the long-standing infection. The treatment plan formulated was non-surgical root canal therapy of tooth #47 to eliminate the infection and allow healing of the periapical lesion, followed by a definitive restoration of the tooth and periodic follow-up to monitor healing.

Table 1. Diagnostic findings of teeth #47, #37, #36, and #17; confirming symptomatic irreversible pulpitis and apical periodontitis for tooth #47

Test	Scale/Interpretation	Tooth #47	Tooth #37	Tooth #36	Tooth #17
Mobility	0=none; 1=slight; 2=moderate; 3=severe	**1**	0	0	0
Periodontal status	0=healthy; 1=signs of inflammation	**1**	0	0	0
Palpation	0=no pain; 1=mild; 2=moderate; 3=severe	**2**	0	0	0
Percussion	0=no pain; 1=mild; 2=moderate; 3=severe	**2**	1	0	0
Cold test	0=no response; 1-4=increasing response	**0**	0	2	2
Heat test	0=no response; 1-4=increasing response	**0**	0	1	1
Electric pulp test (EPT)	Reading 0-10=first detection threshold	**0**	0	6	4

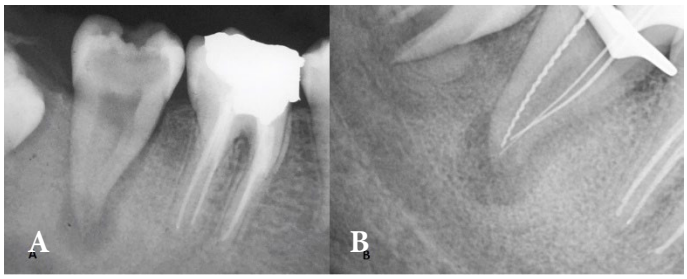

Figure 1. *A*) Initial periapical radiograph of the mandibular right second molar (#47). A large radiolucency is evident surrounding the root apices, indicative of a periapical lesion. The roots are fused, and a faint groove or ribbon-shaped canal tract can be seen, suggestive of a C-shaped canal configuration; *B*) working length configuration

After discussing the findings and obtaining informed consent, the tooth was anesthetized (IAN with 1.8 mL of 2% lidocaine with epinephrine 1/80000; DarouPakhsh, Tehran, Iran) and isolated using a rubber dam. Caries was removed, and an endodontic access cavity was prepared in tooth #47. On entering the pulp chamber, no vital tissue was found, confirming the pulpal necrosis. The pulp chamber anatomy was inspected under magnification (Carl Zeiss Meditec, Dublin, CA, USA), using C-Pilot files size #8 and #10 (VDW GmbH, Munich, Germany), and the complex canal system was carefully explored. The files initially indicated three separate canals that merged in the apical area, consistent with a C-shaped configuration. Working length was determined with an electronic apex locator (Raypex6; VDW, Munich, Germany) and a confirmatory intraoperative radiograph (Fig. 1B). The canals were prepared with the ProTaper Gold rotary system in a gentle crown-down approach. A 5.25% sodium hypochlorite (NaOCl) solution was used throughout instrumentation to dissolve necrotic tissue and disinfect the irregular canal spaces. The canal system was irrigated with a side-vented needle, and care was taken to reach into the isthmus areas of the C-shaped canal. After achieving apical enlargement to approximately a size 25/0.04, the canals were flushed with saline and dried with sterile paper points (Aria Dent, Tehran, Iran). Calcium hydroxide (CH) paste was placed as an intracanal medicament, delivered into all accessible canal areas. CH was chosen for its strong antimicrobial properties and its ability to raise intracanal pH, creating an environment that inhibits clastic cells and helps arrest inflammatory root resorption [9]. A sterile cotton pellet was placed in the pulp chamber, and the access cavity was sealed with a temporary filling (Cavit-G; 3M ESPE, Seefeld, Germany). The patient was advised of the importance of keeping the temporary seal intact and was scheduled for the next visit in two weeks.

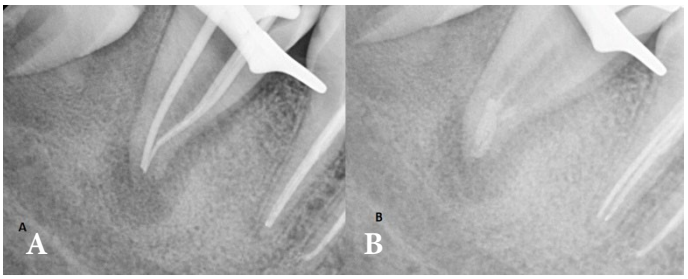

Figure 2. *A*) Master cone placement; *B*) MTA plug placement

Ten days later, the patient returned asymptomatic. The canal system was re-instrumented lightly to remove any residual medicament. A final refinement of the canal shaping was done, and then a master cone fitting was checked. At this stage, removal of the smear layer was performed to enhance sealer penetration. The canals were rinsed with 17% EDTA (ethylenediaminetetraacetic acid) for one min to chelate dentin debris, followed by a final flush with NaOCl; both were activated using Endo-activator (Dentsply Tulsa Dental, Tulsa, OK, USA). Given the C-shaped anatomy, a size #35, 0.04 taper gutta-percha master cone was selected for the distal canal space, and two size #25, 0.04 taper gutta-percha master cones were selected for mesial canals. A radiograph with the master cone in place was taken to verify the length and adaptation (Fig. 2A). The radiograph confirmed an open apex at the distal root end. Owing to the open apex caused by root resorption, an apical plug was applied. MTA (Angelus, Londrina, PR, Brazil) was mixed according to the manufacturer's instructions and delivered to the apical part of the distal canal using a micro-apical placement (MAP) system. Under magnification, MTA was incrementally packed to form a roughly 4–5 mm thick barrier at the root apex. The MTA plug placement was carefully controlled to avoid extrusion into the periapical area (Fig. 2B). A moist cotton pellet was placed against the MTA to allow it to hydrate and set, and the access was sealed with a temporary restoration. The patient was asked to return in 48 h for completion of treatment.

After 24 h, the patient returned for final obturation. The MTA plug was gently tested with a K-file to ensure it had hardened. A warm vertical compaction technique was chosen to fill the complex C-shaped canal system. An epoxy resin sealer (AH-26, Dentsply Maillefer, Ballaigues, Switzerland) was applied to the canal, and thermoplasticized gutta-percha was introduced. The obturation was carried out by injecting and compacting gutta-percha to flow into the irregularities and isthmus of the C-shaped canal. The canal system was densely filled, as confirmed by the absence of voids on a subsequent radiograph. Excess material was removed, and the access cavity was sealed with Cavit

Figure 3. *A*) Obturation with warm vertical technique; *B*) Eight-month follow-up periapical radiograph of tooth #47

temporary cement. A post-operative periapical radiograph (Fig. 3A) showed the root canal filling terminating at the MTA plug with a good apical seal and no extrusion. The patient's occlusion was checked to ensure no high points on the temporary. Thereafter, a permanent composite resin restoration was placed.

Follow-up and outcomes

The patient was scheduled for periodic follow-ups to monitor healing. At a 3-month follow-up, she reported no pain or discomfort in the tooth. The gingival tissues were healthy with no sinus tract, and the previously deep probing depth on the buccal had reduced to 3 mm, indicating likely closure of the drainage tract and healing of the periodontal attachment. A periapical radiograph at 3 months showed early signs of bone fill in the periapical area. The 8-month recall appointment revealed the tooth remained asymptomatic and functional; the patient could chew comfortably on it. A follow-up radiograph taken 8 months post-treatment showed radiographic evidence of healing (Fig. 3B). The patient was advised to continue routine dental care, and a yearly radiographic review was recommended to ensure the area remains healthy.

Discussion

This case highlights the successful management of a C-shaped root canal system with associated symptomatic apical periodontitis and external inflammatory root resorption in a young patient. C-shaped canal morphology presents a unique challenge in endodontics; this complexity makes it easy to miss canal intricacies during treatment [3]. Awareness and early recognition of this configuration are crucial. Pre-operative radiographs may show certain features suggestive of a C-shaped canal, such as fused roots or a faint longitudinal radiolucent line separating root segments [6].

The prognosis for the present case was considered questionable, primarily attributed to the complex C-shaped root canal anatomy, confirmed pulp necrosis, and significant periodontal involvement evidenced by a 7 mm pocket depth. Despite these challenging factors, treatment was pursued considering the patient's strong request and her young age.

What makes the present case distinctive is the combination of C-shaped anatomy with concurrent external inflammatory root resorption and symptomatic apical periodontitis in a young patient, a combination rarely described in the literature. While several reports have described endodontic management of C-shaped mandibular molars, most involved intact root structures and closed apices. Few have documented successful nonsurgical management when *both* complex C-shaped morphology and active external resorption were present (REF). This overlap of pathologies increases the treatment complexity, as resorptive defects further distort canal geometry and compromise apical sealing.

In this case, the contiguous root form and indistinct canal outlines on the radiograph hinted at a C-shape anatomy, which was confirmed upon access opening. The use of magnification and careful exploration with small files allowed negotiation of the entire canal system. The reported incidence of C-shaped canals is highest in mandibular second molars [3]. Thorough debridement of C-shaped canals is challenging. The irregular canal cross-section and presence of fins or lateral canal extensions mean that traditional rotary instrumentation may not contact all surfaces [6, 10]. Research has emphasized the importance of irrigation dynamics in such complex systems; sonic or ultrasonic activation of irrigants can improve penetration into canal recesses [1, 11].

Calcium hydroxide has a well-documented ability to disinfect canals and also helps neutralize the acids from infection that drive root resorption [9, 12]. In infection-related external resorption, its high pH environment inactivates osteoclast activity on the root surface, thus halting progressive resorption [9]. Placement of CH for two weeks in this patient likely aided in eliminating residual bacteria in areas of the canal that instruments and irrigants might not have reached [9]. By the second visit, the absence of exudate and the patient's symptom relief indicated that the infection was under control.

Management of the open apex was a critical aspect of this case. The distal root's apex was resorbed enough to prevent a traditional cone fit and create a risk of irrigant or filling material extrusion. In the past, apexification with long-term CH was the mainstay to induce a calcific barrier at the apex, often requiring 5 to 20 months for barrier formation [13]. While effective in many cases, that approach prolongs treatment and carries the risk of interim fracture or reinfection. MTA plug/apexification has largely replaced extended CH apexification, as it allows immediate formation of an artificial apical plug [13]. In this case, MTA was packed to form a 4–5 mm apical plug, in line with recommendations that a minimum 4–5 mm thickness is needed for an adequate seal [14]. MTA's superior biocompatibility and sealing ability make it ideal for such scenarios [14, 15]. The

material's alkaline pH encourages hard tissue healing; studies have shown that MTA not only provides an apical stop but can also stimulate new bone/dentin/cementum deposition over time [13, 16, 17].

From a comparative standpoint, previously published reports of C-shaped mandibular molars with periapical pathology seldom describe concurrent external root resorption, and even fewer document full radiographic healing without surgical intervention. The successful nonsurgical resolution in our case, therefore, expands the limited body of evidence that conservative management can reverse both periapical bone loss and resorptive activity when microbial control is achieved.

By creating an immediate apical stop, we were able to condense warm gutta-percha against it and densely fill the rest of the canal system without fear of overextension. An epoxy resin-based sealer (AH-26) was used to ensure a hermetic seal, and the thermoplastic obturation technique helped adapt the gutta-percha into the C-shaped canal's fin and web anatomy. Alternate obturation methods, such as core-carrier systems or injectable thermoplasticized techniques, have also been recommended for C-shaped canals to achieve a complete fill [3].

The outcome of this case was favorable, with radiographic evidence of complete periapical healing by the 8-month follow-up. This aligns with the endodontic literature that even large periapical lesions can heal predictably after root canal therapy when infection is thoroughly eliminated [1]. By removing necrotic pulp and disinfecting the canal system, the source of infection driving both the apical lesion and the external resorption was eradicated. New bone formation in the periapex and resolution of the radiolucency illustrate the capacity of periradicular tissues to regenerate once a hostile infectious stimulus is removed [1].

The arrest of external root resorption is particularly noteworthy, as it underscores that external inflammatory resorption is not an autonomous process but is sustained by the presence of bacteria and inflammation [9]. With the root canal sealed, no further resorptive activity occurred, and the root length remained stable. Long-term follow-up is still advisable in such cases to ensure that healing is sustained and to monitor for any rare complications such as reactivation of resorption or cystic healing.

In managing this case, certain adjuncts could be considered in similar future cases. CBCT imaging, for example, can be extremely useful in diagnosing C-shaped morphology and the extent of root resorption pre-operatively [3]. A pre-treatment CBCT might have provided a 3D map of the canal anatomy and resorption crater, aiding in planning [18]. However, even without CBCT, careful interpretation of multiple angled radiographs and tactile feedback during instrumentation allowed us to successfully negotiate the anatomy. The use of a dental operating microscope also greatly facilitated the identification of canal orifices and verification of the MTA plug placement.

However, several limitations should be acknowledged. First, the follow-up period was limited to eight months, which, although demonstrating complete radiographic healing, does not exclude the possibility of long-term complications or recurrence. Second, the case was managed without CBCT, which could have provided more detailed three-dimensional insights into the canal morphology and extent of external root resorption [19]. Third, histological confirmation of periapical healing was not feasible, and the diagnosis was based on clinical/radiographic assessments alone.

Alternative treatment approaches could also have been considered. Traditionally, long-term CH apexification has been used to induce apical closure in immature teeth [20]. While this method is effective, it requires multiple visits over several months, increases the risk of root fracture due to prolonged exposure to CH, and demands strict patient compliance [21]. In contrast, MTA plug/apexification, as used in this case, offers a shorter treatment time, predictable apical sealing, and favorable biological properties [22, 23]. Surgical endodontic management could also be considered in cases of persistent pathology, but was not indicated here due to the favorable nonsurgical outcome.

Patient-specific factors likely contributed to the success of this case. The patient was young (16 years old) and systemically healthy, which enhanced the healing potential of periapical tissues. Younger patients generally demonstrate superior bone turnover and regenerative capacity, which may explain the complete resolution of the periapical lesion within eight months

Conclusion

This case demonstrates that a mandibular second molar with a C-shaped canal configuration and periapical pathology can be effectively treated with non-surgical endodontic therapy despite the complexities. Key success factors included a thorough understanding of the canal anatomy, judicious use of irrigation and interim medication to disinfect all canal recesses, and modern biomaterials like MTA to manage the open apex. With adherence to sound endodontic principles and incorporation of advanced techniques when needed, even challenging anatomic variations can achieve favorable outcomes. The follow-up outcome for our patient (restoration of comfort, function, and radiographic bone healing) is consistent with reports that emphasize the predictability of healing when proper disinfection and sealing are accomplished.

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