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C-shaped canal in a mandibular first molar: A case report

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A C-shaped root canal configuration is the most common anatomical variation of the root canal system and exists mostly in mandibular second molars, but may be found also in other teeth. The management of C-shaped canals is challenging for clinicians in diagnosis, shaping, cleaning and obturation because of the broad spectrum of canal configurations. This case report presents the diagnosis and treatment of a C-shaped canal in a mandibular first molar and discusses the use of CBCT in cases of unusual root canal anatomy.

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■ Introduction

Knowledge of anatomical variations of teeth that require root canal treatment is essential for successful outcomes. The C-shaped canal configuration is one of the anatomical variations of teeth, found mostly in mandibular second molars. This variation was first reported in endodontic literature by Cooke and Cox in 1979¹. Population frequencies of up to 52% in China, and maximum frequencies of 2.7–10.6% in other populations have been found^{2–8}. C-shaped canals are rarely found in other teeth. Some case reports and studies reported variation-shaped canals in maxillary first molars, mandibular first molars, mandibular premolars and third molar teeth^{9–14}.

The most accepted theory for the formation of this unusual ribbon-shaped canal is the failure of Hertwig's epithelial root sheath to fuse either the buccal or the lingual root surface¹⁵.

Both anatomic and radiographic classifications have been proposed for a C-shaped root canal. The common factor of all classifications is that the C-shaped root canal configuration can vary along the root length^{16–18}.

It is very difficult to diagnose C-shaped root canals based on two-dimensional radiographs. In some cases, particular radiographic findings can arouse a clinician's suspicion of C-shaped canal systems in second mandibular molars:

- fused roots
- poorly distinguished floor of the pulp chamber
- working length radiograph with inserted instruments give the impression of a perforation in the furcation area¹⁹
- instruments tend to converge at the root apex²⁰.

The final diagnosis in most cases is determined after opening the pulp chamber and viewing an unusual ribbon shape of the canal.

■ Case report

A 27-year-old female, with generally good health, was referred to the Department of Endodontics, Tel Hashomer, IDF Medical Corps, Israel.

Two weeks prior to her referral, an access cavity was prepared in tooth 46 and the pulp was extir-

pated because of acute pulpitis. Oral inspection and evaluation of the patient's periodontal status revealed good oral hygiene. Clinically, the access cavity of tooth 46 was filled with a temporary restoration. Periodontal probing revealed that pocket depths were less than 3 mm and there was no excessive mobility of the tooth. The tooth 46 was sensitive to percussion without sensitivity to palpation. The adjacent teeth responded positively to a cold test and there was no excessive mobility or sensitivity to palpation or percussion.

The radiographic examination of tooth 46 revealed (Fig 1a):

- a coronal restoration
- fusion of roots in the apical part
- enlargement of the periodontal ligament (PDL) in the periapical area.

The following diagnosis was made: symptomatic apical periodontitis following previously initiated root canal treatment.

Treatment

The tooth was anaesthetised (4% articaine hydrochloride containing 1:100,000 epinephrine) and isolated with rubber dam. The temporary restoration was removed, access to the pulp chamber was gained and four root canal orifices were inspected – two distal and two mesial canals. Irrigation was performed with 3% sodium hypochlorite (NaOCl) using a 27-G needle (KDL, Shanghai, China). The canals were explored with size 10 K-files (Dentsply Maillefer, Ballaigues, Switzerland) and the coronal part of each canal was preflared with a S1 ProTaper instrument (Dentsply Maillefer). Working lengths were determined with an electronic apex locator (Dentaport ZX, Morita, Tokyo, Japan) and confirmed radiographically (K and H hand files size 15; Dentsply Maillefer) (Fig 1b).

Biomechanical preparation was performed using ProFile instruments (Dentsply Maillefer) up to size 30/04 at 250 rpm (X-smart, Dentsply Maillefer) using the crown-down technique and with nickel-titanium (NiTi) hand files up to size 40 (balanced forced technique). All canals were irrigated after each file using 2 ml of 3% NaOCl. A creamy aque-

ous calcium hydroxide dressing was placed in the canals using a Lentulo spiral, and the access cavity was temporised by a double seal with Cavit (ESPE, Seefeld, Germany) and IRM (Caulk, Dentsply DeTrey, Saint-Quentin-Yvelines, France).

In the second visit, 3 weeks later, a rubber dam was placed, the root canals were irrigated with abundant 3% NaOCl, then dried and obturated by cold lateral compaction using NiTi finger spreaders (Dentsply Maillefer) with gutta-percha and AH Plus sealer (Dentsply, York, PA, USA). The access cavity was double sealed with Cavit and IRM (Fig 1c). Only after finishing the obturation was the C-shaped canal system in the apical part of the root discovered. The patient was referred to her dentist for prosthodontic treatment.

At 17-month follow-up

In the 17-month follow-up examination, the tooth was clinically asymptomatic, not tender to percussion, with normal mobility and periodontal probing depths were within normal limits.

Radiographic examination revealed sound periapical tissues and an intact lamina dura (Fig 1d).

Discussion

This case report describes the treatment of a mandibular first molar with an undiagnosed C-shaped root canal system. C-shaped canal configuration is a unique root canal configuration, mostly found in mandibular second molars with a prevalence that ranges between 2.7%–52% in different populations^{2–8}. A few classifications of C-shaped canals have been published, based on anatomic and radiographic appearance. It is agreed that C-shaped canal systems have many variations such as single and ribbon-like, and C-shaped canals from orifice to apex, distinct root canals or fins or webs connecting the individual root canals. Moreover, the configuration may vary along the length of the root^{16–18}. Therefore, C-shaped canals are known to present a complex canal anatomy²¹. Additionally, C-shaped canals are not centralised – in most cases the mesiolingual area of dentine surrounding the canal is thinner than the other side of the root. This area is known as a 'danger zone'²².

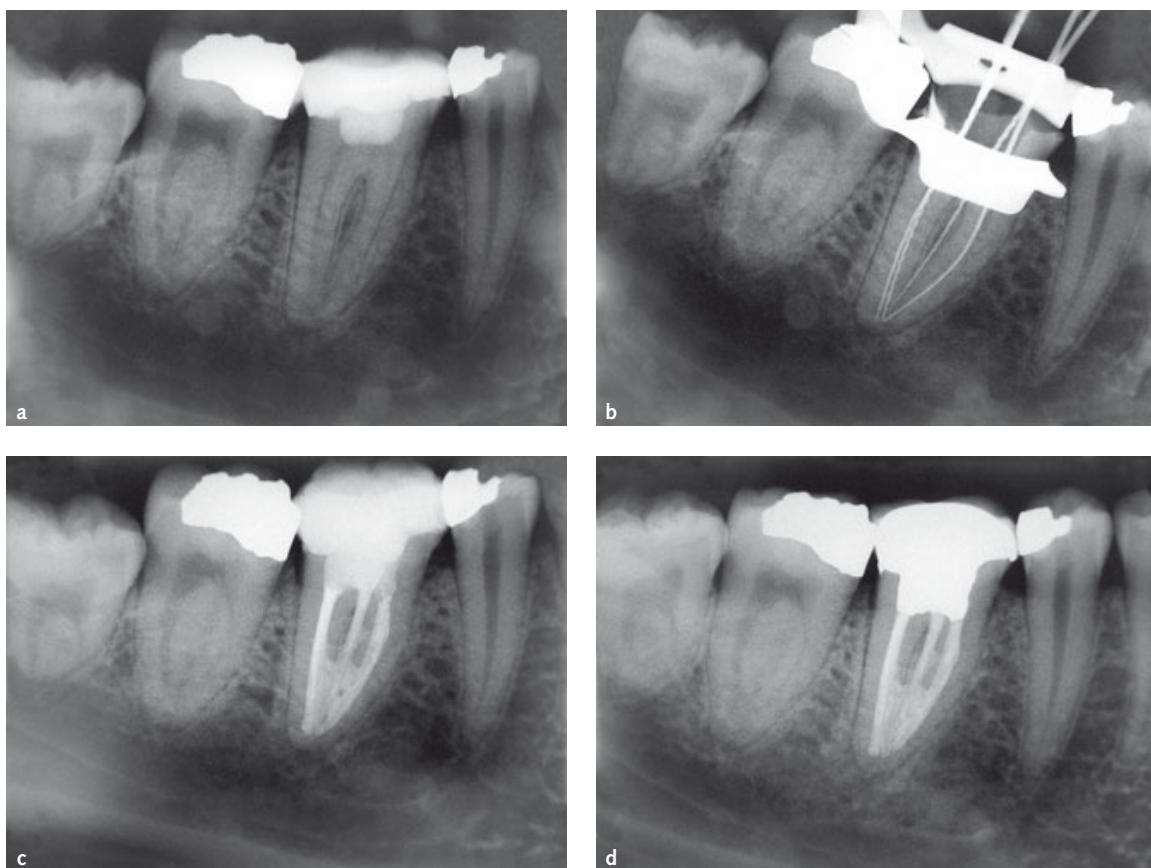


Fig 1 Tooth 46: (a) preoperative periapical radiograph; (b) working length radiograph; (c) postoperative radiograph after root canal filling; (d) a 17-month follow-up radiograph.

Traditional cleaning and shaping of C-shaped canals has been based on hand and rotary files. The use of both types of instruments results in more or less round-shaped canal cross-sections, however they leave up to 66% of the canal wall uninstrumented²³⁻²⁷. Usually, the treatment of infected C-shaped canals using rotary or reciprocating instruments requires more than one visit because some amount of pulp tissue may remain in the root canal system^{26,28}. Therefore, the additional use of tissue dissolving irrigants and intracanal dressings is necessary. NaOCl and calcium hydroxide are the only agents in endodontics that display some tissue-dissolving ability. Moreover, an intracanal dressing with calcium hydroxide increases the tissue dissolving ability of NaOCl during the next appointment²⁹⁻³².

Recently, a new instrument type, the self-adjusting file (SAF) (ReDent Nova, Ra'anana, Israel), has been introduced³³. The SAF expands in the canal and fits itself to the diameter of the root canal. Preparation with SAF is based on apico-coronal

movements that circumferentially remove dentine layers while maintaining the original shape of the canal. The circumferential and uniform preparation allows for efficient removal of pulp tissue^{27,34}. Moreover, SAF has been proven to have an improved cleaning efficacy³⁵. Therefore, a one-visit approach may be considered when using SAF for the cleaning and shaping of C-shaped canals.

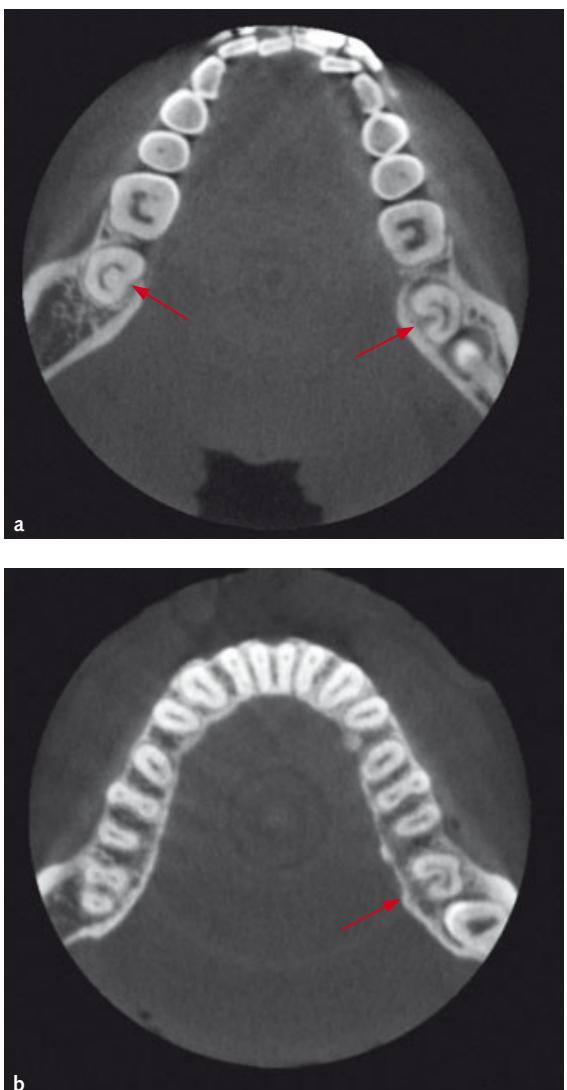
The quality of obturation of oval canals with warm gutta-percha was found to be superior to that with cold gutta-percha. A C-shaped canal can be considered as an extreme form of long oval canal and thermoplasticised gutta-percha obturation techniques may be recommended^{34,36-37}.

It is difficult to recognise a C-shaped canal on a two-dimensional radiograph¹. Radiographs hint of their existence in some cases and are described only for mandibular second molars¹⁹. In most cases, the final diagnosis is determined by the direct viewing of the unusual shape of a C-shaped canal. In the present case, the following radiographic findings suggest the existence of a C-shaped root canal system:

Fig 2 Canal orifices of tooth 46 after obturation.



Fig 3 Examples of CBCT scans revealing C-shaped root canal systems: (a) bilateral C-shaped canals in mandibular second molars (arrows); (b) unilateral C-shaped canal in right mandibular second molar (arrow).



- fusion of roots in the apical portion
- convergence of the instruments to the apex on the working length radiograph (Fig 1c)
- appearance of furcation perforation by instruments in a working length radiograph (Fig 1c).

Despite these findings, a final diagnosis of a C-shaped canal system was not made because:

1. A direct view of the pulpal floor revealed four distinct canal orifices (Fig 2).
2. The prevalence of C-shaped canal in mandibular first molars is extremely rare – until now only one case report has been published¹².

In the present case, canal shaping was performed in the first appointment using rotary nickel-titanium files. Inter-appointment dressing with calcium hydroxide was chosen because of symptomatic apical periodontitis. Tissue dissolving in the C-shaped part of the canal was unintentionally accepted and was reinforced by NaOCl irrigations in the second appointment.

During lateral compaction, the sealer (AH Plus, Dentsply) filled the area of the C-shaped canal where organic tissue was dissolved by NaOCl and calcium hydroxide. Despite a satisfactory two-dimensional view of the final radiograph and the successful follow-up, the high quality of cleaning and obturation was not certain.

As a C-shaped canal can have a different configuration along the root, it is not always possible to identify it after pulp chamber opening¹⁷ (Fig 1). Cone beam computed tomography (CBCT) is a three-dimensional imaging technique that allows this problem to be overcome (Fig 3).

If a CBCT scan had been available prior to the root canal treatment showing the existence of a C-shaped canal system, the treatment approach would have been different. SAF instruments would have been used for canal shaping and thermoplasticised gutta-percha for canal obturation.

The patient needed an additional root canal treatment for tooth 37, 2 months after completion of the root canal treatment of tooth 46 (Fig 4a). Based on radiographic findings (fused roots and conical form) and the fact that tooth 46 had a C-shaped canal configuration, it was assumed that this tooth also had a C-shaped canal system. Biomechanical preparation was performed using the SAF system. The treatment included two appointments with a creamy aqueous calcium hydroxide dressing being applied between appointments because of symptomatic apical periodontitis. During the second appointment, the SAF system was again used for removal of the intracanal calcium hydro-

xide dressing. Obturation was performed using a combined technique: cold lateral compaction of gutta-percha in the apical area using NiTi finger spreaders (Dentsply) and thermoplasticised gutta-percha (Beefill Pack, VDW, Munich, Germany and Machtou pluggers; Dentsply Maillefer) for obturation of the coronal canal part. AH Plus was used as sealer (Dentsply Maillefer) (Fig 4b).

Conclusion

This case report introduces a rare appearance of a C-shaped canal in a mandibular first molar that was undetected during clinical work and revealed only after obturation. Using CBCT during dental treatment of suspected cases may provide the clinician with a better tool to diagnose this complex anatomy and choose appropriate instrumentation and obturation techniques.

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- Fig 4** (a) Preoperative periapical radiograph of tooth 37. (b) Post-operative radiograph following obturation. (c) A 14-month follow-up radiograph.
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