Management of the Diagnostic and Therapeutic Obstacle to Successful Endodontics in C Shaped Canals: A Case Series

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Abstract

Comprehensive knowledge of the anatomy of the root canal system is of paramount importance in successful endodontic treatment. It has been stated that a single tapering canal with a single apical foramen is an exception rather than a rule. Hence, awareness of unusual morphologies in the canal system is critical for favourable outcome of treatment. Efficacious biomechanical preparation and obturation depends upon the timely identification of the root canal system. An important variation of the root canal system is the C shaped canal configuration. It presents with a fine fragile fins or webs joining the root canals causing inadequate debridement of the root canal system compromising the prognosis of treatment. This case series presents successful diagnosis, accurate radiographic visualisation of microanatomy using contrast media and management of four cases of C-shaped mandibular second molars with different morphological variations.

Key-words*: C shaped canal, contrast media, mandibular second molar, root canal treatment, root canal morphology, endodontic treatmen*t

Introduction

Accomplishing success in endodontic therapy necessitates a comprehensive and detailed expertise in the knowledge of the root canal system and its variations. [1-3] Corresponding to diagnosis and treatment planning, precision in endodontic therapy is essential for a favourable outcome. [3] Amongst the different anatomical variations in the root canal systems, the unconventional and complex configuration of the C shaped roots and root canals presents with clinical adversities and challenges, compromising the objectives of endodontic therapy.[4] Cooke and Cox in 1979 first documented the C shaped configuration in root canal anatomy, which was termed owing to the 'C' shaped cross sectional anatomy of the root and/or root canal. [5]

A high prevalence of C-shaped canal configuration has been reported in mandibular second molars ranging from 2.7% to 44.5%.[6] Various explanations have been postulated for its formation, the most comprehendible being the failure of Hertwig's epithelial root sheath to fuse on the buccal or lingual root surface. A prism shaped or conical root results when the sheath fails to fuse on both the buccal and lingual sides.[7] If the Hertwig's epithelial sheath fails to fuse on the lingual side, a buccal groove is formed and vice versa. This sort of fusion is asymmetrical with two roots joined by an attenuated inter-radicular bow, and is inversely proportional to distance between root canals i.e, smaller the distance, higher the incidence of fusion between canals.[8,9]

C shaped root canal configurations generally feature fused roots, cross-section of canal corresponding to the configurations classified by Melton or Fan, and a longitudinal groove either on the lingual or buccal surface of root showing radiographic appearance of a 'third canal' in between two roots.[1,10] Classifications given by Melton *et al*, modified by Fan *et al* are the widely accepted classification systems that characterizes the intricacies of this configuration, enabling adequate biomechanical preparation followed by a hermetic

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seal at the apex. Nonetheless, efficient pulp space therapy of root canal system remains ambiguous due to the complexities associated with the intricate canal morphology, and is highly attributed to their narrow working area and wide fins.[1,7,11]Additionally, the two-dimensional view of the radiograph professes diagnostic obstacles. Hence, conscientious debridement along with precise negotiation of root canals is fundamental in their successful treatment.[12]Shearer *et al* advocated that using a radiopaque contrast medium for evaluation of root canal morphology would be a valuable aid in detecting the exact locations of lateral canals, fins, isthmus of the anastomosis.[13]

By virtue of the morphological variations in C-shaped root and root canal cases, it is necessary to opt for a befitting system for its diagnosis and treatment. These case reports present the successful management of various C-shaped canal configurations in mandibular second molars by accurate diagnosis and strategic treatment, using iopamidol contrast media for visualising the complex canal spaces.

Case Reports

Case I

A 27-year-old female patient reported with a chief complaint of pain on her lower left back tooth since a week. Medical history was non-contributory. Intraoral examination revealed a large composite restoration on tooth #47 FDI with tenderness. Vitality test exhibited delayed response to cold and electric pulp testing. Preoperative radiograph revealed presence of secondary caries below the composite restoration approximating the pulp, with fused mesial and distal root with an invariable anatomy, raising the suspicion of a C-shaped canal [Fig 1a]. The tooth was diagnosed as a necrotic tooth with symptomatic apical periodontitis. Informed consent was obtained from the patient.

Under magnification (Zeiss Opmi Pico) of 2.5X, the tooth was anesthetized followed by isolation with rubber dam. Access to pulp chamber was achieved using Endoaccess bur #2 and refined using EZ bur (Dentsply Maillefer, Switzerland). DG16 explorer was used to locate canal orifices. After debridement of pulp chamber remnants, a C-shaped canal configuration was observed with a single canal adjacent to it i.e., semicolon shaped canal conforming to Fan's anatomic classification C2 [Figure 1b].

The working length estimation was done using apex locater (RootZX II, J.Morita, USA), and confirmed with digital radiographs [Figure 1c]. The biomechanical preparation was done using hand K files and ProTaper Gold rotary files (Dentsply Maillefer, Ballaigues, Switzerland) up to F3. To avoid strip perforation, anti□ curvature filing motion was used. The canals were flushed with 3% sodium hypochlorite (Pyrex, Prime dental products, Mumbai, India), 17% EDTA solution (Dent Wash, Prime Dental Products, Mumbai), normal saline and final rinse with 2% Chlorhexidine solution. Calcium Hydroxide intracanal medicament paste was injected in the canals and the tooth was temporized. The patient was recalled after 2 weeks.

In the following appointment, canals were flushed with 3% sodium hypochlorite and activated using endoactivator (Dentsply Maillefer, Switzerland). After a rinse of distilled water, a mixture containing 3% sodium hypochlorite, 17% aqueous EDTA and contrast medium iopromide (Manus Aktteva Biopharma LLP, Gujarat, India) was used to fill the canals from apex to orifice using a 28 guage side vented needle. A radiograph was taken to visualise canal spaces and isthmi (Fan radiographic type I)[Fig 1d]. Following this, the canals were flushed with distilled water and then with 2% chlorhexidine as the final rinse. The canals were dried using paper points (Dentsply Maillefer, Switzerland). Gutta percha cones were fitted to the working length and a radiograph was taken [Figure 1e]. The canals were obturated using continuous wave technique followed by backfill using thermoplasticized gutta percha (Elements, SybronEndo, Orange, CA, USA) after coating the canals with calcium hydroxide based sealer (Sealapex, SybronEndo, Orange, CA, USA). The access cavity was restored using flowable resin based composite as base followed by bulk fill resin (Filtek Z350 XT, 3M Espe, USA). A post-obturation radiograph revealed sealing of the isthmi. [Figure 1f]

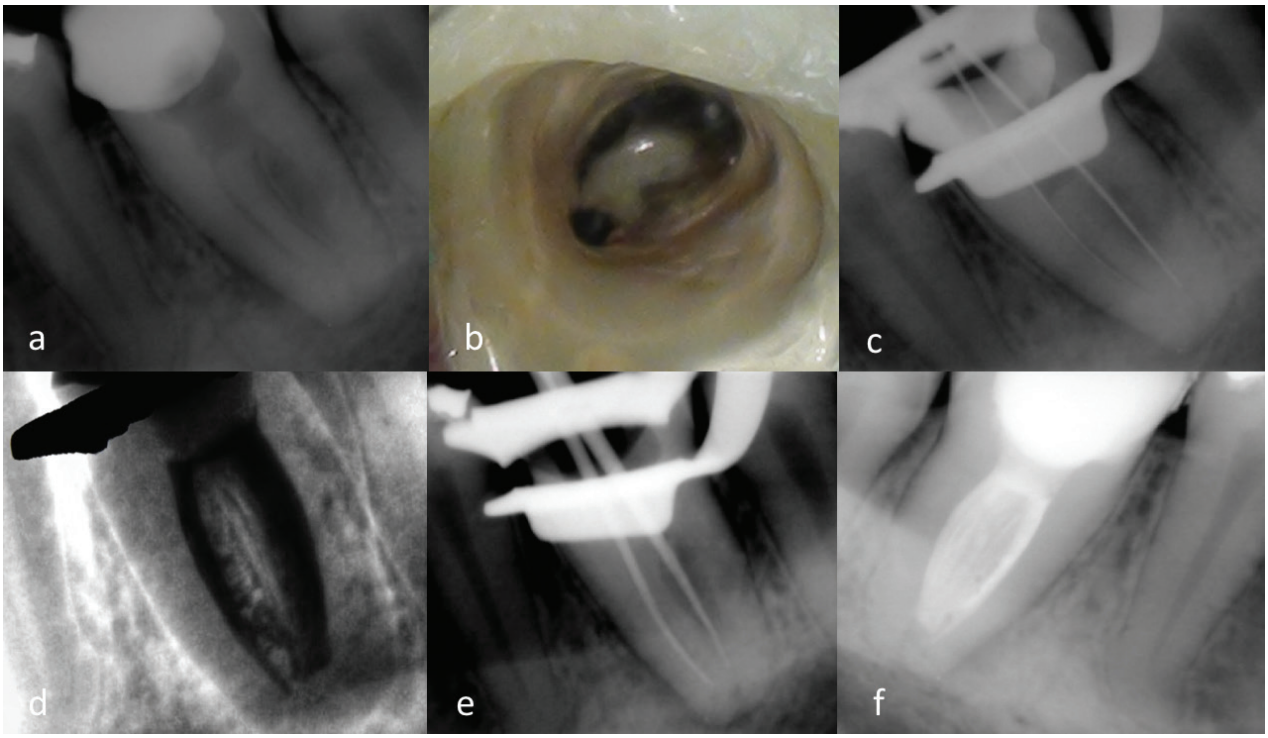

Fig 1 : a)Preoperative radiograph, b)Access cavity showing the location of the orifices of the canals in C-shape, c)Working length radiograph, d) Radiograph with contrast media in the canals, e) Master cone Radiograph, f) Post Obturation radiograph.

CASE 2

A 34-year-old male patient reported with chief complaint of pain in his lower left back tooth since two days. Clinical examination revealed occlusal caries on tooth number 37 FDI with pain on percussion. The tooth exhibited lingering response to electric and cold vitality testing. Intraoral digital radiograph revealed radiolucency involving the enamel, dentin and a pulp horn with mesial and distal roots converging, indicating possible presence of a C shaped canal configuration. [Fig 2a]. The case was diagnosed as irreversible pulpitis with symptomatic apical periodontitis.

Following obtaining informed consent from the patient, local anesthesia was administered with subsequent rubber dam isolation, after which access cavity was prepared under magnification. Two main canal orifices were located joined by a continuous fissure, indicating Fan anatomic C1 configuration at orifice level. [Fig 2b]

Working length estimation was done using apex locator locater and confirmatory digital radiographs. Cleaning and shaping was achieved by hand K files, followed by rotary instrumentation upto #30 with Hyflex CM 4% taper files (Coltene, India). 3% sodium hypochlorite was delivered using Endovac irrigation system (Sybron Endo,India) to facilitate apical cleansing while avoiding irrigant extrusion. Calcium hydroxide intracanal medicament was placed and the tooth was temporized.

On recall after 2 weeks, similar protocol of evaluation of canal anatomy by a combination of contrast media and irrigants was carried out, revealing Fan radiographic type II morphology of the canals. The canals were obturated using 4% gutta percha cone and Sealapex sealer with downpack using heated pluggers (System B, SybronEndo, Orange, CA, USA) [Fig 2c]. Access restoration was done using glass ionomer (Fuji IX, India). Post obturation digital radiograph revealed a thin margin coronally. [Fig 2d,2e]

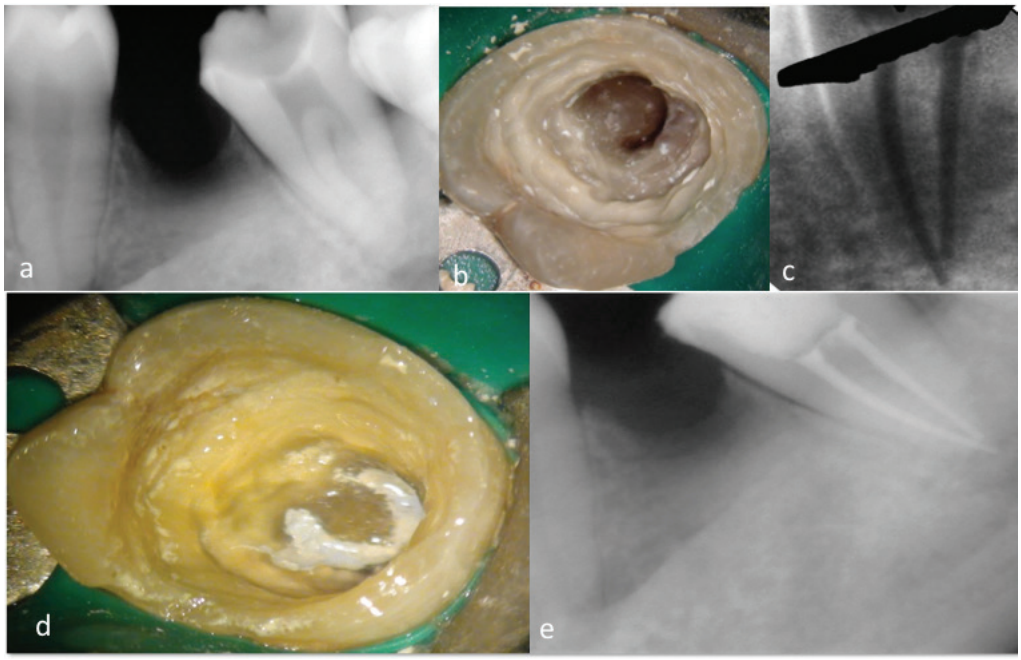

Fig 2: a) Preoperative radiograph, b)Access cavity showing the location of the orifices of the canals in C-shape, c) Radiograph with contrast media in the canals, d)Obturation at the orifice level, e) Post Obturation radiograph

CASE 3

A 26-year-old female reported with chief complaint of decay and pain in lower left back tooth since a month. Clinical examination revealed carious tooth #37 FDI with pulpal involvement and tenderness on percussion. Tooth was responsive to cold test, with pain which lingered after removal of stimulus. Radiographic examination revealed presence of deep occlusal carious lesion approaching pulp with presence of conical and fused roots with thin radiolucent line in-between, suggesting C-shaped root canal[Fig 3a]. The diagnosis was chronic irreversible pulpitis with symptomatic apical periodontitis after which informed consent was obtained from the patient prior to commencing the procedure.

Liquid dam (Oraseal,Ultradent products,Inc.,South Jordan, UT,USA) with wedgets was used for isolation for clear visibility of the pulp chamber. After gaining access into pulp chamber, semicolon shaped orifices were observed. Although a Fan anatomic C2 configuration was observed at the orifice level[Fig 3b], working length confirmatory radiograph revealed this semicolon shaped canal to be dividing into two canals. Hence, a total of three main canals were noticed, where the mesiobuccal and distal canals fused[Fig 3c]. Shaping was achieved with hand K files and protaper rotary instrumentation (upto F3). The disinfection was done using passive ultrasonic irrigation of 3% sodium hypochlorite, 17% EDTA solution and normal saline. Calcium hydroxide intracanal medicament was placed and temporized.

In the second visit, contrast medium radiograph revealed clearly visible canal spaces, showing large isthmus in coronal third, and fusion of the canals at the junction of middle and apical third[Fig 3d]. Necessary changes were done in biomechanical preparation using hand and rotary files along with targeted irrigant delivery to facilitate disinfection of these anastomoses. Master cone was placed to confirm tug back and a confirmatory radiograph was taken[Fig 3e]. The fusion point seemed to be too narrow for solid gutta percha cone to enter. Thus, Elements obturation system was used to successfully deliver plasticized gutta percha into this narrow fusion point and the canals were backfilled using extruder handpiece and condensed at a level slightly below CEJ[Fig 3f]. The access was restored by incremental build-up using flowable (base) and packable (bulk) composites.

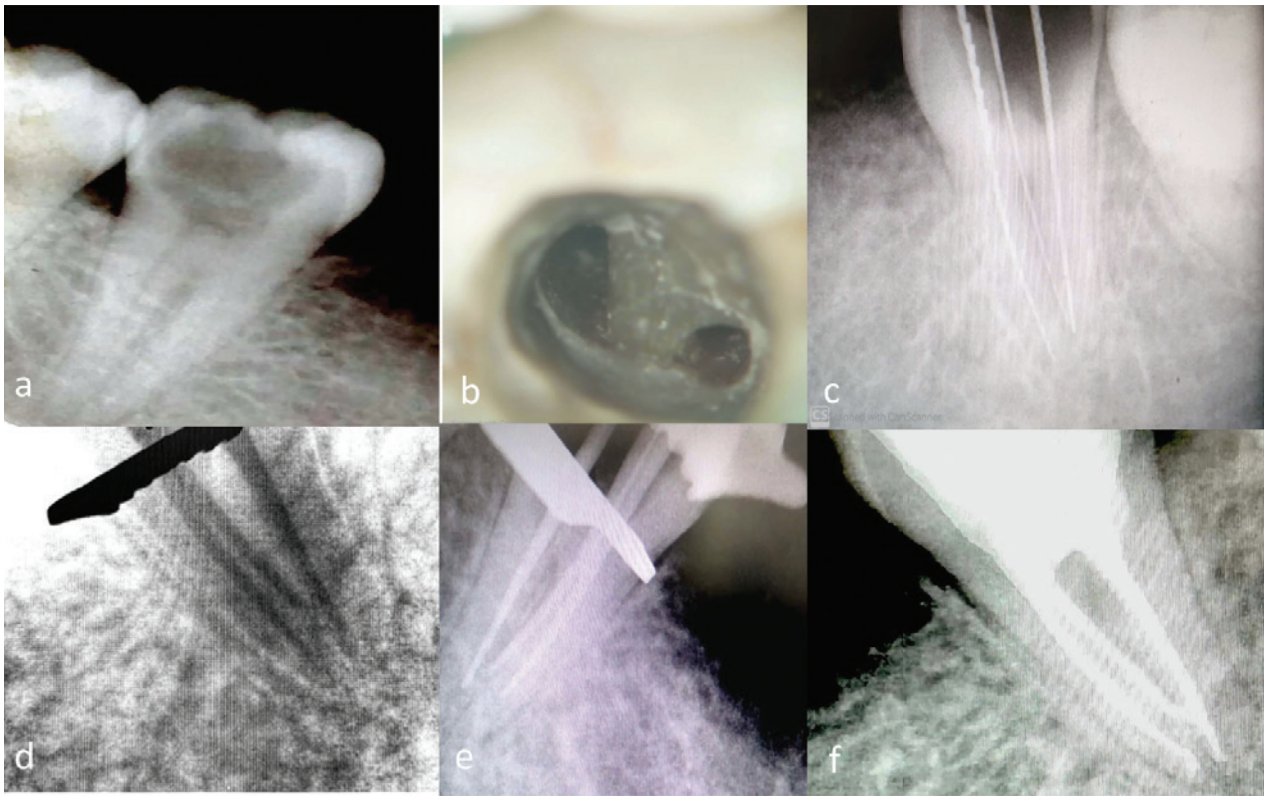

Fig 3: a) Preoperative radiograph, b)Access cavity showing the location of the orifices of the canals in C-shape, c) Working length radiograph, d)Radiograph with contrast media in the canals, e)Master cone Radiograph, f)Post Obturation radiograph

CASE 4

A female aged 22 years reported with pain in lower right back tooth since one month. Clinical examination revealed a restored tooth #47 FDI and tenderness on percussion. Tooth was responsive to cold test, with lingering pain after removal of stimulus. Radiographic examination revealed presence of a deep restoration close to pulp[Fig 4a]. It also revealed presence of dentine fusion with appearance of a 'third canal' in between, suggesting C-shaped root morphology. The case was diagnosed as chronic irreversible pulpitis with symptomatic apical periodontitis.Informed consent was obtained from the patient.

Following isolation with liquid dam, access was gained to the pulp chamber, a semicolon shaped orifice was noticed depicting Fan anatomic C2 configuration[Fig 4b]. Working length estimation was followed by a confirmatory radiograph[Fig 4c]. Cleaning and shaping was acheived by hand K files and rotary instrumentation. Similar disinfection protocols as the previous cases were followed. Intracanal medicament, calcium hydroxide was placed in the canals and recalled after 2 weeks.

On evaluating the canal anatomy with the help of contrast media, the canal spaces revealed an isthmus only in the coronal third, and two separate asymmetrical canals with separate apical exits. The distal canal seemed to be wider than the mesial due to the isthmus[Fig 4d]. A thermoplasticised gutta percha continuous wave condensation technique with System B hand piece was used for the obturation. The canals were backfilled with the extruder handpiece keeping in mind the large isthmus at the orifice level, and condensed at a level slightly below CEJ[Fig 4e,4f]. The access was restored by a sandwich technique using flowable and packable composites.

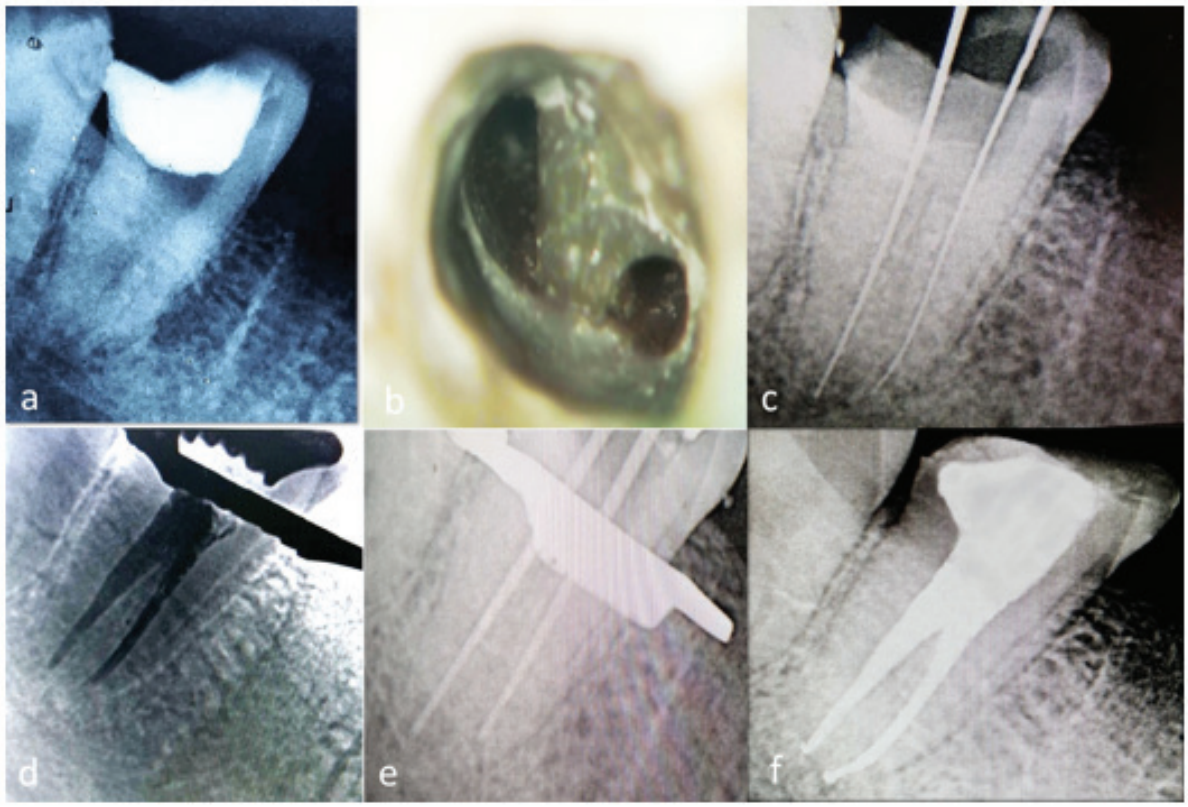

Fig 4: a) Preoperative radiograph, b)Access cavity showing the location of the orifices of the canals in C-shape, c) Working length radiograph, d)Radiograph with contrast media in the canals, e)Master cone Radiograph, f)Post Obturation radiograph

Discussion

The C shaped canal configurations has always been seen in varied forms and never affirms to any confirmed structural form.[14]The earliest classifications for the C shapes configuration were proposed by Manning and Melton *et al*.[1,7] Further, Fan *et al*. modified this classification after analysis using transverse sectioning and micro-computed tomography.[10]Al Fouzan stated that irrespective of presence of canal or orifice independently, there existed a requirement of customary outline of "C" and presence of canals in a C shaped root to be classified under this configuration.[15] These systems of classification help in interpreting anatomies of C-shaped canals and roots. The four cases reported in this case report were treated according to Fan *et al* classifications based on different preoperative radiograph angulations, clinical examination after access opening, working length estimation radiographs and contrast media radiographs.

The C shaped canal configurations have been observed to show an ethnic predilection, the anatomy being more common in Asians.[16]Other than a high incidence in mandibular second molars, the C-shaped configuration has also been reported in maxillary first molars (0.12%), maxillary third molars (4.7%), mandibular third molars (3.5%-4%), mandibular second premolars (1%) and maxillary lateral incisors with type III radicular groove. Bilateral occurrence (70-81%) has also been documented .[17]

The anatomical map of pulpal floor, orifice placed below level of CEJ, persistent bleeding or pain even after location of canal orifices and presence of a fin or web connecting the individual canals are the fundamental criteria to detect C-shaped canal configurations.[16,18] In the present case series, all cases were treated under dental operating microscope. The radiographs of working length estimation have proven to be more helpful than preoperative radiographs in detection of C-shaped canals.[20,21]The instruments converging at the

apex of root or a canal being centred in the pulp chamber and exiting through furcation are the criteria used to determine the presence of C-shaped canals.[22]

Previous studies have stated use of water soluble contrast medium during radiographic diagnosis to significantly enhance radiograph interpretation. Fan *et al* advocated that introduction of a water soluble contrast medium into a C-shaped canal system improves chances of effective canal identification even when a bone image superimposition exists, especially in cases of second molars.[23] This also gives a better understanding of the apical termination of preparation. As the deep canal spaces can be visualised pre-obturation, the preparation may be modified depending upon the contrast media radiograph, whose Visibility of contrast media in pulp spaces could be enhanced with inversion of the image digitally. Since a thermoplasticised obturation was planned for the cases, this contrast method of diagnosis helped in detecting the presence of isthmi, fins and lateral canals, which helped target those areas with adequate control. The anatomic & radiographic classifications of the four cases according to Fan's classifications are depicted in Table 1.

TABLE 1 – Categorization of the case reports presented according to Fan's classification

	Anatomic classification (based on Fan et al. 2004)	**Radiographic classification (based on Fan et al. 2007)**
Case 1	C2 at orifice level	Type I
Case 2	C1 at orifice level	Type II
Case 3	C2 at orifice level	Type I
Case 4	C2 at orifice level	Type III

The contrast media mixture containing 3% sodium hypochlorite, 17% aqueous EDTA and iopromide is similar to the Ruddle solution which contained hypaque (aqueous radiopaque solution of Iodine salts namely, ditrizoate and sodium Iodine) as the contrast dye. The mixture helps control the viscosity of the solution as iopromide alone is highly viscous. Sodium hypochlorite helps in dissolution of pulpal contents and elimination of bacteria along with their toxins from the root canal system; simultaneously disinfecting the intricate spaces and enabling the contrast medium to enter into the slender networks of C-shaped morphology. EDTA, a chelating agent, was used to reduce surface tension and remove the inorganic contents in the canal, thereby allowing unimpeded flow of the mixture. Additionally, iopromide has been shown to have high iodine content, thus diluting it with standard irrigants did not affect the radiopacity extensively. The visibility of the canal spaces on introduction of the solution mixture was excellent, especially on invertion of images digitally. This technique can also be used for detection of perforations, fractures, ledges and for other similar diagnostic measures.

Due to the presence of canal aberrations and irregularities in C-shaped canals, adequate cleaning and shaping presents an arduous challenge.[7,24] Abou-Rass *et al*. advocated anti-curvature filling to prevent strip perforation of the thinner walls.[25]This technique of filing was used in all the above cases to preserve the thin lingual wall in C shaped roots. Cheung LH *et al* suggested the ideal biomechanical preparation of C-shaped canals to be done by rotary instruments with ultrasonic irrigation as an adjunct.[26] In the present case reports, along with rotary instrumentation, the cases were irrigated with sonic and/or ultrasonic irrigation to facilitate cleansibility. Placement of calcium hydroxide as an intracanal medicament for a period of 7-14 days

has been recommended, which was followed whilst treating these cases.[27]

Attaining a three dimensional hermetic seal poses a problem due to complexities of canal anatomy. The favoured method to achieve the goals of obturation in C shaped morphology is warm vertical condensation in which the downpack is preferably done using continuous wave compaction method followed by backfill using the thermoplasticized gutta-percha technique.[16,28]In any case, achieving a three-dimensional seal of root canal is of utmost importance.

Conclusion

A fitting diagnosis and treatment plan following a precise examination plays a principle role in successful management of C-shaped canal configurations. C shaped canals present with varied configurations and has no certainties in the ways it presents. Hence, a profound awareness of the varied presentations of the C shaped canal anatomy will facilitate the management of the cases effectively and also for good long term prognosis.

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