ABSTRACT

Introduction: The patients with C-shaped configuration of the root canal system are definitely a problem in the everyday dental practice. The C-shaped configuration of the root canal can be seen in the mandibular and maxillary molars. The treatment of these teeth is very difficult.

Purpose: To trace the treatment of clinical cases with C-shaped configuration of the root canal system.

Material and methods: There are some different cases that are described with a C-shaped configuration of the root canal system with one, two, three and four separate root canals. Careful exploration of the floor of the pulp chamber, inspection with magnification, use of ultrasonic irrigation and a modified filling technique are of particular use.

Results and Discussion: Clinical cases of a C-shaped pulp chamber and root canal system shows that this root canal aberration occurs in a wide variety and variability with a single root canal up to two, three and four separate root canals. The diameter of the root canal themselves also varies from very wide to such with a small diameter.

Conclusions: Knowledge of the different anatomical variations will improve the endodontic practice of the general dental practitioners.

Key words: Anatomical variation, C-shaped configuration of the root canal system, endodontic treatment

The C-shaped root canal configuration was first documented in endodontic literature by Cooke and Cox in 1979 and is so named for the cross-sectional morphology of the root and root canal of the molar teeth [2]. In these cases instead of the typical shape of the pulp chamber with three root canals, there are the C-shaped orifice of the root canal on the mandibular molars. C-shaped root canal system is a single, ribbon-shaped orifice with an arc of 180° or more (Figure 1). Most often, the C-shape of the pulp chamber is used to describe the mandibular second molars, the maxillary first molars (0.92%) and the maxillary second molars (4.9%) [2, 3, 4, 13, 15]. Single cases of mandibular first molars and mandibular first premolars are reported [14, 15, 16].

Fig. 1. C-shaped configuration of the root canal system of mandibular second molar.

The orifice starts from the mesiolingual line angle of the pulp chamber, curves buccally and ends distally (Figure 1). The convex portion of the C-shape is directed vestibularly.

Root canal structure, below the orifice, can be wide range of anatomic variations with one, two, three or four separate canals. The teeth can be divided into two basic groups [3, 4]:

1. Those with a single ribbonlike morphology from orifice to the apex;
2. Those with more than one separate canal below the orifice.

The first classification of the C-shaped root canals was done by Melton and co-authors in 1991 [6]. Later based on it, Fan [3] made an anatomic classification:

1. Category I (C1) - continuous C-shaped root canal from the orifice to the apex of the root;
2. Category II (C2) - one main root canal and a smaller one;
3. Category III (C3) – two or three root canals;
4. Category IV (C4) - an oval or a round canal;
5. Category V (C5) - no canal lumen or there is one close to the apex. According to this classification, C4 includes teeth that have only a single and very wide canal. In English literature these are the so-called all in one (Figure 2).

Fan suggests that 3 types of teeth with C-shaped configuration of the pulp chamber are included in the radiological classification [4]:

1. Type I. Conical or square root with visible separation of medial and distal part. Medial and distal canal merge near the apical foramen in a single one;

2. Type II. Conical or square root with visible separation of medial and distal part. Medial and distal canal have separate apical foramen but run approximately in parallel and are almost equal in length;

3. Type III. Conical or square root with visible separation of medial and distal part. Medial and distal canal have separate apical foramen, run approximately in parallel but one of them is longer than the other.

MATERIAL AND METHOD

Clinical case No 1 of a mandibular second molar with C-shaped configuration (one wide root canal)

A root and a wide root canal are seen on the diagnostic radiography of a mandibular right second molar with exacerbated chronic periapical periodontitis (Figure 3a). After opening the pulp chamber, the C-shaped configuration of the pulp chamber and a single root canal are confirmed (Figure 3b). It refers to category IV (C4) of Fan’s anatomic classification.

The lengths of the root canals are measured electrometrically with Raypex 4 apex locator. Due to the excessive diameter of the root canal the treatment is performed with hand canal instruments using step-back technique, combined with irrigation with Smear Clear, 3% hydrogen peroxide and distilled water. Periapical lesions are influenced by physiotherapy with iodine-potassium iodide. Sealing the particularly widespread endodontic space is accomplished by the technique of „continuous wave of condensation” through System B and Obtura II.

Clinical case No 2a of a mandibular second molar with C-shaped configuration (two root canals)

The clinical finding is a mandibular right second molar with a C-shaped pulp chamber and two root canals - Category II (C2) according to Fan’s anatomic classification. Figure 4 shows the pulp chamber of the tooth before and after obturation of the endodontic space.

The extension of the endodontic cavity to the vestibular portion of the tooth is probably due to the search of a mesiobuccal orifice of the root canal in the primary treatment, as this is not applicable to this anatomical variation (white arrow on figure 4).
Fig. 4. C-shaped pulp chamber of mandibular second molar: a – C-shape of the open pulp chamber; b - clearly defined C of the pulp chamber with filled canals - C2 or Category II according to Fan.

Figure 5 shows the diagnostic radiograph of the tooth which refers to type III according to Fan’s radiological classification. Figure 5 b is a radiographic image of the tooth with gutta-percha points placed in both root canals and in Figure 5c - after filling. The post obturation radiography presents the filled root canal space and the existing anastomosing network between the main and the accessory canals.

Fig. 5. Mandibular right second molar with a C-shaped root canal system: a - X-ray prior to treatment; b – X-ray with gutta-points in the canals; c - X-ray after filling

The sealing the endodontic space is accomplished by the technique of “continuous wave of condensation” by combining System B and Obtura II for distal root canal and Thermafill obturator and sealer for medial root canal.

Clinical case No 2b of a mandibular second molar with C-shaped configuration (two root canals)

Figure 6 shows a mandibular right second molar with a C-shaped pulp chamber and two root canals - Category II (C2) according to Fan’s anatomic classification. It is interesting that endodontic treatment was made through the crown (as part of a bridge construction). The pulp chamber of the tooth before and after obturation of endodontic space is shown (Fig. 6a and b), as well as preoperative and post obturation radiographs (Figure 6b and d).

Fig. 6. Mandibular right second molar with a C-shaped root canal system: a - open and shaped pulp chamber; b – preoperative radiograph; c - pulp chamber after filling; d – post obturation radiograph.
Sealing the endodontic space is accomplished by Thermafill obturators and sealer.

**Clinical case No 3 of mandibular second molar with C-shaped configuration (three root canals)**

Endodontic retreatment of mandibular left second molar with a C-shaped pulp chamber and three root canals is registered. Evidence for this case is presented in Figure 7. In accordance with the radiograph, the tooth is classified as type I according to Fan’s radiological classification and as category III according to his anatomic classification (C3). Perforation in mesiolingual part of the pulp chamber occurred in previous treatment (black arrow on figure 8b). Probably it was not taken into consideration that the tooth had C-shaped configuration and a mesiolingual orifice of the root canal was searched for. It is interesting to note that a C-shaped pulp chamber and root canals of the contralateral mandibular second molar, as well as the C-shaped pulp chamber and the root canal system of maxillary left second molar are observed with the same patient.

This confirms the conclusion of some authors [8, 9] for presence of similar anatomical facts in contralateral teeth in up to 70% of the cases.

![Fig. 7](image1.png)

**Fig. 7.** Mandibular left second molar with C-shaped configuration and three root canals: a - preoperative radiograph; b - the pulp chamber during the treatment - the two canals with obturation (white arrows), a perforation at one of the ends of the pulp chamber (black arrow) and unfilled third root canal (red arrow); c – post obturation radiograph.

Sealing the endodontic space is accomplished by Thermall obturators and sealer.

**Clinical case No 4 of mandibular second molar with C-shaped configuration (four root canals)**

The demonstrated case of mandibular right second molar with chronic periapical periodontitis. The clinical crown is almost completely destroyed. The configuration of the pulp chamber is C-shaped and has four root canals. Preoperative radiograph shows a root canal type II according to Fan’s radiological classification (Figure 8).

![Fig. 8](image2.png)

**Fig. 8.** Radiographs of mandibular right second molar: a – preoperative; b – with gutta percha points

The typical C-shaped configuration of the pulp chamber is seen in Figure 9a. In Figure 9b shows the pulp chamber with filled root canals of the same tooth and in Figure 9c post obturation radiograph.
Sealing the endodontic space is performed by combined technique of filling a “continuous wave of condensation” using System B and Obtura II and Thermafill obturators and sealer.

RESULTS AND DISCUSSIONS
Clinical cases of a C-shaped pulp chamber and root canal system show that this root canal aberration occurs in a wide variety and variability with a single root canal up to two, three and four separate root canals. The diameter of the root canal themselves also varies from very wide to such with a small diameter.

In literature have found single publications of cases with a C-shaped canal [1, 7, 9, 11, 12]. According to different authors their frequency varies from 2.7% [5, 16] to 8% [9]. The teeth with C-shaped root canal configuration are usually mandibular second molars, and more rarely the mandibular first premolars, the maxillary first molars, as well as the mandibular wisdom-teeth (third molars). The C-shaped configuration of the pulp chamber and the root canal system affects more often Asians than Caucasians [11] with frequency of distribution up to 30%. The probability of finding C-shaped configuration in the contralateral tooth is up to 70% [7, 9, 11].

Successful endodontic treatment of a tooth with a C-shaped configuration is difficult and a real challenge considering decontamination and successful filling of the root canal system. The canal instruments, which use, mainly rotating and the processing of an elliptical canal is difficult and inefficient. The creation of systems, with reciprocal motion for machine preparation, is a significant step forward. It is inappropriate to apply separately the standard technique, step-back or crown-down technique for the preparation of a C-shaped root canal. Secure shaping and cleaning of such type of root canals require knowledge of various techniques for instrumentation and their combination.

Qualitative filling of teeth with a C-shaped root canal system only with the methods of the central point technique or cold lateral condensation is impossible. The difficulties arise from the fact that with the C-shaped root canals it is the possible to have a thin net of anastomoses in root canal system [3, 4, 10].

All this requires good knowledge of and combining different techniques of root canal extension from manual to machine ones.

It is important to choice the method of irrigation, because the endodontic space is complicate with net of anastomosis. Ultrasonic activation of the irrigation solution with 2.5 sodium hypochlorite may be advantageous in removing the infected tissues from the canal system, because the volume endodont contains greater amount of infected channel contents and extrusion of debris or irrigant is possible [7, 15, 16].

Regarding the filling of root canal system one method is not enough to seal the endodontic space. It is necessary to use also cold lateral condensation through combined technique of filling the continuous wave of condensation using System B and Obtura II and Thermall obturators and sealer [6, 11, 15, 16].

It is recommended that cases with C-shaped configuration of root canal system should be referred to a specialist for complete treatment.

CONCLUSION
Due to the unusual root canal system of teeth with a C-shaped root canal system, for successful sealing of endodontic space, it’s necessary to know and learn different techniques of filling and appropriate equipment with suitable appliance.
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