Case Report

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Endodontic management of C-shaped canals: A case series

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Abstract

INTRODUCTION. C-shaped root canals represent a complex anatomical variation, primarily seen in mandibular molars. Their intricate morphology poses significant challenges for diagnosis, cleaning, shaping, and obturation in endodontic practice.

AIM. To present a series of clinical cases illustrating the diagnosis and endodontic management of different types of C-shaped canals based on Fan's classification.

MATERIALS AND METHODS. Four clinical cases involving mandibular molars with C-shaped canal configurations were managed in accordance with CARE and PRICE guidelines. Each case included clinical and radiographic diagnosis, working length determination, cleaning and shaping with either the R2 Reciproc (VDW) or PlexV (Orodeka) system, irrigation with NaOCl and EDTA under ultrasonic activation, and obturation using thermocompaction or single-cone techniques with bioceramic sealers.

RESULTS. All cases demonstrated successful identification and management of C-shaped canal systems (types C1 to C4). Clinical and radiological follow-up at 1 and 3 months showed favorable healing with resolution of symptoms and periapical pathology.

CONCLUSIONS. Early and accurate diagnosis of C-shaped canals, supported by clinical and radiographic examination, is critical for successful endodontic outcomes. The use of magnification, appropriate canal preparation techniques, and bioceramic materials significantly enhances treatment success in such complex anatomical variations.

Keywords: C-shaped canal, endodontic treatment, bioceramic sealer, mandibular molar, case series

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Эндодонтическое лечение С-образных каналов: серия случаев

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Резюме

ВВЕДЕНИЕ. С-образные корневые каналы представляют собой сложный анатомический вариант, преимущественно встречающийся в нижних молярах. Их сложная морфология создает серьезные трудности при диагностике, обработке, расширении и обтурации в эндодонтической практике.

ЦЕЛЬ. Представить серию клинических случаев, иллюстрирующих диагностику и эндодонтическое лечение различных типов С-образных каналов согласно классификации Фана.

МАТЕРИАЛЫ И МЕТОДЫ. Четыре клинических случая, включавших нижние моляры с С-образной конфигурацией каналов, были обработаны в соответствии с рекомендациями CARE и PRICE. В каждом случае проводилась клиническая и радиологическая диагностика, определение рабочей длины, механическая обработка системами R2 Reciproc (VDW) или PlexV (Orodeka), ирригация растворами NaOCl и ЭДТА с ультразвуковой активацией, а также обтурация термокомпакцией или методом одиночного конуса с применением биокерамических силеров.

РЕЗУЛЬТАТЫ. Во всех случаях была успешно проведена идентификация и лечение С-образных каналов (типов С1–С4). Контрольные клинические и рентгенологические обследования через 1 и 3 месяца показали положительную динамику: купирование симптомов и признаки заживления периапикальных тканей.

ВЫВОДЫ. Ранняя и точная диагностика С-образных каналов на основании клинических и радиологических данных является ключевым фактором успешного эндодонтического лечения. Применение увеличения, адекватных методов обработки каналов и биокерамических материалов существенно повышает эффективность лечения при наличии сложных анатомических вариаций.

Ключевые слова: С-образный канал, эндодонтическое лечение, биокерамический силер, нижний моляр, серия клинических случаев

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INTRODUCTION

Understanding the internal anatomy of the tooth is a crucial condition in endodontic therapy. The considerable diversity in the root canal system underscores the importance of treatment strategies guided by an understanding of tooth anatomy [1]. This approach broadens the scope for accommodating and addressing these variabilities, thereby enhancing the success rate of endodontic treatments.

Among these anatomical variations, C-shaped canals are frequently observed in lower molars and premolars. These canals derive their name from the configuration formed when the root canals partially or completely merge, a characteristic visible in cross-sectional views.[2]

Early detection of canal with C-shaped configuration can assist the clinician in effective negotiation and preparation, thereby averting irreversible damage that could potentially compromise the integrity of the tooth.

This study, aimed to discuss the clinical and radiological diagnosis of C-shaped canals as well as their management through clinical cases.

CASE REPORTS

This case series was conducted in compliance with the CARE guidelines, the 2020 PRICE (Preferred Reporting Items for Case reports in Endodontics) guidelines and COPE recommendations to ensure transparent and standardized reporting. All patients were thoroughly informed about the complexity and specific features of their cases, as well as the proposed endodontic procedures. Written informed consent was obtained from each patient for the treatment and for the use of their clinical images and radiographs in this publication.

CASE 1: C-SHAPED CANAL TYPE C1

A female patient in her 20's consulted our department for continuous spontaneous pain that did not respond to analgesics in regard with the tooth 46. The apical diagnosis was a symptomatic apical periodontitis.

The preoperative radiograph demonstrates a C-shaped root canal type 1 of Fan [3], characterized by a conical structure, featuring a subtle radiolucent longitudinal line dividing the root into discernible mesial and distal sections. The mesial and distal canals unite into a singular canal prior to emerging at an open apex [3] (Fig. 1).

A Type I C-shaped root canal with a fan-shaped configuration was identified.

Thus, the treatment plan involved nonsurgical root canal therapy. At the first appointment and after rubber dam isolation, access cavity was performed, revealing a C-shaped canal type I of Fan (Fig. 2).

After radiographic determination of the working length (Fig. 3), the root canal preparation was conducted using R2 file Réciproc (VDW). During instrumentation, a copious irrigation with 2.5% sodium hypochlorite was frequently renewed and associated to an ultrasonic activation. The final activation sequence was performed with an alternation of 2.5% NaOCl, 17% EDTA, and 2.5% NaOCl for 30 seconds each.

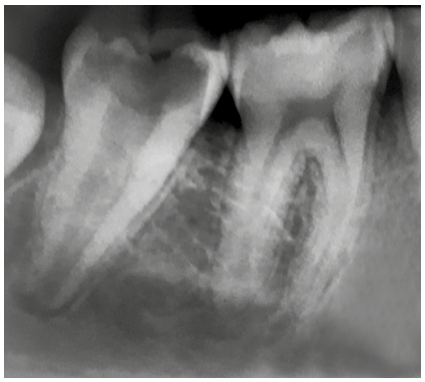


Fig. 1. Preoperative radiograph preparation showing

Рис. 1. Предоперационная рентгенограмма

Fig. 2. Access cavity preparation showing C-shaped canal type I of Fan

Рис. 2. Подготовка полости доступа с визуализацией С-образного канала типа I по Фану

Fig. 3. Determination of working length

Рис. 3. Определение рабочей длины

Calcium hydroxide was given as intracanal medicament and the coronal access cavities were temporarily sealed. Two weeks later, the tooth was asymptomatic. The canals were once again debrided, dried, and then filled in 2 steps.

We begin with a Biodentin apical plug and then we obturated the rest of the canals using the thermocompaction technique (Revo-condensor, MicroMega) (Fig. 4).

During clinical and radiological follow-ups, at 1 month and 3 months, the tooth was asymptomatic demonstrated periapical healing (Fig. 5, 6).

Case 2: C-shaped canal type C2

A female patient in her 40's presented to the dental medicine department in our hospital with asymptomatic apical periodontitis. Radiographic examination showed a type I root configuration, characterized by a tapered root with a subtle radiolucent longitudinal line dividing the root into distinct mesial and distal segments, with the mesial and distal canals converging into a single canal before exiting at the apical foramen [3] (Fig. 7).

The treatment plan included access cavity preparation revealing a semicolon-shaped canal resulting from the discontinuation of the "C" line [4] (Fig. 8).

Radiographic working length determination (Fig. 9, *A*), cleaning and shaping with the PlexV (Orodeka) system, irrigation with 5.25% sodium hypochlorite associated with ultrasonic activation, and obturation using the single-cone technique and a bioceramic sealer One-fil (MediClus) (Fig. 9, *B*, *C*).

Case 3: C-shaped canal type C3

A female patient in her 50's presented for endodontic treatment of tooth 47, exhibiting asymptomatic apical periodontitis and a clinical diagnosis of two separate canals, classified as a Fan type C3 C-shaped canal [4]. Radiographic examination revealed a type I root configuration, characterized by a conical structure with a subtle radiolucent longitudinal line dividing the root into distinct mesial and distal segments, where the canals converge into a single canal before exiting at the apical foramen (Fig. 10) [3].

The treatment plan consisted of access cavity preparation (Fig. 11), working length determination, cleaning and shaping using the PlexV (Orodeka) system, irrigation with 5.25% sodium hypochlorite associated to an ultrasonic activation, and obturation using the single-cone technique with bioceramic sealer One-fil (MediClus) (Fig. 12, 13).

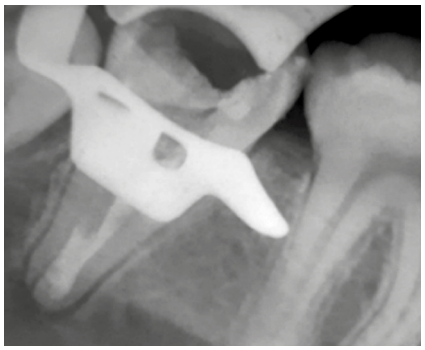


Fig. 4. Periapical radiograph showing the apical plug

Рис. 4. Периапикальная рентгенограмма, показывающая апикальную пробку

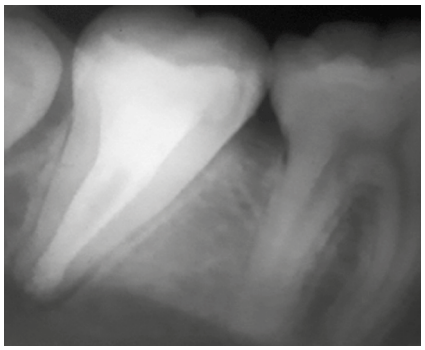


Fig. 5. One month Follow-up radiograph

Рис. 5. Контрольная рентгенограмма через месяц

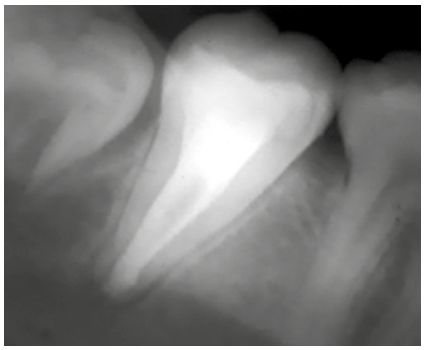


Fig. 6. Three months Follow-up radiograph

Рис. 6. Контрольная рентгенограмма через 3 месяца

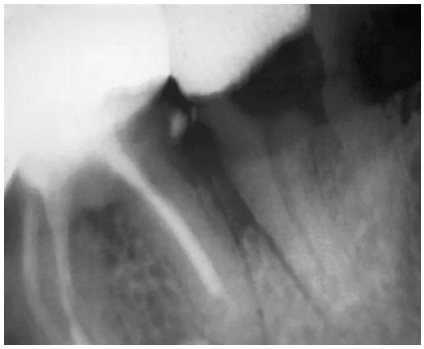


Fig. 7. Preoperative radiograph

Рис. 7. Предоперационная рентгенограмма

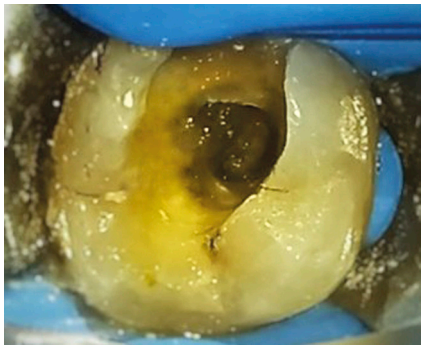
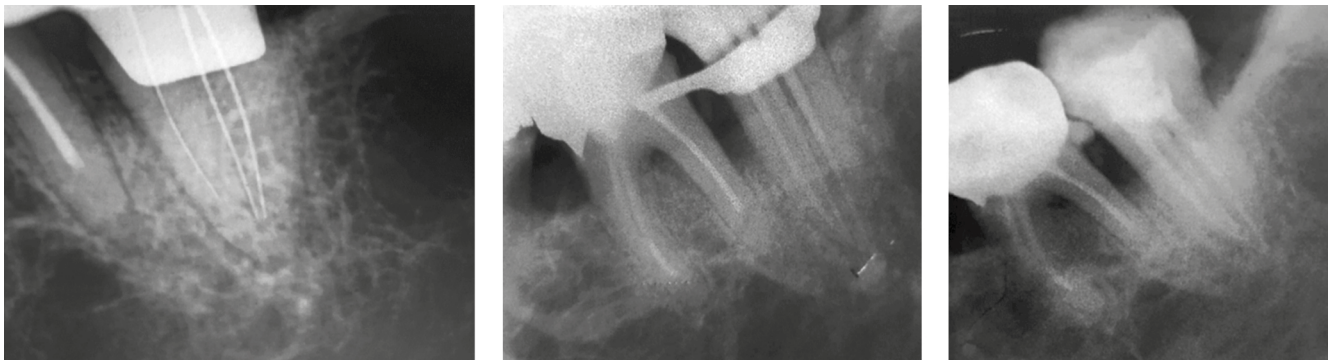


Fig. 8. Clinical examination showing C-shaped canal type C2

Рис. 8. Клиническое обследование, показывающее С-образный канал типа С2



A **B** **C**

Fig. 9. Peroperative radiographs: *A* – working length determination; *B* – cone-fit radiograph; *C* – post operative radiograph

Рис. 9. Интраоперационные рентгенограммы: *A* – определение рабочей длины; *B* –рентгенограмма с конусовидной формой*; C* – послеоперационная рентгенограмма

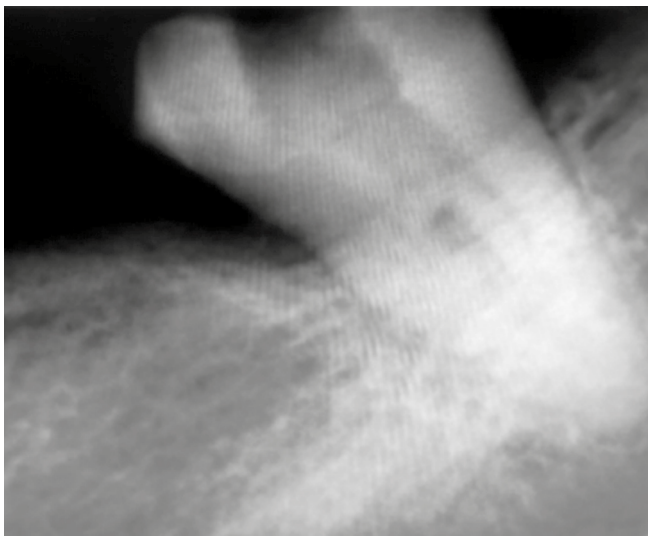


Fig. 10. Preoperative radiograph

Рис. 10. Предоперационная рентгенограмма

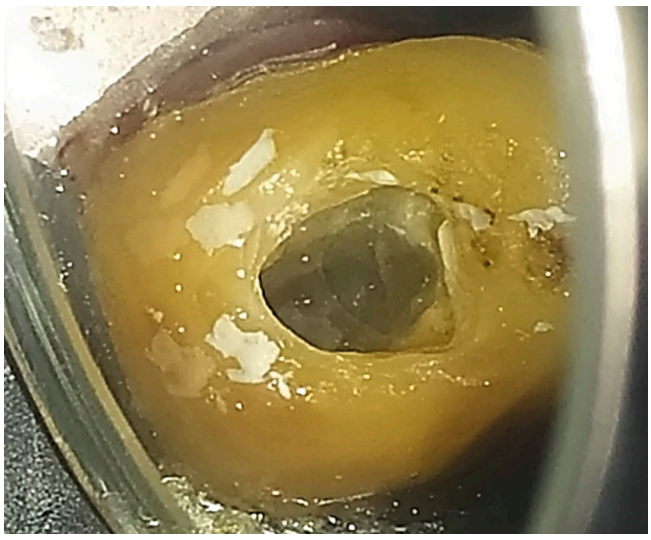


Fig. 11. Clinical examination showing A C-shaped canal type C3

Рис. 11. Клиническое обследование, показывающее С-образный канал типа С3

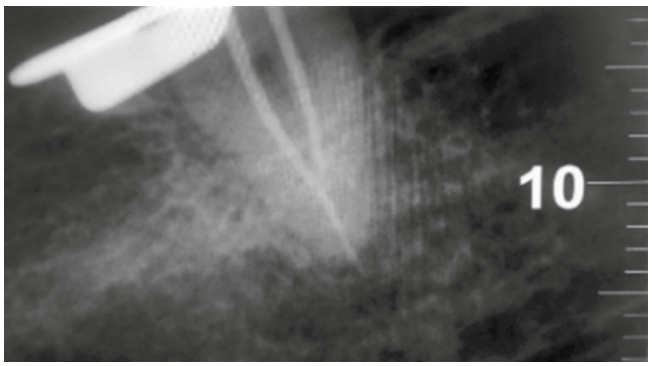


Fig. 12. Cone-fit radiograph

Рис. 12. Рентгенограмма с конусовидным изображением

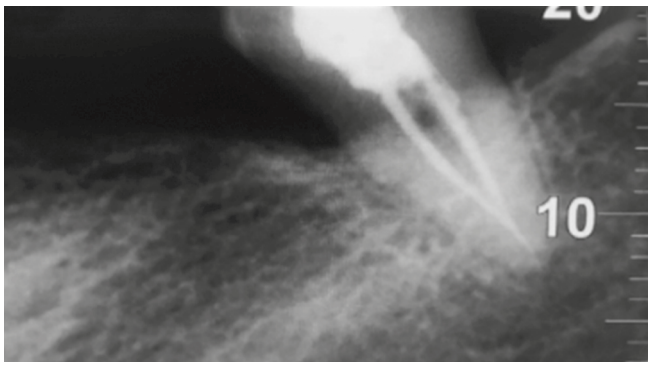


Fig. 13. Post-operative radiograph

Рис.13. Послеоперационная рентгенограмма

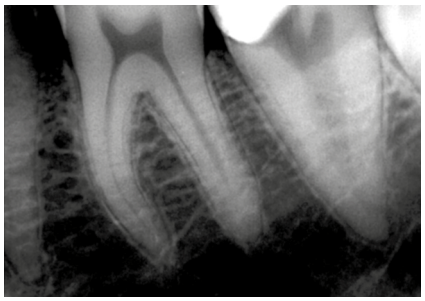


Fig. 14. Preoperative radiograph

Рис. 14. Предоперационная рентгенограмма

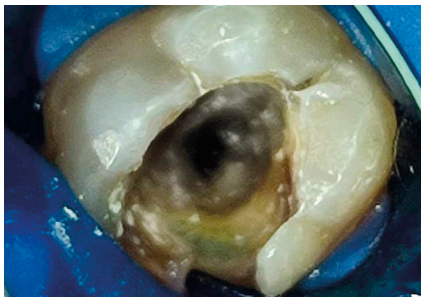


Fig. 15. Clinical examination showing C-shaped canal type C4

Рис. 15. Клиническое обследование, показывающее С-образный канал типа С4

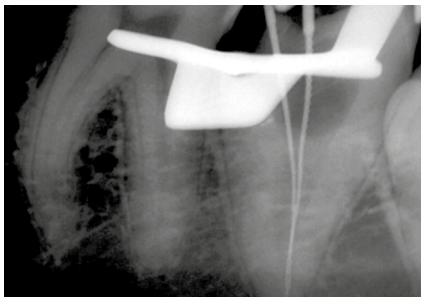


Fig. 16. Determination of working length

Рис. 16. Определение рабочей длины

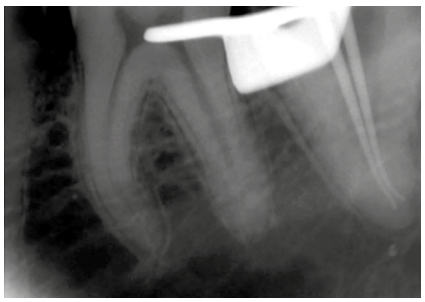


Fig. 17. Cone-fit radiograph

Рис. 17. Конусная рентгенограмма

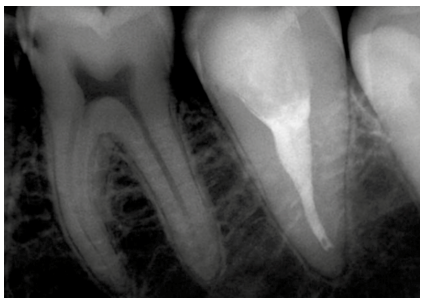


Fig. 18. Post-operative radiograph

Рис. 18. Послеоперационная рентгенограмма

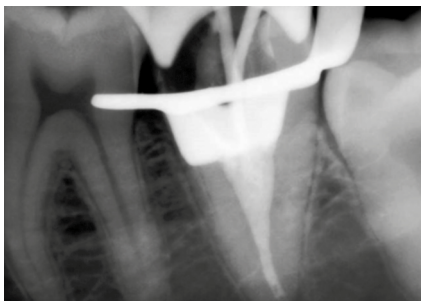


Fig. 19. One-month Follow-up radiograph

Рис. 19. Контрольная рентгенограмма через месяц

Case 4: C-shaped canal type C4

A male patient in his 20's presented to our dental medicine department with continuous spontaneous pain, diagnosed with symptomatic irreversible pulpitis in tooth 47. Radiographic examination showed a type I root configuration, characterized by a conical shape with a subtle radiolucent longitudinal line dividing the root into distinct mesial and distal sections, with the canals converging into a single apical foramen (Fig. 14) [3].

Clinical examination revealed a single, round canal, classified as a Fan type C4 C-shaped canal [4] (Fig. 15).

The treatment plan included working length determination using an apex locator and radiography (Fig. 16), cleaning and shaping with the PlexV (Orodeka) system, ultrasonic activation of the irrigant, and obturation using the single-cone technique with One-fil bioceramic sealer (Fig. 17, 18).

DISCUSSION

Through a series of clinical cases involving the management of various types of C-shaped canals, this study highlights the critical role of accurate clinical and radiographic diagnosis in ensuring effective endodontic treatment of these complex anatomical configurations.

C-shaped root canals represent a significant anatomical variation, predominantly observed in mandibular second molars [5]. Their complex morphology poses challenges in endodontic treatment, requiring a thorough understanding of their etiology and clinical implications. Despite extensive research, the precise mechanisms underlying their formation remain unclear. Several factors have been proposed, including developmental anomalies, genetic predisposition, environmental influences, and ethnic or geographic variations. Developmentally, disruptions in epithelial-mesenchymal interactions during root formation may contribute to this atypical configuration. Genetic studies suggest that specific genes or mutations could influence root canal morphology. Additionally, environmental factors such as trauma, infections, or vascular disruptions during odontogenesis have been implicated. Epidemiological data indicate a higher prevalence of C-shaped canals in certain ethnic populations, particularly among individuals of Asian or Native American descent, suggesting a potential genetic and regional predisposition. Given these multifactorial origins, further research is essential to elucidate the underlying mechanisms and improve treatment strategies for teeth with C-shaped canals [6].

The influence of racial and geographic factors on root canal anatomy further underscores the complexity of C-shaped canals. Variations in prevalence have been documented across different populations, highlighting the role of genetic and environmental determinants.

Notably, C-shaped canals are often found bilaterally, with studies reporting a prevalence of 75.3% for bilateral occurrences and 24.7% for unilateral cases [7]. This distribution appears consistent across genders and tooth locations, suggesting an inherent anatomical pattern rather than a random occurrence. Understanding these racial and regional variations is crucial for improving diagnostic accuracy and refining endodontic treatment approaches [8].

Classification of C shaped canals

Melton et al. classified C-shaped canals based on their cross-sectional morphology, recognizing that their shape may change along the root length. This classification includes 3 classes [9].

However, given the limitations of Melton's system in describing variations along the entire root length, Fan's classification [4] was adopted in our study. In fact, Fan proposed a more comprehensive system with five categories, all illustrated in our study, considering both continuity and segmentation of the canal along the root. This classification includes:

– C1: a continuous C-shaped canal;

– C2: a discontinuous C-shape with at least one arc ⩾ 60°;

– C3: two to three separate canals with no arc exceeding 60°;

– C4: a single round or oval canal;

– C5: a root with no canal lumen, typically near the apex. By using Fan's system, our study ensures a more detailed and clinically relevant classification of C-shaped canals.

Fan et al. have also supplemented their work with a radiological classification, which classified C-shaped roots into three types based on their radiographic appearance [3]:

– **Type I:** A conical or square root with a faint radiolucent longitudinal line separating mesial and distal segments, which merge into a single canal before reaching the apex;

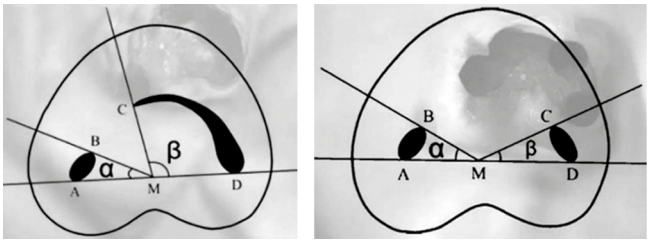
– **Type II:** Similar root shape with a radiolucent line, but the mesial and distal canals remain separate and follow independent paths to the apex;

– **Type III:** A conical or square root with a radiolucent line; one canal follows a curved path, overlapping with the line, while the other remains separate.

Anatomical Characterization of C-Shaped Canals in Molars

The crown structure of teeth exhibiting C-shaped anatomy does not display distinctive characteristics that can assist in diagnosis.

The clinical confirmation of C-shaped canals becomes apparent upon accessing the pulp chamber. In this case, the pulp chamber might extend considerably in the occluso-apical length, often with a shallow bifurcation [4]. As an alternative, the canal might be calcified, concealing its C-shaped configuration. Initially, multiple orifices might be explored. In a genuine C-shaped canal, smooth passage of an instrument from the mesial to distal aspect is achievable without obstructions [7].



A **B**

Fig. 21. Measurement of angles for the C2 (*A*) and C3 (*B*) canal. Both angle α and β are more than 60°
Source: [10]

Рис. 21. Измерение углов для канала С2 (*A*) и С3 (*B*). Оба угла α и β составляют более 60°
Источник: [10]

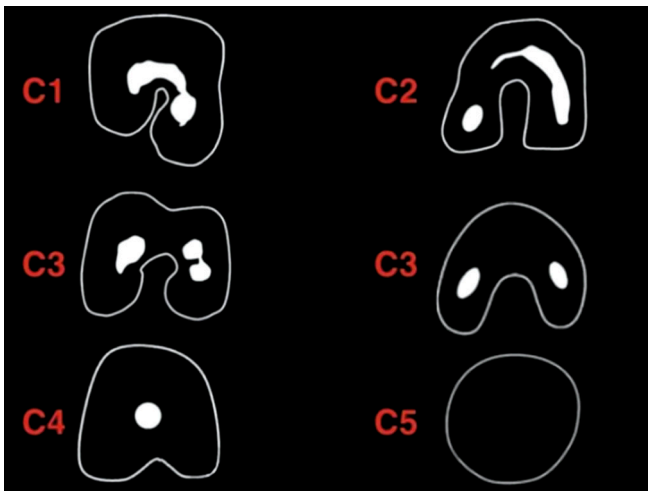


Fig. 20. Fan et al. (2004) classification
Source: [10]

Рис. 20. Классификация Фана и др. (2004)
Источник: [10]

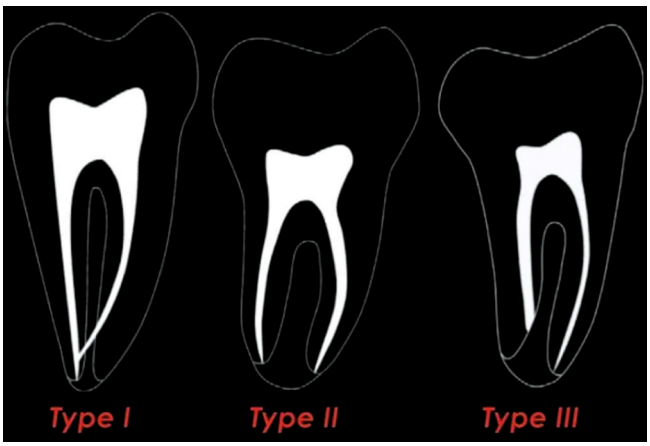


Fig. 22. Radiographic type of C-shaped Canal
Source: [10]

Рис. 23. Рентгенологический тип С-образного канала
Источник: [10]

C-shaped canals exhibit an isthmus that may or may not allow instrument passage. If an additional canal exists alongside a buccal or lingual C-shaped canal, inserting an instrument from either side of the "C" may reach the distal foramen. If the instrument cannot traverse the isthmus, the canal is considered separate [2]. According to Fan et al., a mandibular second molar is classified as having a C-shaped canal system if it meets three criteria: fused roots, a longitudinal groove on the lingual or buccal root surface, and a canal configuration falling under C1, C2, or C3 in Fan's classification [3; 4].

Studies indicate that C-shaped canals often divide into multiple canals in the apical region, particularly when they exhibit a semicolon or continuous shape at the orifice level [11].

In another hand, Aricioğlu et al. were the first to identify a significant association between taurodontism and C-shaped canal configurations. They suggested that this correlation may arise from a common developmental anomaly affecting the dental epithelium. These findings highlight the need for clinicians to anticipate a higher prevalence of C-shaped canals when performing endodontic treatments on taurodont teeth [12].

Clinical Management

Preoperative retroalveolar radiographs taken at 20° mesial or distal angles, are essential for assessing canal morphology. However, their two-dimensional nature limits their accuracy, as they may fail to reveal all root and canal variations.

Still, Cone-Beam Computed Tomography (CBCT) has become an invaluable tool in endodontics, offering significant advantages over conventional imaging methods. In fact, it provides a comprehensive view of root canal morphology, improving diagnostic accuracy and enhances the detection of small anatomical details, including C-shaped canal configurations [13].

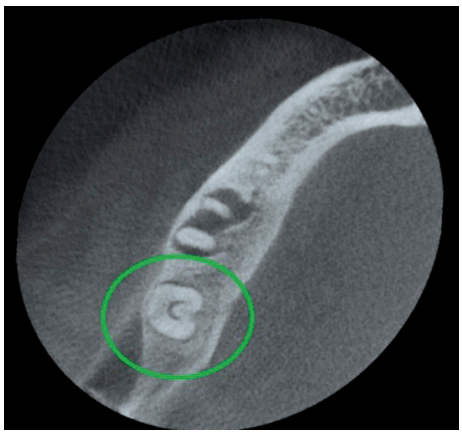


Fig. 23. A preoperative periapical radiograph of tooth 47
Source: [15]

Рис. 23. Предоперационная периапикальная рентгенограмма зуба 47
Источник: [15]

However, CBCT exposes patients to higher radiation doses compared to traditional radiography. As a result, the American Association of Endodontists recommends its use only when conventional imaging is insufficient for a definitive diagnosis [14].

In our cases, retroalveolar X-rays were used as a diagnostic and follow-up tool.

Therefore, precise access cavity preparation is essential for successful treatment, with an operating microscope improving results. For C-shaped canals, adjustments to the access outline help identify and negotiate the entire system. The number of canals varies by orifice shape, from 1 to 3 canals [4].

To navigate these variations, initial files are placed accordingly: three for a continuous orifice, two for an oval, and one for a round orifice. Calcifications and curvatures can obscure canals, requiring careful probing with small K-files to prevent missed canals [2].

Effective cleaning and shaping of C-shaped canals require special attention to isthmuses, troughs, and fins, where debris and pulp tissue tend to accumulate [2]. Instrumentation should be carefully selected, as using files larger than diameter 0.25 in the isthmus may lead to strip perforation. Extracting affected pulp or necrotic tissues from intricate regions of this root canal system with instruments [16], proves challenging. Hence, the use of chemical solutions such as Soduim Hypochlorite (NaOCl) for cleaning and irrigating root canals becomes particularly crucial.

In fact, enhanced irrigant volume and deeper penetration achieved with small instruments through sonic or ultrasonic methods might improve cleaning in the fan-shaped regions of C-shaped canals. However, excessive use of ultrasound can lead to a perforation and breaking of the ultrasonic file [5].

For the obturation, achieving a dense and uniform fill in C-shaped canals is challenging due to their complex morphology. Vertical condensation with thermoplasticized gutta-percha is often preferred over cold lateral condensation, as the latter requires deeper spreader penetration, which is difficult in narrow isthmuses [17]. On the other hand, Bioceramic sealers offer significant advantages in the obturation of C-shaped canals due to their excellent flowability and bioactivity, which enhance the sealing of irregular canal spaces, including isthmuses and fins. Their hydrophilic nature and chemical bonding to dentin improve adaptation, reducing the risk of microleakage and ensuring long-term biocompatibility in these anatomically complex systems [18].

in our case series, we used a bioceramic sealer to fill the c-shaped canals, which guaranteed periapical healing and sedation of the clinical symptoms.

CONCLUSION

C-shaped canals represent significant challenges in diagnosis and treatment. Early detection is key to effective cleaning, shaping, and obturation. This study explored the management of various types of C-shaped canals and highlights the role of the clinical and radiological diagnosis in ensuring effective endodontic treatment of these complex anatomical configurations.

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AUTHOR'S CONTRIBUTION

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