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Case Report

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ROOT CANAL TREATMENT OF TEETH WITH C-SHAPED ROOT CANALS IN 3 MANDIBULAR SECOND MOLARS: A CASE SERIES

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Introduction: C-shaped root canal morphology is an anatomical variation typically resulting from incomplete development or fusion of Hertwig's epithelial root sheath, predominantly observed in mandibular second molars. This unique configuration poses significant challenges for debridement, disinfection, and obturation, thereby impacting endodontic treatment prognosis. This case series presents the endodontic management of 3 mandibular second molars with varying C-shaped root canal configurations identified using cone-beam computed tomography (CBCT) imaging. **Case Report:** Analysis of CBCT images verified different types of C-shaped canals (Case1 C2 type, Case 2 C4 type, and Case 3 C3 type) in all 3 cases mentioned here. Root canal shaping was carried out with a rotary file system (ProTaper Next). In cases 1 and 2, the apical portion of the root canals were filled with a gutta-percha cone and a calcium silicate sealer using the single cone technique. The remaining root canal spaces were then backfilled with a thermoplastic filling system. In case 3, root canals were filled with lateral condensation system. Radiographic and clinical follow-ups were performed after endodontic treatment. **Conclusion:** Clinical and radiographic evaluations guided the treatment planning, while advanced instrumentation techniques were employed to address the complexity of canal morphology. Accurate diagnosis, facilitated by CBCT, and tailored treatment approaches were crucial in achieving favorable outcomes. The cases demonstrated the importance of a comprehensive understanding of C-shaped canal anatomy, emphasizing meticulous preparation and obturation strategies to optimize endodontic success. This case series underscores the significance of recognizing C-shaped canal anatomy in enhancing treatment outcomes. The findings align with prior research on the prevalence of C-shaped canals in specific populations, underscoring CBCT's role in improving diagnostic and therapeutic precision in endodontics.
Key words: root canal treatment, C-shaped canal, CBCT

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ЛЕЧЕНИЕ КОРНЕВЫХ КАНАЛОВ ЗУБОВ С С-ОБРАЗНОЙ АНАТОМИЕЙ КОРНЕВЫХ КАНАЛОВ: ОПИСАНИЕ СЕРИИ СЛУЧАЕВ

Введение: С-образная анатомия корневых каналов представляет собой анатомическую вариацию, обычно возникающую из-за неполного развития или слияния эпителиального корневого влагалища Хертвига. Этот типичный вариант чаще всего наблюдается во вторых молярах нижней челюсти. Такая

уникальная конфигурация создает значительные трудности при очистке, дезинфекции и обтурации, что влияет на прогноз эндодонтического лечения. В данной серии случаев представлено эндодонтическое лечение трёх вторых моляров нижней челюсти с различными вариантами С-образных корневых каналов, выявленных с использованием компьютерной томографии с конусным пучком (КТКП).
Описание случаев: Анализ КТКП изображений подтвердил наличие различных типов С-образных каналов: в случае 1 – тип С2, в случае 2 – тип С4, в случае 3 – тип С3. Формирование корневых каналов проводилось с использованием ротационной системы файлов (ProTaper Next). В случаях 1 и 2 апикальная часть корневых каналов была заполнена гуттаперчевым штифтом и кальцийсиликатным герметиком методом одиночного конуса. Оставшиеся пространства корневых каналов были заполнены термопластичной системой обтурации. В случае 3 корневые каналы заполнялись методом латеральной конденсации. После эндодонтического лечения проводились рентгенологические и клинические контрольные осмотры.
Заключение: Клинические и рентгенологические исследования направляли процесс планирования лечения, а использование современных инструментальных методик позволило справиться со сложной анатомией каналов. Точный диагноз, обеспеченный с помощью КТКП, и индивидуальный подход к лечению стали ключевыми факторами достижения благоприятных результатов. Данные случаи демонстрируют важность глубокого понимания анатомии С-образных каналов, подчеркивая необходимость тщательной подготовки и стратегий обтурации для оптимизации успеха эндодонтического лечения. Эта серия случаев подчеркивает значение учета С-образной анатомии каналов для улучшения результатов лечения. Выводы согласуются с предыдущими исследованиями распространенности С-образных каналов в определённых популяциях, подчеркивая роль КТКП в повышении точности диагностики и терапии в эндодонтии.
Ключевые слова: лечение корневых каналов, С-образный канал, КТКП.

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ТҮБІР ӨЗЕГІНІҢ АНАТОМИЯСЫ БАР ТІСТЕРДІҢ ТҮБІР ӨЗЕГІН ЕМДЕУ: БІРҚАТАР ЖАҒДАЙЛАРДЫҢ СИПАТТАМАСЫ

Кіріспе: түбір өзектерінің С-тәрізді анатомиясы әдетте Хертвиг эпителий түбірлік қынапшасының толық дамымауынан немесе бірігуінен туындайтын анатомиялық вариация болып табылады. Бұл типтік нұсқа көбінесе төменгі жақтың екінші азу тістерінде байқалады. Мұндай бірегей конфигурация эндодонтиялық емдеу болжамына әсер ететін тазалау, дезинфекциялау және обтурация кезінде айтарлықтай қиындықтар тудырады. Бұл жағдайлар сериясында конустық КТ (кткп) көмегімен анықталған с-тәрізді түбір өзектерінің әртүрлі нұсқалары бар төменгі жақтың екінші үш молярын эндодонтиялық емдеу ұсынылған.
Жағдайлардың сипаттамасы: суреттердің КТКП талдауы С-тәрізді арналардың әртүрлі түрлерінің болуын растады: 1 жағдайда-С2 типі, 2 жағдайда – С4 типі, 3 жағдайда – С3 типі. Түбірлік арналарды қалыптастыру айналмалы файлдық жүйені (Protaper Next) қолдану арқылы жүзеге асырылды. 1 және 2 жағдайларда түбір өзектерінің апикальды бөлігі гуттаперч түйреуішімен және жалғыз конус әдісімен кальций силикатты тығыздағышпен толтырылды. Қалған түбірлік канал кеңістіктері термопластикалық обтурация жүйесімен толтырылды. 3 жағдайда түбір өзектері бүйірлік конденсация әдісімен толтырылды. Эндодонтиялық емдеуден кейін рентгенологиялық және клиникалық бақылау тексерулері жүргізілді.
Қорытынды: клиникалық және рентгенологиялық зерттеулер емдеуді жоспарлау процесін бағыттады, ал заманауи аспаптық әдістерді қолдану каналдардың күрделі анатомиясын жеңуге мүмкіндік берді. КТКП-мен қамтамасыз етілген нақты диагноз және емдеуге жеке көзқарас қолайлы нәтижелерге қол жеткізудің негізгі факторлары болды. Бұл жағдайлар эндодонтиялық емдеудің сәттілігін оңтайландыру үшін мұқият дайындық пен обтурация стратегияларының қажеттілігін көрсете отырып, С-тәрізді арналардың анатомиясын терең түсінудің маңыздылығын көрсетеді. Бұл жағдайлар сериясы емдеу нәтижелерін жақсарту үшін С-тәрізді канал анатомиясын есепке алудың маңыздылығын көрсетеді. Нәтижелер эндодонтиядағы диагностика мен терапияның дәлдігін жақсартудағы КТКП рөлін көрсете отырып, белгілі бір популяциялардағы С-тәрізді арналардың таралуы туралы алдыңғы зерттеулерге сәйкес келеді.
Түйінді сөздер: түбір өзегін емдеу, С-тәрізді арна, КТКП.

Introduction

The C-shaped root canal is an anatomical variant that results from insufficient development or fusion of Hertwig's epithelial root sheath in the furcation area during tooth formation [1]. It is formed as a result of root canal orifices creating a C-shape, connected by a fin or web-like structure [2]. This morphological configuration presents significant challenges for debridement, disinfection, and canal filling procedures, which may ultimately impact the prognosis of root canal treatment (RCT) [3].

The existence of C-shaped canal anatomy was first recognized in the 18th century and was described in detail by Keith in the early 20th century [4]. The C-shaped canal has a cross-sectional shape that resembles the letter "C". Unlike the typical round or oval root canal shapes, a C-shaped canal displays a continuous, ribbon-like structure [5]. C-shaped canals are most frequently observed in mandibular second molars, followed by mandibular first premolars, mandibular first molars, and maxillary first and second molars, with a notably higher prevalence in Asian populations [6]. This anatomical feature presents additional challenges for endodontic procedures, including debridement, disinfection, and canal filling, potentially impacting the prognosis of RCT negatively. Notably, in C-shaped root canals, the dentin walls may be thin due to a deep groove along the root, increasing the risk of perforation during endodontic instrumentation. Therefore, it is essential for clinicians to have a thorough understanding of this complex root canal anatomy for effective treatment planning [1].

C-shaped canals present diagnostic and treatment challenges for clinicians. These distinct anatomical features are often difficult to identify on traditional 2-dimensional periapical radiographs, meaning clinicians may only recognize this canal configuration upon encountering the unusual shape of the pulp chamber and its floor. However, with the growing use of cone-beam computed tomography (CBCT) in endodontic treatment planning, clinicians are now better equipped to detect and diagnose C-shaped canals prior to initiating treatment [7].

Several researchers have sought to classify the various configurations of C-shaped canals. The initial classification was proposed by Manning and Melton, who identified 3 distinct categories. Fan et al. [8,9] later expanded this classification into 5 types, utilizing micro-CT to enhance analytical precision and accuracy. The most recent classification describes the following types (Table 1):

Table 1 – A classification of C-shaped root canals

Type	Description
Type 1 (C1)	The C-shape is continuous, with no interruptions or separations.
Type 2 (C2)	The C-shape is interrupted, resembling a semicolon, where both angles α and β are less than 60°.
Type 3 (C3)	Two or three separate canals are visible, with both angles α and β also measuring less than 60°.
Type 4 (C4)	A single round or oval canal is seen in cross-section.
Type 5 (C5)	No visible canal lumen, except possibly near the apex.

Due to the highly complex anatomy of C-shaped canals, morphometric studies focusing on this variation are essential to enhance the mechanical and chemical strategies for root canal cleaning and shaping procedures. A comprehensive description of the various morphologic parameters and anatomical variations within these root canal systems is still lacking [3]. Cleaning and shaping the canal can become even more challenging in the presence of flat fins characteristic of a C-shaped canal. Furthermore, while manual stainless-steel K-files may clean a larger portion of the canal walls in C-shaped configurations, this approach still has limitations [7].

This case series aims to describe the recovery of patients with the RCT of 3 mandibular second molars with different types of C-shaped root canal system configurations.

Case Report

Case 1

A 47-year-old female patient, whose medical status was noncontributory was referred to the Department of Endodontics at the Faculty of Dentistry, Akdeniz University. The patient had no systemic illness. After intraoral and radiographic examinations of the patient, a deep dentin caries was detected in the right mandibular second molar (tooth 47) (Figures 1b and 1c). The intraoral and radiographic examinations of the patient revealed deep dentin caries in tooth 47. Upon examining the obtained CBCT image, a C2 type C-shaped root canal system was identified in tooth 47. After obtaining informed consent from the patient, pulp capping treatment was initiated. Adequate anesthesia was administered, and the tooth 47 was isolated with a rubber dam to prepare an endodontic access cavity (Figure 1a). During the capping treatment, pulp perforation occurred while removing the carious tissue, and the treatment of the tooth 47 was completed with RCT. Working length (WL) was determined with a #10 K-type file using EndoRadar Pro (Woodpecker, Guilin, China). Root canal shaping was

completed using ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) X1, X2, and X3 in sequence. During the preparation, the root canals were irrigated with 2.5% sodium hypochlorite solution. After preparation, the apical portion was filled with ProTaper Next X3 (0.30/07) gutta-percha cone (Dentsply Maillefer) and Dia-Proseal sealer (Diadent, Cheongju, Korea), applied using the single cone technique. The Fi-P Obturation Pen (Woodpecker Obturation System, Woodpecker Medical Instrument Co., Guilin, China) was used to cut the gutta-percha to 4-5 mm short of the WL. The remaining root canal space was then backfilled with the Fi-G Obturation Gun (Woodpecker Obturation System, Woodpecker Medical Instrument Co., Guilin, China) (Figures 1d and 1e). The patient was subsequently referred to the Department of Prosthodontics for permanent restoration. The patient was scheduled for follow-up visits.

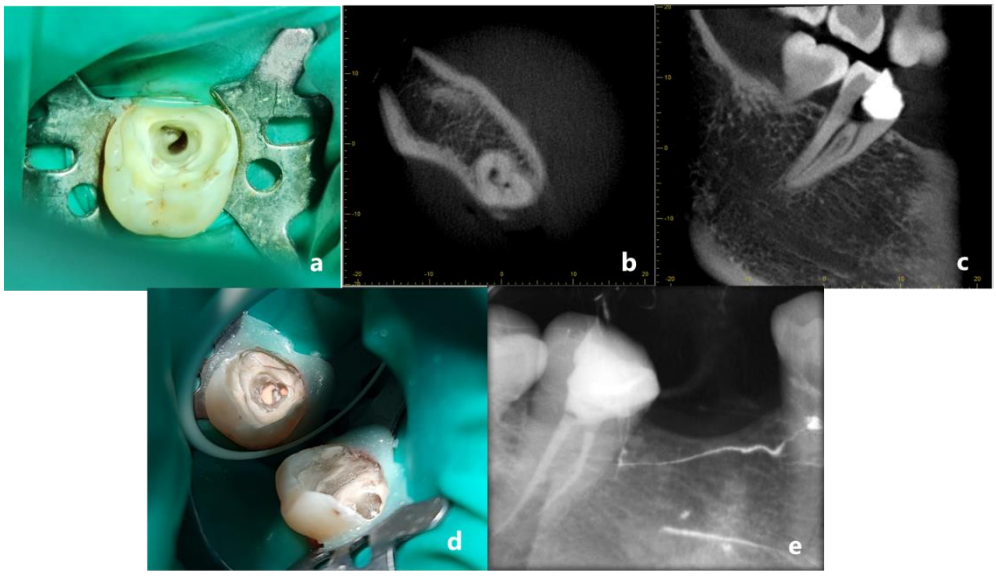

Figure 1 - (a) intraoral view of the tooth after access cavity opening, (b) axial and (c) sagittal CBCT images, (d) postoperative intraoral view, (e) after filling

Case 2

A 58-year-old male patient has presented to our clinic due to dental concerns. The patient's medical history revealed that the patient is using anticoagulant and antiarrhythmic medications. Informed consent was obtained from the patient, and RCT was initiated. Intraoral and radiographic examinations revealed an existing RCT in the right mandibular second molar, along with a radiolucent lesion in the periapical area. It was decided to perform retreatment on the tooth 47, which is classified as C4 type (Figures 1a and 1b). During the initial visit, the previous root canal filling was removed, and calcium hydroxide was employed as an intracanal medicament. 10 days later, during the second visit, apical preparation was performed using the ProTaper Next X4 file. During the preparation, the root canals were irrigated with 2.5% sodium hypochlorite solution. The apical portion was filled with ProTaper Next X4 (0.40/06) gutta-percha cone and Dia-Proseal sealer, applied using the single cone technique. The Fi-P Obturation Pen was used to cut the gutta-percha to 4-5 mm short of the visit. The remaining root canal space was then backfilled with the Fi-G Obturation Gun (Figures 2c and 2d). The patient was subsequently referred to the Department of Prosthodontics for permanent restoration. The patient was scheduled for follow-up visits.

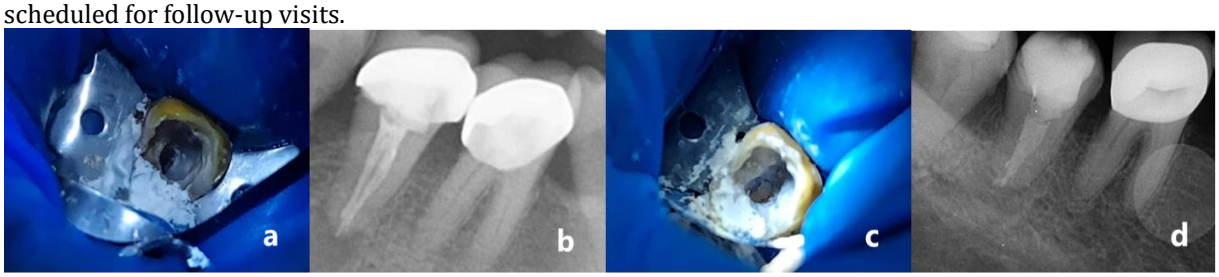

Figure 2 - (a) intraoral view of the tooth after access cavity opening, (b) preoperative radiograph, (c) postoperative intraoral view, (d) after filling.

Case 3

A 46-year-old female patient presented to our clinic due to dental concerns. The patient's medical history revealed no systemic illness. The vitality test performed on the affected tooth returned a negative response. After radiographical examination and CBCT scans, a C3 type C-shaped root canal system was identified in the tooth 47

(Figure 3b). Additionally, condensing osteitis was observed in the periapical region of the tooth. A 2-visit RCT was planned. The canals were prepared using the ProTaper Next X2 files (Figure 3a). During the preparation, the root canals were irrigated with 2.5% sodium hypochlorite solution. In the first visit, calcium hydroxide was used as an intracanal medicament. The canals were filled with ProTaper Next X2 (0.20/06) gutta-percha cone and Dia-Proseal sealer using lateral condensation as the obturation technique (Figures 3c and 3d). The permanent restoration was completed using composite resin (Estelite Sigma Quick, Tokuyama Dental, Tokyo, Japan)

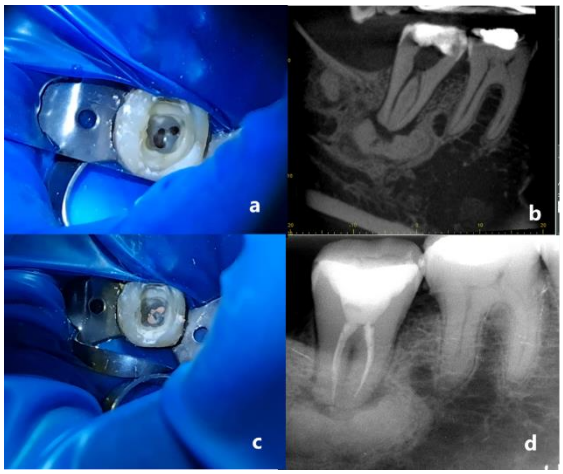

Figure 3 - (a) intraoral view of the tooth after access cavity opening, (b) saggital CBCT image, (c) postoperative intraoral view, (d) after filling

Discussion

In this case series, we discussed the management of C-shaped root canals, a rare and complex anatomical variation seen in Endodontics. C-shaped canals, which are most commonly present in mandibular molars, have a distinct configuration that might make cleaning and filling more difficult. The cases described in this series highlight the importance of accurate diagnosis, proper treatment planning, and the use of appropriate instrumentation to achieve successful outcomes.

The variation in root canal morphology poses a significant challenge for both endodontic diagnosis and treatment. Fan et al. [9] conducted an analysis of the C-shaped canal system using micro-CT and proposed modifications to its classification. They defined the C-shaped canal system as exhibiting three key characteristics: (i) fused roots, (ii) a longitudinal groove on either the lingual or buccal surface of the root, and (iii) at least one cross-sectional canal configuration corresponding to C1, C2, or C3. Their findings indicated that although the C3-type orifice may appear as 2 or 3 separate openings, an isthmus linking these orifices is often detectable.

The morphological variation of a single root and single canal can be easily identified through routine radiographs [10]. For this reason, we did not request CBCT images in case 2. The RCT of C-shaped root canals necessitates a precise instrumentation strategy due to the challenges associated with disinfecting, while preserving the integrity of the root structure. To address this, 3D imaging was employed to assess the aberrant anatomy prior to chemomechanical preparation. Based on CBCT scans taken from the patients, the appropriate instrumentation size and taper for each canal were determined, ensuring adequate mechanical instrumentation while minimizing the risk of excessive dentin removal [11].

In C-shaped canals, intracanal disinfection and filling of the canals are difficult due to differences in root canal anatomy. Effective cleaning of narrow canal isthmuses can be achieved with small files and 5.25% SH, and ultrasonic techniques may improve canal debridement. However, excessive instrumentation with ultrasonics can lead to perforation in the narrow C-shaped canal ramifications [12].

Obturation of C-shaped canals may require modifications to standard techniques, especially for sealing the buccal isthmus, which is challenging with lateral condensation alone. Thermoplasticized gutta-percha, delivered by heated spreaders or injectable systems, is more suitable for this purpose, while proper sealer placement using ultrasonic endodontic files is essential for effective filling, regardless of the filing technique [13].

While such variations are not frequently encountered, their impact on the prognosis of individual cases should not be underestimated. Clinicians must be vigilant in recognizing atypical root morphologies and canal configurations, ensuring that all canals are identified and treated to prevent incomplete root canal preparation and subsequent treatment failure [14]. In a study investigating the presence of C-shaped canals in Turkish sub-population, Kaplan et al. [15] found that of the 1348 mandibular second molars evaluated, 10.7% had C-shaped root canals, which was notably high. C-shaped root canals appeared to be significantly more common in females than in males. According to their study, C2 type radicular groove was the most common, observed in 45.1% of cases. CBCT imaging can assist in identifying C-shaped canals and their configurations effectively. The findings of

their study are consistent with those reported by Nejaim et al. [16] in studies conducted on a Brazilian subpopulation.

Conclusion

This article reports 3 cases of treatment involving C-shaped mandibular second molars. These cases underscore the importance of comprehensive knowledge of such anatomical variations, which can aid in determining the potential root and canal configurations. Additionally, thorough preoperative clinical examination, careful interpretation of radiographs from various angles, the use of necessary CBCT imaging, and a meticulously planned and executed treatment approach are all critical for improving the prognosis of RCT.

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