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Mandibular second premolar with C-shaped canal diagnosed with CBCT technology: case report with 24 months of follow-up

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ABSTRACT

Root canal anatomy can greatly vary by tooth and among teeth with the same type. The aim of this case report was to describe the management of a C-shaped canal in 21-year-old male Saudi patient presented with severe pain in the left second premolar mandibular tooth. It was diagnosed with cone beam computed tomography (CBCT). The C-shaped configuration exhibited fins, web-like connections, or an elongated ribbon-shaped appearance, which rendered cleaning, shaping, and obturation difficult. The use of modern endodontic tools, such as CBCT system; dental operating microscope, which facilitates cleaning and shaping; and bioceramic sealers accelerated sealing and healing. After 24 months of follow-up, clinical and radiographic evaluation revealed the absence of signs and symptoms; reduction in the size of the periapical lesion; and starting of complete healing.

Keywords: C-shaped canal, mandibular second premolar, root canal morphology, vone-beam computed tomography, Saudi patient

Abbreviations
CBCT – Cone beam computed tomography
DOM – Dental Operating Microscope
NM – No Mentioned
OPG – Orthopantomography
RCT – Root Canal Treatment

INTRODUCTION

Successful root canal treatment (RCT) requires a thorough understanding of root canal anatomy, pulp chamber floor assessment, radiograph interpretation, chemo-mechanical planning, and three-dimensional obturation of the root canal system (RCS) [1]. Even in teeth that are unsusceptible to irregular root canal formation, the possibility of abnormal morphology should be considered [1]. To ensure a positive outcome, practitioners must have a comprehensive understanding of root canal anatomy and complexities because the improper handling of the RCS can lead to procedural failure [2].

Premolars exhibit distinct characteristics and frequently show anatomical variations in the number of root canals and roots. C-shaped canals render diagnosis and treatment difficult [3]. The prevalence rates of C-shaped canals in mandibular first and second premolars were 2.3% and 0.6%, respectively, in Western Europe [4]; 3.3% and 1.0%, respectively, in Australia [5]; 4.58% and 1.13%, respectively, in Turkiye [6]; and 1.5% and 0.80%, respectively, in other countries [7]. However, mandibular premolars in a

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Saudi Arabian (SA) population revealed higher prevalence rates (17.4% and 7.4%, respectively) [8]. The first mandibular premolar more often shows altered root and canal morphology than the second mandibular premolar [9]. Karobari et al. [10] evaluated 1230 premolars and recorded the presence of C-shaped canals in 0.40% of the mandibular second premolars and the absence of C-shaped canals in the mandibular first premolars.

The complexity caused by C-shaped canals poses considerable anatomical challenges to RCTs. These canals are difficult to detect through conventional two-dimensional periapical radiography [3]. Therefore, the limited field of view provided by CBCT enhances RCT planning by enabling clinicians to accurately detect and diagnose C-shaped canals before a procedure is initiated [11]. However, even after the recognition of a C-shaped canal, cleaning, shaping, and obturating RCS are difficult throughout an RCT [12]. Recent advancements in endodontic techniques have enhanced the management of complex canal configurations. The incorporation of rotary and hand instrumentation and the use of DOM, CBCT, and modifications in obturation techniques ensure a 3D fill of the canal system [12].

C-shaped mandibular premolars in SA were presented by Al-Mahroos et al. [13], and anatomical variations in canal morphology have been documented in many cases. Table 1 shows the characteristics of case reports involving Saudi patients [1,11,13-16] and corresponding authors' names, cities, gender, and patient ages, premolar location, diagnosis at the time of treatment, and canal classification according to previous and recent systems [3,17-19]. Parameters, such as ratio between the number of canals and roots, locations of radicular grooves, methods for canal assessment and visualization, and main treatment outcomes after different periodical follow-up periods have been proposed. This paper aims to illustrate the diagnosis and management of left mandibular second premolar with a C-shaped canal with a modern endodontic technology with two years follow-up.

CASE REPORT

A 21-year-old male Saudi patient visited the endodontic clinic at Abha City in SA, with a chief complaint of severe spontaneous pain associated with the lower left posterior teeth. The patient's medical history was noncontributory, and no significant finding was obtained on extra-oral assessment. The past dental history revealed multiple simple restorations in the lower mandibular region.

Clinical examination showed that 34# and 35# were previously treated, but 35# responded negatively to a cold test (Endo-Frost, Coltene Whale Dent, Germany) but positively to percussion. In addition, no mobility and no involvement to the periodontal tissue were observed. A preoperative radiograph revealed coronal carious radiolucency involving the pulp with large periapical radiolucency associated with 35#. Additionally, the middle part of the root canal seemed to have disappeared on the periapical radiograph. This phenomenon was called the fast-break phenomenon (Figure 1.A). Therefore, a CBCT instrument with a limited field of view was used in the lower left quadrant. The presence of C-shaped canals with buccal external groove was confirmed, and the common coronal canal diverged into three canals in the middle third (Figures 1.B–D). These canals subsequently converged in the apical third, ultimately emerging through the same foramen (Figure 1.E). According to the classification proposed by Ahmed et al. [17], the tooth had single root, one orifice, three canals in the middle, and one apical foramen (1351-2-1), or it had on cross-section C4b on the coronal third, C5 in the middle third, and C4a in the apical third according to the classification proposed by Fan et al. [3].

Clinical and radiographical examination confirmed pulpal necrosis with symptomatic apical periodontitis. Thus, endodontic treatment was established after the patient received a thorough explanation of the treatment plan and extensive discussions regarding potential complications during treatment and the likelihood of success and failure in root canal procedures. The patient signed a consent form.

Treatment was started by local anesthesia administration and rubber dam isolation. The old defective restoration was removed, and endo Z-bur (Dentsply Maillefer, Ballaigues, Switzerland) was used to modify the access cavity. A C-shaped canal configuration was confirmed under a dental operating microscope (DOM), and the canal was hardly negotiated by 10 K-files (TG Company, China). An apex locator (Root ZX II, J. Morita, Tokyo, Japan) was used for working length determination. The root system was cleaned and shaped with the ProTaper next files (Universal, Gold; Tulsa Dental, Tulsa, OK), and copious irrigation with 5.25% sodium hypochlorite solution and 17% ethylenediaminetetraacetic acid (Meta MD - Cleanser 17% EDTA) was performed. Intracanal medication was conducted during the initial appointments. In the second appointment, the tooth was asymptomatic, and the root canals were dried. Obturation was performed with matching gutta-percha cones (META Biomed, USA) and bioceramic root canal sealer CeraSeal (META Biomed, USA).

The patient presented for regular follow-up showed improvement in signs and symptoms and responded normally to a percussion test. The healing of the apical tissue was observed in preapical radiographs were collected at 3, and 12 months

Author, year/city	Gender/ age	Tooth location, tooth type	Diagnosis	Classification used/root canal configuration	Canals: Roots/ location of radicular groove	Methods of canal visualization	Treatment conclusion and outcome
This case, 2024/ Abha	Male/21	Left, second premolar	Pulp necrosis with symptomatic apical periodontitis	Fan et al./coronal third: C4b, middle third: C5, apical third: C4a Ahmed et al./1351-2-1	3:1/buccal	Periapical, CBCT, and DOM	Reduction in lesion size and absence of clinical symptoms after 24 months
Albader et al. [14], 2022/ Riyadh	Female/18	Left, second premolar	Retreatment due to pain	Fan et al./middle third: C1 and C2, apical third: four independent root canals	4:2/ mesio-lingual	Periapical and CBCT	NM
Shah SA [15], 2022/ Ar-Rass	Female/20	Right, second premolar	Symptomatic apical periodontitis	Vertucci/type V	2:1/NM	OPG, periapical, CBCT, and dental magnification loupes	After 1 year showing the resolution of peri-apical lesion.
Al-Mahroos, et al. [11], 2022/ Dammam	Female/23	Left, first premolar	Necrotic pulp	Fan et al./coronal third: C1, middle third: C2, apical third: C4b Vertucci's/type III	1:1/ mesio-lingual	Periapical, CBCT, and DOM	All cases presented with 1 year with no signs and symptoms and showed normal response to palpation and percussion tests
		Left, second premolar	Failure of the pre-vious RCT	Fan et al./ Coronal third: C1, middle third: C2, apical third: C4b Vertucci's/type III	1:1/ mesio-lingual	Periapical, CBCT, and DOM	
	Female/32	Left, first premolar	Previous pulp therapy with nor-mal apical tissue.	Fan et al./Coronal third: C1/ middle and apical, third: C3 Vertucci's /type V	2:1/ mesio-lingual	Periapical, CBCT, and DOM	
	Female/45	Left, second premolar	Retreatment due to failure of pervi-ous RCT	Fan et al./ coronal third: C1, middle third: C5, apical third: C4a Vertucci's/type XVII	3:1/NM	Periapical and DOM	
Alzahrani [16], 2021/ Albaha	Male/46	Right, first premolar	Symptomatic irreversible pulpitis	Gulabivala et al./ type II	3:1/NM	Periapical and magnifying loups	NM
	Male/29	Left, second premolar	Faulty initiated therapy with asymptomatic apical periodontitis	Gulabivala et al./ type VI	4:2/NM	Periapical and magnifying loups	NM
Alfahadi et al. [1], 2020/ Riyadh	Male/20	Left, first premolar	Symptomatic apical periodontitis due to failure of RCT	Vertucci/type V	2: 1/ NM	Periapical and DOM	NM
Al-Mahroos et al. [13], 2016/ Dammam	Male/29	Left, first premolar	Necrotic pulp	Vertucci/type V Fan et al./coronal third: C1, middle and apical third: C3	2:1/NM	Periapical and DOM	At 1 year, patient reported with asymptomatic tooth and normal apical tissue
		Left, third premolar	Previously treated	Vertucci/type III	2:1/NM	Periapical and DOM	

NM, No Mentioned; DOM, Dental Operating Microscope; OPG, Orthopantomography; RCT, Root Canal Treatment

(Figures 2 A & B). After 24 months follow-up, a CBCT was obtained. It showed a reduction in the preapical lesion size and absence of clinical symptoms (Figure 3). The patient was scheduled for further recall appointments for monitoring the preapical lesion.

DISCUSSION

One of the key factors in successful RCT outcomes in mandibular premolars is having a thorough knowledge of the variation and anatomical complexity of the RCS. Variations in the number and

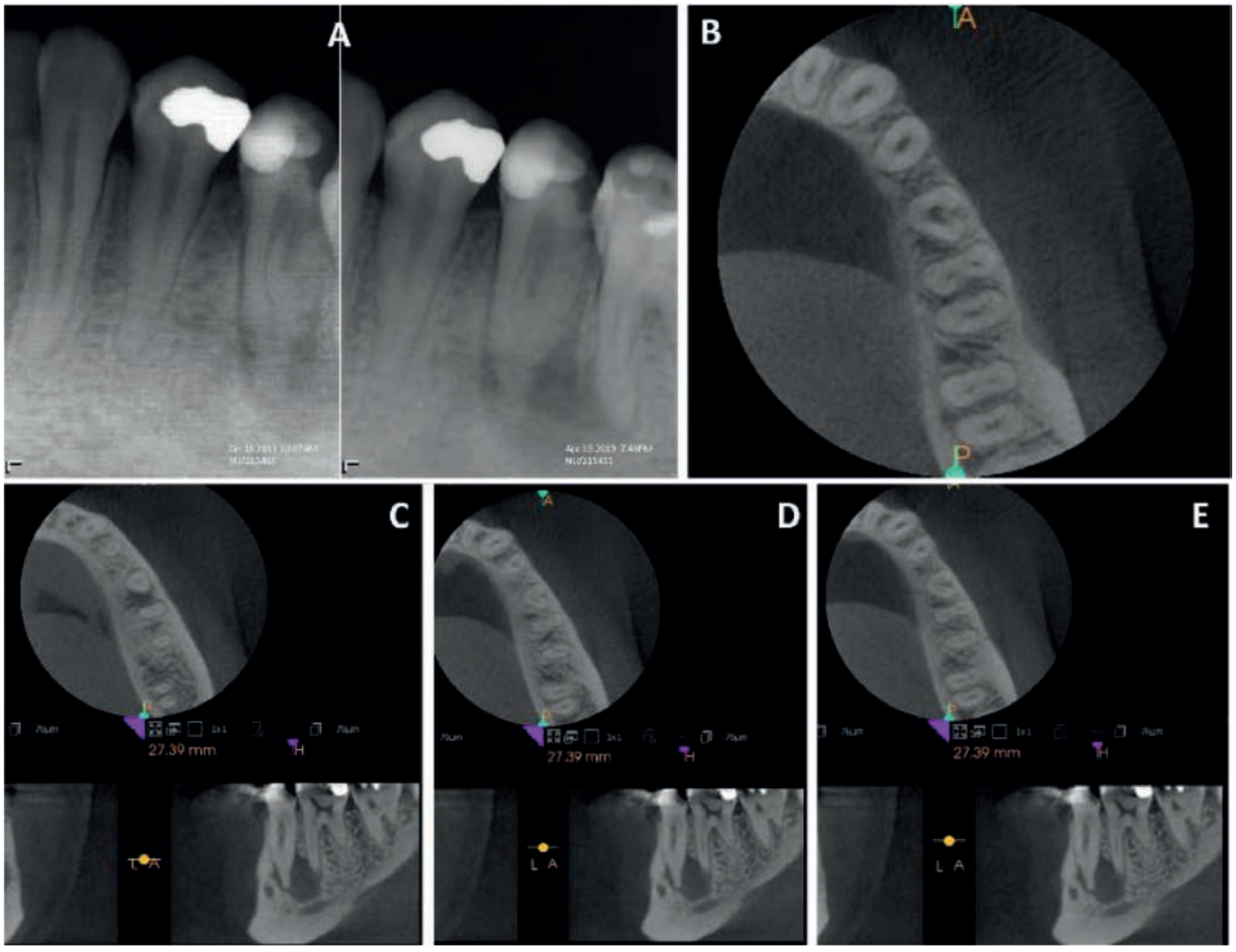

FIGURE 1. Preoperative radiographic assessment, apical lesion associated with 35# (A), CBCT scans reveal C-shaped canal on coronal third with buccal groove (B), three canals in the middle third along with apical lesion (C and D), one apical foramen at end of canal (E)

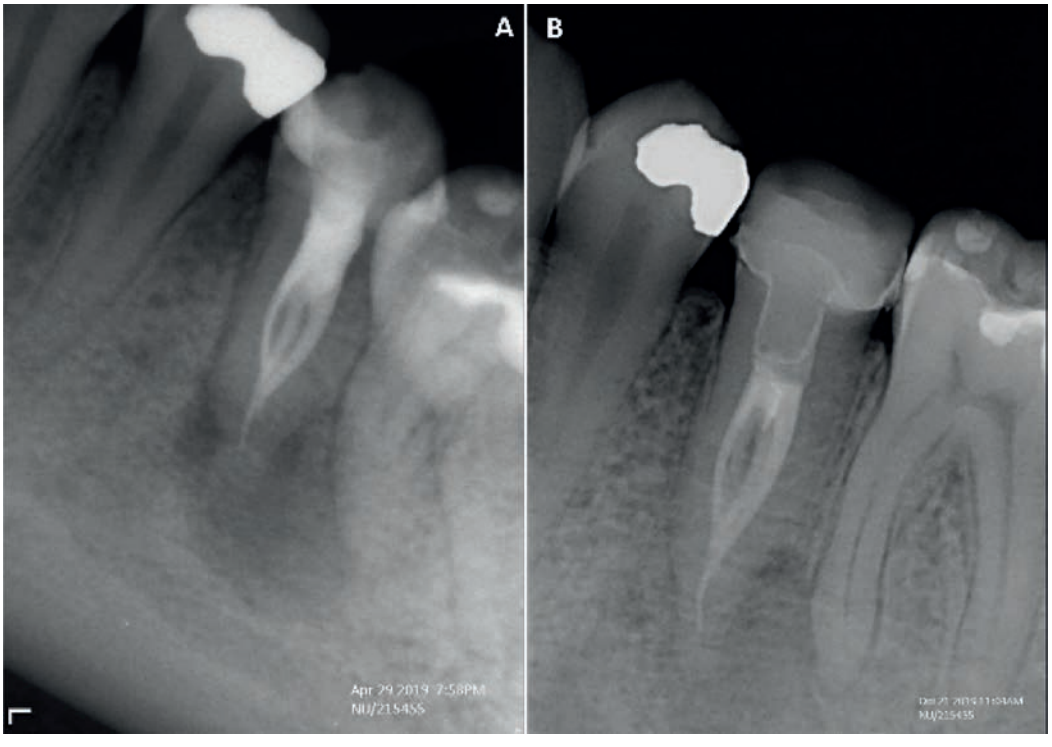

FIGURE 2. Follow-up radiographs showed the healing of the apical lesion: after 3 months (A), after12 months (B)

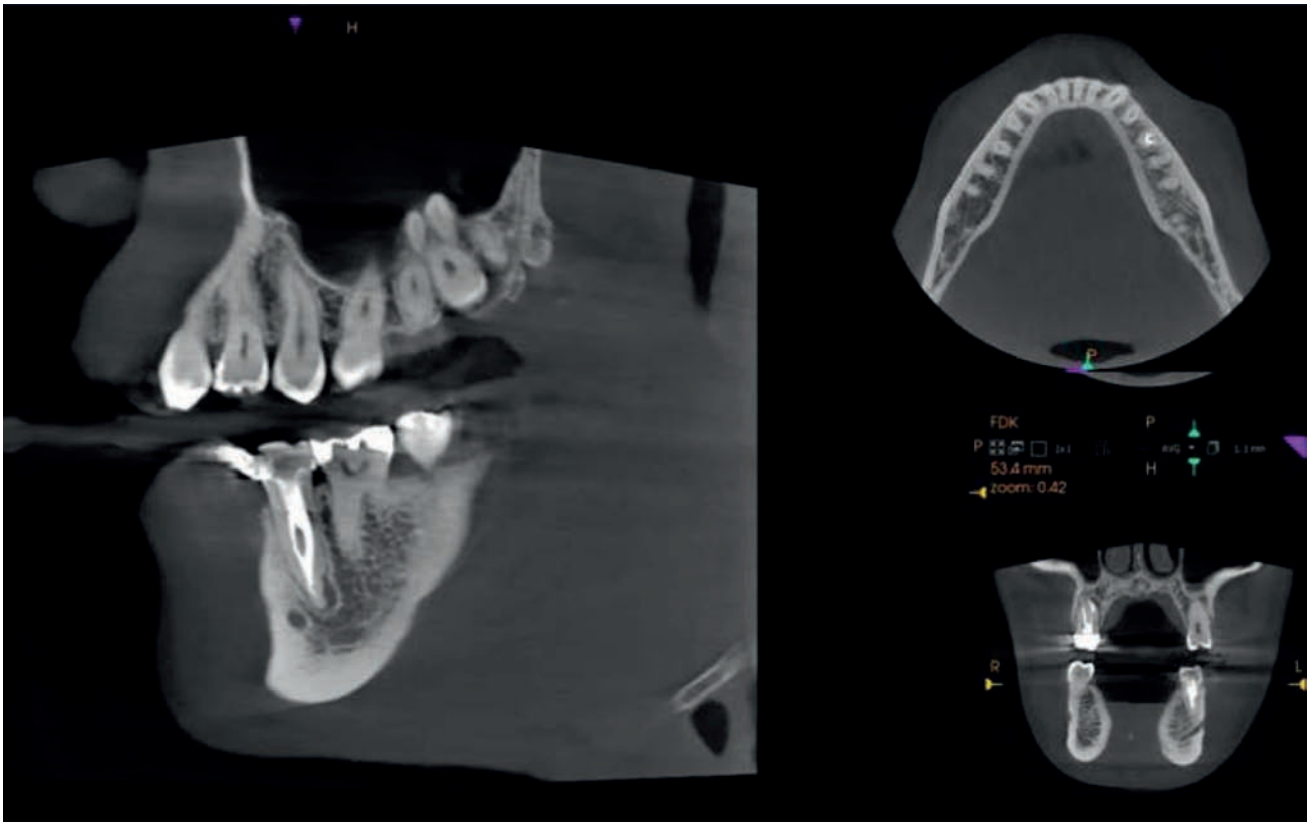

FIGURE 3. Reduction in the size of the apical lesion after 24 months

shapes of the canals are common and hinders treatments [12]. Thus, DOM and CBCT greatly benefit the diagnosis of anatomical variations. This case report described the management of a C-shaped canal associated with the mandibular left second premolar and 24-months follow-up period.

A mandibular premolar typically has a single canal, but two or more canals may form [9]. Additionally, a distinctive C-shaped canal configuration, resembling the letter C in cross-section, can be found in mandibular premolars. This configuration occurs more frequently in the first premolars than in the second premolars [4–7] although C-shaped canal morphology is more commonly associated with mandibular second molars [20]. Therefore, CBCT is highly recommended to ensure proper RCT for symptomatic mandibular premolars.

The interpretation of conventional radiographs facilitates the detection of unusual anatomical features. However, it is often insufficient in providing a comprehensive visualization of complex RCS [21]. Therefore, advancements in dental imaging techniques, such as CBCT scanning, are valuable to the exploration of the C-shaped canal configuration in large samples and potentially challenge the findings of traditional investigations [8, 10]. In the present case, the sudden discontinuity of the canal or the fast-break phenomenon was indicative of the presence of complex morphology. Thus, CBCT scanning was used in other reported cases [11,14,15].

Table 1 summarizes the published cases in SA from 2016 to 2022 and reveals morphological variations among premolars and between genders. Moreover, this case was similar to most published cases with regard to the side of the unusual canal configuration and tooth site, which was the left side [1,11,13–14, 16] and second premolar [11,14–15, 19], respectively. In addition, C4b canal configuration at the coronal third in this particular case was consistent with previous studies [3,7]. However, other studies reported a different pattern; the C1 configuration was predominant in the coronal third [11,13,14].

Typically, developmental grooves form on the mesial and distal surfaces of the roots of mandibular premolars, and the formation of C-shaped canals is closely linked to the presence and size of these root grooves, which are caused by the incomplete fusion of Hertwig's epithelial root sheath in the buccal or lingual surface of the root [12]. These radicular grooves are mostly found on the mesial side of the root, and the mesial walls of a C-shaped canal are thin in these sides near the radicular groove of the walls, especially at the lingual sites [22–23]. However, the radicular groove in the present case was located on the buccal surface, which was the thinnest among the walls. This groove was in the emesio-lingual wall in other cases [11,14].

C-shaped canal poses challenges to instrumentation using most types of NiTi rotary files because of its irregular configuration. Thus, a biomechanical

preparation technique that combines NiTi instrumentation, ultrasonic irrigation, and intracanal medications is recommended. This approach ensures the establishment of a sterile environment prior to obturation and promotes optimal treatment outcomes [24,25]. For the present case, these guidelines were strictly followed during treatment, and bioceramic sealers were used, which improve long-term prognosis by minimizing leakage and enhancing periapical healing [26].

RCT outcomes should be assessed every 6 months for 2–5 years. This approach facilitates the identification and resolution of post-operative issues that may negatively affect a patient [27]. In the present case, 2 years of regular follow-up was conducted, which was longer than the follow-ups documented previously [11,13,15]. The clinical significance of this case is that it demonstrated the importance of knowledge of basic anatomical morphology and the appropriate utilization of radiographic imaging, such CBCT, in the evaluation of the complexity associated with mandibular premolars. This evaluation procedure helps to prevent tooth damage and to prevent complications associated with endo-surgery or extraction.

CONCLUSION

Mandibular second premolars may present with complex anatomical variation, particularly those exhibiting radicular grooves and C-shaped roots. Thus, the utilization of modern diagnostic techniques, such as CBCT and dental microscopy, facilitates the early identification of morphological variations. Additionally, the development of rotary and hand instrumentation, combined by the use of ultrasonics and modified obturation techniques, has improved the prognosis of C-shaped root canals.

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