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CASE REPORT

ENDODONTIC TREATMENT OF CHRONIC APICAL PERIODONTITIS OF THE MANDIBULAR SECOND MOLAR WITH C-SHAPED ROOT CANAL CONFIGURATION IN AN ADOLESCENT PATIENT: A CLINICAL CASE

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Abstract

Background: C-shaped root canal configuration of the mandibular second molar is among the most challenging g anatomical variants in endodontic practice, with a reported prevalence of 8–45% depending on ethnicity. Its complex internal morphology - including isthmuses, lateral recesses, and a ribbon-like canal space -substantially impedes complete mechanical debridement and promotes persistence of microbial biofilm. In adolescent patients, chronic apical periodontitis associated with such anatomy frequently follows an asymptomatic course and may be discovered incidentally on routine radiographic examination.

Objective: To present the clinical decision-making process, step-by-step treatment protocol, and 20-month radiographic outcomes of nonsurgical endodontic treatment of a mandibular second molar with C-shaped root canal configuration in a 14-year-old patient, with particular focus on the justification for single-visit treatment without calcium hydroxide dressing and the management of incidental gutta-percha extrusion.

Materials and Methods: A 14-year-old female patient was referred with asymptomatic chronic apical periodontitis of tooth 4.7, incidentally detected on routine periapical radiography. A C-shaped root canal configuration was identified clinically following access preparation. CBCT was deliberately omitted based on ALARA principles, absence of acute symptoms, and availability of adequate periapical radiographic data. Treatment was completed in a single visit under local anesthesia (4% articaine with epinephrine 1:100,000) and rubber dam isolation. Working length was determined electronically (E-Pex Pro apex locator) and confirmed radiographically. Canal preparation was performed with NiTi rotary instrumentation (SoCo system) to apical size 40.04. A structured three-step irrigation protocol was applied: 3% NaOCl with ultrasonic activation, 17% EDTA (60 sec), and 2% chlorhexidine as a final rinse, with intermediate saline flushes. Obturation was performed using lateral condensation with gutta-percha and a eugenol-free epoxy resin sealer (AH Plus, Dentsply Sirona, Germany). Calcium hydroxide dressing was not used.

Results: A minor incidental extrusion of gutta-percha beyond the apical foramen was noted intraoperatively without sealer extrusion. The patient remained completely asymptomatic throughout the follow-up period. Periapical radiography at 20 months confirmed complete resolution of the periapical lesion, normalization of the periodontal ligament space, and stable obturation without signs of material displacement.

Conclusions: Successful nonsurgical single-visit endodontic treatment of chronic apical periodontitis in a mandibular second molar with C-shaped root canal anatomy is achievable without CBCT or intracanal calcium hydroxide dressing when a structured chemo-mechanical protocol with irrigant activation is rigorously applied. The robust healing capacity of periapical tissues in young patients contributes to favorable long-term outcomes even in anatomically complex cases with minor procedural deviations. The presented protocol offers a reproducible, evidence-based, and radiation-conservative algorithm for managing similar cases.

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Keywords: C-shaped root canal configuration; chronic apical periodontitis; endodontic treatment; mandibular second molar; adolescent patient; periapical healing; activated irrigation.

INTRODUCTION

Chronic apical periodontitis is one of the most prevalent inflammatory conditions affecting the periapical tissues, with a reported radiographic prevalence of 25–52% in the adult population and a notably high occurrence in pediatric patients, in whom the disease frequently follows a clinically silent course [1,9]. Early detection often occurs incidentally during routine dental examination. The primary etiology is the persistence of polymicrobial infection within the root canal-particularly in zones resistant to standard instrumentation [1,4].

C-shaped root canal configuration is one of the most clinically significant anatomical variants in endodontic practice, most frequently identified in mandibular second molars. Its prevalence ranges from 8% to 45% depending on ethnic background — up to 31.5% in Asian and 8–10% in European populations [2,11,15,16]. The morphology results from a developmental failure of Hertwig's epithelial root sheath to fuse along the lingual surface, producing a continuous or partially segmented fin-shaped canal space with prominent isthmuses, lateral recesses, and pronounced internal variability [12,14]. Micro-computed tomography studies confirm that this anatomy is substantially more complex than conventional two-canal configurations, impairing complete mechanical debridement and promoting microbial biofilm persistence [2,3].

Given the limitations of mechanical instrumentation in complex canal systems, irrigation assumes central importance. A structured multi-step protocol — NaOCl for tissue dissolution and antimicrobial action, EDTA for smear layer removal, and CHX for sustained effect against resistant organisms such as Enterococcus faecalis — addresses all components of the infected canal [6,7]. Crucially, irrigant efficacy is substantially enhanced by activation techniques such as passive ultrasonic irrigation (PUI), which improve penetration into isthmuses, lateral canals, and apical deltas [7,19].

The question of intracanal calcium hydroxide dressing in single-visit versus two-visit endodontic treatment remains a subject of ongoing clinical debate. Although calcium hydroxide has long been advocated as an interappointment medicament for its alkaline antimicrobial and tissue-dissolving properties, recent randomized controlled trials have demonstrated comparable periapical healing outcomes between single-visit treatment and two-visit protocols with calcium hydroxide when adequate chemo-mechanical preparation is achieved [20]. This is of particular relevance in young patients, in whom the enhanced tissue repair capacity of periapical tissues may compensate for residual microbial load [5].

Accidental extrusion of root filling material beyond the apical foramen represents an intraoperative complication that has traditionally been regarded as a negative prognostic factor. However, accumulating evidence — including systematic reviews and long-term case series — indicates that limited extrusion of bioinert materials such as gutta-percha, in the absence of bacterial contamination and with intact host immune response, does not necessarily compromise the long-term outcome and may be managed conservatively through clinical and radiographic surveillance [4,8,17].

This age-centered perspective on treatment planning in complex endodontic cases is underrepresented in the current literature.

The aim of the present report is to describe the clinical decision-making process, step-by-step treatment protocol, and 20-month radiographic outcomes of nonsurgical single-visit endodontic management of chronic apical periodontitis of the mandibular second molar with C-shaped root canal configuration in a 14-year-old patient. Special attention is given to the rationale for omitting CBCT and calcium hydroxide dressing, the management strategy for incidental gutta-percha extrusion, and the role of patient age in determining the long-term prognosis. What distinguishes this report from the existing body of C-shaped canal literature is the central role of patient age as both a diagnostic and prognostic variable. The adolescent biological environment — characterized by enhanced periapical regenerative capacity — created conditions under which a conservative, single-visit protocol without CBCT or calcium hydroxide yielded complete healing, even in the presence of an incidental procedural complication.

This case therefore not only addresses anatomical complexity but also integrates biological age as a decisive factor in treatment planning—an aspect that remains insufficiently explored in contemporary endodontic literature.

CLINICAL CASE REPORT

A 14-year-old female patient presented to the dental clinic for a routine examination. She had no complaints at the time of the visit. Medical history was unremarkable. Clinical examination revealed a deep carious lesion on the occlusal surface of tooth 4.7. Percussion and palpation in the area of the tooth were

painless; no response to cold testing was elicited, indicating pulp necrosis. Periapical radiography (Fig. 1) demonstrated a periapical lesion in the apical third of the roots with widening of the periodontal space, consistent with chronic apical periodontitis. Based on the clinical and radiographic findings, a diagnosis of chronic apical periodontitis of tooth 4.7 was established.

Figure 1. Periapical radiograph of tooth 4.7. A periapical lesion with bone rarefaction is observed in the apical third of the roots (indicated by arrow). Note the widening of the periodontal ligament space.

Endodontic treatment was performed under local infiltration anesthesia (4% articaine with epinephrine 1:100,000) with mandatory rubber dam isolation. Following access cavity preparation and pulp chamber debridement, a C-shaped root canal configuration was identified clinically (Fig. 3): the canal system presented as a unified crescent-shaped space with prominent isthmuses and areas of pronounced anatomical constriction across the coronal and middle thirds, consistent with a Type II C-shaped morphology (Fan et al. classification) — defined as a canal system in which the mesial and distal canals remain fused, forming a continuous or semi-continuous crescent-shaped space without complete separation into discrete round canals. CBCT was deliberately omitted in this case in accordance with the ALARA (As Low As Reasonably Achievable) radiation protection principle. The patient's age, asymptomatic presentation, and availability of adequate periapical radiography constituted sufficient justification for this decision, in line with current evidence-based guidelines for CBCT use in endodontics [7]. The decision to omit CBCT was not taken lightly. It was grounded in three converging clinical realities: the patient's adolescent age, which mandates minimization of ionizing radiation exposure; the asymptomatic presentation with no clinical indicators of unusual anatomical complexity beyond what periapical radiography revealed; and the availability of tactile and radiographic diagnostic data sufficient for treatment planning. This approach aligns with the principle-based framework of the ESE (2019) and AAE (2015) guidelines, which restrict CBCT use to cases where two-dimensional imaging is demonstrably inadequate[7]. Diagnostic assessment was based on pulp chamber floor morphology, tactile feedback during instrument negotiation, and sequential periapical radiography, which collectively provided adequate information for treatment planning. It must be transparently acknowledged, however, that the omission of CBCT carries a diagnostic trade-off: the precise subtype of the C-shaped morphology, the true extent of isthmus anatomy, and the volumetric dimensions of the periapical lesion remained incompletely characterized without three-dimensional imaging.

Working length was established at 21 mm using an electronic apex locator (E-Pex Pro, Eighteeth, China) and confirmed with periapical radiography (Fig. 2). Canal patency was verified with a #8 K-file. Glide path was established with manual K-files to size #15. Coronal flaring was performed with orifice-shaping rotary files (08.17 taper) to improve straight-line access and irrigant delivery. Full canal preparation was subsequently completed with the NiTi rotary system SoCo (SoCo, China) using a crown-down technique to a final apical size of #40.04. Particular attention was given to uniform instrumentation of isthmuses and lateral recesses of the C-shaped space while preserving maximum root dentin volume. The canals were irrigated with 3% NaOCl (heated to 37°C, 2 ml per canal) after each instrument change, delivered via side-vented needles to maximize irrigant distribution while minimizing extrusion risk.

Figure 2. Periapical radiograph of tooth 4.7 with K-files inserted in root canals for working length determination (indicated by arrows). Working length: 21 mm.

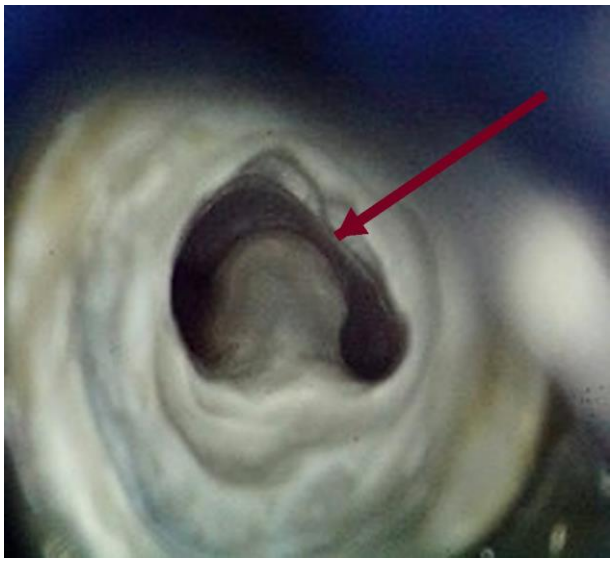

Figure 3. Photograph of canal orifices after coronal flaring of tooth 4.7 root canals, demonstrating Type II C-shaped configuration. Note the continuous crescent-shaped canal space with prominent isthmus (indicated by arrow) connecting the mesial and distal components.

A structured three-step chemical irrigation protocol was applied upon completion of mechanical preparation. Step 1: final irrigation with 3% NaOCl with passive ultrasonic activation (PUI) for 60 seconds per canal using an ultrasonic endodontic tip (Satelec P5 Newtron, Acteon, France; operating frequency: 25–30 kHz; used with size 15 endodontic file tip) to enhance penetration into isthmuses and lateral recesses [19]. Step 2: application of 17% EDTA solution for 60 seconds with sonic agitation to remove the smear layer and expose dentinal tubules, thereby improving sealer adhesion. Step 3: final rinse with 2% chlorhexidine gluconate (CHX) for sustained antimicrobial activity against resistant organisms including Enterococcus faecalis [18]. Between NaOCl and CHX irrigations, thorough intermediate flushing with sterile isotonic saline was performed to prevent para-chloroaniline formation, which carries cytotoxic risk and staining potential [7]. It should be noted that some authors advocate replacing CHX as a final irrigant with sterile saline or a final alcohol rinse to eliminate any residual PCA formation risk; however, the available evidence from randomized clinical trials supports the safety and efficacy of the NaOCl-saline-CHX sequential protocol when adequate intermediate saline flushing is performed [18]. All irrigants were delivered to the full working length via 30-gauge side-vented needles (Monoject, Covidien, USA) positioned 1–2 mm short of the apex.

The decision to complete treatment in a single visit without intracanal calcium hydroxide dressing was made on the basis of the following clinical considerations: (1) the patient was asymptomatic at presentation with no signs of acute exacerbation; (2) thorough chemo-mechanical preparation with activated irrigation was completed, providing adequate microbial elimination within a single appointment; (3) the robust healing capacity of periapical tissues in young patients reduces the biological demand for prolonged interappointment medicament [5]; and (4) a multicentre randomized controlled trial by Fonzar et al. (2017) demonstrated equivalent one-year radiographic healing outcomes between single-visit and two-visit protocols with calcium hydroxide dressing [20]. Single-visit treatment also eliminates the risk of coronal microleakage during the interappointment period and reduces the overall number of patient visits, which is particularly relevant in the pediatric population. These findings are further supported by a systematic review and meta-analysis by Su et al. (2011), which confirmed no statistically significant difference in periapical healing rates between single-visit and multiple-visit endodontic treatment of teeth with apical periodontitis, regardless of the use of intracanal medicament [22]. These findings are corroborated by the most recent Cochrane systematic review [21], which analysed 47 randomized controlled trials and confirmed no detectable difference in radiological success or complication rates between single- and multiple-visit endodontic treatment. The specific criteria applied for single-visit treatment selection in this case were: (1) asymptomatic presentation with confirmed pulp necrosis and no acute exacerbation; (2) absence of sinus tract, swelling or drainage; (3) ability to achieve complete chemo-mechanical preparation within one appointment; (4) systemically healthy, cooperative patient; and (5) absence of anatomical complications precluding complete preparation. When acute inflammation, exudate, or systemic immunocompromise are present, multiple-visit protocols remain the preferred approach. Clinicians should note that these selection criteria are essential; single-visit treatment is not universally applicable, and cases with acute exacerbation, incomplete preparation, or systemic immunocompromise require individualized assessment. It must be emphasized that the conclusions drawn from a single clinical observation cannot be generalized, and the presented protocol should be validated in larger prospective cohort studies before broad clinical adoption. After final drying of root canals with sterile paper points, a pre-obturation periapical radiograph with master cones in place was taken (Fig. 4). Obturation was performed using the lateral condensation technique with size 35.04 master gutta-percha points and a eugenol-free epoxy resin sealer (AH Plus, Dentsply Sirona, Germany; composition: epoxide-amine resin base, barium sulfate radiopacifier; eugenol-free; characterized by excellent sealing ability, low solubility, and proven biocompatibility). Accessory gutta-percha cones were added and thermal trimming was performed to ensure complete hermetic sealing. A photograph of the

completed obturation of canal orifices is shown in Fig. 5, demonstrating complete filling of the C-shaped canal space including the isthmus region — a critical indicator of obturation quality in C-shaped systems. During obturation, incidental minor extrusion of a small amount of gutta-percha beyond the apical foramen was noted, without sealer extrusion. In view of the bioinert properties of the filling material, absence of clinical signs of inflammation, and adequate disinfection of the root canal system, a conservative management strategy with dynamic follow-up was adopted. The final restoration was performed with light-cured composite resin Charisma Classic (Heraeus Kulzer, Germany). The final radiograph is shown in Fig. 6.

Figure 4. Periapical radiograph of tooth 4.7 before obturation with gutta-percha master cones in place. The master cones are visible within the C-shaped canal space (indicated by arrows), confirming adequate working length and canal filling coverage.

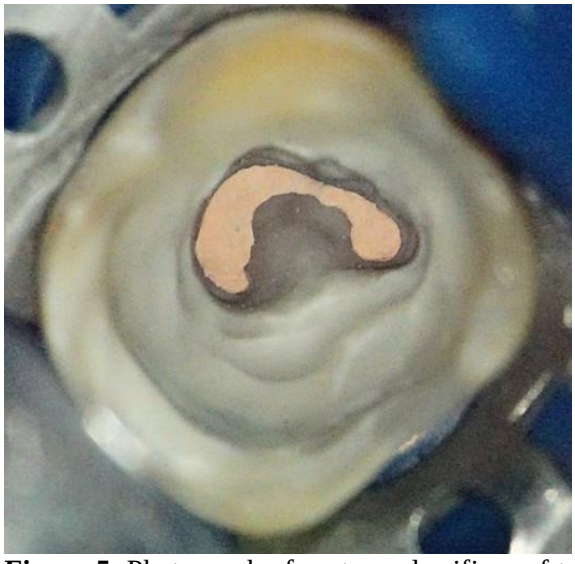

Figure 5. Photograph of root canal orifices of tooth 4.7 after completed obturation. The C-shaped canal space is filled with gutta-percha, confirming complete obturation of the isthmus and lateral recesses.

Figure 6. Periapical radiograph of tooth 4.7 after root canal obturation and composite restoration. Note the incidental minor extrusion of gutta-percha beyond the apical foramen (indicated by arrow). No sealer extrusion is observed.

The patient remained asymptomatic throughout the postoperative period. Follow-up radiographic examination at 20 months (Fig. 7) demonstrated complete resolution of the periapical lesion and normalization of the periodontal space, indicating a favorable long-term outcome of endodontic treatment.

Figure 7. Periapical radiograph of tooth 4.7 at 20-month follow-up after endodontic treatment. Complete resolution of the periapical lesion and normalization of the periodontal ligament space are evident (indicated by arrow). The extruded gutta-percha is no longer visible, consistent with progressive resorption.

DISCUSSION

The presented clinical case illustrates the successful nonsurgical endodontic management of chronic apical periodontitis in a mandibular second molar with C-shaped root canal configuration in an adolescent patient. The case is notable for four clinically relevant features

that collectively challenge conventional approaches: the presence of complex C-shaped anatomy identified without CBCT, the completion of treatment in a single visit without intracanal calcium hydroxide, the occurrence of incidental gutta-percha extrusion managed conservatively, and the complete periapical healing documented at 20 months. Each of these aspects warrants individual discussion.

1. C-shaped Canal Anatomy: Diagnostic and Therapeutic Implications

The C-shaped root canal system presents unique challenges at every stage of endodontic treatment. The continuous or semi-continuous canal space creates a fin-like configuration that conventional rotary instruments cannot fully negotiate, leaving islands of unprepared dentin and biofilm-laden tissue — most critically in the isthmus region [2,3]. In the present case, recognition of the C-shaped morphology was based on pulp chamber floor anatomy, tactile instrument feedback, and radiographic interpretation — without CBCT. While CBCT undoubtedly provides superior spatial resolution and three-dimensional anatomical mapping, current clinical guidelines from the European Society of Endodontology (ESE) and the American Association of Endodontists (AAE) recommend its use only when the benefit justifies the additional radiation dose [7]. For an asymptomatic adolescent with no acute pathology, the available two-dimensional radiographic and clinical data were sufficient to identify the C-shaped morphology and plan treatment accordingly. The successful outcome in this case validates this conservative diagnostic approach. The favorable outcome does not negate this diagnostic limitation — it reflects a fortunate convergence of adequate chemo-mechanical preparation and favorable adolescent periapical biology. Clinicians facing similar cases should apply the same ESE/AAE framework on an individual basis, recognizing that in more complex or symptomatic presentations, CBCT may be indispensable.

2. Irrigation Protocol and the Role of Irrigant Activation

The inadequacy of mechanical instrumentation alone in C-shaped canals is well-established in the literature [2,10]. The chemical irrigation protocol therefore constituted the cornerstone of treatment in this case. The sequential use of NaOCl (tissue dissolution, broad-spectrum antimicrobial), EDTA (smear layer removal, chelation of mineral components), and CHX (sustained biofilm inhibition) represents a synergistic approach that addresses all components of the infected root canal system. Of particular importance was the application of passive ultrasonic irrigation (PUI), which has been shown to significantly enhance irrigant penetration into isthmuses, lateral canals, and the apical delta — structures that are especially prevalent in C-shaped systems — compared to conventional syringe delivery [19]. The intermediate saline flush between NaOCl and CHX is a non-negotiable safety step: the two agents react to form the cytotoxic precipitate para-chloroaniline, which can cause periapical tissue damage and staining if introduced inadvertently [7]. The use of CHX as a final irrigant following NaOCl has been the subject of ongoing debate due to the potential formation of para-chloroaniline (PCA) when the two agents come into direct contact. However, the risk is effectively neutralized by thorough intermediate flushing with sterile physiological saline, as employed in the present case. A randomized clinical trial by Kurt et al. (2022) demonstrated that the NaOCl-saline-CHX sequential protocol achieves superior antimicrobial outcomes in one-visit treatment of mandibular molars compared to protocols omitting CHX, without adverse periapical tissue reactions [18]. The benefit of CHX — particularly its substantivity against Enterococcus faecalis — justifies its inclusion when the saline flush protocol is rigorously observed. An alternative approach advocated by some authors involves replacing CHX with a final 70% ethanol rinse, which effectively denatures residual proteins and provides antimicrobial action without any risk of PCA formation. However, ethanol lacks the prolonged substantivity of CHX against resistant biofilm organisms such as Enterococcus faecalis, which may be a relevant consideration in heavily infected canal systems.

3. Single-Visit Treatment Without Calcium Hydroxide: Evidence and Rationale

The omission of calcium hydroxide dressing remains a debated decision. Its high alkalinity (pH >12) disrupts bacterial membranes, denatures proteins, and dissolves organic tissue — yet its efficacy is reduced in anatomically complex systems where direct contact is limited [6]. Importantly, Fonzar et al. (2017) and subsequent trials have shown equivalent radiographic healing at one year between single- and two-visit protocols, provided adequate chemo-mechanical preparation is achieved [20]. In adolescent patients, the robust regenerative capacity of periapical tissues — greater cellularity, vascularity, and reparative potential — may further reduce the biological need for interappointment medicament [5,9]. Single-visit treatment also eliminates coronal microleakage risk and reduces procedural burden for young patients.

4. Incidental Gutta-Percha Extrusion: Prognosis and Management

The intraoperative extrusion of a small amount of gutta-percha beyond the apical foramen represents a recognized complication of root canal obturation, with a reported incidence of 5–20% in clinical studies. While traditionally regarded as an unfavorable outcome, the biological consequences of gutta-percha extrusion

depend critically on the nature of the extruded material, the volume extruded, the presence or absence of concurrent sealer extrusion, and — most importantly — the microbiological status of the root canal system at the time of obturation [4,8]. Gutta-percha is a bioinert thermoplastic material that does not elicit a significant foreign body reaction at low volumes and is subject to progressive encapsulation and resorption in the periradicular tissues over time, as documented in long-term case series by Malagnino et al. (2021) [17]. In the present case, the absence of sealer extrusion, the complete elimination of root canal infection prior to obturation, and the patient's age and immune competence collectively supported a conservative management strategy.The complete radiographic resolution of the periapical lesion at 20 months, despite the extruded gutta-percha, confirms that infection eradication — rather than the technical perfection of obturation — is the primary determinant of periapical healing [1,8]. It must be emphasized that the favorable outcome in this case should not be interpreted as evidence that gutta-percha extrusion is clinically insignificant. The biological consequences depend critically on multiple variables — including volume extruded, presence or absence of concurrent sealer extrusion, microbiological status of the canal at the time of obturation, and host immune competence — and differ substantially between cases. Minor extrusion of bioinert material in a disinfected canal, as in the present case, carries a fundamentally different prognosis than extrusion of sealer or infected debris. Conservative management is therefore appropriate only under carefully defined conditions, with structured follow-up at 6, 12, and 24 months.

5. Regenerative Potential in Adolescent Patients

Patient age is a clinically relevant factor in both treatment strategy and prognosis. Periapical tissues in young patients exhibit higher cellularity, greater vascularity, and more active bone remodeling than in adults [5,9]. These properties translate into a faster and more complete healing response following adequate endodontic treatment. Silva et al. (2022) demonstrated that healing rates in younger patients markedly exceed those in adults, even with larger periapical lesions [5]. This biological advantage likely contributed to the complete bone regeneration at 20 months and underscores the importance of timely diagnosis in this age group — particularly given the asymptomatic presentation common among young patients.

Limitations

This report describes a single clinical observation, and the conclusions drawn must be interpreted with appropriate caution. The absence of CBCT precludes a definitive three-dimensional characterization of the C-shaped anatomy and the precise volumetric assessment of the extruded material. Future studies involving larger patient cohorts, standardized CBCT-based canal classification, and extended follow-up periods (beyond 2 years) are needed to validate the generalizability of the presented protocol.

Taken together, this case reinforces a paradigm shift in contemporary endodontics—from a purely mechanical and technique-driven approach toward a biologically guided, patient-specific treatment model. The integration of conservative diagnostics, advanced irrigation strategies, and individualized clinical decision-making demonstrates that predictable outcomes can be achieved even in anatomically complex cases without reliance on advanced imaging or multi-visit protocols. Importantly, the findings emphasize that successful endodontic therapy is determined less by procedural perfection and more by effective microbial control and the biological capacity for healing.

CONCLUSION

The present case demonstrates that nonsurgical single-visit endodontic treatment of chronic apical periodontitis in a mandibular second molar with C-shaped configuration can achieve complete periapical healing at 20-month follow-up, without CBCT or intracanal calcium hydroxide. The key determinant was rigorous application of a three-step activated irrigation protocol — 3% NaOCl with ultrasonic activation, 17% EDTA, and 2% chlorhexidine — which offset the inherent limitations of mechanical instrumentation in this anatomy.

The incidental extrusion of a small amount of gutta-percha did not adversely affect the clinical outcome under conditions of complete microbial elimination and active periapical surveillance. The patient's favorable biological environment was a clinically significant contributing factor in the healing process. These findings support the application of single-visit endodontic protocols in selected asymptomatic young patients with anatomically complex root canal systems, provided that evidence-based irrigation standards are strictly observed.

The presented protocol — comprising ALARA-guided diagnostics, NiTi rotary instrumentation, ultrasonic irrigant activation, and single-visit obturation — offers a reproducible, evidence-based, and radiation-conservative algorithm for managing endodontic cases of similar complexity. Broader validation through prospective multicenter studies with standardized CBCT assessment and extended follow-up periods is warranted. What distinguishes this report from the existing body of C-shaped canal literature is the central role of patient age as both a diagnostic and prognostic variable. The adolescent biological environment — characterized by enhanced periapical regenerative capacity — created

conditions under which a conservative, single-visit protocol without CBCT or calcium hydroxide yielded complete healing, even in the presence of an incidental procedural complication. This age-centered perspective on treatment planning in complex endodontic cases is underrepresented in the current literature and warrants further investigation in prospective cohort studies with standardized age-stratified outcome reporting.

Future research should focus on age-stratified, multicenter prospective studies integrating clinical, radiographic, and biological parameters to further refine personalized endodontic treatment protocols for complex anatomical variations.

DECLARATION

Ethics approval and consent to participate: This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (revised 2013). As this report describes the clinical management of a single patient with standard-of-care treatment, formal ethics committee approval was not required under current institutional guidelines. Written informed consent was obtained from the patient's legal guardian prior to initiation of treatment, including consent for the use of clinical photographs and radiographic images for educational and scientific publication purposes in anonymized form. The written consent form was signed by the legal guardian, archived in the patient's clinical record at Dental Clinic "Smile Design", Kaspiysk, and is available to the journal editors upon request.

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Competing Interests

The authors declare no competing interests related to this publication.

Informed Consent

Written informed consent for publication was obtained from the patient's legal guardian. The patient's identity is protected through full anonymization of all clinical data and images.

Author Contributions

Gasanov Mark Arturovich — development of the clinical case concept, writing the main text of the article, clinical management of the patient.

Murtazaliev Kamil Ruslanovich — participation in data collection and editing of the article text.

Gasanov Murad Ilyasovich — collection and analysis of clinical data, preparation of discussion of results.

Mamaev Abdurashid Akhmedovich — assistance in the analysis of clinical data, peer review, preparation of the reference list.

Bilalov Islam Rustamovich — writing the discussion section, peer review of the text.

Rakhmanov Abdurakhman Ruslanovich — participation in writing the conclusion, provision and processing of clinical photographs.

Kurbanov Omi Ramazanovich — peer review and final text revision; scientific supervision.

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