

CASE REPORT

Treatment of Oehlers type III dens invaginatus in young permanent teeth: case reports

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Abstract

Background: Dens invaginatus (DI) is a developmental dental anomaly whose clinical manifestations and treatment plans vary depending on its type and severity. Type III DI is one of the primary pathways of periradicular infection. This report presents a series of cases of endodontic treatment of type III DI with periradicular lesions in young permanent teeth. **Cases:** Four cases with type III coronal DI (CDI) and periradicular lesions were included. Following oral and radiographic examinations, the patients underwent endodontic treatment. Among them, three cases accepted endodontic access to invaginations, chemomechanical instrumentation, medication, obturation, and periodontal surgical procedures when clinically indicated. The other patient also underwent main root canal treatment simultaneously. After long-term follow-up (1–3 years), all patients were free of clinical symptoms or positive clinical signs, with evidence of reduced or resolved periapical radiolucency and normal pulp vitality. **Conclusions:** By disinfecting and obturating the invagination canal, the pulp vitality of the affected type III CDI tooth can be preserved with minimal damage to the tooth structure, thereby promoting further root development in young permanent teeth.

Keywords

Dens invaginatus; Dens in dente; Young permanent teeth; Endodontic treatment; Pulp vitality

1. Introduction

Dens invaginatus (DI) is a developmental anomaly of teeth formed by the invagination of the crown/root surface before tissue mineralization [1, 2]. Excessive proliferation of the inner enamel epithelium and abnormal growth of the dental papillae are the main pathological features of DI; however, the specific etiology remains unclear. Most scholars believe that DI is affected by both genetic and environmental factors, and abnormal gene expression related to tooth development may cause changes in tooth growth and morphology [3]. The forces from adjacent teeth, trauma, and infection are also related to the occurrence of DI.

DI includes two categories: coronal and radicular DI, with the former being more common [4]. Oehlers further divided coronal DI (CDI) into three types based on radiological manifestations [5]. In type I, the invagination is minimal and limited to the crown. In type II, the invagination invades the pulp chamber or root canal in the form of a blind sac, without connection to the periodontal ligament but with connection to the pulp. In type III, the invagination penetrates the root, communicating with the periodontal ligament via a pseudo-foramen, named type IIIA, or an apical foramen, named type IIIB, without connecting to the pulp.

Treatment methods for Oehlers type III CDI are complex

and diverse. The location of the pseudo-foramen, pulp condition, degree of root development, periradicular status, and development of dentin are important factors that affect the treatment plan [6, 7]. After a secondary infection, there are many challenges in treatment owing to the complexity of the pulp chamber and the invaginated canal system of the affected tooth [8]. To the best of our knowledge, there are currently few, if any, well-established or evidence-based treatment strategies and guidelines for type III CDI. Our aim was to present a series of cases of endodontic treatment of type III DI with periradicular lesions in young permanent teeth and to summarize some identifiable patterns, thereby offering references for dental practitioners.

2. Case presentation

2.1 Case 1

An 11-year-old patient was referred to our department with the chief complaint of spontaneous pain and swelling of the left upper anterior tooth for 3 weeks.

Oral examination: The crown color of tooth 22 was normal, and the labial-lingual diameter was significantly increased. The response to the temperature test was normal. There was a fistula in the labial gingiva of tooth 22, and severe pain

on vertical percussion was observed. An access to the pulp chamber had already been made before the initial visit.

Radiographic examination: A periapical radiograph showed that the main canal was divided into two parts by an invagination (Fig. 1A). Cone-Beam Computed Tomography (CBCT) showed extensive destruction of the alveolar bone on the apical and labial sides of tooth 22, which had an invagination extending beyond the enamel-cementum junction and opening into the periodontal ligament through a pseudo-foramen in the apical third of the root; however, there was no obvious communication with the main root canal (Fig. 1B). The patient was diagnosed with type IIIA CDI and apical periodontitis.

Treatment: Pulpectomy of tooth 22 was performed under a microscope with infiltration anesthesia. Two narrow root canals were identified and probed in the mesial and distal regions. Further chemomechanical preparation was carried out with intermittent irrigation with 1% sodium hypochlorite solution, 3% hydrogen peroxide, and physiological saline. The canals were then addressed with calcium hydroxide. The pain was relieved after 2 weeks. The canals were obturated by warm vertical compaction with Gutta Percha and the AH Plus epoxy resin sealer (2209000297, AH Plus, Dentsply Sirona, York, PA, USA) (Fig. 1C,D). The orifice was sealed with a resin composite. At the third visit, one month later, a fistula was still observed, and there was no significant change in the area of radicular radiolucency. Periodontal surgery was used to control inflammation. Granulation tissue in the apical region was scraped off by flipping the lip flap. Mineral Trioxide Aggregate (MTA) (000200844, Dentsply Sirona, Tulsa, OK, USA), a calcium silicate-based material with good biological, antibacterial, and bioactive properties, was used for retrograde filling and restoration of the invagination (Fig. 1E,F). One week after the surgery, the sinus tract healed. The periapical shadows disappeared six months later. After two years of follow-up, there were no clinical symptoms or positive signs.

2.2 Case 2

An 11-year-old patient presented with a chief complaint of pain while chewing on the lower anterior teeth.

Oral examination: Conical protrusions were observed on the lingual surfaces of teeth 31 and 41 (Fig. 2A). The pulp sensitivity test was normal. Both teeth exhibited slight pain on vertical percussion and physiological tooth mobility.

Radiographic examination: A periapical radiograph showed periapical radiolucency in teeth 31 and 41, as well as invagination with a central invaginated canal extending from the pulp chamber to the apical foramen (Fig. 2B). CBCT images showed that the invagination and root canal existed independently in a concentric circular shape and that the main root canal was irregular (Fig. 2C). The patient was diagnosed as having type IIIB CDI and chronic periapical periodontitis.

Treatment: The coronal entrance of the invaginations on teeth 31 and 41 was searched using an endodontic explorer and a K-file under a microscope. Conservative endodontic access to the invagination was achieved, while the main root canal pulp was not exposed. Routine preparation of invaginated canals and intracanal medications were performed (Fig. 2B,D,E). At the second appointment, after 3 weeks, the

affected teeth had no clinical signs or symptoms. The MTA was packed in the apical third and confirmed radiographically. The patient was recalled a week later for final obturation with thermoplasticized gutta-percha. A coronal seal was ensured using zinc phosphate cement, followed by composite resin (Fig. 2F–H). At the 3-year follow-up, the patient was asymptomatic. The affected teeth showed a normal response in the pulp vitality test, and the results measured using the Laser Doppler Flowmeter were similar to those of the adjacent teeth.

2.3 Case 3

A 7-year-old patient was referred to our department with pain along with swelling of the mandibular incisors for 3 days. Incision and drainage of gingival abscess had been performed in the emergency department, and antibiotics were administered to control the infection.

Oral examination: A talon cusp could be seen on tooth 31 (Fig. 3A), which exhibited slight pain on vertical percussion and degree I tooth mobility. The response of the pulp to the temperature test was normal. CBCT examination revealed an irregular image of invagination extending from the crown to the apical foramen, which was not fully closed (Fig. 3B). The patient was diagnosed with type IIIB, CDI acute periapical periodontitis.

Treatment: Endodontic access to the invagination was achieved under a dental surgical microscope, and routine preparation was performed. Intracanal calcium hydroxide was placed for 2 weeks, at which time the tooth was asymptomatic, and iRoot SP Injectable Root Canal Sealer (23002SP, iRoot SP, Innovative BioCeramix, Vancouver, BC, Canada), composed of calcium silicate, calcium hydroxide, zirconium oxide, and bioactive glass, was injected into the invaginated root canal (Fig. 3C). A coronal seal was ensured using zinc phosphate cement, followed by composite resin (Fig. 3D). After 18 months of follow-up, no clinical symptoms or positive signs were observed (Fig. 3E,F). Radiographic imaging of the affected tooth revealed no periapical radiolucency. The main root canal thickened, and the open apex closed.

2.4 Case 4

A 12-year-old patient presented with a chief complaint of a gingival abscess on the right upper anterior tooth that had persisted for more than 2 years.

Oral examination: A barrel-shaped crown was observed on tooth 12, with invaginated pits on the lingual fossa. The tooth exhibited slight pain on vertical and horizontal percussion and a fistula on the labial gingiva. Sensitivity of the pulp to temperature was normal. CBCT examination showed concavity on the mesial sides of the root, communicating with the periodontal ligament via the pseudo-foramen, with a large area of periradicular radiolucency of approximately $8 \times 6 \times 5$ mm (Fig. 4A). Another “strip-shaped” discontinuous invagination that invaded the root canal in the blind sac was observed on the lingual side of the root canal. The patient was diagnosed with type II and type IIIA CDI with chronic periradicular periodontitis.

Treatment: During the first visit, we explored and unblocked the lingual invagination of type II CDI under a mi-

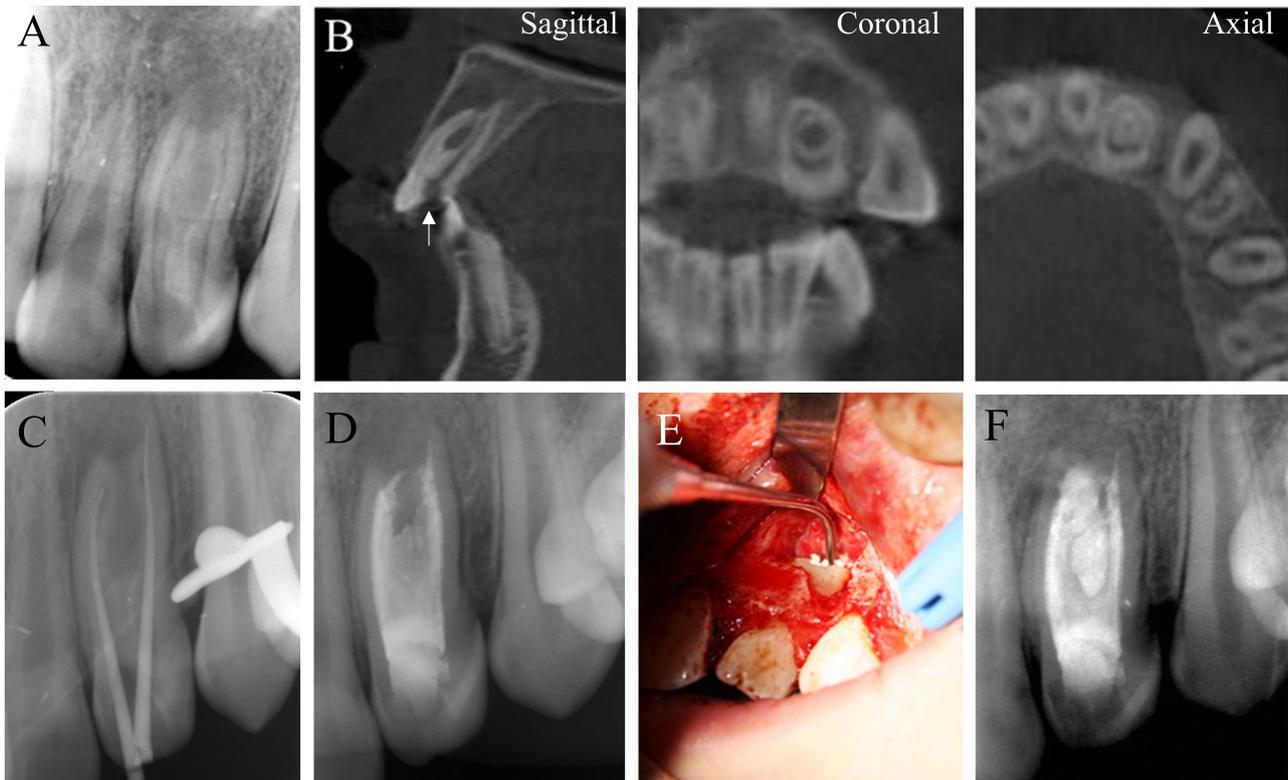


FIGURE 1. The treatment and radiographs of case 1. (A,B) Preoperative periapical radiograph and CBCT images of the CDI. White arrow indicated that an access to the pulp chamber had already been made before the initial visit. (C,D) Non-surgical root canal treatment with warm vertical compaction. (E) Periodontal surgery and retrograde filling of the invagination. The approach was made from the labial side. (F) Postoperative periapical radiograph after retrograde filling of the invagination.

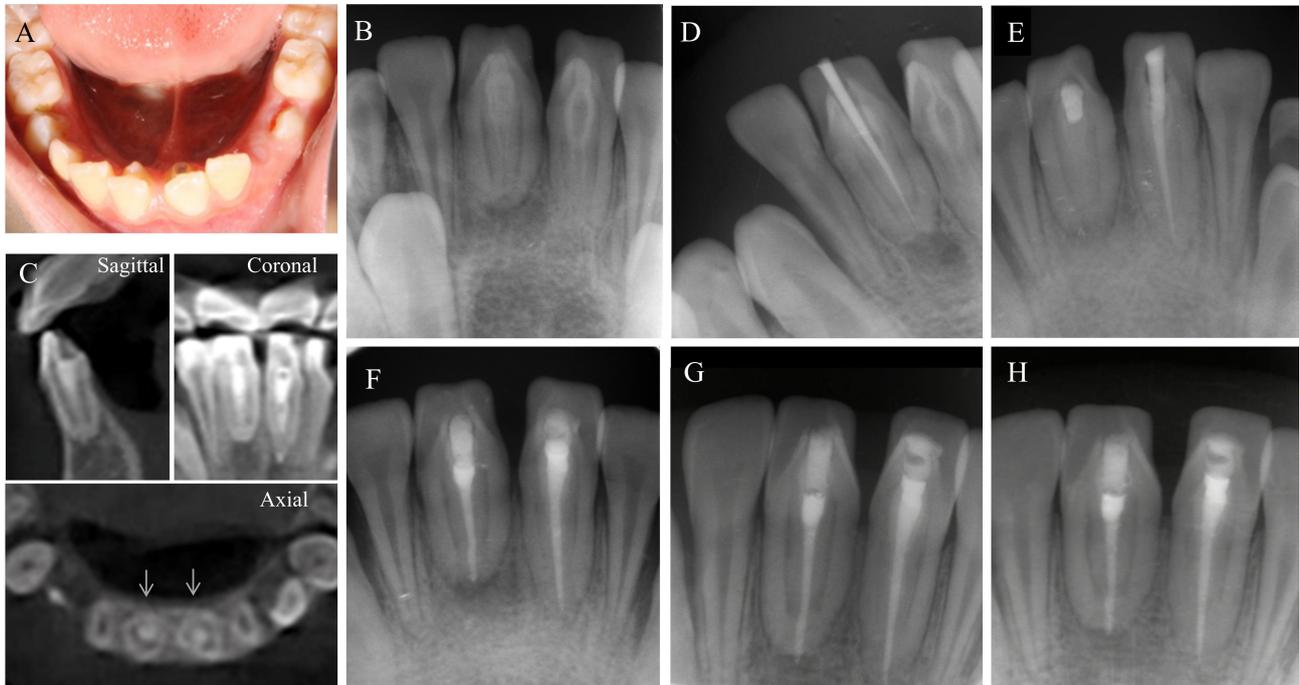


FIGURE 2. The treatment and radiographs of case 2. (A) Preoperative clinical views. (B) Preoperative periapical radiograph image of the invaginations. (C) Intraoperative CBCT images after intracanal medicament of invaginated canals. (D,E) Apical barriers and filling of the invaginations. (F–H) Postoperative radiographs after MTA and warm gutta-percha obturation of the invaginated root canal at 1, 3 and 6-month recall. It was observed that periapical lesions healed over time.

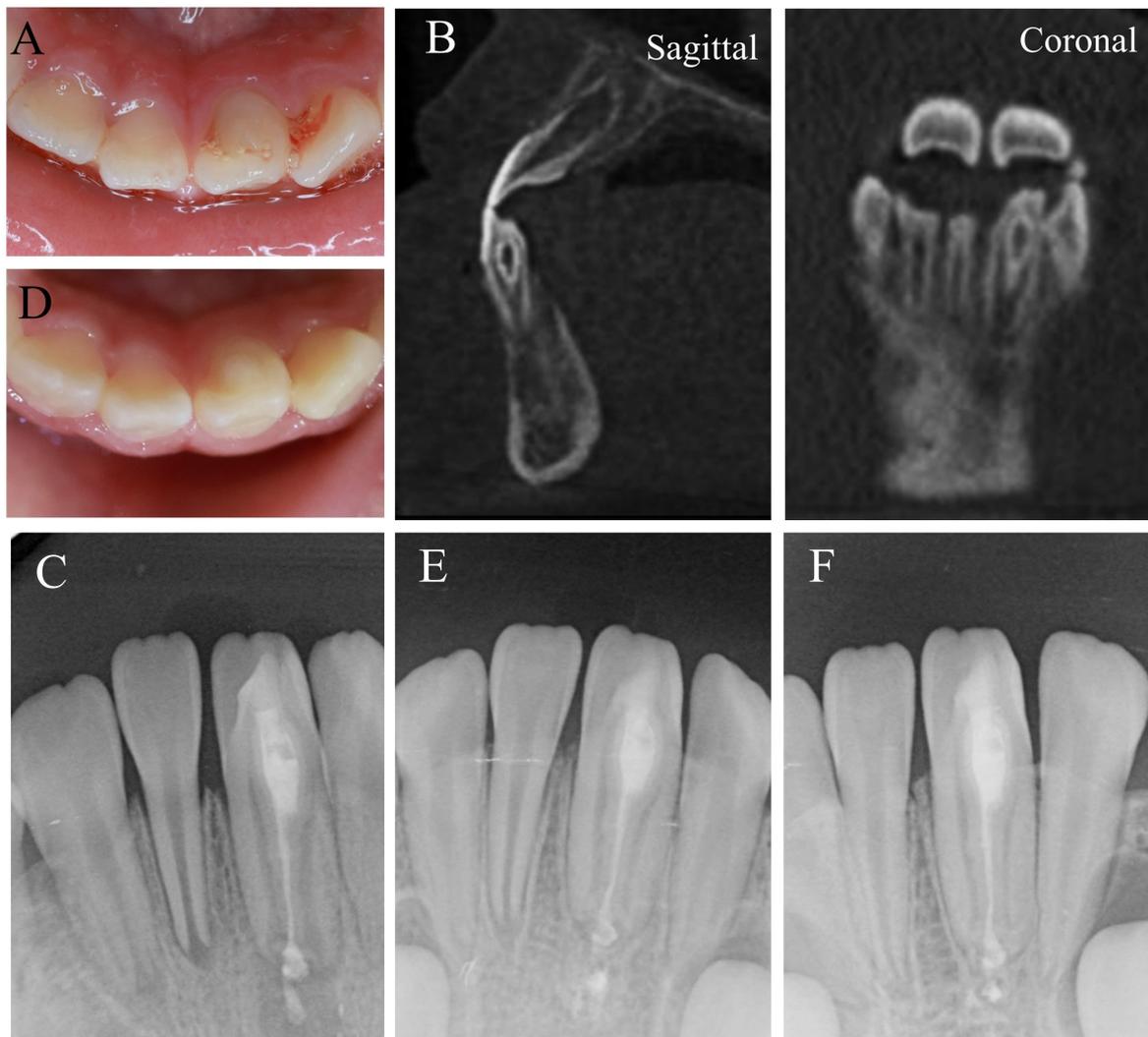


FIGURE 3. The treatment and radiographs of case 3. (A) Preoperative clinical view. (B) Preoperative CBCT images of the CDI. (C) Postoperative periapical radiograph after the invaginated canal filling immediately. (D) Postoperative clinical view at 7-month recall. (E,F) Postoperative periapical radiograph at 7-month and 18-month recall. Over time, root lengthening, apical foramen closing, and thickening of the root canal wall were observed. Additionally, the overfilled iRoot SP sealer paste does not affect the healing process of the periapical region due to its superior biocompatibility and therefore does not need more intervention.

croscope, followed by the regular preparation of K files and P drills. After irrigation with 3% hydrogen peroxide and sodium hypochlorite, the invaginated canals were filled with iROOT BP (Innovative BioCeramix, Vancouver, Canada) (Fig. 4B). A coronal seal was ensured using glass ionomer cement, followed by composite resin. Invagination in type IIIA CDI was not observed. One month later, we made an appointment for periodontal surgery. At the second visit, the sinus tract was still discharging pus (Fig. 4C). Dental flap surgery was performed in the area of teeth 11–14, and bone defects were observed in the mesial region of tooth 12 (Fig. 4D). The cysts and granulation tissues were scraped off during periodontal surgery. The iROOT BP was used to retrofill the invagination canal (Fig. 4E). The gingival flaps were then repositioned and sutured (Fig. 4F,G). Five months after the surgery, no symptoms were reported; however, the affected tooth was sensitive to vertical and lateral percussion, and the fistula could

still be observed. X-ray examination revealed a high-density filling image on the mesial side of the root neck of tooth 12, with a reduced range of periradicular radiolucency. The fistula was rinsed with chlorhexidine and treated with iodine-glycerin every 2 weeks. Two months later, the imaging shadow and gingival fistula disappeared. At 1-year follow-up, no clinical symptoms or positive signs were observed.

3. Discussion

The clinical presentations of DI can be summarized as follows: an enlarged crown with increased labial-lingual and/or mesiodistal diameter; a labial groove associated with incisor notches; barrel-shaped or cone-shaped teeth; a deep palatal pit or groove; an exaggerated talon cusp, *etc.* [9, 10]. The surface of the invaginated part is often covered with enamel, whereas some lack enamel with only a thin layer of dentin separating

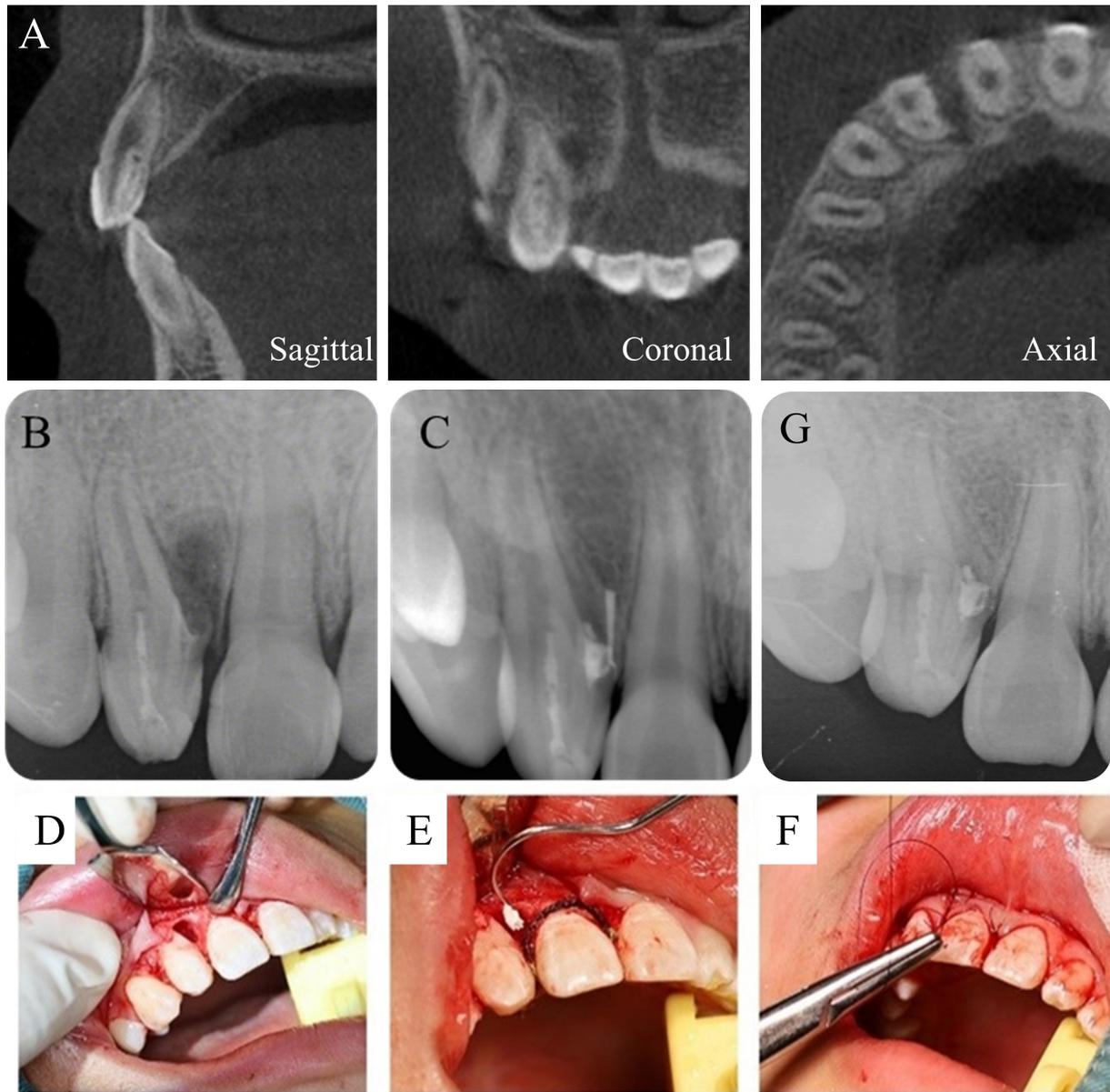


FIGURE 4. The treatment and radiographs of case 4. (A) Preoperative CBCT images of the DI. (B) Filling of type II CDI. (C) Filling of type III CDI, gutta-percha point shows the sinus tract. (D–F) Periodontal surgery and retrograde filling of the invagination. (G) Postoperative radiograph after retrograde filling at 3-month recall.

it from the pulp chamber. Bacteria are easily retained, which may lead to infection of the pulp and/or periradicular tissue, manifesting as spontaneous pain, crown discoloration, gum swelling, or fistula.

Considering the complexity of the root canal system distribution of type III CDI, an understanding of these categories will be helpful when discussing the appropriate treatment options for each lesion. Therefore, the three-dimensional (3D) imaging formed by CBCT is essential for diagnosis and management [11]. The shape, structure, and degree of the invaginated part and its relationship with the main root canal and periodontal tissue can be observed by CBCT, which directs treatment by providing comprehensive information about the internal morphology.

It is well known that both CDI types, IIIA and IIIB DI, communicate directly with periodontal spaces through invagi-

nated canals. Periradicular inflammation was observed during or shortly after the eruption of the affected tooth through invaginations [12]. Despite swelling, sinus tract formation, and periradicular bone resorption, the pulp in young permanent teeth often remains vital or shows signs of reversible pulpitis. As observed in cases 2, 3, and 4, previous studies have reported that some teeth with type III CDI and periapical lesions still have normal pulp tissue [13–15].

For young permanent teeth, it is important to maintain pulp vitality for further root development [9]. Therefore, the correct assessment of pulp status is crucial for decision-making. Examination of the pulp status of the affected young permanent teeth should include dental history, pulp sensitivity testing (cold test, laser Doppler flow meter, *etc.*), percussion, looseness, change of crown color, gingival condition, and periradicular shadow on radiography. We recommend that a dental his-

tory of pain, discoloration of the crown, and periapical shadow should be present at the time of pulp necrosis diagnosis in patients with type III CDI. When the infection of the pulp tissue is not clear, cleaning, shaping, and filling should be performed first to seal the invagination. The necessity of further treatment depends on the patient's clinical manifestations.

Generally, the treatment process of type III CDI teeth with periapical lesions is complex and challenging [10], especially in young permanent teeth. A dental history of pain, sinus tracts, and periradicular shadows often leads to the misdiagnosis of chronic apical periodontitis, thereby resulting in inappropriate treatment plans. We recommend that early obturation of the invaginated canal and proper periodontal treatment can prevent the spread of inflammation to the periapical tissues, thereby avoiding any impact on the vitality of the dental pulp. The enamel on the surface of the invagination can be a guiding clue when searching for invaginated canals. The existence of irregular and narrow invaginated canals makes it difficult for instruments to enter, thereby posing challenges to thorough cleaning and shaping. During treatment, engine-driven rotary nickel-titanium instruments should be used with caution, particularly for invaginated canals in the case of instrument separation [16, 17]. Irrigation with a large amount of sodium hypochlorite solution combined with ultrasound equipment should be applied. In addition, the bubbles formed by irrigation with 3% hydrogen peroxide may be helpful for debriding [18, 19]. Bio-ceramics are the optimal choice of filling materials for invaginated canals or barriers, which might be beneficial for pulp survival [7]. Compared with MTA, iROOT SP does not cause tooth discoloration and is easy to perform. It may be more suitable for affected teeth with an open apical foramen, and may play an inducing role. Furthermore, the biocompatibility of iROOT SP as a root canal sealing material was superior to that of AH Plus [19].

If irreversible pulpitis or pulp necrosis is confirmed, appropriate endodontic treatment—such as pulpotomy, apexification, apical barrier technique, pulp revascularization, or root canal treatment—should be selected based on the extent of infection and the stage of root development [20, 21]. If endodontic treatment is ineffective and cannot eliminate periradicular inflammation, further measures can be performed through surgical procedures, such as periodontal flap surgery and retrofilling [15, 22]. If inflammation remains poorly controlled, intentional replantation should be considered [23]. Alternatives include restoration or orthodontic treatment following tooth extraction [24]. A multidisciplinary consultation is recommended to formulate a personalized treatment plan.

In type IIIB CDI, pain, gingival swelling or fistulas, and apical shadows on radiographic examination do not always indicate pulpal necrosis. Inflammation can be eliminated and pulp vitality can be maintained by cleaning and filling the invaginated canal. Previous case reports demonstrated the success of this treatment method [10, 15, 22, 25]. In this way, damage to the tooth structure and technical sensitivity can be greatly reduced, and the prognosis is promising. As in this report, vital pulp tissue was preserved in case 2, and continuous development of the root was observed in case 3. Minimal invasion of the pulp significantly affects root lengthening, apical foramen closure, thickening of the root canal wall, and

prognosis of the affected tooth. Some dentists remove all invaginated tissues and prepare the main canals to improve disinfection effectiveness [26]. Careful consideration should be given to removing all invaginated structures.

For type IIIA CDI, apexification of the invaginated canal with a widely open foramen fails to form a hard-tissue barrier if the invagination is located lateral to the main canal [18, 26]. Periodontal surgery is always necessary to eliminate infections around the tooth root and seal the pseudo-foramina, regardless of the pulp status. In some cases, invagination divides the root canal into two or more parts, and the subsequent inflammation induced by invagination affects the periradicular tissue, as shown in Case 1. Considering that pulp necrosis is likely to occur during periodontal treatment along with iatrogenic pulp exposure, root canal treatment was performed [27, 28]. In some infected teeth with type III A DI, the periradicular shadow was limited to one side of the root and did not affect the apical tissue. Simply filling the invaginated canal and/or retrograde filling to seal the pseudo-foramen through periodontal flap surgery can effectively control inflammation [29]. As in Case 4, vital pulp was preserved.

However, the present study has certain limitations. The number of cases included in this series of case reports is limited. Furthermore, we were unable to collect complete case data, including imaging records, for all included patients throughout their treatment and follow-ups. Although favorable results have been achieved in the current stage, the long-term prognosis and efficacy of the applied treatments still require further follow-up observations.

With the recent development of guided endodontics technique, 3D models produced from CBCT volume have been used to understand the complex morphology of root canal, and the surrounding tissue defects and to develop treatment strategies for rare types of CDI [30]. Using computer-aided design software and 3D printers, a guide can be designed to access the invagination and/or main canal [31]. This technique reduces iatrogenic damage to the teeth and ensures predictable outcomes.

4. Conclusions

In brief, type III CDI facilitates bacterial invasion through its invaginated canals, often leading to periradicular or periodontal infections, clinically manifested as pain, swelling, sinus tract formation, and radiolucencies. A diagnosis of pulp necrosis and/or chronic apical periodontitis requires not only a history of dental pain but also objective findings, such as crown discoloration and periapical radiolucency. Managing type III CDI in young permanent teeth is notably challenging, requiring a comprehensive strategy that integrates endodontic intervention for the invaginated root canal and/or periodontal therapy to preserve pulp vitality, minimize hard dental tissue damage, and reduce treatment complexity.

ABBREVIATIONS

DI, Dens invaginatus; 3D, three-dimensional; CDI, coronal DI; CBCT, Cone-Beam Computed Tomography; MTA, Mineral Trioxide Aggregate.

AVAILABILITY OF DATA AND MATERIALS

All relevant patient data are contained within this article.

AUTHOR CONTRIBUTIONS

YXL and QG—designed the study. YXL, ZYL, BYW, LZ and QYG—performed the treatment. QYG and FL—provided assistance and advice for this study; reviewed and edited the manuscript. YXL and ZYL—wrote the manuscript. All the authors have read and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the institutional research ethics committee of the College of Stomatology, Xi'an Jiaotong University (protocol number [2022]09). Consent for publication was obtained from the patient's legal guardian, with assent from the patient. The case reports adhere to the ethical standards of the aforementioned institution, as well as the principles of Declaration of Helsinki.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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