IEJ Iranian Endodontic Journal

Nonsurgical Endodontic Treatment of Type IIIa Dens Invaginatus in an Immature Maxillary Central Incisor: A Case Report

Fatemeh Rezaei [a], **Mahta Fazlyab** [a*]

a Department of Endodontics, Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University

Article Type: **Case Report**

Received: 06 Nov 2024
Accepted: 05 Dec 2024
Published: 01 Jan 2025
Doi: *10.22037/iej.v20i1.46440*

**Corresponding author*: Mahta Fazlyab, No 9, 9th Neyestan Alley, Pasdaran Ave, Tehran, Iran.

E-mail: fazlyabmahta@gmail.com

Dens invaginatus is a developmental anomaly resulting from the infolding of enamel and dentin into the dental pulp. Oehlers' Type IIIa dens invaginatus poses significant challenges due to its intricate anatomy and frequent association with immature teeth. This case report outlines the nonsurgical management of a nonvital immature maxillary central incisor with Type IIIa dens invaginatus, presenting with a chronic apical abscess and a history of trauma to the associated primary incisor. Treatment involved thorough chemomechanical debridement followed by bio-obturation using calcium-enriched mixture cement. Regular follow-ups revealed complete resolution of the periapical lesion. This case underscores the importance of precise diagnosis, individualized treatment planning, and the application of advanced biomaterials in addressing complex presentations of dens invaginatus. The successful outcome emphasizes the efficacy of nonsurgical techniques in preserving immature teeth while restoring function and aesthetics.

Keywords: Apexification; Calcium-enriched Mixture Cement; Cone-beam Computed Tomography; Dens Invaginatus; Immature Tooth; Nonsurgical Endodontic Treatment

Introduction

Traumatic injuries to primary teeth occur in ~24.2% of cases globally [1]. Due to the close anatomical relationship between primary teeth and developing permanent successors, such injuries can significantly impact permanent dentition [2]. The extent of damage depends on factors such as patient age, trauma type, root resorption, and the developmental stage of the permanent tooth. Severe injuries, including intrusion and avulsion, are most likely to disrupt permanent tooth development, leading to delayed eruption, enamel hypoplasia, discoloration, malformation, or odontoma-like anomalies [3, 4]. Immediate management often focuses on emergencies, but long-term follow-up with clinical and radiographic evaluations is crucial to minimize damage to successor teeth [5, 6].

Dens invaginatus (DI), or dens in dent, is a common anomaly caused by enamel organ invagination into the dental papilla before mineralization. Its etiology includes trauma, genetic factors, infection, and developmental changes. DI prevalence ranges from 0.39% to 13.5%, most frequently affecting upper lateral and central incisors [7-11]. Oehlers' classification [12] categorizes DI into three types:

Type I: Invagination confined to the crown.
Type II: Invagination extends beyond the CEJ but doesn't communicate with the periodontal ligament (PDL).
Type III: Invagination extends apically into the root and communicates with the PDL either laterally (IIIa) or through the apical foramen (IIIb).

Clinical diagnosis of DI is based on crown morphology, which can vary from normal to unusual forms such as an incisal notch, labial groove, or exaggerated cingulum, and radiographic findings. Cone-beam computed tomography (CBCT) is particularly valuable for assessing the anomaly's extent, root canal anatomy, and associated lesions [13-16].

Treatment depends on the pulp status, root development, and anomaly complexity. Undetected cases are prone to pulp necrosis and apical periodontitis due to debris accumulation.

Management options include prophylactic restoration, vital pulp therapies, regenerative endodontics, nonsurgical or surgical root canal treatments, intentional replantation, or extraction for necrotic cases [14, 17]. This report details the nonsurgical endodontic treatment of an immature maxillary central incisor with Type IIIa DI and a periapical lesion.

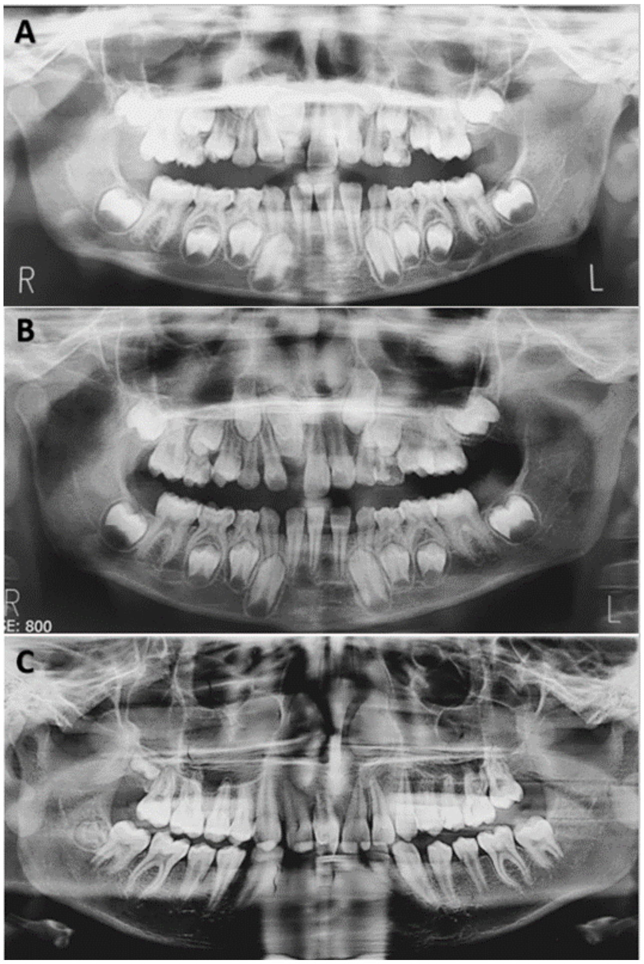

Figure 1. *A)* Intrusion of primary right central incisor during early childhood; *B)* Delayed eruption of a permanent right central incisor; *C)* Erupted permanent right central incisor with an unusual morphology

Case Presentation

A 14-year-old boy was referred by an orthodontist to the Endodontic Department of the Faculty of Dentistry of Tehran Medical Sciences Branch of Islamic Azad University, complaining of suppuration from the gingiva of the right maxillary central permanent incisor. His medical history was non-contributory. There was a history of trauma to the primary right central incisor at the age of five (Figure 1A), which did not receive any treatment until it led to the delayed eruption of a permanent successor (Figure 1B). Afterward, the patient continued to be monitored by a pediatric dentist until his maxillary right central incisor erupted with an unusual form (Figure 1C). At the time of referral to the endodnotist, the patient was under orthodontic treatment.

Extra-oral examination did not reveal any abnormalities. During the intraoral examination, the maxillary left central incisor exhibited an anatomical variation with no signs of caries or restorations. A sinus tract was also found in the mucosa adjacent to the tooth. (Figures 2A and 2B). Response to pulp sensibility tests [electric pulp tester (Analytic Technology, Redmond, WA, USA) and cold spray (1,1,1,2-tetrafluoroethane)] was negative. The tooth was slightly sensitive to palpation and percussion. There was grade II mobility. The probing depth in mesiobuccal and mesiopalatal aspects was approximately six mm; in other aspects of the tooth, it was 4 mm.

A #25 gutta-percha (Meta Biomed, Cheongju-si, Republic of Korea) was used to trace the sinus tract, and radiography was acquired. A periapical lesion was found in the area where the gutta-percha was inserted (Figures 2C and 2D). The diagnosis was pulp necrosis and chronic apical abscess. Upon evaluation of the CBCT images, a type IIIa dens invaginatus was identified, with a pseudo canal extending into the root and associated with the periapical lesion (Figures 2E and 2F). Main and pseudo canals merged and communicated with the PDL, making a wide-open apical foramen.

Treatment options, including regenerative endodontic procedures, nonsurgical root canal treatment, surgical root canal treatment, intentional replantation, and extraction, were presented to the parents who assented to extraction. In consultation with the orthodontic department, their treatment plan was to save a tooth as long as possible or at least until he became 18 years old and could replace it with an implant. The recommended treatment option was regenerative endodontic procedure due to the immature root development of the affected tooth. Still, because of the uncertain nature, a higher number of treatment appointments, and the probability of requiring additional treatment, the definitive treatment plan, which was approved, consisted of nonsurgical root canal therapy. The patient's parent signed the written informed consent form.

Local anesthesia administration was done using infiltration of 2% lidocaine with 1:80000 epinephrine (Darupakhsh, Tehran, Iran). After tooth isolation with a rubber dam, a small round bur (Jota, Rüthi, Switzerland) was used to prepare two access cavities to the main and pseudo canal (Figure 3A). The measuring of the working length was done with an apex locator (Root ZX, J. Morita, Kyoto, Japan) and confirmed radiographically (Figures 3B and 3C). Chemo-mechanical cleaning and shaping were performed using NiTi rotary files (V-Taper Gold, FANTA, Shanghai, China), conventional stainless steel hand K-files (Mani, Tochigi, Japan), and Gates Glidden drills (Mani, Tochigi, Japan). Disinfection was accomplished by rinsing with 5.25% sodium hypochlorite (NaOCl) (Doradent, Tehran, Iran), and passive ultrasonic irrigation (Ultra X, Eighteeth, Changzhou, China)

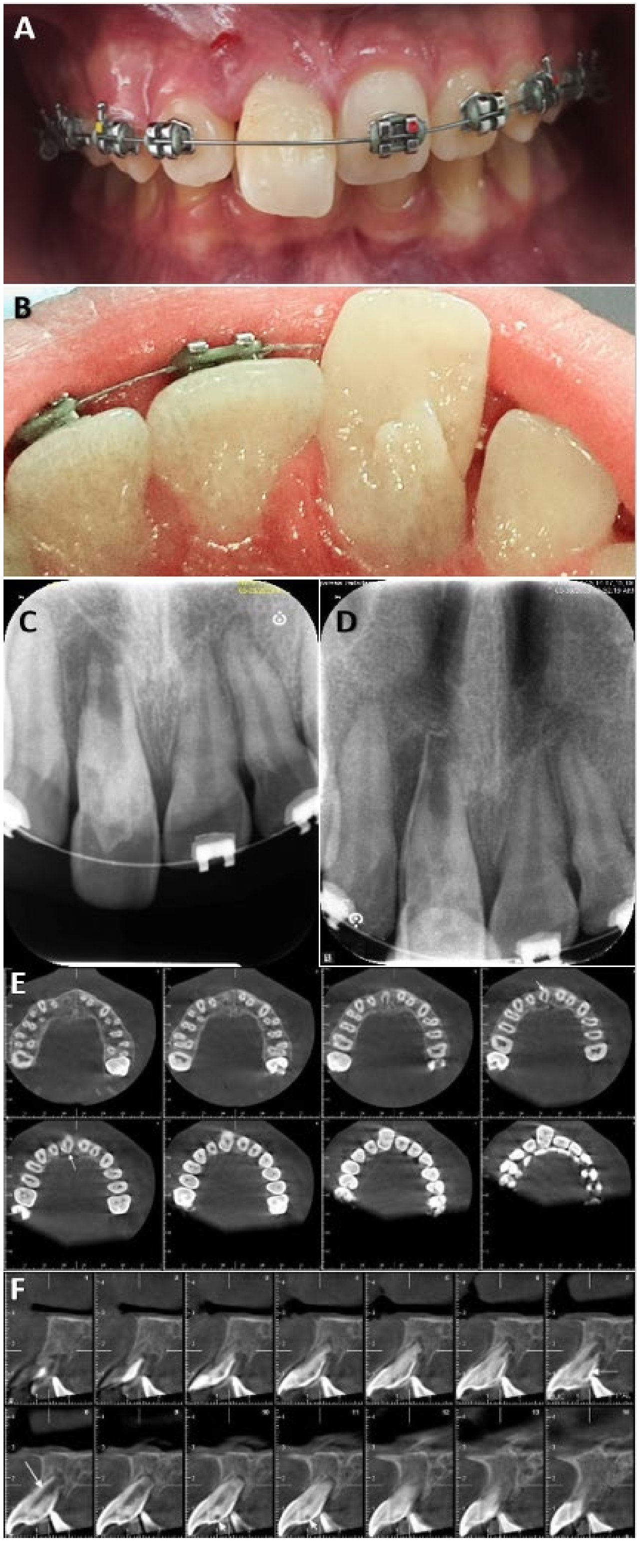

***Figure 2**. A)* Preoperative photograph indicating the sinus tract and unusual anatomy; *B)* The exaggerated cingulum in the palatal aspect of the right maxillary central incisor; *C)* Preoperative periapical radiograph indicating invagination and associated periapical pathosis; *D)* Periapical radiograph of tracing of the sinus tract; *E)* CBCT images (axial sections); *F)* CBCT images (coronal sections)

was performed to improve its effectiveness. 17% ethylenediaminetetraacetic acid (EDTA) (Doradent, Tehran, Iran) was used for 1 min, followed by 30 sec of NaOCl irrigation as the final irrigant to remove the smear layer. Subsequently, the canals were irrigated with sterile saline and dried using paper points (Meta Biomed, Cheongju-si, Republic of Korea).

Calcium-enriched mixture (CEM) cement (BioniqueDent, Tehran, Iran) powder and liquid were mixed per the manufacturer's recommendations. The sterile amalgam carrier was used to insert the mixture into the dried canals, e.g., bio-obturation. An apical plug was placed by carefully adapting CEM cement to the apical third of the root canal using pluggers (FANTA, Shanghai, China). Correct placement of the plug was assessed radiographically, and then the entire length of the canal was filled with CEM cement. After about an hour, the setting of CEM cement was confirmed. Finally, the composite resin (3M ESPE, St Paul, MN, USA) was used to restore the access cavity (Figures 3D and 3E).

One week later, the sinus tract diminished, and the soft tissue was healed. After one month, the results of the palpation and percussion, periodontal probing depth, and mobility were normal. Three months following the treatment, the radiographic examination indicated the initial signs of healing, so orthodontic forces were applied to the tooth (Figure 3F). Radiographic assessment at the six-month follow-up revealed significant healing of the periapical lesion (Figure 3G). At the fifteen-month follow-up, cementogenesis and precipitate of cementum were observed at the root end adjacent to the CEM cement (Figure 3H).

Discussion

This case report demonstrates the successful nonsurgical management of an immature maxillary central incisor with Type IIIa dens invaginatus. Despite the high failure rate associated with complex root canal anatomies, a CBCT-guided diagnosis, adjunctive disinfection techniques, and bio-obturation with calcium silicate cement achieved periapical healing and a favorable long-term prognosis [18-21].

The primary dentition in children under the age of five is susceptible to traumatic injuries, which can lead to unforeseen adverse effects on the development of their permanent successor, often becoming apparent only after eruption. Intrusion injuries to primary teeth are commonly known to cause developmental disturbances in developing permanent teeth. The development of the tooth germ may be influenced by external forces, potentially arising from trauma to the primary predecessor, leading to the development of DI [6]. Regular clinical and radiographic

Figure 3. *A)* Access cavity preparation demonstrating two distinct canal orifices; *B)* K-files in both canals; *C)* Intraoperative periapical radiograph of length determination; *D)* Postoperative periapical radiograph immediately after obturation; *E)* Postoperative photograph after restoration and reshaping of the crown; *F)* Orthodontic forces were applied to the tooth three months after treatment; *G)* Six-month follow-up periapical radiograph; *H)* Fifteen-month follow-up periapical radiograph

assessments are crucial for connecting the trauma to primary teeth and the subsequent developmental anomalies in their permanent successors [5, 6]. In the present case, the identified anomaly of the permanent maxillary right central incisor, classified as Oehlers' type IIIa dens invaginatus, is likely due to the intrusion of its primary predecessor during early childhood.

Teeth with DI are characterized by structural defects such as pits, which facilitate the colonization of microorganisms, resulting in the progression of caries and pulp involvement. It is common for pulp necrosis to develop within a few years of eruption without significant symptoms and sometimes even before root maturation. In most cases, DI is accidentally detected in radiographs. Thus, early diagnosis and treatment are necessary to prevent further pulp necrosis [22, 23]. In this case, the patient was referred with a chronic apical abscess in an immature tooth, although he was under orthodontic treatment, and early referral could prevent such consequences.

According to the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology Joint Position Statement, "Limited field of view CBCT should be considered the imaging modality of choice for initial treatment of teeth with dental anomalies" [24]. In the present case, CBCT has been beneficial in diagnosis and treatment planning [25], by revealing the type and extent of the anomaly, the anatomy of the root canal system, and the size of the periapical lesion.

The treatment options for cases of necrotic pulp include regenerative endodontic procedures, nonsurgical root canal treatment, surgical root canal treatment, intentional replantation, or even extraction [26-30]. The latter two options are only recommended for hopeless cases that cannot be treated or for cases with aesthetic or functional issues related to unusual crown morphology and supernumerary teeth. The preferred initial strategy should be nonsurgical treatment. Surgical treatment is the second option and is only necessary if the conservative root canal treatment fails or if the tooth has anatomical variations that make nonsurgical treatment impossible [31]. Nonsurgical root canal treatment in teeth with open apices is complicated due to undesirable crown/root ratio, thin dentinal walls, and the absence of an apical constriction. Apexification and apical plug are used in these teeth. The use of calcium hydroxide for apexification has been widespread for decades. However, it takes about 3 to 18 months, with the possibility of root canal system reinfection and tooth fracture during this period. The apical plug has been reported as an alternative that may decrease the number of treatment appointments and expenses, although it does not promote continued root development. The regenerative endodontic procedure is a biologically based treatment that allows for the continuation of root development, unlike the apexification and apical plug techniques. Although it causes root development, there are several drawbacks and unfavorable outcomes, such as discoloration, poor root development, root canal calcification or obliteration, and increased treatment appointments compared with the apical plug technique [32]. In this case, the decision was made to perform nonsurgical root canal treatment and place an apical plug with the approval of the patient's parents.

Ensuring complete disinfection of the root canal system is essential for promoting the healing of periapical tissues. Oehlers' type III DI presents a significant endodontic challenge due to the complicated root canal anatomy. It is challenging to accurately measure the working length, clean, shape, and fill the root canal without apical constriction. Some areas may be inaccessible to instruments, making it difficult to shape and clean an irregular root canal system properly. Adjunctive irrigation techniques are recommended to clean this complex root canal system effectively. In the present case, we used copious NaOCl irrigation and passive ultrasonic activation to maximize debridement and disinfection. 17% EDTA was used as a chelator to remove the smear layer. Studies have demonstrated that these techniques effectively remove additional bacteria and smear layers from the root canal [33, 34].

After completing the root canal preparation, the filling procedure is commonly performed using gutta-percha. When the root canal's apical anatomy is unsuitable for conventional filling methods and materials, mineral trioxide aggregate (MTA) could be an alternative. MTA, a calcium silicate-based material, promotes the formation of apical hard tissue and exhibits exceptional biocompatibility and sealing ability [35]. MTA has several drawbacks, including extended setting time, potential for discoloration, high expense, and handling problems [36]. Some efforts have addressed these drawbacks. Various calcium silicate-based cements have been developed, including Biodentine, CEM cement, Endosequence, Endocem MTA, and Bioaggregate. CEM cement was utilized as the root canal filling material rather than MTA in this case. CEM cement possesses outstanding biocompatibility, favorable sealing capability, bioactivity, good handling properties, and a relatively shorter setting time (less than an hour) [37-40]. We filled the entire canal length with CEM cement because retention was unnecessary for restorative purposes, and composite resin was used to fill the access cavity below the CEJ after confirming the setting of CEM cement. Calcium silicate-based cements can induce cementogenesis in the periapical area [37]. In the present case, cementogenesis and precipitation of cementum were observed during the fifteen-month follow-up at the root end adjacent to the CEM cement.

There is conflicting evidence regarding the relationship between orthodontic treatment and DI and the impact of orthodontic tooth movement on periapical healing. It has been suggested that DI may serve as a predisposing factor for root resorption in patients undergoing orthodontic treatment. According to a recent studies, orthodontic treatment did not significantly impact the changes in the size of the periapical radiolucency in root canal-treated teeth [22, 41, 42]. In this case, orthodontic forces were applied to the tooth three months after treatment once the initial signs of healing were observed.

Conclusion

Although a high rate of endodontic treatment failure has been reported in dens invaginatus due to complex root canal anatomy, with the aid of a cone-beam computed tomography-based diagnosis and treatment plan, along with adjunctive disinfection techniques and a three-dimensional seal with calcium silicate-based cement, nonsurgical root canal treatment of a type IIIa dens invaginatus in an immature maxillary central incisor led to periapical healing and a good long-term prognosis.

Acknowledgment
The authors thank the patient for permitting them to publish this case.

Conflict of interest
None.

Funding support
None.

Authors' contributions
Conceptualization: MF; Methodology: FR; Formal Analysis and Investigation: MF/FR; Writing-Original draft preparation: MF/FR; Writing-review and editing: MF/FR; Supervision: MF. All authors read and approved the final manuscript.

References

1. Patnana AK, Chugh A, Chugh VK, Kumar P, Vanga NRV, Singh S. The prevalence of traumatic dental injuries in primary teeth: A systematic review and meta-analysis. Dent Traumatol. 2021;37(3):383-99.
2. Andreasen JO, Sundström B, Ravn JJ. The effect of traumatic injuries to primary teeth on their permanent successors. I. A clinical and histologic study of 117 injured permanent teeth. Scand J Dent Res. 1971;79(4):219-83.
3. Altun C, Cehreli ZC, Güven G, Acikel C. Traumatic intrusion of primary teeth and its effects on the permanent successors: a clinical follow-up study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(4):493-8.
4. de Amorim Lde F, Estrela C, da Costa LR. Effects of traumatic dental injuries to primary teeth on permanent teeth--a clinical follow-up study. Dent Traumatol. 2011;27(2):117-21.
5. Caeiro-Villasenín L, Serna-Muñoz C, Pérez-Silva A, Vicente-Hernández A, Poza-Pascual A, Ortiz-Ruiz AJ. Developmental Dental Defects in Permanent Teeth Resulting from Trauma in Primary Dentition: A Systematic Review. Int J Environ Res Public Health. 2022;19(2).

6. Mallineni SK, Al-Mulla H, Anthonappa RP, Chan JC, King NM. Developmental Disturbance of a Maxillary Permanent Lateral Incisor Following Trauma at the Age of 16 Months: A 6-Year Follow-Up. J Clin Pediatr Dent. 2019;43(3):207-10.
7. Alani A, Bishop K. Dens invaginatus. Part 1: classification, prevalence and aetiology. Int Endod J. 2008;41(12):1123-36.
8. Alves dos Santos GN, Sousa-Neto MD, Assis HC, Lopes-Olhê FC, Faria-e-Silva AL, Oliveira ML, Mazzi-Chaves JF, Candemil AP. Prevalence and morphological analysis of dens invaginatus in anterior teeth using cone beam computed tomography: A systematic review and meta-analysis. Arch Oral Biol. 2023;151:105715.
9. Isaltino MDC, de Oliveira NG, de Melo Júnior PMR, Lyra CVV, Fernandes PHF, de Albuquerque DS. Nonsurgical Endodontic Treatment of Type II Dens Invaginatus in A Maxillary Lateral Incisor: A Case Report. Iran Endod J. 2024;19(3):232-6.
10. Amiri M, Mirzaie A. Photodynamic Therapy in a Lateral Maxillary Incisor with Dens in Dente Type II and Primary Endodontic Lesion: Case Report. Iran Endod J. 2024;19(2):130-3.
11. Zargar N, Ashraf H, Asnaashari M, Soltaninejad F, Amiri M. Treatment of Peri-Invagination Lesion and Vitality Preservation in Type III Dens Invaginatus in Bilateral Immature Maxillary Lateral Incisors: A Case Report. Iran Endod J. 2023;18(3):186-91.
12. Oehlers FA. Dens invaginatus (dilated composite odontome). I. Variations of the invagination process and associated anterior crown forms. Oral Surg Oral Med Oral Pathol. 1957;10(11):1204-18 contd.
13. Kiarudi AH, Eghbal MJ, Safi Y, Aghdasi MM, Fazlyab M. The applications of cone-beam computed tomography in endodontics: a review of literature. Iran Endod J. 2015;10(1):16-25.
14. Zhu J, Wang X, Fang Y, Von den Hoff JW, Meng L. An update on the diagnosis and treatment of dens invaginatus. Aust Dent J. 2017;62(3):261-75.
15. Heydari A, Rahmani M. Treatment of Dens Invagination in a Maxillary Lateral Incisor: A Case Report. Iran Endod J. 2015;10(3):211-3.
16. Jafari Z, Kazemi A, Shiri Ashtiani A. Endodontic Management of a Two-Rooted Maxillary Central Incisor Using Cone-Beam Computed Tomography: A Case Report. Iran Endod J. 2022;17(4):220-2.
17. Bishop K, Alani A. Dens invaginatus. Part 2: clinical, radiographic features and management options. Int Endod J. 2008;41(12):1137-54.
18. de Oliveira NlG, da Silveira MTo, Batista SM, Veloso SRM, Carvalho MdV, Travassos RMC. Endodontic Treatment of Complex Dens Invaginatus Teeth with Long Term Follow-Up Periods. Iran Endod J. 2018;13(2):263-6.
19. Wei C, Wang D, Shen L, Lu P, Meng Z, Zhou R. Treatment opinions for dens invaginatus: A case series. Exp Ther Med. 2024;27(4):138.
20. Fonseca FO, Vasconcellos BnC, Costa MM, Ribeiro Sobrinho AnP, Tavares WLF. Combined Endodontic and Surgical Therapy for Resolution of Type III Dens Invaginatus. Iran Endod J. 2020;15(2):117-23.
21. Asgary S. Bio-Obturation for Internal Root Resorption in Contralateral Mandibular Molars: A Five-Year Case Study. Cureus. 2024;16(12):e76056.
22. Hook H, Power G. Dens invaginatus: a review of its aetiology, diagnosis and clinical management. Dental Update. 2024;51:428-32.
23. Norouzi N, Kazem M, Gohari A. Nonsurgical Management of an Immature Maxillary Central Incisor with Type III Dens Invaginatus Using MTA Plug: A Case Report. Iran Endod J. 2017;12(4):521-6.
24. AAE and AAOMR Joint Position Statement: Use of Cone Beam Computed Tomography in Endodontics 2015 Update. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015;120(4):508-12.
25. Safi Y, Fazlyab M, Asgary S, Fazlalipour M. A Novel Technique for Minimizing the Metal Artifacts on Anterior Teeth in Cone-Beam Computed Tomography. Iran Endod J. 2019;14(1):79-83.
26. Asgary S, Shamszadeh S, Nosrat A, Aminoshariae A, Sabeti M. Management Strategies for Immature Teeth with Pulp Necrosis: An Umbrella Review of Systematic Reviews. Iran Endod J. 2024;19(4):242-53.
27. Alencar MN, Kowaltschuk TC, Kowalczuck A, Carneiro E, da Silva Neto UX, Ditzel Westphalen VP. Regenerative Endodontic Treatment of a Traumatized Immature Necrotic Permanent Incisor: A Case Report. Iran Endod J. 2022;17(3):146-50.
28. Rojas-Gutiérrez WJ, Pineda-Vélez E, Agudelo-Suárez AA. Regenerative Endodontics Success Factors and their Overall Effectiveness: An Umbrella Review. Iran Endod J. 2022;17(3):90-105.
29. Feli M, Taheri A, Mehrabani M. Revascularization of a Previously Treated Mandibular First Molar with Open Apices: A Case Report. Iran Endod J. 2024;19(2):120-3.
30. Roghanizadeh L, Fazlyab M. Revascularization and Apical Plug in an Immature Molar. Iran Endod J. 2018;13(1):139-42.
31. Siqueira JF, Rôças IN, Hernández SR, Brisson-Suárez K, Baasch AC, Pérez AR, Alves FRF. Dens Invaginatus: Clinical Implications and Antimicrobial Endodontic Treatment Considerations. J Endod. 2022;48(2):161-70.
32. Nosrat A, Homayounfar N, Oloomi K. Drawbacks and unfavorable outcomes of regenerative endodontic treatments of necrotic immature teeth: a literature review and report of a case. J Endod. 2012;38(10):1428-34.
33. Naladkar K, Chandak M, Sarangi S, Agrawal P, Jidewar N, Suryawanshi T, Hirani P. Breakthrough in the Development of Endodontic Irrigants. Cureus. 2024;16(8):e66981.
34. Orozco EIF, Toia CC, Cavalli D, Khoury RD, Cardoso F, Bresciani E, Valera MC. Effect of passive ultrasonic activation on microorganisms in primary root canal infection: a randomized clinical trial. J Appl Oral Sci. 2020;28:e20190100.
35. Asgary S, Parirokh M, Eghbal MJ, Ghoddusi J, Eskandarizadeh A. SEM evaluation of neodentinal bridging after direct pulp protection with mineral trioxide aggregate. Aust Endod J. 2006;32(1):26-30.
36. Parirokh M, Torabinejad M. Mineral Trioxide Aggregate: A Comprehensive Literature Review-Part III: Clinical Applications, Drawbacks, and Mechanism of Action. J Endod. 2010;36(3):400-13.
37. Asgary S, Aram M, Fazlyab M. Comprehensive review of composition, properties, clinical applications, and future perspectives of calcium-enriched mixture (CEM) cement: a systematic analysis. BioMedical Engineering OnLine. 2024;23(1):96.
38. Nosrat A, Asgary S. Apexogenesis of a symptomatic molar with calcium enriched mixture. Int Endod J. 2010;43(10):940-4.
39. Nosrat A, Asgary S, Eghbal MJ, Ghoddusi J, Bayat-Movahed S. Calcium-enriched mixture cement as artificial apical barrier: A case series. J Conserv Dent. 2011;14(4):427-31.
40. Rahimi S, Mokhtari H, Shahi S, Kazemi A, Asgary S, Eghbal MJ, Mesgariabbasi M, Mohajeri D. Osseous reaction to implantation of two endodontic cements: Mineral trioxide aggregate (MTA) and calcium enriched mixture (CEM). Med Oral Patol Oral Cir Bucal. 2012;17(5):e907-11.
41. Chaturvedula BB, Muthukrishnan A, Bhuvaraghan A, Sandler J, Thiruvenkatachari B. Dens invaginatus: a review and orthodontic implications. Br Dent J. 2021;230(6):345-50.
42. Kim S, Hwang S-J, Seo M-S. Effect of orthodontic treatment on the periapical radiolucency of endodontically treated teeth: a CBCT analysis. BMC Oral Health. 2023;23(1):289.

Please cite this paper as: Rezaei F, Fazlyab M. A Successful Nonsurgical Endodontic Treatment of Type IIIa Dens Invaginatus in an Immature Maxillary Central Incisor: A Case Report. Iran Endod J. 2025;20(1): e9. Doi: 10.22037/iej.v20i1.46440.