Preservation of Pulp Vitality in Type IIIA Dens Invaginatus with an Extensive Peri-invagination Lesion: a case Report with 5-year Follow-up

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Dens invaginatus may be associated with peri-invagination lesions and vital pulp concurrently. This case report examines the successful preservation of vital pulp and minimally invasive treatment of invagination for Oehlers type IIIA dens invaginatus with an extensive peri-invagination lesion. A healthy 19-year-old man presented with occasional swelling of the left maxillary anterior region. Pulp vitality tests revealed vital and healthy tooth pulp. CBCT indicated Oehlers type IIIA dens invaginatus with an invagination parallel to the pulp cavity. The diagnosis was type IIIA dens invaginatus with a peri-invagination lesion. The treatment plans involved preservation of the vital pulp and minimally invasive treatment of the invagination. A 5-year follow-up revealed that both healing of the peri-invagination lesion and preservation of the vital pulp had been successful. Pulp vitality can be preserved in type IIIA dens invaginatus associated with a peri-invagination lesion through minimally invasive treatment of the invagination.

Keywords: *dens invaginatus, minimally invasive, peri-invagination lesion, vital pulp preservation*

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Dens invaginatus is a developmental malformation of teeth, induced by an invagination of the enamel organ into the dental papilla during tooth development.[1,2] The invagination may also result from the infolding of the Hertwig sheath and lead to radicular dens invaginatus.[3,4] According to the classification proposed by Oehlers[5], there are three types of dens invaginatus:

- Type I: the enamel-lined invagination is confined within the crown of the tooth and does not extend beyond the cementoenamel junction.
- Type II: the invagination invades into the root but remains confined within it as a blind sac.
- Type III: the invagination penetrates through the root and communicates with the periodontal ligament laterally (IIIA) or apically (IIIB) as a pseudoforamen.

Among the above types, type III was reported as the least common, with an incidence of 4.6~5%, followed by type II (15~29.5%) and type I (65.9~79%).[6,7]

In teeth with type III dens invaginatus, the variable anatomy of invagination could be associated with the anatomy of the pulp chamber, leading to several morphological changes of the root canal system, such as wave-like constrictions, dilatation or tear-shaped structures.[1] The morphological complexities of the invagination and pulp and the possible connections between them sometimes make it difficult for dental practitioners to determine whether the pulp is under pathosis or if endodontic treatment should be performed.[1,7] Thus, there are conflicting opinions on conserving vital pulp or treating invagination together with the pulp.[8,9]

One option is to perform endodontic treatment as well as treating invagination, especially in dens invaginatus associated with pulpal diseases. It has been

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reported that the dentine surrounding the invagination may contain connective tissue inclusions or communications to the pulp tissue.[10] The lined enamel within the invagination could also be associated with possible defects or dehiscence, or hypomineralised.[1] Thus, in many case reports, pulpal pathosis was found in teeth with type III dens invaginatus (Table 1).[1,7,11-14] To treat these teeth, endodontic treatment, in addition to sealing or removal of the invagination, or combined with a surgical procedure, should be considered.[8,15,16]

There is another clinical scenario where the invagination may have no communications with the pulp tissue in teeth associated with type III dens invaginatus.[5,17,18] In such cases, the invagination may be affected by microbial contamination through the coronal path in the oral cavity and subsequently induce peri-invagination periodontitis.[1] Meanwhile, the pulp tissue could remain vital and healthy. The treatment protocol for this type of dens invaginatus with vital pulp is to treat the invagination in isolation from the root canal system (Table 1)[18,19]; however, due to the aberrant anatomy of the invagination and the irregular root canal morphology associated with it, the complication of pulp exposure might be increased.[8] Thus, creating a minimally invasive path to the invagination and minimising damage to healthy dentine is critical for preserving vital pulp. Nevertheless, to the best of the present authors' knowledge, minimally invasive treatment was rarely mentioned in the reported cases associated with type III dens invaginatus. Moreover, most cases published in the literature had a follow-up period of 2 years or less, indicating a lack of long-term prognosis reported.

The purpose of the present case report was to examine the preservation of pulp vitality and the successful management of a vital type III dens invaginatus associated with an extensive periradicular lesion through minimally invasive treatment of the invagination. After a 5-year follow-up period, a satisfactory outcome was reported.

Case report

A 19-year-old man reported to the dental hospital with the chief complaint of recurrent swelling in the left maxillary anterior region for the last 12 months. At the initial visit, the patient was asymptomatic. His medical and dental history were not significant. Extraoral examination revealed no asymmetry, and intraoral examination revealed that the maxillary left lateral incisor had a relatively short and small crown (Fig 1a). A pit associated with caries was found on the palatal surface of the tooth (Fig 1b). There was no pain on percussion, palpation or biting. The periodontal conditions were within the normal limit (2~3 mm probing depth, no mobility or sinus tract). The maxillary left lateral incisor responded normally to both cold and hot thermal tests and the electric pulp vitality test, similar to the contralateral tooth.

A parallel periapical radiograph was taken and the radiographic interpretation revealed an invagination within the maxillary left lateral incisor (Fig 1c). The invagination had a hollow strip-shaped structure with high density, starting from the crown and extending to the middle third of the root. A large periradicular radiolucency was seen around the apex of the tooth. The lesion centred slightly at the mesial side of the tooth with its mesial margin adjacent to the periradicular region of the maxillary left central incisor.

A CBCT scan (NewTom VGI, NewTom, Verona, Italy) was taken of the maxillary left lateral incisor as a complementary examination. The CBCT exposure parameters were 110 kVp and 5.2 mA with a 6 × 6 cm field of view and 90-mm voxel size. The CBCT images revealed Oehlers IIIA dens invaginatus of the maxillary left lateral incisor (Fig 1d to f). The invagination started from the palatal surface of the crown and extended to the middle third of the root with an apical opening at the palatal side of the root (Fig 1f). There were no communications between the invagination and the pulp chamber or root canal system. The root canal was visualised and located on the labial side of the invagination. The periradicular radiolucency of the maxillary left lateral incisor was well-defined, centred on the apical opening of the invagination at the palatal side of the root, with a volume of 13 × 8 × 8 mm. Thus, a diagnosis was made of Oehlers type III dens invaginatus of the maxillary left lateral incisor with a peri-invagination lesion and normal pulp.

The treatment plan for the maxillary left lateral incisor was to preserve the vital pulp, clean the contaminated dentine or potential caries and seal the invagination. Informed consent was obtained from the patient before the treatment started. All the procedures were performed under a dental operating microscope (OPMI Pico, Carl Zeiss, Göttingen, Germany). Under rubber dam isolation (Coltène, Altstatten, Switzerland), an access opening to the invagination was prepared from the pit of the palatal surface of the maxillary left lateral incisor using a fine diamond bur (TC-11, MANI, Tochigi, Japan). The path was prepared parallel to the normal endodontic access path since the CBCT images showed that the invagination was on the palatal side and parallel to the pulp cavity (Fig 1f). After gaining access, the invagination was exposed as

a narrow path associated with carious tissue and soft necrotic debris (Fig 2a). No bleeding or purulent exudate was observed within the invagination. A size #8 C-file (VDW, Munich, Germany) was used to achieve the glide path of the invagination. The working length of the invagination was measured using an electronic apex locator (DentaPort Root ZX, J. Morita, Kyoto, Japan) and confirmed by radiographs. The invagination was prepared using ultrasonic instruments ET 40 and ET 20D (Acteon, Merignac, France) to remove the enamel layer, then ProTaper Next rotary files (Dentsply Sirona, Charlotte, NC, USA) were used to prepare the invaginated path up to size X2. Subsequently, size #30 and #35 stainless-steel K-files (VDW) were used to further prepare the invagination. During instrumentation, 5.25% sodium hypochlorite (Peking University Hospital of Stomatology, Beijing, China), 17% ethylenediaminetetraacetic acid (EDTA, Peking University Hospital of Stomatology) and passive ultrasonics (Acteon) were used to irrigate and disinfect the invagination (Fig 2b). Mineral trioxide aggregate (MTA) (Dentsply Sirona) was used to fill the entire invagination using an endodontic plugger (Fig 2c). A moist cotton pellet was placed over the MTA and the access opening was sealed with temporary cement (Ceivitron, DongQuan, Taiwan, China). After 1 week, the patient returned asymptomatic. The access cavity was permanently restored with resin composite (Filtek Z 350 XT, 3M, St Paul, MN, USA). Cold thermal and electric pulp vitality tests were conducted again to verify the vitality of the pulp. The maxillary left lateral incisor responded normally to both tests.

At the 1-, 2-, 3- and 5-year follow-up visits, the patient was free of symptoms. The tooth responded normally to the cold thermal test and electric pulp vitality test. The periodontal condition was normal with no sinus tract. The radiograph showed that the periradicular radiolucency reduced continuously after the first year of treatment (Fig 3a to d). At 5 years, the radiolucency completely disappeared, indicating a complete healing of the apical pathosis (Fig 3e and 4a to f).

Discussion

Determining whether an apical lesion of dens invaginatus is associated with the root canal system, the invagination or both is important for diagnosing and making treatment plans.[19] Thus, preoperative CBCT imaging is necessary to understand the position of the apical pathosis, the type of dens invaginatus, and its relationship with the root canal system.[12,20] In the present case, the interpretation of the CBCT imaging revealed a parallel invaginated path to the pulp cavity with no connections between each other. Since the apical lesion was distributed around the opening of the invagination other than around the apex, it was suspected that the pulp could possibly be vital. Moreover, both thermal and electric pulpal vitality tests revealed vital pulp. Thus, the lesion in the present case was regarded as a peri-invagination lesion that was induced solely by the infected invagination.

The challenge of vital pulp preservation in teeth affected by dens invaginatus is to accurately address the necrotic invaginated path without impacting the remaining pulp tissue vitality.[14] Due to the anatomical complexity of the invagination, the dental operating microscope and ultrasound instruments were used in the present case to acquire conservative access to the invagination under the minimally invasive principle. To clean the invagination, diamond ultrasound tips and stainless-steel K-files were utilised in addition to regular rotary NiTi instruments and chemical disinfection approaches to thoroughly instrument the invaginated path that was lined by hard enamel-like tissues.[21] The invagination was obturated by MTA in the present case. The high biocompatibility and superior sealing property of the material could better prevent bacteria from penetrating into the invagination, safeguard the fracture resistance of the tooth, promote apical healing of lesions and enhance the effects of pulp preservation, even if there are potential connections with the pulp tissue.[17,19,22,23] The outcome of the present case was favourable over a 5-year follow-up period.

To the best of the present authors' knowledge, there were 18 reported Oehlers type III dens invaginatus cases in permanent teeth in the recent 20 years, with variations in pulp vitality, treatment plan and outcome (Table 1). Of these cases, seven revealed vital pulp in preoperative examinations, as in the present study. Five of these treated the invagination and tried to preserve pulp vitality[18,24-27], whereas the other two also performed non-surgical endodontic treatment for the root canals.[28,29] Apical surgery was conducted in one of the cases to ensure the cleaning and sealing effects of the complex invagination.[24] For sealing the invagination, gutta-percha and sealer were used in six cases to obturate the path.[18,24-27,29] The other one used MTA to seal the apical foramen prior to gutta-percha obturation.[28] The outcomes revealed that the teeth responded normally to pulp vitality tests in all cases except the one in which endodontic treatment was performed. The follow-up duration ranged from 4 months to 10 years. Four cases with follow-up durations longer than 18 months reported complete healing of the radiolucency[25-27,29], whereas the other three cases (with 4-month, 6-month

Table 1 Reported cases of the pulpal status and treatment approaches of Oehlers type III dens invaginatus in permanent teeth in the last 20 years.

Study	Year of publication	Oehlers classification of invagination	Pulp vitality	Periapical lesion	Endodontic treatment	
Li et al[32]	2022	IIIB	No response to the electric pulp vitality test	Yes	Yes	
Hernández et al[29]	2022	IIIA	One of the two cases had necrotic pulp, the other had vital pulp	Yes	Yes	
Zhang et al[26]	2022	IIIB	One of the teeth with dens invaginatus was vital whereas the other was non-vital	Yes	Root canal therapy performed only on the non-vital tooth	
Ali et al[33]	2022	IIIA	No response to the electric pulp vitality test	Yes	Yes	
Kalogeropoulos et al[27]	2022	IIIB	Normal	Yes	No	
Kamio et al[18]	2021	IIIA and IIIB	Normal	Yes (peri-invagination lesion)	No	
Lee et al[17]	2020	IIIA	No response to the electric pulp vitality test	Yes (peri-invagination lesion)	No	
Zhang and Wei[12]	2017	IIIB	Necrosis	Yes	Yes	
Agrawal et al[13]	2016	IIIB	Necrosis	Yes	Apexification using MTA	
Zoya et al[31]	2015	IIIB and II	No response to the electric pulp vitality test	Yes	Yes	
Nosrat and Schneider[14]	2015	IIIB	Necrosis	Yes	Yes	
Wayama et al[35]	2014	IIIA	Not mentioned	Yes	Yes	
Narayana et al[34]	2012	IIIB	No response to the thermal pulp vitality test	Yes	Performed the pulp revascularisation procedure	
Lichota et al[30]	2008	III	No response to cold and electric pulp testing	Yes	Yes	
Štamfelj et al[36]	2007	III	Pulp sensitivity testing not performed	Yes	No	
Steffen and Splieth[28]	2005	III	The tooth responded to thermal and electrical stimuli	Yes	Yes	
Nallapati[24]	2004	III	Normal response to cold	Yes (peri-invagination lesion)	No	
Gound and Maixner[25]	2004	III	Normal	Yes	No	

	Treatment of invagination	Apical surgery	Follow-up duration	Outcome
	Prepared the invagination, then sealed it with iRoot BP	Yes, with intentional replantation	4~39 mo	Eight of ten cases healed with no lesion or other adverse effects
	Prepared the invagination, then sealed it with gutta-percha and sealer	No	6~120 mo	Healing of the periapical lesion in both cases
	Prepared the invagination, then sealed it with gutta-percha and iRoot SP sealer	No	18 mo	Complete healing of the periapical lesions of both teeth
	Prepared the invagination, then sealed it with MTA	Yes	1 y	Complete healing of the periapical lesion
	Prepared the invagination, then sealed it with gutta-percha and bioceramic sealer	No	2 y	The pulp was normal. There is complete healing of the periapical lesion
	Prepared the invagination, then sealed it with gutta-percha	No	6 mo	The pulp was normal. The lesion decreased
	Prepared the invagination, then sealed it with MTA	No	2 y	The pulp responded normally to pulp vitality testing. Significant progression of periapical healing was evident
	Removed the invaginated tissue	Yes	6 mo	Healing on the soft tissue and on the periapical lesion
	Prepared the invagination, then sealed it with gutta-percha	No	2 y	Significant osseous healing of the periapical lesion
	Prepared and sealed the invagination with MTA	Yes	1 y	Successful treatment outcome
	Prepared the invagination, then sealed it with gutta-percha	No	6 mo	Significant osseous healing of the preoperative lesion
	Retrograde preparation and seal of the invagination with gutta-percha and sealer	Yes	18 y	The tooth associated with crown fracture, but a satisfied healing of periapical lesion was revealed from radiograph
	Removed the invaginated mass	No	12 mo	The periapical lesion appeared to have normal trabeculation with the appearance of bridge formation
	Prepared the invagination, then sealed it with gutta-percha	No	24 mo	Satisfactory bone healing was revealed
	No	No	Extraction	-
	Prepared the invagination, then sealed it with gutta-percha and MTA	No	1 y	Apical repair was observed
	The invagination was prepared and sealed with gutta-percha and dual-cured paste	Yes	4 mo	Progressive healing of the lesion
	Prepared and sealed with gutta-percha	No	6 y	The radiolucent defect had healed completely

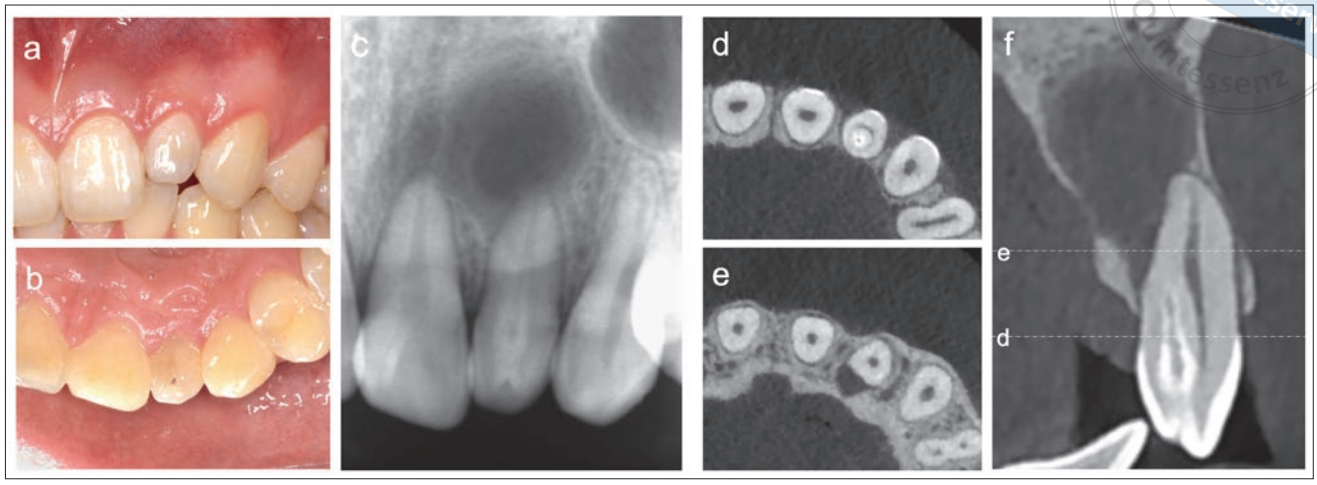

Fig 1 Labial view of the preoperative intraoral examination of the maxillary left lateral incisor with Oehlers type IIIA dens invaginatus **(a)**. The palatal view shows a pit associated with caries on the palatal side of the maxillary left lateral incisor **(b)**. The preoperative radiograph shows a hollow strip-shaped high-density invagination that starts from the crown and propagates into the middle third of the root, inside the maxillary left lateral incisor. A large apical radiolucency is shown around the apex of this tooth **(c)**. Axial sections of CBCT images **(d and e)**. The sagittal section of the CBCT images shows an Oehlers type IIIA dens invaginatus inside the maxillary left lateral incisor **(f)**. The dashed lines in **(f)** indicate the cutting sections of **(d and e)**.

Fig 2 Images captured under the dental operating microscope during the treatment of dens invaginatus. The coronal access to the invagination with a minimally invasive cavity, with decayed tissue found along the invaginatus path **(a)**. Completion of cleaning and preparation of the invagination without damaging the pulp **(b)**. Obturation of the invagination with MTA under the dental microscope **(c)**.

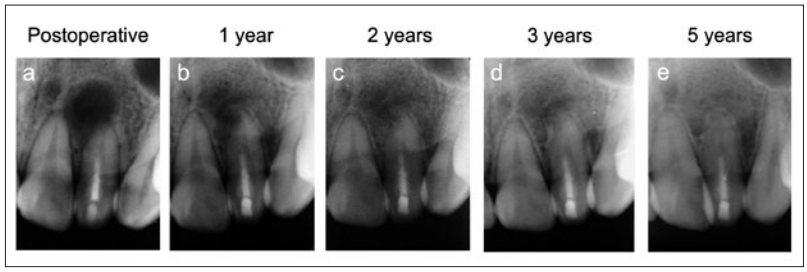

Fig 3 Postoperative radiograph after sealing the invagination using MTA **(a)**. The 1- **(b)**, 2- **(c)** and 3-year **(d)** follow-ups indicate a continuous decrease of the peri-invagination lesion. The 5-year follow-up shows complete healing of the peri-invagination lesion **(e)**.

and 1-year follow-ups) reported partial but progressive healing of the radiolucency.[18,24,28] The present case showed complete healing at the 5-year follow-up. Through these cases, it could be concluded that vital pulp is not commonly seen in permanent teeth associated with type III dens invaginatus; however, if this is the case, addressing only the invagination could possibly preserve vital pulp. A long follow-up duration might be required for complete healing of the lesion, as shown in the present case and the other cases reported.

Non-vital pulp was revealed in 9 of the 18 type III dens invaginatus cases[12-14,30-35], whereas pulp vitality was not mentioned in 2 of the 18 cases.[35,36] Non-surgical endodontic treatments only were performed in 5 of these 11 cases[13,14,30,32,33], whereas apical surgery was also carried out in 4 of them.[12,31,32,35] In one case, the invaginated mass was removed and a pulp revascularisation procedure was conducted.[34] In the last of the 18 cases, tooth extraction was performed.[36] It could be seen that pulp vitality was affected in over half of the reported type III dens invaginatus cases. To treat these cases, surgical, non-surgical or regenerative endodontic approaches could be utilised separately or together to control the infection of the root canal system and the invagination.

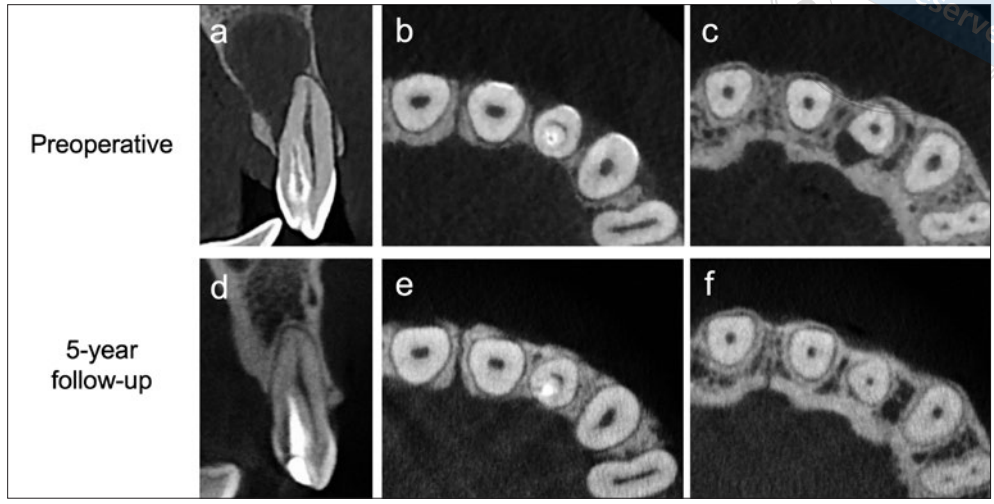

Fig 4 Preoperative CBCT images of the maxillary left lateral incisor **(a to c)**. The 5-year follow-up CBCT images show complete healing of the radiolucency **(d to f)**.

Conclusion

This case report demonstrates successful vital pulp preservation of type IIIA dens invaginatus with a large peri-invagination lesion. In summary, type IIIA dens invaginatus could be associated with vital pulp. Clinicians should be aware of this when examining and diagnosing such cases. Both preoperative pulp vitality tests and CBCT examination are important to reveal the pulp status, anatomical structure of the invagination and the relationship between the invagination and the pulp cavity. Vital pulp could be preserved successfully through minimally invasive treatment of the invagination combined with a series of effective infection control strategies.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Fei LIN contributed to the diagnosis and treatment of the clinical case, literature review and manuscript draft; Dr Lin YUE supervised the treatment of the clinical case and revised and approved the manuscript.

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