Universidad Europea

TRABAJO DE FIN DE GRADO

Grado en Odontología

TREATMENT PROTOCOLS FOR DENS IN DENTE

Madrid, Curso 2020/2021

Número identificativo 210

Abstract

Aim To review and discuss current literature available on treatment protocols for Dens in dente and evaluate the efficiency of these protocols.

Introduction Dens in dente, also referred to as Dens invaginatus (DI), is an anatomical malformation that is found frequently in permanent maxillary lateral incisors. This anomaly poses challenging for clinicians when diagnosing or treatment planning due to the complex anatomy of the root canal system. Early detection and diagnosis play a pivotal role in long term treatment success. With the use of advanced radiographical imagining in Endodontics today, treatment protocols have advanced over the last decades, providing clinicians with a variety of treatment options available depending on the case at hand.

Materials and methods In-depth analysis of literature using articles and case studies from impact journals from the last 20 years to compare protocols.

Discussion Depending on the type of DI present and the condition of the main pulp, different protocols can be applied. The main protocols that are used today are: prophylactic surgery, preventative sealing, conventional root canal therapy, endodontic apical surgery, exodontia and intentional reimplantation.

Conclusion The main principle in selecting the correct treatment protocol is based on maintaining the vitality of the pulp or preserving the tooth by the least invasive method possible.

Key words Classification of dens in dente, Dentistry, Dens in dente, Dens Invaginatus, Endodontics, Root Canal therapy, Treatment protocols.

Abbreviations DI= Dens invaginatus, RCT= Root canal therapy PR= pulp revascularisation MTA= mineral trioxide aggregate NaOCl= Sodium hypochlorite

Objetivo Revisar y discutir la literatura actual disponible sobre los protocolos de tratamiento del Dens in dente y evaluar la eficacia de estos protocolos.

Introducción El Dens in dente, también denominado Dens invaginatus (DI), es una malformación anatómica que se encuentra con frecuencia en los incisivos laterales maxilares permanentes. Esta anomalía supone un reto para los clínicos a la hora de diagnosticar o planificar el tratamiento, debido a la compleja anatomía del sistema de conductos radiculares. La detección y el diagnóstico tempranos desempeñan un papel fundamental en el éxito del tratamiento a largo plazo. Con el uso de imágenes radiográficas avanzadas en endodoncia, los protocolos de tratamiento han avanzado en las últimas décadas, proporcionando a los clínicos una variedad de opciones de tratamiento disponibles dependiendo del caso en cuestión.

Materiales y métodos Análisis en profundidad de la literatura, utilizando artículos y estudios de casos de revistas de impacto de los últimos 20 años, para comparar los protocolos.

Discusión Dependiendo del tipo de DI presente y del estado de la pulpa principal, se pueden aplicar diferentes protocolos. Actualmente los más utilizados son: la cirugía profiláctica, el sellado preventivo, la endodoncia convencional, la cirugía apical endodóntica, la exodoncia y el reimplante intencional.

Conclusión El factor principal a considerar para seleccionar el protocolo más adecuado se basa en, mantener la vitalidad de la pulpa o preservar el diente mediante el método menos invasivo posible.

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Acknowledgments

I would like to begin by thanking all my professors at the Universidad de Europea Madrid for guiding me throughout the last six years. I thank each and every one of you for helping me every step of the way in achieving this significant milestone in my life, whilst sharing your invaluable knowledge with me along the way. I am eternally grateful for all the experiences I have been given since studying in Madrid.

I would like to thank my family, whom without none of this would ever be possible. I am forever indebted to you by the sacrifices you have all made to ensure I achieve my dreams. Thank you for the continued support throughout the years, in the good times and in the bad. But most importantly, thank you for always believing in me, even when I lacked belief in myself. I dedicate this last piece of work to my Grandfather, my greatest accolade in life and my greatest strength. Last but not least, my Aunt. Who has shown me the greatest love and support throughout my life, I owe it all to you.

1. Introduction

1.1. Definition, Prevalence, History and Histopathology

Dens in dente, also referred to as Dens invaginatus (DI), can be defined as an anatomical anomaly that is frequently found in the permanent maxillary lateral incisors. It consists of a 'deepening or invagination of the enamel organ into the dental papilla prior to calcification of the dental tissues (Hüksmann 1997)' (1), with a prevalence of approximately 0,3% to 10% in permanent teeth (2) and is rarely found in primary dentition (3). The anomaly is usually diagnosed upon casual radiographical findings, only in some cases will the patient present symptoms such as 'pain and/or swelling associated with the involved tooth' (3)(4).

The malformation presents a thin layer of enamel and dentine that separates the pulpal tissue, and that histopathologically can be described as hypoplastic (5). The invagination allows entry of irritants and bacteria into the area and therefore presents as a risk factor for the development of dental caries, or pulp necrosis if not diagnosed early (6).

With the lining of the invagination easily retaining bacteria, dental caries is more prone and this predisposition can lead to an infection of the pulp or the periapical tissues when not treated (7). In some cases, channels may also exist between the invagination and the pulp (6).

It is found most commonly in the maxillary lateral incisors (1), followed by maxillary central incisors and rarely in canines, premolars or molars (7). Additionally, cases are rarely found in the mandible (8). A study carried out by Hamahsa & Al-Omari (2004) showed that in 1660 patients examined, 61 out of 14090 teeth had an invagination, and of those 90% were lateral incisors and only 6.5% were posterior teeth (1). It should also be noted that deciduous teeth are rarely involved, (8) with only 4 case reports presented of patients with dens in dente in primary teeth (7). It must also be highlighted that males are more prone to affection of dens in dente when compared to females, with a ratio of 3:1 (9).

Many authors have also discussed if the anomaly can present as an asymmetrical or symmetrical phenomenon. With the latter being the consensus. Grahnen et al. (1959) study of 3020 lateral incisors found that in 43% of these patients, bilateral symmetry was found (1). Therefore, clinical and radiographical examination of the contralateral tooth is advised upon diagnosis (10).

It has also been reported that this anomaly can be found alone or in association with other dental malformations or syndromes. For example, microdontia, macrodontia,

taurodontism and dentinogeneis imperfecta (10).

The first reference to this anomaly dates back to 1897, where Busch was the first to use the term 'dens in dente' to imply the radiographic appearance of a tooth within a tooth (1). Later in 1951, Hunter referred to the anomaly as 'dilated composite odontome' to infer to the abnormal dilation of the dental papilla. Whereas, Colby in 1956 introduced the term 'gestant anomaly' (1). Other existing synonyms of this malformation are: invaginated odontome, dilated gestant odontome, tooth inclusion, dentoid in dente, dents telescopes (6).

Regarding the aetiology, it seems that both genetical and environmental factors play a role with the interaction between mesenchymal and epithelial cells in tooth development (7). Even though there is a general consensus amongst literature that the anomaly is of embryonic origin, due to an epithelial invagination within the depths of the ecto-mesenchymatous papilla (8), there is still much confusion whether genetical factors are the predominant theory. Therefore, no concrete conclusion overrules (1). 'External forces from adjacent teeth, trauma and infection may also contribute to the aetiology' (7)(11)(12).

1.2 Classification

'The first documented attempt to classify dens invaginatus was by Hallet (1953) who suggested the existence of four types of invagination based on both clinical and radiographic criteria' (1).

'However, the system described by Oehlers (1957) appears to be the most widely used due to its ease in application' (1). The system classifies the anomaly based on the extent of invagination by using radiographic analysis. Three main types exist, as seen in ***Figure 1.***

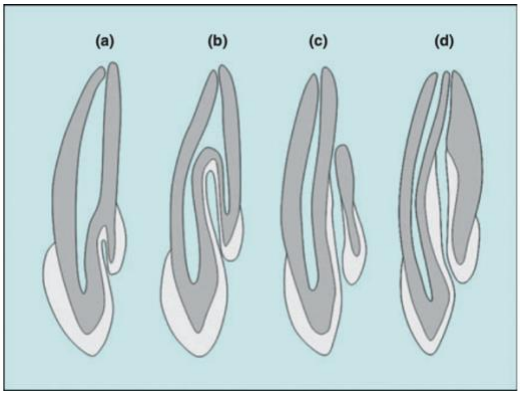


Figure 1 Oehlers (1957) classification of dens in dente. ***(a)*** Type I ***(b)*** Type II ***(c)*** Type III A and ***(d)*** Type III B (13)

Type I can be classified as a minimal invagination (enamel-lined) that is confined to the crown and does not extend the cemento-enamel junction.

Type II presents an invagination that extends into the pulp chamber but has no communication with the periodontal ligament, therefore confined to the root canal.

Type III A can see an invagination that extends through the root and communicates with the periodontal ligament space in a lateral direction, creating a so called 'psuedo-formaen'. This type of invagination usually presents no communication with the

pulp, which should be noted at it affects treatment protocol choices.

Type III B similarly extends through the root with communication of the periodontal ligament at the level of the apical foramen with no communication of the pulp.

It is very important that type II and III must be differentiated and classified correctly using radiographs as they can be misinterpreted and lead to incorrect treatment planning (13).

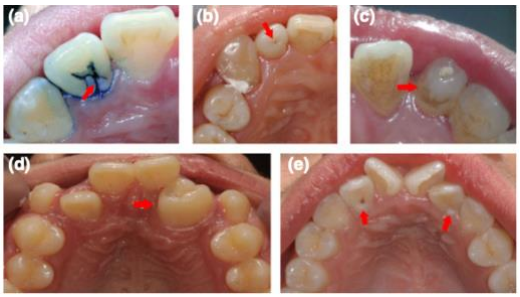
It must be highlighted that in type IIIB lesions, any infection within the invagination can lead to an inflammatory response within the periodontal tissues which is known as 'peri-invagination periodontitis' (6) (14).

1.3 Clinical Presentation

Upon exploration we can find specific morphological changes that can suggest the presence of this malformation (7). However, changes alone in morphology of the crown do not suggest a definitive diagnosis of dens in dente, but can suggest the need for further radiographical examination to confirm a definitive diagnosis (7). An important clinical sign to recognise is the entrance of the invagination, which presents itself as a 'deep foramen caecum on the palatal or occlusal surface of the tooth' (7). Although some teeth present normal morphology and appear normal (10), the following morphological changes have been identified in teeth with dens in dente: (7)(15)

1. Palatal pit or groove, which is always the entrance to the invagination.
2. Cone-shaped teeth with either absence of an incisal edge or increased height of cervical-lingual collars.
3. Dilated crown when compared with contralateral teeth. Usually enlarged crowns with increase labial-lingual and/or mesiodistal diameter or enlarged cingulum's.
4. Microdontic teeth.
5. Talon cups or dens eviginatus, in some cases we have both dens invaginatus and eviginatus existing in the same tooth simultaneously.
6. Presence of labial groove.

Figure 2. Images highlighting the main morphological changes (7)



(a) Palatal groove **(b)** Palatal pit on palatal surface **(c)** Cone shape tooth **(d)** Dilated crown **(e)** Bilateral talon cups, with a palatal pit in tight maxillary lateral incisor (7)

1.4 Diagnosis and Treatment

Clinically, an early diagnosis is desirable for a good prognosis of treatment (7). When choosing the correct protocol, a thorough preoperative evaluation of

the severity and complexity of the invagination should be carried out (13). In general, when diagnosing this anomaly, clinicians can face great difficulties due to the absence of clinical and radiographic signs (10). Therefore, conventional 2-Dimensional radiographs taken at different angles and cone-beam CT imaging can be useful to examine the canals in a three-dimensional view to classify the type and depth of invagination for establishing a treatment plan (13). It is usually challenging and limited by various factors, such as the clinician's knowledge, radiographic limitations and lack of general consensus on this anomaly (10) . For this reason, the anomaly is usually undetected in many cases until pulpar pathologies or complications arise (1). Complications such as internal root resorption, fractures and peri-invagination periodontitis can occur (1)(2)(6).

Treatment of this pathology will be dependent on the classification and type of invagination present (13). In general, current treatment protocols consist of: early detection of the lesion, prophylactic or preventive sealing of the invagination, root canal treatment, endodontic apical surgery, and intentional replantation (5). Up until the 1970s, teeth affected by this anomaly were considered to have an extremely poor prognosis and the preferred treatment option for severe invaginations were extractions (Hüksmann 1995)(10)(13). In some complex cases today, extraction is still the first option when the clinician faces a case of severe invagination with abnormal crown morphology that not only causes functional problems, but also affect aesthetics (Rotstein et al.1987) (13). In addition, following the trend of prevention in modern-day dentistry, dens in dente has phased more into an endodontic approach from an extraction-oriented one (5).

'As pulpal involvement of teeth with coronal invaginations may occur in a short time after tooth eruption, an early diagnosis is mandatory to instigate preventive treatment (6)'. It has also been noted that in cases that present dens in dente in immature teeth, a proposed treatment option is pulp revascularization (PR) (7). This must be considered as immature teeth are more prone to fracture (13)(16) .

2. Objectives

1. To identify the current available treatment protocols used for achieving a successful treatment for dens in dente patients.
2. To evaluate the efficiency of these protocols using clinical studies.
3. To present a brief comparison of these protocols depending on the type of anomaly present.
4. To explore future protocols based on evolving technology in endodontics today by reviewing the progression through the last decades in Dentistry.

3. Materials and methods

An in-depth analysis of literature was carried out to evaluate the specific topic in question. Numerous current articles and impact journals from mainly the last 20 years were used to assess the trends in protocols available today at present. Case studies were also included due to their clinical relevance and to assess the success of each treatment protocol. Inclusion criteria was based on the use of keywords and using 25 articles from recent years to ensure only updated protocols were reviewed and included. Exclusion criteria was based on any articles or case studies not written in English, or in which other pathologies other that DI were included. These articles were excluded due to having no clinical relevance. Keywords used were: Classification of dens in dente, Dens in dente, Dens Invaginatus, Endodontics, Root Canal therapy, Treatment protocols.

4. Discussion

4.1 Treatment protocols

When approaching treatment planning in cases of DI, the apical periodontium must be examined (3). Even if there is an absence of radiographic signs, pulp vitality should always be performed (3). This complete diagnosis will consequently affect the treatment outcome. If the pulp is unaffected, then the tooth can be restored to avoid access of any bacteria entering the invagination and seal it from the oral environment (3). However, since these teeth have a tendency of progression into non vital teeth, in many cases it is beneficial to carry out endodontic treatment prior to any restoration (3).

Therefore in summary, the general objective seen amongst literature for permanent teeth with DI is to preserve the health of the pulp if at all possible (10) (17). However, were disease has developed, then a decision has to be made whether to treat the invagination and the pulp separately, or combined (10). It should be highlighted that there can be a tendency to combine both surgical and non-surgical (such as conventional RCT therapy) approaches in the same tooth depending on the classification and prognosis (3). Both of these alternatives can be achieved using modern day endodontic techniques and materials (10). As previously mentioned above, the main treatment protocols that are used today are: prophylactic surgery, preventative sealing, conventional root canal therapy, endodontic apical surgery, exodontia and intentional reimplantation (5). In addition, these advanced treatment options available today have provided hope for teeth

that could not be saved before and treated via extraction (7).

As primary teeth are infrequently affected by DI, treatment protocols won't be as extensively discussed (3). Throughout literature there has only been four well known cases of presentation of DI in primary dentition, as seen in ***Figure 3*** (3). Therefore, protocols are relatively simple, and extraction is only indicated in cases in which the periapical lesion influences the permanent tooth germ (7). Normally, depending on the condition on the pulp, conventional root canal therapy or composite resin can also be used (7). Moreover, if the patient simultaneously presents supernumerary teeth, extraction of these additional teeth is selected (7).

Table 1 Reported cases of dens invaginatus in primary dentition

Author/ year reported	Age	Sex	Primary tooth affected	Evidence of infection	Treatment given
Rabinowitch[8] 1952	3 y	Male	Maxillary canine	Yes	Extraction
Holan[9] 1998	5 y	Male	Mandibular canine	Yes	Root canal treatment
Kupietzky[10] 2000	1 y	Male	Maxillary central incisor	No	Composite restoration
Eden et al[11] 2002	11 y	Male	Mandibular second molar	Yes	Extraction

Figure 3. Recorded cases of DI in primary teeth (3)

4.1.1 Type I

Type I is the most common type of DI and the easiest to treat due to its minimally invasive behaviour, as the invagination is confined to the crown not extending the CEJ (7). For this type of DI, prophylactic filling is the preferrable choice of treatment when no pulpal affection exists (7)(6). This option is effective due to the absence of involvement of the pulp (7) (18).

In the past, there has been a wide variety of techniques used for prophylactic treatment (6). For instance, the preparation of the invagination entrance is made and an amalgam restoration is placed (6). Other more contemporary techniques now include the placement of flowable composite resin to seal the invagination from the external environment and preventing bacterial entry (7). A fissure sealant can also be placed, for when the entrance to the canal is difficult to access due to size (7)(6).

It is always essential to carry out periodic follow ups in these patients as any development in pathology or loss vitality could mean the need for further extensive treatment, such as RCT (7)(6).

On the other hand, if pupal affection exits in this type, then a different protocol must be carried out. If the tooth presents limited pulpitis, we can perform a pulpotomy, such as in immature teeth (7). However, if there is extensive pulpitis then RCT will be needed where the debridement of both the main canal and invagination must be cleaned thoroughly (7). In immature teeth with extensive pulpitis, and where extraction is not chosen, apexification of pulp revascularizion (PR) is more efficient (7). An open apex

is treated by forming an apical plug using calcium hydroxide or MTA (6).

4.1.2 Type II

Type II presents an invagination that extends into the pulp chamber but has no communication with the periodontal ligament, therefore confined to the root canal (13). Depending on the extent of the invagination into the pulp, a treatment protocol will be chosen. If a tooth presents type II DI but no caries, a preventive prophylactic treatment is sufficient (7). However, if caries is present with a vital pulp, the invagination alone will be treated (7). When analysing failure in treatment, 13.4% were accounted by the sole treatment of the invagination in type II DI (7). This can be discussed further and related to the type of filling material used: composite resin, amalgam or glass ionomer. Which in theory, can all lead to a possible failure in treatment due to microleakage or irritation of the pulp which consequently causes a loss of vitality (7). Due to this factor, MTA is the chosen filling material due to its biocompatibility and antibacterial properties (7)(19). Antiseptic control is also an important factor in treatment (20). It can be achieved by using intracanal medicants, for example calcium hydroxide or triple antibiotic paste(ciprofloxacin, metronidazole, minocycline)(6).

If any periapical lesion is present upon diagnosis, RCT will be the first elected method before surgery (7). The procedure can be done by filling both the invaginated canal and main canal separately, thereby leaving the invagination, or removing the invagination completely (7)(21). By leaving the invagination in place consequently leads to a more difficult and complex treatment, as cleaning and debridement becomes more challenging (7). However, an overall increase in tooth root structure strength is seen when the invagination is left in place (7). During removal of the invagination, caution must be taken. The decision should be made and tailored to the specific cases in question as it not applicable to all cases (7). Thereby when permitted, the use of magnification to access the entrance is done using fast hand piece burs and ultrasonics (6). Once the access is complete and the entrance is permitted, MTA for example can be used to obturate the invagination or canal alone and sealed with composite (6). When the invagination is located near the CEJ, it can be removed by coronal pre-flaring (7). This removal can be carried out due to the developments in technology in endodontics and the use of microscopes and ultrasonics combined (7). Although additionally, other instruments such as a fissure bur, K-file or H-file may also be used to aid the removal of the invagination (7).

For immature teeth with an open apex, apexification is the chosen protocol (7). If the tooth also presents a radiolucent image, inferring to a periapical lesion, then PR can be performed (7).

4.1.3 Type III

Type III DI has two clinical presentations, Type IIIA and B. Both extend through the root and communicate with the periodontal ligament space and in type A via a lateral direction, creating a so called 'psuedo-foramen'(13). This type of invagination usually presents no communication with the pulp (13). Therefore this more complex root canal system means it is necessary to carry out complementary CBCT 3-Dimesntional radiographs to assess the invagination and guide treatment (7). It is common to find both pulpal affection and periapical lesions in this classification (7). The first step in treatment planning in this case is to assess the condition of pulp vitality in the main pulp (14). This will be the deciding factor in the chosen protocol (7). The invagination will normally be treated as a normal canal to preserve vitality (6).

Firstly, if the main canal is vital, it is recommended to clean and obturate the invaginated canal to ensure vitality of the main canal (7).

Secondly, if both the main canal and invagination are infected, debridement of both canals must be carried out separately and filled (7). It should also be noted the location of the canal. For example in a type IIIA where the main canal is located laterally and is immature with a wide open apex then apexification or PR is recommended (7). On the contrary, if the invaginated canal presents a wide-open foramen and apexification is performed, it has been proven the failure in forming a hard tissue barrier to seal the canal from the main canal when the pseudo-foramen is laterally placed (7). This can be said to occur due to the low regenerative ability of the pseudo-foramen and the placement of MTA as a barrier is recommended (7).

However if for instance, the invaginated canal is located more centrally within the main canal, 'the main canal obtains further development through apexification or PR of the invaginated canal(7)'. With the canals having communication with the periodontal ligament, the main canal will suffer any effect of medication placed in the invaginated canal as if it was placed directly into the main canal (7). Therefore, some authors have suggested to remove the invaginated canal completely using ultrasonics and fast hand piece burs, common to type II treatment, to ease and facilitate endodontic treatment (7)(6).

In summary, only if conservative treatment such as RCT, apexification or PR fails will surgery be indicated (7). Extraction is the final option when endodontic and/or combined therapy fails, or if complicated root anatomy exits (7). If extraction is carried out, it is usually followed by prosthodontic treatment (6). 'Intentional reimplantation has only been reported in very complex forms of type III' (6).

A summary of treatment options can be seen below in ***Figure 4*** and ***5*** (7).

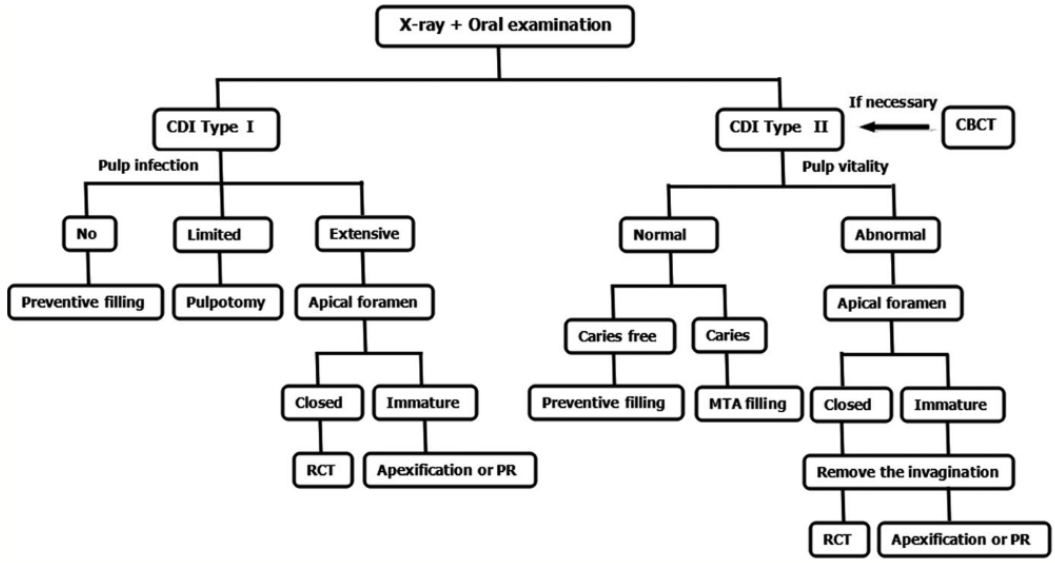


Figure 4. Summary of treatment options for Type I and II DI (7)

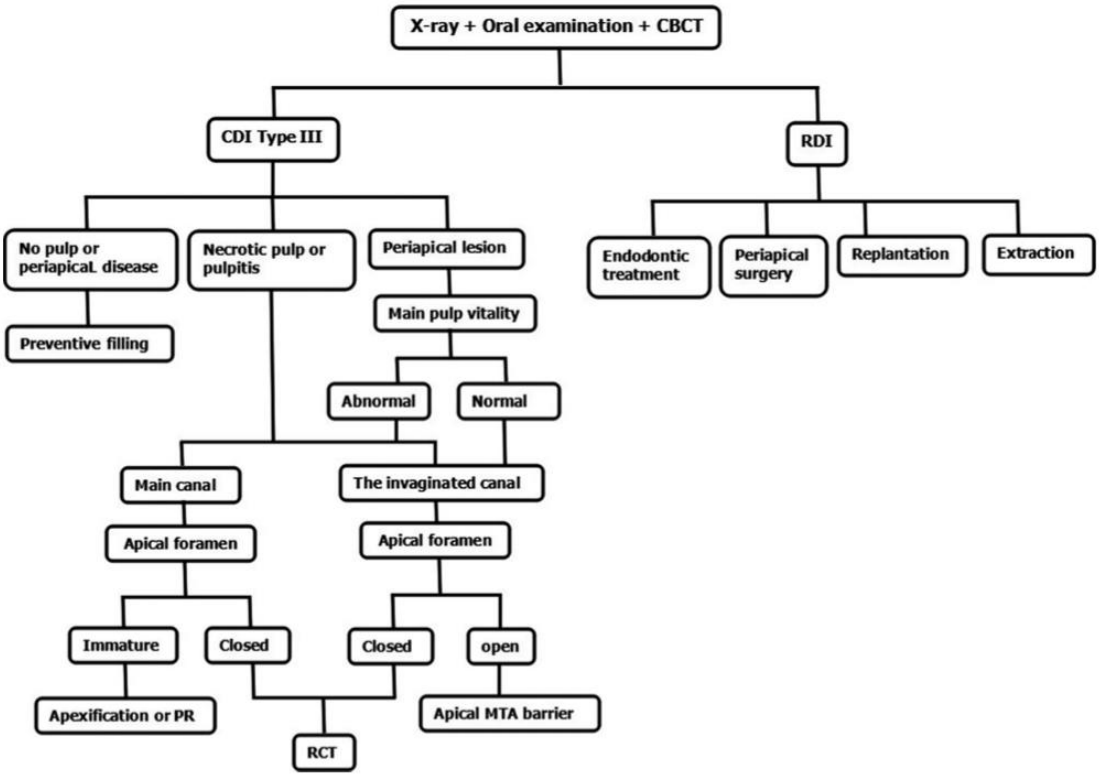


Figure 5. Summary of treatment options for Type III DI (7)

4.2 Case studies

From various case studies researched, a select few cases have been chosen and discussed below that are clinically relevant to the treatment protocols reviewed in the section above. Each case study includes a different diagnosis and alternative treatment protocol used by the clinician when approaching a case of DI. The efficiency of each protocol can be appreciated by the conclusion of results of each case by the use of control follow up radiographs and clinical examination carried out by the clinician.

4.2.1 Case study: Nonsurgical endodontic treatment in open-apex and immature teeth with aid of an apical barrier

In general, with regards to an open apex, clinicians can face difficulties of overfilling the canal or in forming an adequate apical seal due to the lack of apical stop (22) (23) (24). Therefore, additional challenges arise when a patient presents with both DI and an open root apex (22). The use of an apical barrier in endodontics for different apical lesions has been seen throughout literature (22) and 'the insertion of an apical plug is an alternative to conventional long-term apexification with calcium hydroxide' (23). Materials such as collagen can be used as an apical barrier as they obtain characteristics that provide 'complete hemostasias, support new tissue growth and absorb in one to 14 days when left in situ' (22).

One case study presented in a scientific journal using the selected technique of conventional RCT and an apical membrane to treat an Oehlers type II DI in an immature apex, can be of clinical relevance when apexification or PR are not the first line in treatment choice. The case of a 15-year-old patient with open apexes and bilateral Oehlers type II DI in the maxillary lateral incisors was selected. The patient also presented 'extensive peri-radicular radiolucency, internal resorption and a vestibular fistula in the left maxillary lateral incisor' (22). The patient was referred to the endodontist specialist with a chief complaint of pain and swelling one month prior to examination. Upon examination, additional complementary tests were carried out and periapical radiographs and gutta-percha points were used to aid diagnosis. It should also be noted both incisors were of peg shaped anatomy. As seen in ***Figure 6.*** Due to the anatomy of these teeth, access to the apical portion was difficult. The final diagnosis given to the patient was Oehlers type II DI and chronic apical periodontitis for both maxillary lateral incisors. The treatment plan suggested for the right lateral incisor (tooth 12) was RCT with the use of an 'apical plug of MTA cement, followed by restoration with resin-based cement

and dentinal adhesive for root reinforcement' (22). In regard to the left lateral incisor (tooth 22), conventional RCT.

Treatment was started on tooth 12 first, with three appointments scheduled. In the first appointment the clinician placed the anaesthesia, rubber dam and prepared the access cavity. The type II invagination was removed using a Mueller bur with the aid of radiographs to check the inclination and direction of the bur to avoid over instrumentation of the dentin structure. Number 70 K-file was used to identify the working length, and manual instrumentation was performed. Throughout the instrumentation, it was made sure that the dentin structure was preserved to ensure enough structural support for the post to be placed later. The canal was irrigated using 0.5% sodium hypochlorite solution (NaOCl) and calcium hydroxide paste was placed within the canal. A week later the second appointment was performed. The tooth showed no signs or symptoms, and the sinus tract was closed. The clinician removed the calcium hydroxide and cleaned the canal once again with NaOCl to prepare for the placement of the collagen membrane via the apex. The membrane was chosen to be placed 'to provide a resorbable extra radicular barrier against which MTA could be packed' (22). In this specific case, due to the size and limited access, the membrane was indicated to be cut into small pieces and placed in the apex and packed with a plugger. Once the collagen was placed into the defect and an apical seal was achieved at the cavosurface of the root apex, MTA was compacted to 'create an artificial apical barrier with a thickness of 4mm' (22). The canal was then sealed with a temporary filling using provisional cement. On the third, and final appointment, the provisional cement was removed, and the canal cleaned and dried using paper points. The remaining root canal was then reinforced using a fibre composite post and the crown obturated using resin-based composite. A summary of treatment can be seen in ***Figure 7***. (22)

For tooth 22, again the clinician initiated non-surgical endodontic treatment. Anaesthesia was administrated and rubber dam isolation was placed to open and prepare the access cavity. The canal was cleaned and shaped with placement of an intracanal medicament. Finally, the canal was obturated using 'gutta-percha and AH 26 by using the lateral condensation technique' (22). A summary of treatment can be seen in ***Figure 8.*** (22)

Lastly, one week post treatment, the patient remained symptom free and the complete healing of the sinus tract was visible. Using control radiographs, after four years the patient maintained asymptomatic, and a reduction of periapical lesion was also noted (22).

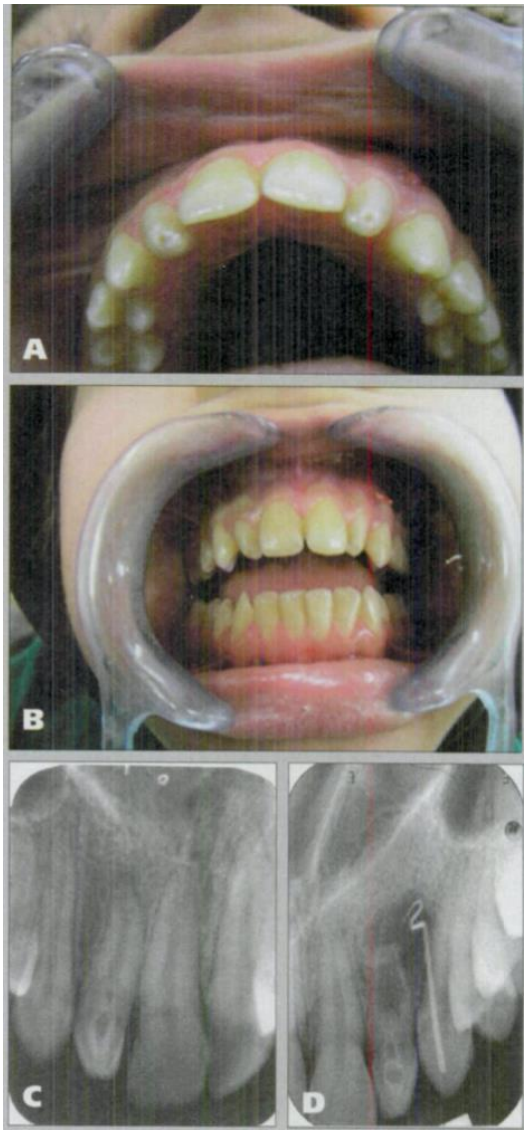


Figure 6. Case one **A.** Peg shaped crowns on both lateral incisors. **B.** Clinical examination **C.** Tooth 12 type II DI **D.** Tooth 22 type II DI with sinus tract (22)

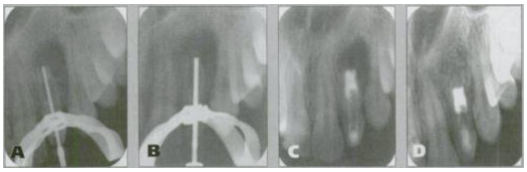


Figure 7. Case one Treatment of tooth 12 **A.** Working length with k-file 70 **B.** Collagen membrane placement **C.** Apical barrier with MTA **D.** Control follow up, four years post treatment with osseous healing (22)

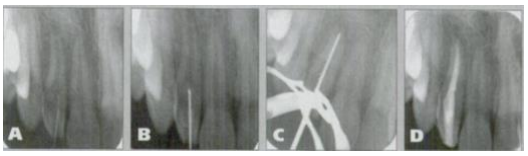


Figure 8. Case one Treatment of tooth 22 **A.** and **B.** Cavity access preparation **C.** Working length with K-file **D.** Final radiograph after obturating (22)

A similar case of a 23-year-old patient who was referred from the orthodontist department to the endodontist, this was due to the finding of type II DI with an open apex and a large peri-radicular radiolucency upon routine examination in the upper left maxillary lateral incisor. The patient's initial complaint was the 'space between her anterior teeth' (22). It was also highlighted that the patient presented bilateral agenesis of the canines. The clinician carried out additional complementary tests to confirm the diagnosis. The contralateral tooth was also examined, and no anatomical malformation was found. The final diagnosis presented to the patient was 'Oehlers type II DI with necrotic pulp and chronic peri-radicular periodontitis in the left maxillary lateral incisor' (tooth 22)(22) .The proposed treatment plan was conventional RCT using an apical barrier and MTA. The treatment was also split into three appointments. On the first appointment, the access cavity was prepared, and the invagination was removed. The canal was prepared using both K-files and NaOCl to clear the

canal of debris. Paper points were used to dry the canal which was then filled with calcium hydroxide paste and sealed with a temporary cement. The following week the second appointment was carried out. The provisional was removed and the apical membrane made from collagen was placed in the apex. MTA was used to obturate the apical portion of the canal against the collagen membrane which was then sealed with zinc oxide eugenol as a temporary filling. On the final appointment the clinician verified that the MTA was correctly set, and remaining root canal was obturated with gutta-percha and AH 26 using the lateral condensation technique. To finish the treatment, the crown was obturated with resin-based composite. Control radiographs were carried out six months post treatment, which confirmed complete healing. ***Figure 9*** shows a summary of treatment (22).

Figure 9. Case two Treatment of tooth 22 **A.** Initial radiograph of type II DI in the left maxillary lateral incisor **B.** Working length with K-file **C.** Apical plug using a collagen membrane with MTA **D.** Six months post treatment control radiograph, showing complete healing and the initiation of orthodontic treatment (22)

In conclusion, from both cases presented using non-surgical endodontic treatment, successful healing of peri-radicular lesions in the management of type II DI was proven. In both cases the invagination was removed completely without failure of treatment. The use of an apical barrier in aiding MTA compaction was also proven to be able to create an adequate apical seal. Therefore, when clinicians face a type II DI case, apexification or PR are not the only treatment options available. Depending on the case, conventional RCT is also an applicable treatment option (22).

4.2.2 Case study: Nonsurgical conventional root canal therapy on type II DI without the removal of invagination

As previously mentioned in the ***Figure 4,*** the indicated treatment protocol for type II DI in a closed apex, is the removal of the invagination followed by conventional RCT (7). An interesting case published in a scientific journal presents an 11-year-old patient who was referred to the endodontist specialist after multiple failed attempts to carry out conventional RCT on a maxillary right lateral incisor (tooth 12). The lateral incisor presented pain upon percussion, sensitivity and recurrent sinus tract in the vestibular area. The general practitioner who initiated treatment located one canal, and with various placements of intracanal medicaments over 8 months, failure of relief of symptoms lead to the referral to the endodontist specialist. Upon examination, in conjunction with radiographs, type II DI with a peri-radicular lesion was diagnosed. Tooth 12 also responded negatively to the

pulp sensitivity test. On the first appointment, the clinician placed anaesthesia and isolated the tooth using a rubber dam. The access cavity was then modified leading to the discovery of the second canal, the invagination present in the radiographs. The canals 'were negotiated with 15 K-flexofile and irrigated with 2.5% NaOCl' (25). Root ZX apex locator was used in determining the working length followed by instrumentation of the canals. Firstly, the primary canal was instrumented using manual instrumentation (size 50K-file) and step-back technique. Preparation of the cervical third was carried out with Gates-Glidden burs. Secondly, the invagination, which is the secondary canal was instrumented using a size 40 K-file. Throughout the treatment the selected choice of irrigant used was 2.5% NaOCl, excluding the step of preparation of the cervical third of the primary canal with the Gates-Glidden burs. The final irrigation cycle was carried out by rinsing the canal with 5mL of 17% EDTA for 3 minutes, which was activated using ultrasonic stream and followed by sterile saline solution at 5mL. The canal was then dried, and the clinician placed calcium hydroxide paste with a temporary filling. The second appointment was carried out two weeks later after the confirmation of tooth 12 being asymptomatic and the curation of the sinus tract. Both canals were obturated using the lateral condensation technique with gutta-percha and AH plus cement. The crown was obturated using composite resin. Control radiographs were taken at 6,12 and 18 months which provided evidence of complete periapical healing. The patient then proceeded to begin orthodontic treatment (25). ***Figure 10*** provides a summary of treatment on tooth 12 (25).

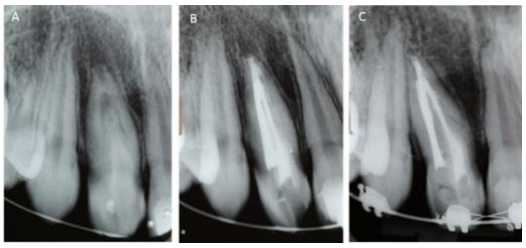


Figure 10. Conventional RCT on tooth 12 **A.** Maxillary lateral incisor presenting type II DI and a peri-radicular lesion **B.** Final radiograph after endodontic treatment **C.** 18-month follow up control radiograph showing complete bone repair (25)

To conclude, this complex case showed that the presence of type II DI with a secondary canal can be often misdiagnosed by general practitioners and lead to the failure of conventional RCT. In addition, when treating type II DI, the secondary canal can be left and treated in conjunction to the primary canal whilst still resulting in a successful resolution of the peri-radicular lesion.

4.2.3 Case study: Surgical intervention to treat an open apex, coronal radicular invagination with an associated peri-radicular radiolucency

Surgery as a treatment option for DI is indicated if conservative treatment such as conventional RCT, apexification or PR fails (7). However, in cases of RDI,

peri-radicular surgery is a viable treatment option (7)(8). This surgical technique including a retrograde filling with the use of gutta-percha was demonstrated in a case of a 23-year-old patient who upon examination presented radiographic findings of: 'open apex, coronal radicular invagination and a short root with an associated peri-radicular radiolucency which began at the apex and extended along the distal side of the root' on maxillary right lateral incisor (tooth 12) (8). See below ***Figure 11.***

Figure 11. Maxillary lateral incisor presenting an immature apex, 5 years prior to necrosis or sinus (8)

The patient's chief complaint was a 'sinus in the area of the apex of the maxillary right lateral incisor' with 'slight swelling associated with a labial sinus' (8). It should also be noted that the crown of tooth 12 presented an anatomical malformation, with a conical and microdontic appearance. See ***Figure 12*** (8)**.** The tooth did not respond to thermal or electric tests that were performed to diagnose the vitality of the pulp. However, the tooth was sensitive to percussion and presented slight mobility of 2mm. The final diagnosis of 'chronic peri-radicular abscess with periodontitis was made' (8) and the chosen treatment was peri-radicular surgery using a full-thickness muco-periosteal flap. 'This procedure results in minimal loss of hard tissues, permitted subsequent restoration of the tooth' (8). The tooth after diagnosis and prior to surgery can be seen in ***Figure 13*** (8).

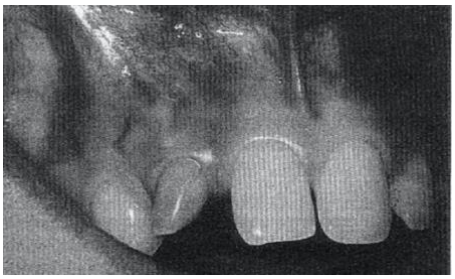


Figure 12. Intraoral view of tooth 12, with microdontic and conical shape with a sinus present at the apex (8)

Figure 13. Maxillary lateral incisor with an immature apex, DI, short root with peri-radicular radiolucency and microdontic appearance (8)

Anaesthesia was administrated and a flap was made using an intrasulcular

incision. The cortical bone was affected by the lesion so the use of a round bur with a slow handpiece to limit the margins was necessary. Saline irrigation was used. 'Curettage of the soft tissue around the root-end of the tooth was undertaken' (8) and placement of haemostatic plug in the bony defect at the apex was placed. The plug consisted of alginate calcium fibres and surgical wax. NaOCl at 2% was used to irrigate the canal via the apical opening, with the aid of curved files. The haemostatic plug was removed and replaced after irrigation and cleaning of the cavity. Zinc oxide-eugenol cement was then carried into the canal on a pre-curved file and using an amalgam carrier, gutta-percha was heated and compacted using a spacer. 'Another increment of gutta-percha was compacted with a spreader of the diameter of the cavity completed the filling'(8). A helicoidal tungsten-carbide bur was used to finish the filling and cold burnished. As seen in ***Figure 14*** (8)**.**

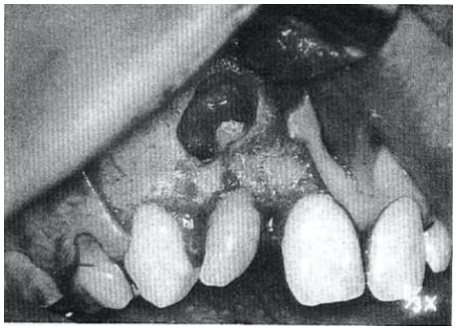


Figure 14 .Tooth 12 compacted with gutta-percha and cold burnished (8)

'The mixture of alginate fibres and surgical wax was removed and the bony crypt rinsed with physiological saline and the flap was repositioned and sutured' (8). ***Figure 15*** shows the final radiograph (8)

Figure 15. Final radiograph shows obturated canal (8)

The patient was prescribed post treatment medication of antibiotics and anti-inflammatories with the addition of a chlorohexidine mouthwash. Post-operative reviews including radiographs and clinical examinations that were carried out at 15 and 30 days followed by 2,3,6,9 and 12 months. Complete osseous healing was seen.

This case provides evidence of a successful treatment of DI when using an invasive surgical technique. The success of this treatment provides promise for surgical intervention for more complex severe cases of DI that cannot be treated conventionally but can be saved from extraction.

4.3 Future trends

The importance of radiography as a diagnostic tool has been emphasised throughout various literature. In addition to the use of conventional radiographs that are used routinely in endodontics for diagnostic purposes, such as periapicals, in the past decade there has been an increase in the use and development of three-dimensional imaging (7)(26). Previously, radiographs were limited to simply to two-dimensional images (26), and even though DI can be 'detected by routine radiographs, cone-beam computed tomography (CBCT) has aided not only in diagnosis and classification, but also in improved treatment planning of complicated cases' (26) (27). This is due to the technique offering the clinician with a more precise and accurate view of the canals (7).'Various authors have reported the benefits of CBCT in management of complex endodontic cases' (26). Therefore, on the basis of current literature, it is evident that in the future with further advances in technology, treatment protocols for DI are also likely to evolve.

5. Conclusion

In conclusion, it has been presented that the treatment protocols used to treat DI are different according to the different types of DI present and the condition of the main pulp. The main principle in selecting the correct treatment protocol is based on maintaining the vitality of the pulp or preserving the tooth by the least invasive method possible. The efficiency of these protocols has been seen throughout clinical cases presented in literature and impact journals throughout the last decades. It is important to highlight that each case requires a careful diagnosis and treatment planning upon selection of protocol as not all cases can be treated in the same methodical manner. Finally, we can predict an evolution in upcoming protocols for DI, provided that technological advances within Dentistry also continue to evolve.

6. Responsibility

In terms of social sustainability, this literature review shows importance in the field of Endodontics in Dentistry due to the lack of general consensus surrounding aspects of Dens in dente. Therefore, this review highlighted the need to raise awareness for more research to be carried out to gain a wider understanding of the anomaly for the use of general practitioners, thus improving patient care. Considering economic sustainability, treating DI at an early stage prevents the patient from needing conventional RCT or further surgical intervention which would essentially cost more. In addition, with regards to environmental sustainability,

an early diagnosis can lead to preventive treatment which serves as an advantage for the patient and environment as no detrimental impact is caused on either factor. Fewer materials are used, and the patients' health is preserved.

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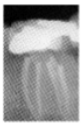

CLINICAL ARTICLE

Dens invaginatus. Part 1: classification, prevalence and aetiology

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Abstract

Alani A, Bishop K. Dens invaginatus. Part 1: classification, prevalence and aetiology. *International Endodontic Journal*, **41**, 1123–1136, 2008.

Aim To review and discuss the aetiology, prevalence and classification of this dental anomaly together with the morphology of an invagination and the most appropriate nomenclature.

Summary This review considers the different possible nomenclatures and concludes that dens invaginatus is the most appropriate description. The paper highlights the different reported prevalence figures and concludes that the problem is probably one of the most common of the dental developmental abnormalities with maxillary lateral incisors most commonly affected. The paper suggests that the classification system described by Oehlers (1957a) is probably the most clinically relevant and that the morphological features associated with this problem may increase the risk of pulpal pathology developing and complicate any possible endodontic treatment.

Key learning points

- The aetiology of dens invaginatus is still unknown, although there is some evidence that it may be genetic in origin.
- The problem is probably more prevalent than most clinicians are aware of and this is because of the diagnostic difficulties associated with the anomaly.
- The nature of the problem may increase the risk of pulp disease and complicate any root canal treatment.

Keywords: aetiology, classification, dens in dente, dens invaginatus, nomenclature, prevalence.

Received 21 January 2008; accepted 19 July 2008

Introduction

Dens invaginatus is a developmental anomaly resulting in a deepening or invagination of the enamel organ into the dental papilla prior to calcification of the dental tissues (Hülsmann 1997). A number of other terms have also been used to describe the condition.

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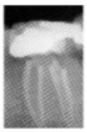
doi:10.1111/j.1365-2591.2008.01469.x



CLINICAL ARTICLE

Dens invaginatus. Part 2: clinical, radiographic features and management options

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Abstract

Bishop K, Alani A. Dens invaginatus. Part 2: clinical, radiographic features and management options. *International Endodontic Journal*, **41**, 1137–1154, 2008.

Aim To describe the possible clinical and radiographic features of this developmental anomaly, review previous treatment recommendations and suggest management options based on the classification of the problem.

Summary This paper describes the clinical and radiographic features related to the different types of dens invaginatus and highlights those features which may indicate the presence of a previously undetected invagination. Aids to clinical diagnosis are described together with a description of the possible radiographic features, which may suggest the presence of an invagination. Previous treatment suggestions are described and suggestions as to possible management options, based on current endodontic knowledge and the classification of the problems are described.

Key learning points

- Thorough clinical and radiographic examination is required to diagnose and successfully treat minor to severe invaginations.
- Modern clinical techniques may facilitate the management of invaginations once considered untreatable.

Keywords: dens in dente, dens invaginatus, microscopy, mineral trioxide aggregate, root canal treatment.

Received 21 January 2008; accepted 19 July 2008

Introduction

In the first paper, the prevalence, classification and aetiology of dens invaginatus was discussed. In this second of the series, the possible clinical presentations of the problem will be highlighted and the treatment options considered.

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Journal section: Operative Dentistry and Endodontics
Publication Types: Case Report

doi:10.4317/jced.56944
https://doi.org/10.4317/jced.56944

Relationship between internal root resorption and dens in dente

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Received: 17/02/2020
Accepted: 14/05/2020

Pérez-Alfayate R, Mercadé M, Vera J. Relationship between internal root resorption and dens in dente. J Clin Exp Dent. 2020;12(8):e800-4.

Article Number: 56944 *http://www.medicinaoral.com/odo/indice.htm*
© Medicina Oral S. L. C.I.F. B 96689336 - eISSN: 1989-5488
eMail: jced@jced.es
Indexed in:
Pubmed
Pubmed Central® (PMC)
Scopus
DOI® System

Abstract

Background: The aim is to report the treatment and follow-up of three lateral incisors with internal root resorption and dens in dente as a possible cause for their development, managed by root canal treatment and apical obturation with MTA or gutta-percha.

Case description: This case report presents three clinical cases in which dens invaginatus type 2 is shown as a potential cause for the development of internal root resorption. Two cases were filled with a MTA apical plug technique and one with gutta-percha, and all were follow-up through time.

Practical implications: The incidence of the association of internal root resorption with dens invaginatus may be underestimated and should be studied.

Key words: *Dens in dente, dens invaginatus, internal root resorption, Mineral Trioxide Aggregate, palatal invagination.*

Introduction

Dens invaginatus is one of the most common developmental anomalies, with a prevalence of around 0.3% to 10% (1), resulting in invagination of the enamel organ into the dental papilla before calcification of the teeth (2). Oehlers, in 1957 (3), classified this anomaly into three basic types, in which treatment options and prognosis were different: types 1 and 2 are characterized by incomplete invaginations, while types 3a and b are characterized by more complete invaginations. Regarding incomplete invaginations, type 1 has a prevalence of approximately 79%, being the most common (4). Invagination remains confined to the crown and does not extend beyond the level of the external cementoenamel junction (3). In type 2, which is less frequent, 15% of invaginations extend into the root, ending as a blind sac without communicating with the periodontium (3).

Regarding internal root resorption (IRR), which is the progressive destruction of intraradicular dentin of the canal walls as a result of clastic activities (5), many injurious events such as trauma, caries and periodontal infection, heat, calcium hydroxide procedures, vital root

A review of dens invaginatus (dens in dente) in permanent and primary teeth: Report of a case in a microdontic maxillary lateral incisor

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An unusual presentation of dens invaginatus affecting a microdontic permanent lateral incisor in a 19-year-old female patient is reported and pertinent literature reviewed. The patient was referred to the oral and maxillofacial radiology clinic of the authors' institution for radiographic examination of her maxillary teeth. Dens invaginatus was identified on the maxillary right lateral incisor in the anterior periapical radiographs. The tooth was microdontic and clinically simulated a primary tooth. Dens invaginatus occurs rarely in primary dentition although it is fairly common in permanent teeth. Only 4 instances of dens invaginatus affecting the primary dentition have been reported in the literature. The etiology, pathophysiology, association with other dental anomalies, as well as management aspects of this common anomaly, are discussed. *(Quintessence Int 2006;37:125–129)*

Key words: dens in dente, dens invaginatus, permanent tooth, pulp vitality

Dens invaginatus is a developmental anomaly affecting permanent and, less commonly, primary dentition. It is characterized by the inversion or infolding of the enamel and dentin toward the pulp chamber, usually appearing as an opening on the surface of the crown. The coronal invagination may be limited to the region of the crown or may extend deeper into the radicular region with or without involving the pulp. Dens invaginatus, also known as *dens in dente* or *gestant odontome,* most commonly affects permanent maxillary incisor teeth.[1] Primary teeth are infrequently affected.[1] This defect is commonly diagnosed as an incidental radiographic finding unless the patient presents with pain and/or swelling associated with the involved tooth. Because of the fact that teeth with dens invaginatus are predisposed for caries, pulp infections, and eventually periapical infections, early diagnosis is desirable.

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Case Report

Dens in dente: A minimally invasive nonsurgical approach!

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Abstract

Dens invaginatus, also known as dens in dente, is a rare anomaly affecting human dentition. The condition results in invagination of an amelodental structure within the pulp. This case report discusses the current management protocol of dens invaginatus using a minimally invasive and nonsurgical treatment option. As with most conditions, early diagnosis and preventive measures help minimize complications in dens invaginatus cases.

Keywords: Dens invaginatus; microscope; minimally invasive; nonsurgical

INTRODUCTION

"Dens in dente" is a developmental malformation incident due to the in folding of enamel and dentin or an accentuation of the lingual pit of an incisor before calcification sets in. Various causes of this condition have been proposed which include focal growth retardation (Kronfeld 1934), infection (Fischer 1936, Sprawson 1937), rapid proliferation of a part of the inner enamel epithelium into the dental papilla (Rushton 1937), increased localized external pressure (Euler 1939, Atkinson 1943), fusion of two tooth germs (Bruszt 1950), trauma (Gustafson and Sundberg 1950), distortion and protrusion of the enamel organ during tooth development (Oehlers 1957), and absence of signaling molecules for morphogenesis and therefore, genetic factors are involved (Grahnen *et al*., 1959, Casamassimo *et al*., 1978, Ireland *et al*., 1987, and Hosey and Bedi, 1996).[1-3] The maxillary lateral incisor is most commonly affected and one of the reasons being the external forces applied on the lateral incisor tooth bud by the developing central incisor or canine which develops 6 months prior.[4]

Many classifications have been elaborated on the clinical and radiographic appearances of this anomaly. However, Oehlers classification is most widely used due to its ease of application [Figure 1a] with the only disadvantage being that it fails to explain the true extent and complexity of the invagination as it is based on the radiographic representation. Therefore, a classification for treatment protocol needs to be devised on the basis of advanced three-dimensional (3D) imaging.

A wide array of treatment modalities ranging from the placement of sealants to retrograde fillings is rendered on the severity of invagination. Success in endodontic treatment is achieved when a tooth has predictable morphology that can be easily debrided by cleaning and shaping followed with a 3D obturation.[5] Atypical anatomy confirms difficulty in the endodontic treatment.

CASE REPORT

A female patient aged 13 years referred to the Department of Conservative Dentistry and Endodontics in M. A. Rangoonwala Dental College, Pune, for evaluation and treatment of constant pain and draining sinus in relation to maxillary anterior tooth [Figure 1b]. Clinical examination revealed tenderness and sinus tract in the buccal mucosa associated with the maxillary left lateral incisor. The radiograph showed complex tooth anatomy with an

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Date of submission : 24.05.2016
Review completed : 02.07.2016
Date of acceptance : 05.08.2016

Access this article online
Quick Response Code:
Website: www.jcd.org.in
DOI: 10.4103/0972-0707.190014

How to cite this article: Hegde V, Morawala A, Gupta A, Khandwawala N. Dens in dente: A minimally invasive nonsurgical approach!. J Conserv Dent 2016;19:487-9.

A nonsurgical endodontic treatment in open-apex and immature teeth affected by dens invaginatus

Using a collagen membrane as an apical barrier

Maryam Gharechahi, DDS, MS; Jamileh Ghoddusi, DDS, MS

Dens invaginatus (DI) is a developmental anomaly of teeth that results from an invagination of the enamel organ into the dental papilla before calcification.[1] Among the other names for this condition are "dens in dente," "invaginated odontome," "tooth inclusion" and "dentoid in dente."[2] The prevalence of DI ranges from 0.04 percent to 10 percent[3]; the maxillary lateral incisors are affected most commonly and the central incisors are affected less frequently.[4]

DI's clinical appearance varies considerably. In affected teeth, the morphology of the crowns can appear normal; however, teeth with DI also can have unusual features such as a greater labiolingual diameter or a cusp that is peg shaped, barrel shaped, conical or talon shaped. If these teeth have open root apexes, they present the clinician with an additional challenge in controlling the apical extent of the root filling and in restoring the apical portion of the tooth.[5]

The use of barrier membranes in endodontic surgery was advocated by Duggins and colleagues[6] for the management of root perforation, by Pecora and colleagues[7] for the management of large periapical lesions

ABSTRACT

Background. The authors' objective in this case report is to demonstrate an effective nonsurgical endodontic treatment in open-apex teeth affected by dens invaginatus (DI) by using a collagen membrane as an apical barrier and using a mineral trioxide aggregate (MTA) apical plug.

Case Descriptions. The authors present two cases of DI with open apexes in maxillary lateral incisors. In the first case, an adolescent had bilateral Oehlers type II DI and extensive periradicular radiolucency, internal root resorption and a vestibular fistula in the left maxillary lateral incisor. In the second case, an adult had Oehlers type II DI and an incomplete apex in the left maxillary lateral incisor. For both patients, the clinician placed a collagen membrane through the apexes of the left maxillary incisors to provide a resorbable extraradicular barrier against which MTA cement could be packed. The clinician obturated the adolescent's right lateral incisor.

Results. In the adolescent, the vestibular sinus tract was closed after one week. At subsequent follow-up examinations, the periradicular regions were completely healed, and postoperative radiographs revealed good bone healing in the lateral incisors. The teeth were asymptomatic and healing was achieved without any need for further endodontic surgical intervention. In the adult patient, the tooth was symptom free after one week, and radiography performed six months after the procedure showed complete healing.

Conclusions and Clinical Implications. Despite complex anatomy and diagnoses of DI and open apexes, both patients successfully underwent nonsurgical endodontic treatment involving the use of a collagen membrane and an MTA apical plug. Using an extraradicular barrier clinically can help improve the adaptation of MTA in the apexes of open-apex teeth to achieve a complete seal.

Key Words. Dens invaginatus; endodontic therapy.
JADA 2012;143(2):144-148.

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doi:10.1111/j.1365-2591.2008.01399.x

CASE REPORT

Dens invaginatus and treatment options based on a classification system: report of a type II invagination

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Abstract

Kristoffersen Ø, Nag OH, Fristad I. Dens invaginatus and treatment options based on a classification system: report of a type II invagination. *International Endodontic Journal*, **41**, 702–709, 2008.

Aim To give an overview of treatment options for dens invaginatus based on a classification system.

Summary Dens invaginatus is a dental malformation which may give endodontic complications. Treatment may vary in relation to anatomy, and a classification system for dens invaginatus forms the basis for discussion. A clinical case, classified as a type II invagination (Oehlers' classification), is also presented. Clinical and radiographic examination revealed an invagination penetrating into the apical third of the root canal in tooth number 12. The tooth was immature with an open apex, apical pathosis and a labial fistula. To control the infection, ultrasonic removal of the invagination was necessary, as the invagination prevented complete cleaning and shaping of the root canal. After chemo-mechanical preparation and dressing with calcium hydroxide, an apical plug of MTA was placed, followed by restoration of the tooth with resin-bonded composite. Healing of the lesion with hard tissue formation was confirmed at follow-up.

Key learning points

- Knowledge about classification and anatomical variations of teeth with dens invaginatus is important in endodontic decision making.
- A classification system may be helpful when treatment options are considered.
- Classification of dens invaginatus requires a thorough preoperative radiographic examination.

Keywords: apexification, dens invaginatus, endodontic treatment.

Received 11 October 2007; accepted 4 January 2008

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Australian Dental Journal
The official journal of the Australian Dental Association

Australian Dental Journal 2017; 62: 261–275

doi: 10.1111/adj.12513

An update on the diagnosis and treatment of dens invaginatus

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ABSTRACT

Dens invaginatus is a malformation with varying anatomical features, posing challenges to treatment. Early and accurate diagnosis plays a significant role in selecting the appropriate treatment. The diagnosis of teeth with a complex root canal system including dens invaginatus has made progress with the application of three-dimensional imaging techniques in endodontics. Advanced treatment options provide hope for teeth that could not be saved before. This review discusses diagnostic methods and treatment options for teeth with dens invaginatus, and provides guidelines for the management of dens invaginatus cases in clinic. Current as well as traditional diagnostic techniques are summarized. Treatment options including state-of-the-art alternatives are presented for coronal dens invaginatus and radicular dens invaginatus.

Keywords: cone-beam computed tomography, dens invaginatus, diagnosis, radiographic examination, treatment.

Abbreviations and acronyms: CBCT = cone-beam computed tomography; CDI = coronal dens invaginatus; CT = computed tomography; DI = dens invaginatus; micro-CT = microcomputed tomography; MTA = mineral trioxide aggregate; PR = pulp revascularization; RCT = root canal treatment; RDI = radicular dens invaginatus; RG = radicular groove; SCT = spiral computed tomography.

(Accepted for publication 9 March 2017.)

INTRODUCTION

Dens invaginatus (DI) is a developmental anomaly of a tooth caused by the invagination of the crown and/or the root surface before mineralization occurs.[1–3] The prevalence of DI ranges 0.3–10%.[4] DI is most often found in the maxillary lateral incisors, followed by the maxillary central incisors, while it is rare in the canines, premolars and molars.[1,5,6] Also, the bilateral occurrence of DI is not uncommon.[7,8] This anomaly may occur concomitantly with other dental anomalies such as hypodontia, hyperdontia or macrodentia.[9–11]

Dens invaginatus mostly affects the permanent teeth, but sometimes also the deciduous teeth may be affected.[12] Until now, only five case reports have presented patients with primary teeth with DI (Table 1).[12–16] DI has also been found in patients with supernumerary teeth or mesiodens, but this is an unusual phenomenon.

The aetiology of DI is unclear, but seems to involve both genetic and environmental factors.[4,5,17] The interaction between mesenchymal and epithelial cells plays an important role in tooth development.[18–20] This interaction is regulated by various signalling proteins such as fibroblast growth factors, bone morphogenetic proteins, tumour necrosis factors, Wnts and sonic hedgehog.[21,22] Variations in the genes involved in these signalling pathways affect tooth formation and tooth morphogenesis.[21,23,24] A patient with numerous dental anomalies including DI was reported to have a deletion of the chromosome region 7q32.[25] Focal excessive cell proliferation of the internal enamel epithelium, and abnormal growth of the dental papilla were suggested as pathological factors of DI.[17,26,27] External forces from adjacent teeth, trauma and infection may also contribute to the aetiology of DI.[4,17]

Coronal and radicular DI are the main types of DI.[28,29] The main difference between the two types is the origin of the invagination.[30] The coronal type is more common, and is caused by the invagination of the enamel organ into the dental papilla before

§These authors contributed equally to this study and should be considered co-first authors.

Indian Journal of Dental Sciences.
September 2012 Issue:3, Vol.:4

www.ijds.in

Review Article

Indian Journal of Dental Sciences

E ISSN NO. 2231-2293 P ISSN NO. 0976-4003

Dens Invaginatus (Tooth Within Tooth). A Review Of The Literature And Diagnostic And Management Guidelines For Practicing Dentists.

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Submission : 10th October 2011
Accepted : 13th May 2012

Quick Response Code

Abstract
Dens invaginatus is a maldevelopment of the dental germ which occurs as a result of the invagination of the enamel organ. These cases may present difficulties with respect to its diagnosis and treatment because of canal morphology.It frequently leads to caries, pulpal and periodontal involvement with necrosis and loss of attachment. The knowledge of classification and anatomical variations of teeth with dens invaginatus are of great importance for correct treatment Due to the complexity of the malformation, treatment options in former days were limited. This article presents a profound review of the literature regarding etiology, epidemiology and histology. It discusses clinical appearance and diagnosis and it provides guidelines for decision-making and treatment of invaginated teeth.

Key Words
Dens invaginatus, aetiology,classification,diagnosis, management.

Introduction

Dens invaginatus is a developmental anomaly resulting from the invaginations of the enamel organ into the dental papilla during the soft tissue stage of development. As the hard tissues are formed, the invaginated enamel organ produces a small tooth within the future pulp chamber. This kind of tooth malformation was described first by Ploquet in 1794 who discovered this anomaly in a whale's tooth[1].

Dens invagination in a human tooth was first described by a dentist named 'Socrates' in 1856 [2]. Synonyms for this malformation are: Dens in dente, invaginated odontome, dilated gestant odontome, dilated gestant odontome, dilated composite odontome, tooth inclusion, dentoid in dente, gestant odontome, dents telescopes.

Aetiology

The aetiology of dens invaginatus malformation is controversial and remains unclear. Over the last decades several theories have been proposed to explain the aetiology of dental coronal invaginations:

- Kronfeld (1934) suggested that the invagination results from a focal failure of growth of the internal enamel epithelium while the surrounding normal epithelium continues to proliferateand engulf the static area[3].
- Rushton (1937) proposed that the invagination is a result of rapid and aggressive proliferation of a part of the internal enamel epithelium invading the dental papilla. He regarded this as benign neoplasma of limited growth[4].
- Oehlers (1957) considered that distortion of the enamel organ during tooth development and subsequent protrusion of a part of the enamel organ will lead to the formation of an enamel-lined channel ending at the cingulum or occasionally at the incisal tip. The latter might be associated with irregular crown form[5,6].
- Atkinson (1943) suggested that the problem was the result of external forces exerting an effect on the tooth germ during development[7]. Such forces could be from adjacent tooth germs, e.g. the central incisor or canine which develop at least 6 months prior to the lateral incisor[8] whilst other external factors such as trauma[9] and infection[10] have also been suggested as a cause.
- During tooth development the ectomesenchymal signalling systems that occur between the dental papilla and the internal enamel epithelium affect tooth morphogenesis[11]. These signals have specific roles such as the regulation of growth and the folding of the enamel organ[12]. The absence of certain molecules can result in abnormally shaped teeth as well as defects in the developing tooth germ[13]. For this reason the proposal that genetic factors may be the cause of dens invaginatus has some credibility[14-16]. Support for this possible cause also comes from a reported case of an individual lacking chromosome 7q32 who presented with dens invaginatus in addition to other dental abnormalities such as hypodontia[17]. There is further support from a clinical study of 3020 Swedish children that reported 2.7% of patients with dens invaginatus, 43%

IEJ
Iranian Endodontic Journal

Sealing Ability of Mineral Trioxide Aggregate and Calcium-Enriched Mixture Cement as Apical Barriers with Different Obturation Techniques

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ARTICLE INFO

Article Type:
Original Article

Received: 03 Mar 2014
Revised: 09 Jun 2014
Accepted: 29 Jun 2014

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ABSTRACT

Introduction: Endodontic treatment in pulpless immature teeth is challenging due to the lack of an apical stop. Insertion of an apical plug is an alternative to conventional long-term apexification with calcium hydroxide. The aim of this study was to compare the apical microleakage of mineral trioxide aggregate (MTA) and calcium-enriched mixture (CEM) cement as apical plugs with three different obturation techniques. **Methods and Materials:** This experimental study was conducted on 130 single rooted human teeth with one canal. Samples were randomly divided into 2 experimental groups (n=60) and two negative and positive control groups containing 5 samples each. After cleaning and shaping, an open apex configuration was prepared in all samples. MTA or CEM cement apical plugs with 5 mm thicknesses were placed. Then, each group was divided to 4 subgroups and the remaining space of root canals were filled with either lateral compaction or thermoplasticized injectable gutta-percha or was obturated by filling the entire canal with apical plug material. In one remaining subgroup the canal space was left unfilled. Microleakage was measured by the fluid filtration method and results were analyzed by means of the two-way ANOVA test. **Results:** There were no significant differences between microleakage of MTA and CEM cement apical plugs (P=0.92). The difference between three obturation methods was not significant, either (P=0.39). **Conclusion:** MTA and CEM cement have similar sealing ability as apical plugs and no significant difference was found in microleakage of the three groups.

Keywords: Apexification; Apical Plug; Apical Seal; Calcium-Enriched Mixture; Mineral Trioxide Aggregate; Microleakage; Root Canal Obturation; Root Canal Sealing Material

Introduction

Endodontic treatment of an open-apex tooth with a necrotic pulp has always been challenging. For many years, calcium hydroxide (CH) has been advocated for apexification and induction of an apical hard tissue matrix which can limit the obturating material within the canal space [1]. The main drawback of this procedure is the need for multiple appointments and this long-term treatment procedure makes the tooth susceptible to fracture [2, 3]. Therefore, one-step apexification or apical plug technique was suggested. There are many reports that disclose successful treatment of the open-apex teeth by means of mineral trioxide aggregate (MTA) as an apical plug. Several review articles have also described clinical procedures with MTA as an apical plug [4]. MTA is a biocompatible material [5, 6] with few drawbacks like long setting time, tooth discoloration potential [4], and difficult manipulation [7].

Another biomaterial for this purpose is calcium-enriched mixture (CEM) cement which consists of different calcium compounds [8]. CEM cement has good sealing ability as retrograde filling material [9] and has shown satisfactory pulpal response as a direct pulp capping agent [10].

An important factor for successful endodontic treatment in open-apex teeth is the sealing ability of apical plug. Few studies

International Endodontic Journal (1997) 30, 145–149

Surgical treatment of a periradicular lesion on an invaginated maxillary lateral incisor (*dens in dente*)

Clinical Article

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Summary

The complex anatomy of invaginated teeth make their root canal treatment difficult. Moreover, this treatment may compromise the future of the tooth if it is destined to support a post-retained coronal restoration. This case reports the successful surgical root canal treatment of an invaginated tooth using a retrograde filling with gutta-percha. After surgical exposure of the root-end and cleaning of the root canal, the gutta-percha was compacted in the root canal which had been coated previously with a zinc oxide–eugenol cement. The gutta-percha was then cold-burnished. Periapical radiographic examination after 1, 2, 3, 6 and 12 months showed periapical healing with osseous formation. This procedure, resulting in minimal loss of hard tissues, permitted subsequent restoration of the tooth.

Keywords: *dens in dente*, dens invaginatus, gutta-percha, retrograde filling.

Introduction

Dens in dente has always been considered a spectacular dental anomaly. It is of embryonic origin and results from epithelial invagination within the depths of the ecto-mesenchymatous papilla. At a given moment during the development of the tooth, an amelodentinal structure, more or less developed, forms within the pulp (De Smit *et al.* 1984). Clinically, the *dens in dente* is distinguished by anomalies of form, volume or structure which can affect both the crown and the root (Ohlers, 1957). The more frequently seen abnormalities of the crown are accentuation of the cingulum, increase in the bucco-lingual or mesio-distal dimension or, on the contrary, decrease in these dimensions. Anomalies of the root may affect only part of it or sometimes extend to the apex. Radiographically, it sometimes gives the appearance of a tooth within another tooth, hence the name *dens in dente*. With regard to the epidemiology, this anomaly is most often found in the maxillary lateral incisor (Pindborg, 1970). Cases are rarely found in the mandible. One may also note that deciduous teeth are very rarely involved.

Because of the disturbed structure, the enamel covering the invagination is hypomineralized and therefore fragile. Chewing may result in the destruction of this layer and expose the pulp at a specific surface, sometimes even only as a pinpoint exposure. This explains the frequently observed pulpal necrosis of these teeth in the absence of frank caries. This necrosis may develop even before the complete maturation of the tooth (Villa *et al.* 1959).

The difficulty in treating such teeth is enhanced by the complexity of their anatomy. Dechaume (1966) and Farmer & Lawton (1966) proposed extraction as the treatment of choice to avoid complications. Root canal therapy has since been proposed to maintain these teeth in the dental arch (Grossman 1974, Tagger 1977, Zillich *et al.* 1983). In some cases, pulpectomy and root canal filling can be performed immediately (De Smit & Dermaut 1982, Camus *et al.* 1986). Sometimes, however, the state of root development necessitates an additional step using calcium hydroxide to allow apexification (Fergusson *et al.* 1980, Shay 1984). The complexity of the internal anatomy of the tooth presents problems which might result in failure, the root canal treatment cannot always presume obturation which extends to the apex (De Smit & Dermaut 1982). Therefore, a surgical approach can be indicated, consisting of an apical resection extending to the apical limit of an orthograde root filling or, when this simple resection is not possible, a retrograde filling may be indicated (Weine 1982).

The case presented here reports the successful treatment of an invaginated tooth presenting with an apical

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CLINICAL PRACTICE ARTICLE

Nonsurgical endodontic management of dens invaginatus: a report of two cases [version 1; peer review: 2 approved]

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v1 **First published:** 02 Dec 2019, **8**:2039 (https://doi.org/10.12688/f1000research.21188.1)
Latest published: 02 Dec 2019, **8**:2039 (https://doi.org/10.12688/f1000research.21188.1)

Abstract

Dens invaginatus is a malformation affecting mainly the superior lateral incisors. It is defined as an infolding of the crown hard tissues, including the enamel and dentin, and can extend up to the root apex. Root canal treatment of this abnormality is considered difficult due to the complex anatomy presented by these teeth. This case series presents nonsurgical endodontic treatment in two cases of dens invaginatus (type II and III) in maxillary lateral incisors. This nonsurgical or conventional endodontic treatment results in healing of the periapical lesions associated with both cases, with no need for extra intervention e.g. surgical or invasive management. The manual instrumentation associated with sodium hypochlorite and calcium hydroxide were able to completely heal the lesions. Radiographic exams were carried out to control and asses the healing. Nonsurgical treatment was successful in both cases with adequate repair after a 6-year follow-up with radiographic and tomographic assessments.

Keywords

Dens invaginatus, Follow-up, Root canal treatment.

Open Peer Review

Reviewer Status ✓ ✓

	Invited Reviewers	
	1	**2**
version 1 published 02 Dec 2019	✓ report	✓ report

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Any reports and responses or comments on the article can be found at the end of the article.

Lee et al. BMC Oral Health (2020) 20:29
https://doi.org/10.1186/s12903-020-1008-x

BMC Oral Health

CASE REPORT Open Access

Treatment of peri-invagination lesion and vitality preservation in an immature type III dens invaginatus: a case report

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Abstract

Background: To report a case of type III dens invaginatus associated with peri-invagination periodontitis in an immature permanent mandibular central incisor with open apex, in which only the invagination area was treated and vitality was preserved.

Case presentation: A 9-year-old boy was referred complaining of pain in the mandibular left central incisor. After radiographic examination, an invagination into the pulp chamber of the tooth associated with periapical radiolucency was detected. Endodontic access was performed and the orifice was identified under a dental operating microscope. The invagination area was chemo-mechanically cleaned. After 1 week, the invagination was obturated with mineral trioxide aggregate. During the 2-year follow up period, the tooth was asymptomatic. Radiographic examination revealed significant progression of periapical healing and root development in the main root canal of the tooth.

Conclusion: Non-surgical root canal treatment of the invagination may preserve pulp vitality, and continuous root development of the tooth.

Keywords: Anomaly, Dens Invaginatus, Oehler type III invagination, Peri-invagination periodontitis, Root development, Vitality

Background

Dens invaginatus (DI) is a developmental anomaly, which results in the deepening or invagination of the enamel organ into the dental papilla before the calcification of dental tissues [1–3]. It is a rare malformation of the teeth, which shows a broad spectrum of morphological variations, in the form and size of the crown and root [3]. Thus, when the pulp complex is infected, cleaning and shaping procedures are more complicated than the usual root canal system [1, 3–5].

While the tooth that is most frequently affected by DI is the permanent maxillary lateral incisor, the occurrence of DI in the mandibular central incisor is rare [5–8]. The generally accepted classification for this anomaly is that proposed by Oehler [9], who categorized it based on the depth of enamel invagination observed radiographically.

A partial invagination limited to the crown of tooth in which the lesion does not extend pass the cementoenamel junction (CEJ) or the pulp was classified to Oehler Type I. In Oehler Type II, the partial invagination extends beyond the crown and CEJ. In type II, pulp may be involved but remain within the root anatomy and there is no communication of the lesion with periodontal ligament. Type III of this classification, in which the invagination continues apically through the root and shows a second foramen into the periodontal tissue, is of particular interest [10]. Oehler Type III invagination is a complete invagination with the lowest incidence amongst the three types [11]. The complex anatomical structures are subdivided into Type III A and Type III B according to the characteristics of communications with the periodontal tissue. Type III A is defined as an invagination extends through the root and communicates laterally with the periodontal ligament space through a pseudo-foramen. There is usually no

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CASE REPORT

Management of dens in dente associated with a chronic periapical lesion

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SUMMARY

Dens in dente is characterised as a developmental anomaly resulting from invagination of the enamel organ into the dental papilla. It is a rare malformation of teeth, showing a wide spectrum of morphological variations such as gemination, microdontia, taurodontism, dentinogenesis imperfecta, supernumerary tooth and hyperplasias, resulting frequently in early pulp necrosis. Maxillary lateral incisors are the commonest teeth to be affected by dental malformations—supernumerary tooth, talon cusp, congenitally missing tooth and dens in dente. We describe the management of a case of dens in dente in a maxillary lateral incisor with a periradicular lesion.

BACKGROUND

Dens in dente in a human tooth was first reported by Ploquet in 1794 and described by a dentist named 'Socrates' in 1856.[1] It is thought to occur when there is an infolding of the crown surface before calcification, resulting in variation in size and form during development of a tooth. This developmental malformation is also known as dens invaginatus, dilated composite odontome and dilated gestant odontome. It may occur in deciduous, permanent or supernumerary tooth and the reported incidence is estimated to range from 0.04% to 10%.[2] Males are affected more frequently than females, with a ratio of 3:1. Any teeth in the maxillary or mandibular arch may be affected, but the maxillary lateral incisors are the most frequently affected, followed by permanent central incisors, premolars, canines and molars.[3 4] A bilateral occurrence of this condition is frequently observed and it has been reported in association with taurodontism, microdontia, gemination and dentinogenesis imperfecta.[5 6] Oehler classified dens in dente in three categories according to the extension of the penetration and communication with the periodontal ligament or periapical tissues as degree 1, degree 2 and degree 3.[7] Degree 2 is an enamel lined cavity invading the root, which may/may not communicate with the pulp. Such cases, if not treated appropriately, lead to rapid periapical involvement.

The patient is usually unaware of this condition and the anomaly is detected with the help of an intraoral periapical (IOPA) radiograph taken for any other indication. Radiological examination shows a radio-opaque invagination similar in density to enamel, extending into the central region of the crown at a variable distance from the tooth. The following case report describes the management of a rare case of dens in dente in a maxillary lateral incisor associated with a chronic periapical lesion.

CASE PRESENTATION

An 8-year-old boy reported to the outpatient department of pedodontics with preventive dentistry, with pus discharge from the upper right anterior region for the past 6 months. Family and medical histories were found non-contributory. The dental history given by the patient revealed that the sinus would heal spontaneously, only to reappear in a few days. Extraoral examination revealed no significant findings. On intraoral clinical examination, the sinus was present in the periapical region of the upper right central incisor (tooth 12) with slight inflammation (figure 1). The presence of a discoloured pit on the lingual surface of tooth 12 was also noted. Radiological examination revealed a well-circumscribed radiolucent area at the undeveloped apex of the tooth, suggestive of a periapical pathological lesion (figure 2). When the IOPA radiograph was thoroughly examined, an identical tooth-like structure, resembling the typical appearance of dens in dente, was found in the root area close to the cementoenamel junction. Based on these peculiar clinical and radiological features, a definitive diagnosis of dens in dente was established.

TREATMENT

In the present case, pulpal necrosis occurred before the root end closure of the affected tooth, leading to the development of periapical lesions. Also, IOPA X-ray revealed a large root canal with irregular volume and a lateral large opening of the root

Figure 1 Intraoral clinical examination showing sinus in relation to tooth 12.

To cite: Mehta V, Raheja A, Singh RK. *BMJ Case Rep* Published online: [*please include* Day Month Year] doi:10.1136/bcr-2015-211219

Developmental Disturbance of a Maxillary Permanent Lateral Incisor Following Trauma at the Age of 16 Months: A 6-Year Follow-Up

Sreekanth K Mallineni*/ Hessa Al-Mulla** /Robert P Anthonappa*** / Joseph CY Chan****/ Nigel M King*****

A 3 year and 8 months old Chinese boy was referred for a consultation regarding his missing maxillary anterior teeth. He had a history of trauma to his primary maxillary anterior teeth due to a fall at the age of 16 months. Clinical examination of the patient indicated multiple carious lesions and inadequate oral hygiene. Radiographic examination revealed intrusion of the primary left lateral incisor, with evidence of damage to the permanent tooth germ. Subsequently, the patient was followed-up for almost six years during which his permanent maxillary left lateral incisor erupted exhibiting an unusual morphology. Clinically enamel hypoplasia and radiographically dens invaginatus were evident in affected tooth.

Keywords: *Trauma, Enamel hypoplasia, Dens invaginatus*

INTRODUCTION

The reported prevalence of traumatic injuries in primary dentition varies from 15% to 35%.[1] Trauma to a primary tooth can be responsible for the malformation of the succedaneous developing tooth germs. Experimental work on animals and observational studies on humans have established that if a region of the jaws is adversely stimulated during the period of tooth development, permanent teeth may fail to develop or be dwarfed.[2] Consequences of trauma to a primary teeth, as reported in the literature, include delayed development, enamel discoloration, enamel defects, dilacerations of the crown and/or root, malformation of the crown, and odontoma like malformations of the permanent tooth.[3-6] However, the majority of dental malformations are incidental findings, and few authors have even chosen not to speculate on their etiology. One possible reason for the damage can be attributed to the close anatomic relationship between the roots of primary incisors and permanent tooth germs,[3,5,7] which highlights that any type of trauma to the primary teeth may be of importance. However, the degree of damage to the permanent tooth is dependent on the age of the patient, extent of the trauma, and the stage of development of permanent tooth germ.[8]

Intrusion and avulsion are the most severe injuries that affect the developing tooth germ in children aged between 0-2 years of age[5,8] which corresponds to the time of calcification of the enamel matrix.[4,5,8] Although it has been reported that 88% of intruded primary teeth would erupt spontaneously, the treatment option for severely intruded of primary anterior teeth is extraction.[9] Re-implantation of avulsed primary teeth is contra-indicated.[9]

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Management of a Permanent Maxillary Lateral Incisor with Vital Pulp and Necrotic Dens Invaginatus Type III

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ABSTRACT

This is a case report on the management of a vital lateral incisor with a radiolucent cervical area associated with the presence of necrotic pulp due to a dens invaginatus (DI) type III. A nine-year-old boy presented to a university pediatric dental clinic with dental trauma. The examination showed poor oral hygiene, an uncomplicated fracture in the permanent maxillary left central incisor, and a fistula near the permanent maxillary right lateral incisor. A radiograph showed that the right lateral incisor had incomplete root development and a type III DI. Although sensitive to thermal pulp testing, tracing of the fistula indicated that the radiolucent area was associated with the DI, extending laterally to the periodontal ligament. Endodontic treatment was performed only in the invagination, keeping the root canal of the lateral incisor vital. After two years of follow-up, complete root formation and injury repair associated with invagination were observed. (J Dent Child 2017;84(3):149-51)

Received March 27, 2017; Last Revision June 5, 2017; Accepted June 7, 2017.

KEYWORDS: ENDODONTICS, DISTURBANCES IN DENTAL DEVELOPMENT, DENS IN DENTE

Dens invaginatus is a developmental anomaly resulting from invagination of the enamel organ in the dental papilla before the calcification of dental tissues.[1-4] The cause of this anomaly is still unknown. Possible etiologies include trauma, infection, focal growth retardation, changes in factors that regulate the formation of the enamel organ, and genetic factors.[1-3,5,6]

Invaginations can be classified into three categories, according to their depth and the existence of communication with the pulp tissue or periodontal ligament, regardless of the affected tooth.[7] In type I, invagination is minimal and confined within the crown and does not extend beyond the level of the cementoenamel junction; in type II, the invagination is coated with enamel and extends into the pulp chamber but remains within the root canal without communication with the periodontal ligament; type III invagination extends through the root and communicates with the periodontal ligament space in the apical foramen or through a pseudoforamen laterally. In type III, the invagination extends beyond the cementoenamel junction, penetrating the root, usually without communication with the pulp, and revealing a second side or apical foramen of the root surface.

The treatment of dens invaginatus may vary according to the type of invagination and pulp diagnosis. The

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Management of Dens Invaginatus Type II Associated with Immature Apex and Large Periradicular Lesion Using Platelet-rich Fibrin and Biodentine

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Abstract

Dens invaginatus (DI) poses peculiar challenges in endodontic treatment of teeth because of distortion of pulpal space. A case of Oehlers type II DI with open apex and large periapical lesion is reported. The case was managed using cone-beam computed tomography (CBCT), operating microscope, platelet-rich fibrin (PRF), and Biodentine. A 15-year-old male patient presented with palatal swelling. Pulp sensibility testing of right maxillary lateral incisor was negative. Intraoral periapical digital radiograph revealed an Oehlers type II DI with open apex and periapical radiolucency. A CBCT scan was performed to study the anatomy, determine the true extent of the periapical lesion, and form a treatment plan. A diagnosis of Oehlers type II DI with pulp necrosis and acute periapical abscess was made. Two-visit endodontic treatment was performed. In the first visit, the invaginated central mass was removed under operating microscope, chemo-mechanical preparation was done, and double antibiotic paste dressing was placed. In the second visit, the canal was sealed with apical matrices of PRF and Biodentine as filling material. The patient was asymptomatic and radiographs revealed continued healing of the osseous defect at follow-up visits. A CBCT scan at 30 months showed complete continuity of periodontal ligament space, healing of labial and palatal cortical plates, and formation of intercortical bone. The advances in endodontic armamentarium and technology, like CBCT and operating microscope, have made successful treatment of challenging cases possible. PRF and Biodentine as apical matrices and filling material, respectively, proved to be effective in the present case. *(J Endod 2017;43:1750–1755)*

Key Words

Apexification, Biodentine, cone-beam computed tomography, dens invaginatus, platelet-rich fibrin

Significance

This case report describes possibilities of better management and improved prognosis for endodontically complex cases owing to advancements in technology (CBCT) and biomaterials (Biodentine and PRF). This approach could help clinicians who come across similar anomalies while caring for patients.

Endodontists are often challenged by teeth with anomalous and complex root canal morphologies. The knowledge of such anatomic variations and thorough understanding of basic endodontic principles is essential for management of such cases. Dens invaginatus (DI) is a well-known dental anomaly occurring most commonly in maxillary lateral incisors (1). It is characterized by invagination of the enamel organ into the dental papilla before calcification has occurred (2). The incidence of DI ranges from 0.04% to 10% (3).

DI refers to a congenital infolding of a toothlike structure within a tooth. The most commonly accepted classification of DI was given by Oehlers in 1957 (4). Three subtypes are designated, which are based on the extent of apical migration of an enamel-lined invagination. In type I, the invagination is minimal and enamel-lined, it is confined within the crown of the tooth and does not extend beyond the level of the external cemento-enamel junction. In type II, the enamel-lined invagination invades into the root but remains confined within it as a blind sac. There may, however, be a communication with the pulp. The invagination may or may not be grossly dilated; in the former case, there is often a corresponding dilatation of the root or crown. In type III, the invagination penetrates through the root and "bursts" apically or laterally at foramen, sometimes referred to as a "second foramen" in the root. There is usually no communication with the pulp, which lies compressed within the wall around the invagination process.

Endodontic treatment can be predictable only when the entire root canal system is debrided and disinfected. Many previously published cases have shown the struggle in treatment of teeth with the DI (5–7). Earlier, imaging in endodontics was limited to 2-dimensional intraoral periapical radiographs. Although DI can be detected by routine radiographs, cone-beam computed tomography (CBCT), a 3-dimensional imaging modality, has aided not only in diagnosis and classification, but also in improved treatment planning of complicated cases (6,8–10). Various previous authors have reported the benefits of CBCT in management of complex endodontic cases (11, 12).

Biodentine is a calcium-silicate–based cement. Its powder is composed of tricalcium silicate, dicalcium silicate, calcium carbonate, and zirconium oxide. The liquid

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2017.04.005

INTERNATIONAL
ENDODONTIC JOURNAL

doi:10.1111/iej.12867

REVIEW

A new system for classifying tooth, root and canal anomalies

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Abstract

Ahmed HMA, Dummer PMH. A new system for classifying tooth, root and canal anomalies. *International Endodontic Journal*, **51**, 389–404, 2018.

Understanding the normal anatomical features as well as the more unusual developmental anomalies of teeth, roots and root canals is essential for successful root canal treatment. In addition to various types of root canal configuration and accessory canal morphology, a wide range of developmental tooth, root and canal anomalies exists, including C-shaped canals, dens invaginatus, taurodontism, root fusion, dilacerations and palato-gingival grooves. There is a direct association between developmental anomalies and pulp and periradicular diseases that usually require a multidisciplinary treatment approach to achieve a successful outcome. A number of classifications have categorized tooth, root and canal anomalies; however, several important details are often missed making the classifications less than ideal and potentially confusing. Recently, a new coding system for classifying root, root canal and accessory canal morphology has been introduced. The purpose of this article is to introduce a new system for classifying tooth, root and canal anomalies for use in research, clinical practice and training, which can serve as complementary codes to the recently described system for classifying root, as well as main and accessory canal morphology.

Keywords: anomalies, classification, c-shaped canals, dens invaginatus, palato-gingival groove, taurodontism.

Received 5 August 2017; accepted 9 October 2017

Introduction

Knowledge and understanding of the complexity of root and root canal systems are basic requirements for successful root canal treatment (Vertucci 2005). Root and canal anatomy is complex with several systems being available for classifying root canals and accessory canal morphology (Yoshiuchi *et al.* 1972, Vertucci *et al.* 1974, Yoshida *et al.* 1975, Matsunaga *et al.* 2014, Versiani & Ordinola-Zapata 2015). With an increasing range of anatomical complexities being reported and the deficiencies of the existing systems becoming more apparent, new systems for classifying root, root canal (Ahmed *et al.* 2017a) and accessory canal morphology (Ahmed *et al.* 2017b) have been proposed to provide detailed information for use by clinicians, trainees and academics.

The development of a tooth is a complex biological process moderated by a series of epithelial–mesenchymal interactions (Shrestha *et al.* 2015). Disturbance of the epithelial–mesenchymal interactions can alter normal odontogenesis causing a developmental anomaly [anomaly is a Greek word meaning 'irregular'; a deviation from what is regarded as normal] (Shrestha *et al.* 2015). Depending on the stage of tooth development, various anomalies either in root/canal number, size and/or shape can occur (Shrestha *et al.* 2015). The

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International Endodontic Journal

doi:10.1111/iej.12013

CASE REPORT

The diagnosis and conservative treatment of a complex type 3 dens invaginatus using cone beam computed tomography (CBCT) and 3D plastic models

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Abstract

Kfir A, Telishevsky-Strauss Y, Leitner A, Metzger Z. The diagnosis and conservative treatment of a complex type 3 dens invaginatus using cone beam computed tomography (CBCT) and 3D plastic models. *International Endodontic Journal*, **46**, 275–288, 2013.

Aim To investigate the use of 3D plastic models, printed from cone beam computed tomography (CBCT) data, for accurate diagnosis and conservative treatment of a complex case of dens invaginatus.

Summary A chronic apical abscess with a draining sinus tract was diagnosed during the treatment planning stage of orthodontic therapy. Radiographic examination revealed a large radiolucent area associated with an invaginated right maxillary central incisor, which was found to contain a vital pulp. The affected tooth was strategic in the dental arch. Conventional periapical radiographs provided only partial information about the invagination and its relationship with the main root canal and with the periapical tissues. A limited-volume CBCT scan of the maxilla did not show evidence of communication between the infected invagination and the pulp in the main root canal, which could explain the pulp vitality. A novel method was adopted to allow for instrumentation, disinfection and filling of the invagination, without compromising the vitality of the pulp in the complex root canal system. The CBCT data were used to produce precise 3D plastic models of the tooth. These models facilitated the treatment planning process and the trial of treatment approaches. This approach allowed the vitality of the pulp to be maintained in the complex root canal space of the main root canal whilst enabling the healing of the periapical tissues.

Key learning points

- Even when extensive periapical pathosis is associated with a tooth with type III dens invaginatus, pulp sensibility tests should be performed.
- CBCT is a diagnostic tool that may allow for the management of such teeth with complex anatomy.

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International Endodontic Journal

doi:10.1111/j.1365-2591.2010.01734.x

CASE REPORT

The use of cone beam computed tomography in the conservative management of dens invaginatus: a case report

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Abstract

Patel S. The use of cone beam computed tomography in the conservative management of dens invaginatus: a case report. *International Endodontic Journal*, **43**, 707–713, 2010.

Aim To report the use of cone beam computed tomography (CBCT) in the assessment of dens invaginatus.

Summary Chronic periradicular periodontitis associated with an infected invagination was diagnosed in an immature mandibular lateral incisor tooth. A CBCT scan revealed essential information for the management of the tooth. There was no communication between the invagination and the main root canal. Endodontic treatment was carried out on the invagination. The root canal with a vital pulp was left untreated, thus allowing the tooth to mature and continue to develop.

Key learning points

- The true nature of dens invaginatus cannot always be estimated from conventional radiographs.
- Cone beam computed tomography is a useful diagnostic tool in the management of dens invaginatus.

Keywords: cone beam computed tomography, dens invaginatus.

Received 18 February 2010; accepted 10 March 2010

Introduction

Dens invaginatus is a dental malformation caused by an infolding of the enamel organ into the adjacent dental papilla during the development of the tooth (Hülsmann 1997). Other terms for this dental anomaly include 'dens in dente' and 'dilated composite

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doi:10.1111/j.1365-2591.2006.01201.x

CASE REPORT

Calcium hydroxide barrier over the apical root-end of a type III *dens invaginatus* after endodontic and surgical treatment

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Abstract

Soares J, Santos S, Silveira F, Nunes E. Calcium hydroxide barrier over the apical root-end of a type III *dens invaginatus* after endodontic and surgical treatment. *International Endodontic Journal*, **40**, 146–155, 2007.

Aim To report the simultaneous endodontic and surgical treatment of a tooth associated with Oehlers type III ***dens invaginatus*** and a persistent periapical lesion, which comprised root-end resection, root-end filling and application of a calcium hydroxide barrier placed on the resected dentine surface.

Summary Three root canals were identified in a tooth with a type III ***dens invaginatus***, which presented with a necrotic pulp, wide foraminal opening and extensive periapical lesion, and with a previous history of acute abscess, intracanal exudate and fistula. After root canal preparation followed by intracanal application of calcium hydroxide pastes, the clinical–pathological status persisted. After periapical curettage and root-end resection, the root canals were filled, followed by root-end filling with Sealer 26 mixed with zinc oxide powder to a clay-like consistency. Calcium hydroxide paste was then applied over the exposed dentinal surface forming a covering over the root apex. At the 20-month follow-up examination the patient had no symptoms and no fistula; advanced periapical bone repair was obvious on the radiograph.

Key learning points

- Because of the variable morphology and extent of invagination, type III ***dens invaginatus*** represents a challenge for conventional treatment, often leading to the need for a surgical approach.
- Sealer 26 thickened with zinc oxide powder provided satisfactory clinical properties for use as a root-end filling material.
- Application of a calcium hydroxide barrier over the resected root-end is a potential treatment option to encourage tissue repair.

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Read, Learn and Earn
CONTINUING EDUCATION

Combined Endodontic and Surgical Treatment of Dens Invaginatus-Associated Extraoral Fistula

A Case Report with Seven-year Follow-up

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ABSTRACT

Dens invaginatus (dens in dente) is a developmental malformation of permanent or deciduous teeth that has various complex forms. It most commonly affects permanent maxillary lateral incisor teeth, and rarely affects the mandibular teeth. In this report, a rare case of dens invaginatus of a mandibular lateral tooth with an extraoral fistula is presented. A 10-year-old patient was referred to our clinic with extraoral symptoms that could not be diagnosed by medical doctors. Successful treatment with endodontic treatment and periapical surgery is described. Seven-year follow-up of the case is provided.

Dens invaginatus is described as a developmental malformation resulting from the invaginations of the enamel organ into the dental papilla during the soft tissue stage of development.[1] The incidence of dens invaginatus is reported to vary from 0.25% to 6.8 % in the literature.[2-9] Even though the incidence numbers are not high, dens invaginatus is a more common finding in permanent teeth than other developmental dental anomalies.[9]

The etiology of dens invaginatus is still unclear; however, several theories have been proposed to illustrate possible etiologies, including abnormal pressure from surrounding area, local growth retardation and genetic factors.[3] There are three types of dens invaginatus, determined by the depth of the invagination as classified by Oehlers.[4] They are:

Type I: The invagination is minimal and enamel-lined; it is confined within the crown of the tooth and does not extend beyond the level of the external amelo-cemental junction.

Type II: The invagination is enamel-lined and extends into the pulp chamber but remains within the root canal with no communication with the periodontal ligament.

Type IIIA: The invagination extends through the root and communicates laterally with the periodontal ligament space through a pseudo-foramen. There is usually no communication with the pulp, which lies compressed within the root.

Type IIIB: The invagination extends through the root and communicates with the periodontal ligament at the apical foramen. There is usually no communication with the pulp.

Dens invaginatus is generally overlooked because of the absence of any clinical signs of the anomaly. Most cases of dens invaginatus are diagnosed after a routine radiographic evaluation using a panoramic X-ray or periapical radiograph. However, early diagnosis of the situation is very important since the presence of an invagination is considered to increase the risk of caries, pulpal pathosis and periodontal inflammation, particularly in Oehlers Type III invaginatus. In this instance, bacteria may invade the tract to the deep supporting tissue through an apical or lateral opening, to such an extent that periradicular pathology develops.[5]

The maxillary lateral incisor is the most frequently affected tooth. However, any tooth can be involved.[2] According to the lit-

CASE REPORT

Endodontic treatment of dens invaginatus type III with three root canals and open apical foramen

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Abstract

Jung M. Endodontic treatment of dens invaginatus type III with three root canals and open apical foramen. *International Endodontic Journal*, **37**, 205–213, 2004.

Aim To describe the conservative endodontic treatment and the 1-year follow-up of a permanent maxillary lateral incisor with dens invaginatus.

Summary Frequently, the root canal treatment of invaginated teeth is challenging because of problems associated with gaining access to the root canals and with variations of canal morphology associated with this type of malformation. The present case describes the complex root canal treatment of dens invaginatus in a maxillary lateral incisor with three root canals (Oehler type III), incomplete apex formation, necrotic pulp and abscess formation. After gaining access to two root canals and the invagination with the help of a dental operating-microscope, the canals and the invagination were instrumented and calcium hydroxide dressing was applied for 6 months. Apexification and osseous bone repair were achieved, and the canals were filled with gutta-percha. A follow-up after 1 year showed that the tooth was free of any clinical symptoms and the periapical condition was normal.

Key learning points

- The present case demonstrates that conservative root canal treatment can be performed successfully even in severe cases of dens invaginatus.
- The use of a dental operating microscope can help in the management of complicated cases of invaginated teeth through conventional root canal treatment.

Keywords: apexification, case report, conservative endodontic treatment, dens invaginatus.

Received 2 June 2003; accepted 13 November 2003

Introduction

Dens invaginatus is a malformation occurring in permanent, deciduous (Holan 1998, Eden *et al.* 2002) or supernumerary teeth (Ruprecht *et al.* 1986, Serrano 1991, Jiménez-Rubio

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Type 2 *Dens Invaginatus* in a Maxillary Lateral Incisor: A Case Report of a Conventional Endodontic Treatment

C M Aguiar * / J P M G Ferreira ** / A C Câmara *** / J A P de Figueiredo ****

Dens invaginatus is a rare malformation of the teeth resulting from the invagination of the tooth crown before biological mineralization occurs. In most cases, the thin or incomplete enamel lining of the invagination cannot prevent the entry of bacteria into the pulp, which leads to pulp necrosis with an eventual periapical inflammatory response. The treatment options include preventive sealing or filling of the invagination, root canal treatment, endodontic apical surgery and extraction. The root canal treatment of such teeth is often complicated because of their anatomical complexity. This case describes a successful non-surgical endodontic treatment of a maxillary lateral incisor with type 2 dens invaginatus with a large periradicular lesion. At follow-up examinations after 6 and 12-months, the tooth was asymptomatic and the healed lesion was evident radiographically.

Keywords: *calcium hydroxide, dens invaginatus, root canal treatment*
J Clin Pediatr Dent 33(2): 17–20, 2008

INTRODUCTION

Dens invaginatus is a rare malformation of the teeth resulting from the invagination of the tooth crown before biological mineralization occurs.[1-3] Different classifications have been suggested.[4] The most commonly used classification was proposed by Oehlers,[5] who classified *dens invaginatus* into 3 types according to their expression.[6] In type 1, the invagination is lined by enamel and ends as a blind sac within the confines of the crown. In type 2, the enamel-lined invagination extends apically beyond the external cemento-enamel junction, ending as a blind sac and never reaching the periapical tissues. It may or may not communicate with the pulp tissue. In type 3, the invagination forms a second foramen in the apical area or ends somewhere in the periodontal ligament. It does not communicate with the pulp. Enamel can be found throughout the invagination, and sometimes cementum may be observed in the invagination.[1]

Radiographically, the roots present smaller dimensions with the presence of a radiopaque formation with a density similar to that of enamel, which is invaginated from the cusp through variable extensions into the root. This invagination varies in shape and size and may present a loop-like or pear-shaped configuration or a slightly radiolucent structure, or even more extensive and bizarre shapes, simulating a "tooth within a tooth."[7] In most cases, *dens invaginatus* is detected by chance on the radiograph.[4]

Clinically, unusual crown morphology or a deep foramen *coecum* may be important hints of its existence. However, these patients often seek out a dentist because of acute pain.[4] The crown of an affected tooth may appear normal or display alterations in size and shape.[3] The finding most often associated with *dens invaginatus* is early pulpal involvement when channels extend from the invagination into the pulp. Because the invagination forms a space conducive to dental caries, bacteria and their by-products gain access to the dental pulp via the channels, resulting in pulp pathosis.[8-10]

Several treatment modalities have been described for these teeth, all related to the degree of anatomical complexity.[11] The treatment options include preventive sealing or filling of the invagination, root canal treatment, endodontic apical surgery, intentional replantation and extraction.[1] Root canal treatment of such teeth is often complicated by the unusual forms and location of invaginated and pulpal spaces that complicate a thorough debridement.[6]

This case describes a successful non-surgical endodontic treatment of a maxillary lateral incisor with type 2 *dens invaginatus* with a large periradicular lesion.

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ISSN 0970 - 4388

Nonsurgical management of two unusual cases of dens in dente

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Abstract

The management of two unusual cases of dens invaginatus in a maxillary and a mandibular lateral incisor with a periradicular lesion are reported. The patient presented with pain and localized swelling. Despite the complex anatomy and diagnosis of dens invaginatus, nonsurgical root canal treatment was performed successfully. Furthermore essential clinical considerations and treatment options are suggested. Early diagnosis and management are important to avoid complications.

Key words: Complex internal anatomy, Dens invaginatus, Infolding, Root canal

Dens invaginatus is a variation in the development of a tooth, which is thought to occur when there is an infolding of the surface of the crown before calcification has begun. The dens invaginatus (syn. dens in dente) with a frequency of 0.04–10% is a rare dental malformation.[1] The condition may occur in any deciduous or permanent tooth. The teeth most affected are maxillary lateral incisors with a prevalence of 0.25–5.1% followed by central incisors, premolars, canines, and molars.[2] The mandibular occurrence of this anomaly is rare. Bilateral occurrence is not uncommon and occurs in 43% of all cases.[3] Although, there is no specific sex predilection; the condition exhibits a high degree of inheritability. The presumed etiology of this phenomenon has been related either to focal growth retardation or focal growth stimulation or to localized external pressure to certain areas of the tooth bud.

Radiographically this anomaly demonstrates a radiopaque invagination, equal in density to enamel, extending from the cingulum into the root canal. Oehlers has classified dens invaginatus into three types depending upon its extent in the crown, root and upto apex.[4]

Dens invaginatus may also present as a syndrome occurring in association with other odontogenic anomalies, such as peg shaped lateral incisors, dens evaginatus of posterior teeth, supernumerary teeth, congenitally missing teeth, and sensor neural hearing loss.[5] Various techniques of treating dens invaginatus have been reported including conservative restorative treatment, nonsurgical root canal treatment, endodontic surgery, intentional replantation, and extraction.[6] This article presents two cases of the conservative management of type-II dens invaginatus and discusses the various treatment options available in its management.

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Case 1

A patient reported with a history of pain in left mandibular region. Medical and familial history was noncontributory. The tooth responded to thermal and electrical stimuli; periodontal probing revealed a normal and intact periodontium. The tooth had an enamel projection in the center of its lingual surface with a deep lingual invagination with no evidence of caries [Figure 1]. The radiographic examination showed a mature tooth with a dens invaginatus with periapical radiolucency [Figure 2]. There was no sinus tract information

Local anesthesia was administered, rubber dam was placed and a wide mesio-distal oval shaped opening was made to provide adequate endodontic access. A central canal and two rudimentary canals on the mesial and distal side were found [Figure 3]. There was no direct communication between the mesial and distal canals. Radiopaque dye was placed in the pulp chamber and three separate root canals were located by endogram. The canals were biomechanically prepared with Profile rotary and hand instruments and copiously irrigated with 3% sodium hydrochloride. Calcium hydroxide was inserted in all the canals and the tooth was temporarily sealed. After 3 weeks, tooth was obturated by vertical condensation [Figure 4]. The patient returned for clinical and radiographic follow up for 1 year. Apical repair as well as absence of clinical symptoms was observed.

Case 2

A female patient was referred for evaluation and treatment of constant pain and draining sinus in relation to maxillary left anterior tooth. Clinical examination revealed swelling, tenderness, and sinus tract in the buccal mucosa associated with her maxillary left lateral incisor. The radiograph showed a mature tooth with a dens invaginatus with an extended area of periapical radiolucency. Medical and family history was noncontributory. Following isolation of the tooth with

Endodontic treatment of dens in dente associated with a chronic periapical lesion using an apical plug of mineral trioxide aggregate

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Dens in dente is a developmental anomaly that predisposes the tooth to develop caries and pulp periapical pathologies. A chronic lesion can develop without any clinical symptoms of the pathology. The purpose of this case report is to decribe the endodontic treatment of dens in dente associated with a periapical lesion using a mineral trioxide aggregate apical plug. *(Quintessence Int 2007;38:93.e124–128)*

Key words: apical plug, dens in dente, endodontic treatment, healing, mineral trioxide aggregate, periapical lesion

Dens in dente, also known as dens invaginatus, is a dental malformation that is characterized by the invagination of enamel into the interior of the tooth. Because of its complexity and variation of form, this anomaly may cause difficulties in diagnosis and treatment planning. The first report of this anomaly was made Oehlers,[1] and since then other authors have reported this developmental defect in greater detail.[2–4] Its etiology is controversial and unclear, but various theories have been proposed to explain its origin, including failure of the enamel epithelium to grow, proliferation of the internal part of the enamel epithelium, fusion of dental germs, infection, and trauma.[2] Clinically, the morphology of the crown of a tooth affected by dens in dente can be normal or have an unusual appearance with a larger mesiodistal diameter at the cervical level than at the incisal level, hypoplastic enamel, or the presence of a coronal palatal sulcus. Dens in dente may be associated with other anomalies, such as cone-shaped teeth, hypoplasias, syndromes, taurodontism, microdontia, or dentinogenesis imperfecta. The tooth most commonly affected is the upper lateral incisor, but it may occur, in decreasing order of incidence, in central incisors, canines, and premolars. Bilateral occurrence is not uncommon, and there are cases of double and triple invagination and also reports of occurrences in deciduous teeth.[3] Radiological examination shows a radio-opaque invagination similar in density to enamel extending into the central region of the crown at a variable distance from the tooth.

Because of the presence of invagination, the tooth has a greater susceptibility to caries since the invagination allows food debris to

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doi:10.1111/j.1365-2591.2007.01205.x

CASE REPORT

Contemporary treatment of class II dens invaginatus

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Abstract

Sathorn C, Parashos P. Contemporary treatment of class II dens invaginatus. *International Endodontic Journal*, **40**, 308–316, 2007.

Aim To present the nonsurgical management of a tooth with class II dens invaginatus with an open apex utilizing contemporary techniques.

Summary Root canal treatment of teeth with complex root canal anatomy such as dens invaginatus can be problematic because infected pulpal tissues may remain in inaccessible areas of the canal system. The cleaning and debridement of such root canal systems are therefore challenging and may sometimes be considered impossible. An immature apical root-end development is another challenge in root canal treatment especially in controlling the apical extent of the filling material and achieving an apical seal. When difficulties in cleaning and filling combine, management options may include surgical intervention or extraction. This article reports the nonsurgical endodontic treatment of a case of an open apex and dens invaginatus utilizing the operating microscope, endodontic ultrasonic instruments and mineral trioxide aggregate.

Key learning point

• Teeth with class II dens evaginatus and an open apex may be managed successfully with contemporary nonsurgical materials and techniques.

Keywords: dens invaginatus, dental operating microscope, mineral trioxide aggregate apexification.

Received 27 April 2006; accepted 25 August 2006

Introduction

Dens invaginatus is a developmental anomaly resulting from the invagination of the enamel organ into the dental papilla during the soft tissue stage of development. As the hard tissues are formed, the invaginated enamel organ produces a small tooth within the future pulp chamber. In the severe type of dens invaginatus, there is a folding of

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