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Dens invaginatus: diagnosis and clinical management. Literature review

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ABSTRACT

Dens invaginatus (DI) is a dental alteration that occurs before mineralization and is a consequence of the folding of the enamel organ within the dental papilla. Its characteristics allow the rapid onset and progression of carious lesions and, consequently, pulp and periapical disease. This article summarizes data from original articles and literature reviews from the Scopus and PubMed databases. In this sense, the aim of this literature review is to present guidelines for the clinical management of DI according to its etiology, classification and diagnosis, to improve the effectiveness of the treatment and prognosis of this very complex alteration.

Keywords: *dens in dente*; clinical diagnosis; disease management; literature review.

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INTRODUCTION

Dens invaginatus (DI) is a structural dental anomaly resulting from the folding of the external dental tissues into the pulp before the calcification process. Of still unknown etiology and with a prevalence ranging from 0.3 to 26%, the clinical characteristics of this anomaly represent a gateway for bacterial contamination and its products, causing pulpal and periapical pathology (1-6). Oehlers' classification is currently the most widely used, which indicates that invaginations can be grouped into three different types according to their radiographic presentation, from the crown to the root (1, 4, 6, 7).

The diagnosis of DI is made based on the morphology of the crown and the findings provided by complementary examinations. Two-dimensional radiographic examination is reliable for diagnosis. Currently, helical computed tomography (SCT), cone beam computed tomography (CBCT), dental operating microscope (DOM) and X-ray micro-computed tomography (micro-CT) systems are introduced to improve the accuracy in the diagnosis of DI (1, 5).

Clinical approaches to treatment vary according to the type of DI (1) and can range from preventive coronal sealing of the invagination, non-surgical endodontic treatment, apical surgery, intentional reimplantation and even exodontia of the tooth. Current technology allows us to treat a wide range of DI cases with favorable prognosis (5).

This review analyzes the concept, classification, epidemiology, etiopathogenesis, complementary examinations, diagnosis, treatment and prognosis of DI, with the aim of helping clinicians to choose the correct approach, favoring the preservation of the tooth with this anomaly.

CONCEPT

DI, also known as dens in dente, dilated compound odontoma, dents telescopes or gestational anomaly, is a malformation of tooth development resulting from the folding of the external dental tissues into the dental papilla. This alteration can occur both in the crown and on the root surface before mineralization occurs (1, 2, 6, 8).

CLASSIFICATION

The term "*dens invaginatus*" was introduced by Hallett in 1953, who also introduced the first classification, suggesting the existence of four types of invagination. In 1972, Schulze and Brand suggested twelve variations of the clinical and radiographic appearance of invagination (9, 10). Subsequently, this classification was reordered by Oehlers in 1957 and it is the one most commonly used today due to its simple nomenclature. According to Oehlers (7), there are two types of DI: *dens invaginatus coronalis* (DIC) and *dens invaginatus radicularis* (DIR). DIC is the most common and it is characterized by folding of the enamel organ into the dental papilla before mineralization occurs. According to its radiographic presentation, DIC was classified according to Oehlers as follows:

- **Type I:** Invagination is minimal and enamel-lined. It is limited only to the dental crown and does not go beyond the amelocemental junction (1, 7).
- **Type II:** The invagination is covered with enamel and goes beyond the amelocemental junction to the pulp chamber, remaining inside the root canal, but without communication with the dental pulp or the periodontal ligament (1, 7). A case of type II DIC with lateral communication with periodontal ligament has been reported (8), so an additional subcategorization of Oehlers DIC type II into three subtypes representing the extent of invagination in the coronal, middle and apical third has been proposed (9).
- **Type IIIA:** Invagination extends along the root and communicates laterally with the periodontal ligament through a pseudoforamen without pulp communication (1, 7).
- **Type IIIB:** Invagination extends along the root and communicates apically with the periodontal ligament without pulp communication (1, 7, 8, 10).

A case of type IV DI has been described in an upper lateral incisor, due to the presence of a lateral and apical invagination as in type III, which at the same time has communication with the dental pulp (8).

DIR, also known as palato-gingival groove, developmental radicular anomaly or radicular groove, is less common and is characterized by invagination of Hertwig's root sheath into the root after crown formation. There are two subtypes: in the first, invagination is lined with cementum and related to an axial radicular groove; in the second, invagination is lined with enamel within the root. Its etiology is probably due to the differentiation into ameloblasts of the epithelial cells that form part of the epithelial sheath of Hertwig. DIR can be confused radiographically with DIC type III due to the large size of the root; however, in DIC type III, both the crown and the root are involved in the invagination, whereas in DIR only the root is involved (1).

EPIDEMIOLOGY

It was recently believed that the prevalence of DI was 0.04-10% (2). Currently, this value ranges from 0.3-26% (11, 12, 13). The prevalence of DI is significantly higher when CBCT is used for diagnosis (9-10.7%) compared to that obtained when two-dimensional imaging is used (0.25-7.7%) (4).

It is unilateral in most cases (1, 2, 11) and predominates in the permanent dentition (2, 4). Maxillary lateral incisors are the most affected (2, 11), followed by maxillary central incisors and supernumerary teeth (8). Its frequency in canines, premolars and molars is rare (14). Its appearance is concomitant with other anomalies, such as hypodontia, hyperdontia, macrodontia and supernumeraries (1, 2, 4). A genetic component is attributed to it (2, 4). It is not related to sex, age or systemic diseases (2). More than 50% of DI cases are type I according to Oehlers, followed by type II and III (2, 11). Approximately 20% of DI cases present apical pathology. Regarding their clinical appearance, more than 40% of cases present normal crown morphology, while the rest are amorphous, barrel-shaped and conical, respectively (2).

ETIOLOGY

Its etiology is still unclear, but it seems to involve both genetic and environmental factors (1, 2). Some of the theories that explain the etiology of DI are as follows:

- The result of an alteration in the signaling and interaction processes of a particular group of cells that are surrounded by cells that continue to proliferate normally.
- Due to the stimulation and proliferation of enamel organ cells within the papilla during tooth formation.
- Due to external mechanical forces that influence the tooth germ during development.
- Trauma and infections (4).

DIAGNOSIS

Early diagnosis of DI is important for prognosis (1). In the absence of clinical signs, DI can easily go unnoticed. Its presence increases the risk of caries, pulp and periapical pathology, internal resorption, and complicates endodontic therapy (2). Even before caries develops, interruptions in the invaginated enamel surface can allow microorganisms to penetrate into the canal system. The occurrence of apical periodontitis increases with increasing severity of invagination (8).

Clinical presentation

Often, the initial diagnosis is made according to the morphology of the crown. It varies from a normal presentation to a conical or barrel shape. A deep blind hole in the palatal or occlusal surface of the tooth is the entrance of the invagination (1).

Clinical presentations of DI can be (1):

- Presence of a palatal fossa or groove, resulting from a bifurcation of the cingulum (Figures 1 and 2).
- Barrel or cone-shaped teeth (Figure 3).
- Dilated crown with a larger mesiodistal and/or vestibulo-palatal diameter.
- Microdontic teeth.
- Presence of claw cusp or *dens evaginatus*, especially in cases of DIC type II.
- Presence of a labial groove associated with incisor notches, especially in the upper central incisors.

Supplementary tests

Two-dimensional radiographic images

It is the most widely used method to diagnose DI (1, 8). However, it has limitations, such as anatomical noise, geometric distortion and superimposition of images of other teeth and adjacent structures (4).

The reported radiographic presentations of DI are as follows (1, 7):

- Radiographic presentation of DIC type I: Linear radiolucent image of the fissure limited to the crown (Figures 1 and 3).
- Radiographic presentation of DIC type II: A radiolucent pocket with a radiopaque rim extending into the root as a blind sac without reaching the apical area and without connection to the periodontal ligament (Figure 2).
- Radiographic presentation of DIC type IIIA: Invagination is located laterally to the main canal, which extends from the crown to the apical third of the root and communicates with the periodontal ligament through a pseudoforamen.
- Radiographic presentation of DIC type IIIB: Invagination is centrally located within the main canal. Radiolucent lines are present both mesially and distally around the invagination.

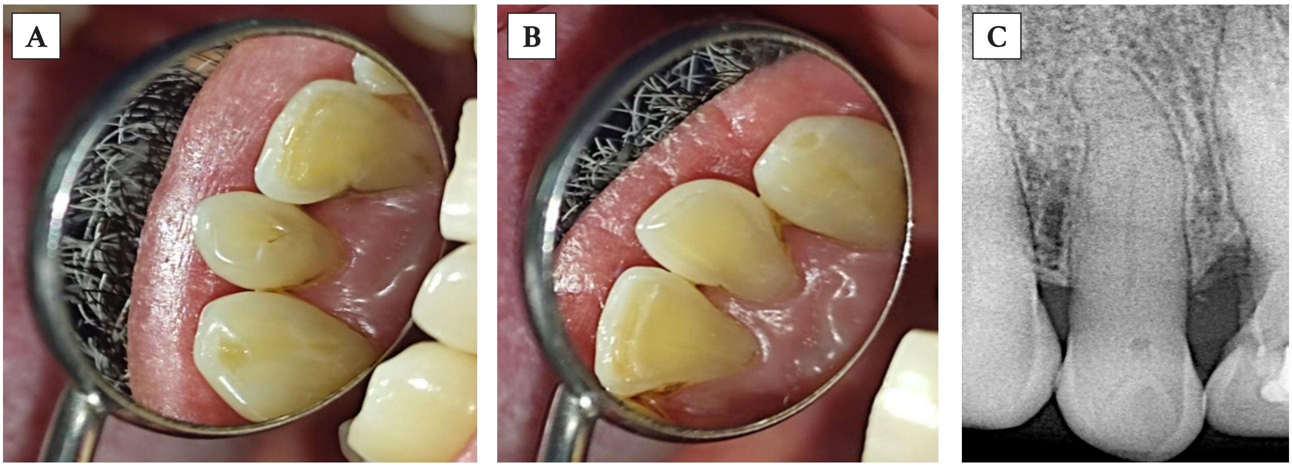

Figure 1. Tooth 2.2 (A) with *dens invaginatus* in the form of a palatal groove and its contralateral, tooth 1.2 (B), which presents normal anatomy (unilateral presentation). Periapical radiograph (C) of tooth 2.2, showing *dens invaginatus* type I according to Oehlers.

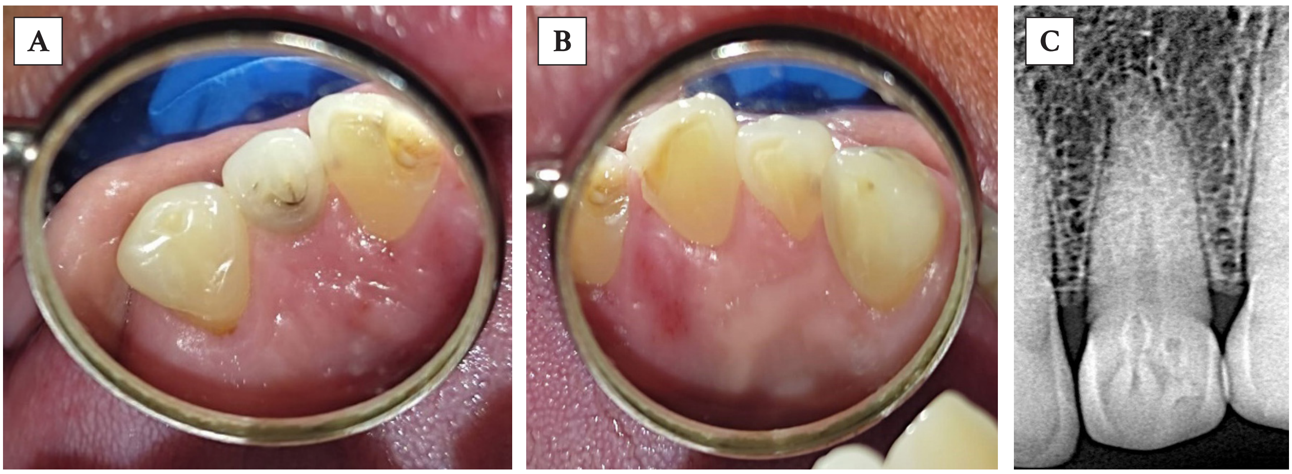

Figure 2. Tooth 2.2 (A) with *dens invaginatus* in the form of a palatal fossa and its contralateral, tooth 1.2 (B), which presents normal anatomy (unilateral presentation). Periapical radiograph (C) of tooth 2.2, showing two invaginations and *dens invaginatus* type II according to Oehlers.

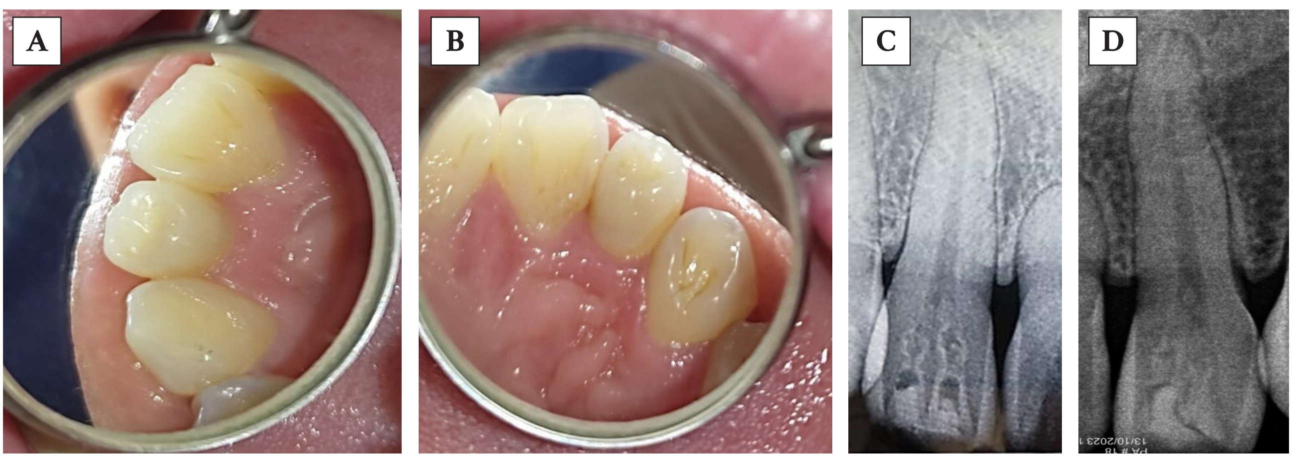

Figure 3. Teeth 1.2 (A) and 2.2 (B) with barrel-shaped dens invaginatus (bilateral presentation). Periapical radiographs of teeth 1.2 (C) and 2.2 (D), showing, respectively, two invaginations and *dens invaginatus* type I according to Oehlers.

Three-dimensional images

Three-dimensional images have far surpassed two-dimensional radiographs in terms of accuracy and detail. Today, SCT, CBCT and micro-CT have been introduced for the diagnosis and treatment of DI. The main difference between these techniques is the thickness of the section, a factor of great importance when evaluating the accuracy of images of the root canal system. SCT, CBCT and micro-CT slice thicknesses are 650-1000, 80-200 and 5-50 μm, respectively (1). The possible computed tomography representations of DI in cross section are as follows:

a. Invagination is in the central part of the main canal, and this appears as a hyperdense area surrounding the invagination.
b. Invagination is in the lateral part of the main canal, and this is shown as a C-shaped hyperdense area on one side of the invagination.
c. Invagination is in the central part of the main canal, and this is observed as two opposing hyperdense crescent-shaped areas.
d. Invagination is in the lateral part of the root, and the main canal is shown as a hyperdense area with no connection to invagination.
e. The main duct appears as a hyperdense area and may be rounded or C-shaped.
f. Only the hyperdense area of the main canal (1) appears.

Three-dimensional imaging techniques for the treatment and diagnosis of DI are as follows:

- **Spiral computed tomography (SCT):** It has lower accuracy compared to CBCT. It is useful for locating additional root canals, identifying the internal structure of a C-shaped canal and confirming anatomical variations of the root canal system (1).
- **Conical Beam Computed Tomography (CBCT):** It has low radiation dose, high resolution, accuracy, and requires less time for the evaluation of anatomically complex root canal systems. However, images lose quality in the presence of highly radiopaque objects (4). It is usually used for diagnose complex cases of DIC (types II and III) and DIR (1).
- **Micro-computed tomography (micro-CT):** It can only be used for the investigation of small samples. It is used for the analysis of the internal anatomy of the root of extracted teeth, of different instruments for root canal preparation and for the analysis of bone characteristics (1).

TREATMENT

DI complicates both diagnosis and treatment in any tooth (1), due to the anatomy, canal system and incorporated invagination (10, 15). In the deciduous dentition, extraction is suggested when the tooth is impacted, crowded, supernumerary or if there is a periapical lesion affecting the permanent tooth germ. Otherwise, composite resin should be selected based on the condition of the pulp (1, 3). In the permanent dentition, treatment varies according to the type and shape of the malformation. Treatment options range from preventive sealing to regenerative endodontic therapy (10). In all cases, the aim is to maintain the vitality of the pulp and preserve the tooth structure by means of a minimally invasive method (2).

Treatment of DIC type I

Different sealing methods can be used, depending on the initial depth of invagination (3). When this is minimal and limited to the crown, prophylactic filling with composite resin or pit and fissure sealant is chosen. In limited pulpitis and immature teeth, pulpotomy should be considered. If the pulp is extensively infected or there is a periapical lesion, root canal treatment is required. In case of an immature root, regenerative endodontic therapy is chosen. When root canal treatment fails, it can be complemented with surgical therapy (1). In exceptional cases, it may present deep periodontal pocket with vital pulp, which is treated with surgery and preventive treatment with mineral trioxide aggregate (MTA) (3).

Treatment of DIC type II

If the affected teeth have pits or grooves without dental caries, preventive sealing is the first option. If the invagination has caries and the pulp is intact, sealing with composite resin, amalgam or glass ionomer can be chosen, after disinfection with chlorhexidine or 1% sodium hypochlorite (3). Most caries in DIC type II are associated with irreversible pulpitis or pulp necrosis, which makes root canal treatment unavoidable (3). In these cases, the main canal and the invaginated canal are treated separately. However, residual debris from the invaginated canal affects the cleanliness and obturation of the main canal. If the invagination is close to the amelocemental junction, it should be removed during coronal widening. If, on the other hand, it extends into the middle or apical third of the root, it is removed with the aid of microscopic techniques, magnifying loupes, passive ultrasonic irrigation (PUI) and hand instruments. In an immature root, apexification may be the main choice (16), although recently there have been reports of cases successfully treated with pulp revascularization (PR), maintaining the canal walls and reducing the periapical radiolucent area (1).

Treatment of DIC type III

It depends on the state of vitality of the pulp and two options are chosen: separate treatment of the invaginated canal while maintaining the vitality of the main canal or treatment of both canals in case of pulp necrosis (3, 17).

When the main canal is immature with an open apex, apexification or pulp revascularization is suggested. In such cases, MTA, Biodentine and collagen membranes have proven to be appropriate as an apical barrier. In type IIIA, apexification fails to form a hard tissue barrier due to the low regenerative capacity of the cells around the lateral pseudo-hole. In contrast, in type IIIB, better results are obtained because the main and invaginated canals communicate with the periodontal ligament (3).

Low speed Gates Glidden burs or K and H files, which allow good operator control, can be used for instrumentation of the tooth (1). Machined instruments should be used with caution in the invaginated canal due to its irregular shape and the enamel coating in this area which could further weaken the tooth. Passive ultrasonic instrumentation has also been shown to be effective in these cases (5).

Irrigation with 2.5% sodium hypochlorite is essential, as it cleans and accesses areas that manual or rotary instruments cannot reach, without altering the dentin structure or the characteristics of the root canal. A continuous irrigation of 5 mL of 17% EDTA for 3 min into the root canal is also suggested to remove the smear layer and expose the dentinal tubules (6).

As an intraoral medication, the use of calcium hydroxide is suggested for at least 21 days, especially in cases of necrotic teeth with periapical lesion (6).

For obturation, the lateral compaction technique or thermoplastic obturation is used, as they allow the softened gutta-percha to enter inaccessible areas. It is also proposed to associate the lateral compaction technique with a bioceramic sealant to fill the canal irregularities; however, there is a risk of sealant extrusion when the apex is open (6).

The association of non-surgical and surgical endodontic therapy (CBCT, surgical microscope, magnifying loupes, machined instruments and bioceramic sealants) are important to ensure a predictable result in type III DIC (6, 18). Extraction is the last resort when the above-mentioned fails (19).

DIR Treatment

Treatment options such as endodontic intervention, periapical surgery, reimplantation or extraction may be considered (3). Due to insufficient understanding of the internal root structure in reported cases of DIR, extraction is usually chosen rather than some effort to save the teeth. However, if the affected teeth are indispensable for esthetics or masticatory function, extraction should be considered with great caution (1).

PROGNOSIS

A sufficiently large sample has not yet been studied to allow definitive conclusions about the prognosis of this anomaly. However, the cases reported so far with follow-up periods from 6 months to 27 years indicate a good prognosis (17). It is also evident that, as new technologies are developed and used, the prognosis of this anomaly will improve considerably.

DISCUSSION

DI is a dental anomaly that implies a special consideration in endodontics due to its complex clinical and radiographic presentations, which lead to rapid progression of carious lesion, pulp and periapical disease. In addition to its high prevalence in permanent anterosuperior teeth, it is a situation that affects the quality of life of the individual, both esthetically and functionally. Therefore, it is of utmost importance to know its etiology, prevalence, classification and clinical and radiographic characteristics for early diagnosis and timely treatment.

There is a consensus regarding the unknown etiology of this anomaly and the theories that suppose its formation are many (1, 2, 4). Most of them are due to genetic and intrinsic factors over which there is no control. However, there are also extrinsic causes resulting from traumas and infections that deserve special caution, especially at early ages.

Despite the passage of many years, the classification proposed by Oehlers in 1957 is still in force and is preferred by the dental community due to its simple nomenclature and easy application. This classification divides DI into three types: type I, type II, type IIIA and IIIB (1, 7). However, Kritika et al. (8) proposed to extend this classification into three additional subtypes for type II DI. At the same time, Gul et al. (9) proposed a type IV DI in an upper incisor. Both proposals in recent years respond to the need to develop more specific treatment protocols according to the type of case.

Regarding the prevalence of DI, the results obtained in research in recent years are different. Kfir et al. (11) found a prevalence of DIC of 26% in an Israeli population, with a similar prevalence rate among men and women. Alexoudi et al. (12) reported that the prevalence of DI ranged from 0.3 to 26% (12). Yalcin et al. (2) found a prevalence of DIC of 5.11%, with a higher frequency in female patients. While Hegde et al. (13) reported a prevalence of DI of 1.1% in an Indian population, with a higher frequency in females than in males. Finally, González-Mancilla et al. (4) reported a prevalence of DI of 0.090 (95% CI): 0.072-0.108; $p < 0.001$), with no significant differences by sex, in studies that made use of CBCT as a diagnostic aid. The difference in these results is probably determined by the ethnic characteristics of each study population and by the different diagnostic criteria and methods used. Regarding the latter, CBCT has demonstrated a statistically higher prevalence for the detection of DI than that obtained using two-dimensional imaging (4). This may be due to the greater accuracy of CBCT in identifying the complex anatomy of the canal system, thus representing an effective and essential tool for the diagnosis of this anomaly.

Although most studies report a higher prevalence of type I DIC with regards to the other two types (II and III) (2, 4, 11), Hegde et al. (13) reported a higher prevalence of type II DIC in an Indian population, with the following results: type I (22.1%), type II (61.03%), type IIIA (10.4%) and type IIIB (6.5%). Again, this may be due to the ethnic characteristics of the population studied.

Treatment varies according to the clinical and radiographic characteristics of each type of DI (10) and its consequent hard tissue, pulp and periapical conditions. Volodymyr (3) reported, in a literature review, that treatment options for type I DIC generally range from preventive sealing, root canal treatment to apexification. However, there are exceptions such as the one reported in the review by Zhu et al. (1), where three cases of type I DIC with immature root were treated with apexification, while surgical intervention was necessary due to lack of symptomatology control.

As mentioned before, most cases of DIC type II are associated with irreversible pulpitis or pulp necrosis, so literature reviews of the last 5 years (1, 3) report proposals focused on root canal treatment in concomitance with the use of microscopic techniques, magnifying loupes, PUI and hand instruments. In this context, Zubizarreta-Macho et al. (16) propose the use of splints made by three-dimensional digital impression that would allow precise, conservative and safe cavity access to teeth affected by anatomical malformations.

Type III DIC cases are often difficult to manage due to their complex root canal system. Pradhan et al. (5) propose the use of CBCT as an effective diagnostic aid, ultrasonic instrumentation for the removal of infected tissues and the use of digital optical microscopy for better visualization of the canals. In their case report, they said they used the Schilder hot vertical compaction technique for the final obturation. Fonseca et al. (6) also made use of CBCT to accurately and clearly determine the anatomy of DIC type III. As a filling technique, they used the lateral compaction technique associated with a bioceramic sealant, which generated a better obturation of the root canal due to the excellent fluidity of the cement. At the same time, they considered the use of an operating microscope to be essential for the success of the case. Abu Hasna et al. (15) made use of the lateral compaction technique to treat a case of type III DIC associated with periapical lesion. However, they used two-dimensional radiographs for diagnosis and indicated that DI associated with periapical lesion can be treated with nonsurgical endodontics, resulting in an acceptable resolution of the periradicular lesion after 6 years of follow-up. Arora et al. (17) also made use of two-dimensional radiographs to diagnose a case of DIC type III and digital optical microscopy to improve access to the cavity and used a combined technique of lateral condensation and vertical compaction of gutta-percha with a sealer. Lee et al. (18) made use of periapical radiography and CBCT to diagnose a case of DIC type III. They employed a surgical operating microscope to carefully explore the root canal and MTA to fill and seal the pseudo-root canal. DIR cases generally have a poor prognosis, and the treatment of choice is extraction (1, 3), probably due to poor knowledge of the internal root anatomy.

Although studies with larger samples are still needed to draw definitive conclusions about prognosis (17), the studies already reported show a favorable prognosis in most cases due to the use of new technologies in combination with non-surgical and surgical endodontic therapies (6, 18), which will ensure clinical success.

CONCLUSIONS

Although the etiology of DI is still unknown, its high prevalence warrants an exhaustive and early diagnosis with three-dimensional imaging, such as CBCT, in concomitance with conventional and emerging methods. The clinical and radiological criteria to be considered before choosing the treatment are the following: type of DI, depth of invagination, proximity of the invagination to the pulp, its projection into the main root canal, possibility of adequate root canal treatment and infection control, pulp vitality, condition and size of the apex, accessibility to the instruments and materials necessary for the planned treatment. All this would lead to choose the best intervention protocol according to the case of DI presented in the consultation, generating favorable results in less time and with better prognosis.

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