

DENS INVAGINATUS: AETIOLOGY, CLASSIFICATION, PREVALENCE, DIAGNOSIS AND TREATMENT CONSIDERATIONS

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SUMMARY

Dens invaginatus is a developmental malformation of teeth. Affected teeth show a deep infolding of enamel and dentine starting from the foramen caecum or even the tip of the cusps and which may extend deep into the root. Teeth most affected are maxillary lateral incisors.

The malformation shows a broad spectrum of morphologic variations and frequently results in early pulp necrosis. Root canal therapy may present severe problems because of complex anatomy of teeth. Aetiology, classification, prevalence, diagnosis and treatment considerations are reviewed.

Key words: *Dens invaginatus (DI), malformation*

INTRODUCTION

Dens invaginatus is a developmental malformation resulting from an invagination of enamel organ into the dental papilla, beginning at the crown and sometimes extending into the root before calcification occurs.¹⁻⁴ This condition most commonly occurs in permanent maxillary lateral incisors, followed by maxillary central incisors, premolars, canines and less frequently in the molars.⁵⁻⁹ Cases of bilateral and multiple occurrence have also been reported.^{6,10} The presence of double dens invaginatus is extremely rare.² Involvement of deciduous teeth have also been reported.¹¹

This kind of malformation was first described by 'Ploquet' in 1794 in whale's tooth.³ DI was first described as "a tooth within a tooth" by Salter in 1855.⁹ DI in human tooth was first described by a dentist named Socrates in 1856.³

A number of different terms have been used to describe this condition; such as Busch in 1897 first suggested the use of 'dens in dente' which implies the radiographic appearance of "tooth within a tooth".¹² Hunter suggested the term "dilated composite odontome".¹³ Of the various terms 'dens invaginatus' would appear to be the most appropriate as it reflects the infolding of the

outer portion (enamel) into the inner portion (dentin) with the formation of a pocket and dead space.¹

Synonyms for this malformation are: Dens in dente, invaginated odontome, dilated gestant odontome, dilated composite odontome, tooth inclusion and dens telescope.^{3,4,6}

Aetiology of dens invaginatus

Over the last few decades, several theories have been proposed to explain the aetiology of this malformation but it is still unclear.

- Growth pressure of dental arch resulting in buckling of enamel organ.¹⁴
- Kronfeld suggested that it results from a focal failure of growth of internal enamel epithelium.¹⁵
- Rushton proposed that the invagination is a result of rapid and aggressive proliferation of a part of internal enamel epithelium invading the dental papilla.¹⁶
- Oehlers considered that distortion of the enamel organ during tooth development and subsequent protrusion of a part of the enamel organ will lead to

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the formation of an enamel-lined channel ending at the cingulum or occasionally at the incisal tip.¹⁷

- The 'twin-theorie' suggested a fusion of two tooth-germs.¹⁸
- Infection was considered to be responsible for the malformation.¹⁹
- Gustafson and Sundberg discussed trauma as a causative factor.²⁰
- Genetic factor cannot be excluded.^{21,22}
- It may result from a deep infolding of foramen caecum during tooth development which in some cases may result in a second apical foramen.²³
- Ectomesenchymal signaling system between dental papilla and the internal enamel epithelium can affect tooth morphogenesis.²⁴ These signals have specific roles such as tooth morphogenesis and the folding of enamel organ.²⁵

Classification of dens invaginatus

The first classification of invaginated teeth was published by 'Hallet' in 1953.^{1,26} Most commonly used classification was proposed by Oehlers in 1957 is shown in Figure 1.¹⁷ He described the anomaly occurring in three forms (coronal invaginations);

Type I: An enamel-lined minor form occurring within the confines of the crown not extending beyond the cemento-enamel junction.^{1,2} (Fig 1A)

Type II: An enamel-lined form which invades the root but remains confined as a blind sac. It may or may not communicate with the dental pulp.^{1,2} (Fig 1B)

Type III A: A form which penetrates 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.^{1,2} (Fig 1C)

TYPE III B: A form which penetrates through the root and perforating at the apical area through a pseudo-foramen. The invagination may be completely lined by enamel, but frequently cementum will be found lining the invagination.^{1,2} (Fig 1D)

In 1958, Oehlers also described the radicular form of invagination.²⁷ This type is rare and is thought to arise secondary to a proliferation of Hertwig's root sheath and radiographically, the affected tooth demonstrates an enlargement of the root.²⁸

In 1972, Schulze & Brand proposed a more detailed classification, including invaginations starting at the incisal edge or the top of the crown and also describing dysmorphic root configuration.²⁹ (Figure 2)

Prevalence of dens invaginatus

The prevalence of dens invaginatus ranges from 0.04%-10%.^{4,6} The prevalence studies are given in table 1. The teeth most affected are permanent maxillary lateral incisors and bilateral occurrence is not uncommon and occurs in 43% of all cases.^{3,7}

Cakici et al. reported that DI was detected in only maxillary lateral incisors with no gender difference and the most commonly observed was type I dens invaginatus (81.25%).⁴⁷ In another study, most common type was also type I.⁴⁸

The permanent maxillary lateral incisor appears to be the most frequently affected tooth with posterior teeth less likely to be affected.⁴⁹ Evidence of DI in mandibular teeth have also been reported.^{6,50} Swanson & McCarthy explained about bilateral invagination.⁵¹ Primary dentition involvement have also been reported in in different studies.^{52,53,54}

Histological findings

The dentin below the invagination may be intact without irregularities.^{55,56} It may also contain strains

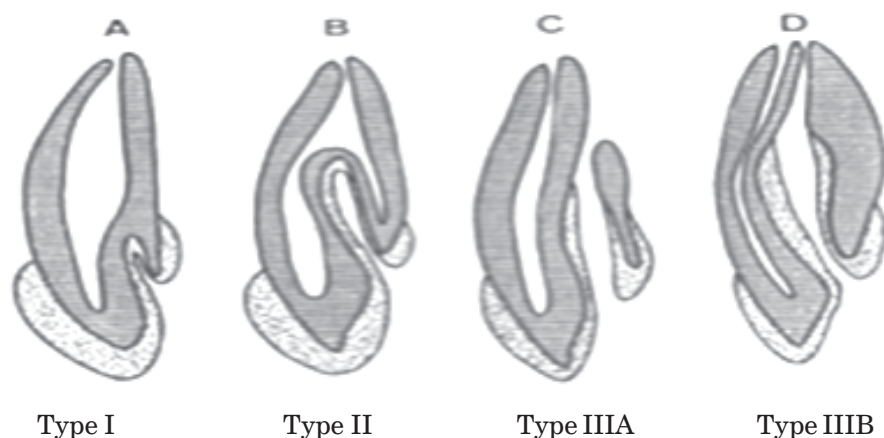


Fig 1: Oehler's classification of dens invaginatus (Coronal types)



Fig 2: Classification of dens invaginatus by Schulze & Brand(1972)

of vital connective tissue or even fine canals with communication to the dental pulp.^{14, 57, 58}

The enamel was described as irregularly structured.^{14, 59} Beynon reported hypomineralized enamel at the base of the invagination whereas Morfis, in a chemical analysis, detected up to eight times more phosphate and calcium compared with the outer enamel.^{59, 60} Bloch-Zupan et al. described that internal enamel exhibited atypical and more complex rod shapes and its surface presented the typical honeycomb pattern but no perikymata, which, however, were observed on the outer surface of the tooth.⁶¹

Diagnosis

In most cases a DI is detected by chance on the radiograph.³ Clinically, unusual crown morphology ('dilated', 'peg-shaped', 'barrel-shaped') or a deep foramen caecum may be important hints. Maxillary lateral incisors are the teeth most susceptible to coronal invaginations so these teeth should be investigated thoroughly clinically and radiographically, at least, in all cases with a deep pit at the foramen caecum at the lingual aspect of incisor teeth. However, in cases with peg shaped lateral incisors usually exhibit pit at the tip of the conical crown.^{3, 4, 62}

Normal conventional radiograph can not provide detailed structural information about this malformation. A latest radiographic technology, spiral computed tomography, have been introduced by Robinson et al and Sponchiado et al which is not only helpful in diagnosis of dens invaginatus but also provide 3-dimensional image of variations in root canal anatomy.^{4, 63}

Clinical features

The invagination allows entry of irritants into an area which is separated from pulp tissue by only a thin

layer of enamel and dentine and presents a predisposition for the development of dental caries. In some cases, the enamel-lining is incomplete and channels may also exist between the invagination and the pulp.^{57, 58} Therefore, pulp necrosis often occurs rather early, within a few years of eruption, sometimes even before root end closure.^{53, 60}

Other reported sequelae of undiagnosed and untreated coronal invaginations are abscess formation, retention of neighboring teeth, displacement of teeth, cysts, internal resorption and facial cellulitis recently diagnosed.⁶⁵⁻⁷³

Clinical identification of the invagination entrance can be difficult as entrances can be unremarkable and be similar to normal fissures. To aid in the identification process, the use of methylene blue dye can be utilized.⁷⁴ (Fig 3)

General features of teeth with DI include peg-shaped formation, incisal notching, increased labio-lingual and mesio-distal diameter, conical morphology and the presence of an enlarged palatal cingulum or cusp.^{3, 74} (Fig 4(a,b) & 5)

The dental literature on dens invaginatus malformations contains several case reports presenting invaginated teeth coincident with other dental anomalies, malformations and even dental or medical syndromes. (Table 2)

Radiographic features

General radiographic features are;

Type I and Type II

In general both Types I and II DI begin coronally with a narrow undilated fissure. This then dilates into a uniglobular mass that either ends within the coronal

TABLE 1: PREVALENCE STUDIES ON DENS INVAGINATUS

AUTHORS	YEAR	SAMPLE	FREQUENCY
Muhlreiter ³⁰	1873	500 maxillary lateral incisors	2.8%
Atkinson ¹⁴	1943	500 maxillary lateral incisors	10% of teeth
Boyne ³¹	1952	1000 maxillary incisors	8%
Shafer ³²	1953	2542 Full-mouth surveys	1.3% of patients
Hallet ²⁶	1953	586 Full-mouth surveys	6.6% of lateral incisor 0.5% of central incisors
Amos ³³	1955	1000 Full-mouth surveys	5.1% of patients
Amos ³³	1955	203 Full-mouth surveys	6.9% of students of dentistry
Grahnen et al. ³⁴	1959	3020 right maxillary incisors	2.7% of patients
Ulmansky & Hermel ³⁵	1964	500 Full-mouth surveys	2% of patients
Poyton & Morgan ³⁶	1966	5000 Full-mouth surveys	0.25% of patient
Miyoshi et al. ³⁷	1971	Extracted maxillary lateral incisors	38.5% of teeth
Fujiki et al. ³⁸	1974	2126 Lateral maxillary incisors	4.2% of teeth
Thomas ³⁹	1974	1886 Full-mouth survey	7.74% of patients
Gotoh et al. ⁴⁰	1979	766 Maxillary lateral incisors	9.66% of teeth
Ruprecht et al. ⁴¹	1986	1581 Full-mouth surveys	1.7% of patients
Ruprecht et al. ⁴²	1987	300 Full-mouth surveys	10% of patients
Thongudomporn and Freer ⁴³	1998	111 Full-mouth surveys	26.1% of patients
Backman & Wahlin ⁴⁴	2001	739 Full-mouth surveys	6.8% of patients
Hamasha & Al-Omari ⁴⁵	2004	1660 Full-mouth survey	2.95% of patients and 0.65% of teeth
Ezoddini et al. ⁴⁶	2007	480 Dental panoramic Tomographs	0.8%
Cakici et al. ⁴⁷	2010	1012 Full-mouth surveys	1.3%

portion (Type I) or invades the radicular portion (Type II). As the invagination invades the coronal and radicular portion, the outline of the pulp space can change resulting in 'blunting' of the pulp horns. The defect may vary in size and shape from a loop like, pear-shaped or slightly radiolucent structure to a severe form resembling tooth within a tooth. The outline of the invagina-

tion is generally well defined with an opaque layer of enamel.^{1-3, 38, 74} (Figures 7 & 8)

Type III

Type IIIa presents as a deep fissuring of the tooth that exits on the lateral surface of the root. The root canal adjacent to the invagination may be undulating and abnormal. Bacterial ingress down the invagination

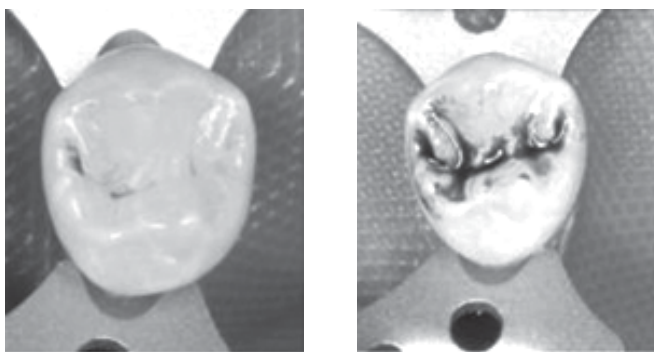


Fig 3: Methylene blue dye applied under rubber dam isolation, revealing staining of the distal fissure. This tooth required root canal treatment secondary to loss of vitality due to an invagination

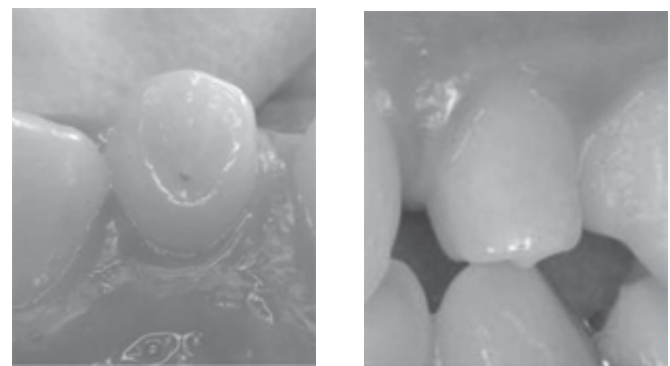


Fig 4 (a,b): Tooth having DI with conical crown Fig 5: maxillary lateral having DI enlarged cingulum

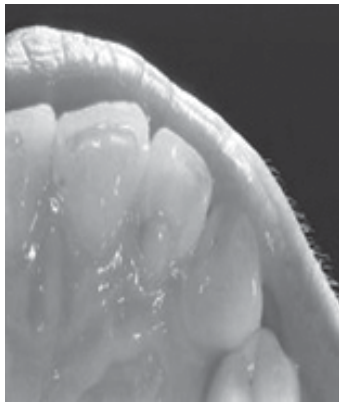


Fig 5: Maxillary lateral incisor having DI with enlarged cingulum

can result in a peri-invagination periodontitis. The nature of the peri-invagination is wide and present in a blunder-buss formation.^{1, 3, 74} As a result of intricate communications between the invagination and the root canal; the latter will almost definitely lose vitality if the invagination is infected.^{74, 88}

In contrast, Type IIIb DI is more difficult to identify and fully locate, as it is superimposed on the root canal system exiting apically from within the root canal. This apical formation can present with an immature apex and in most cases presents with a well-established periapical lesion (Figure 8 & 9).⁷⁴

Management of dens invaginatus

The treatments options are;

- 1) Prophylactic or preventive sealing of the invagination⁸⁹
- 2) Root canal treatment^{6,7}
- 3) Endodontic apical surgery^{90, 91}
- 4) Intentional replantation⁹²
- 5) Extraction^{93,94}

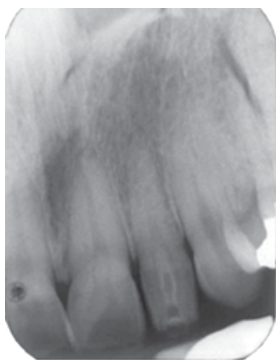


Fig 6: Type I Dens invaginatus

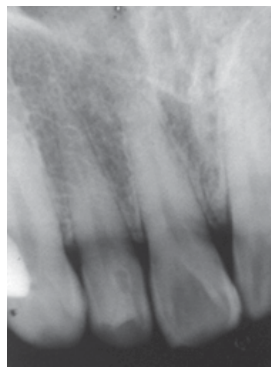


Fig 7: Type II Dens invaginatus



Fig 8 & 9: Type IIIb Dens invaginatus. Enamel lined fissure opening up into the apical portion, which has blunder-buss morphology.



Fig 10 A



Fig 10 B

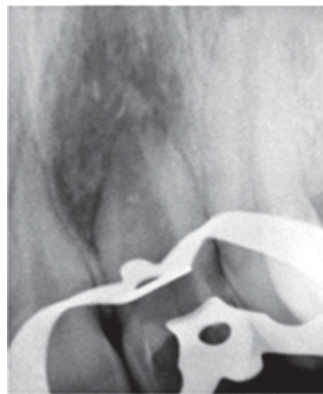


Fig 10 C



Fig 10 D

- Fig 10A.** The access opening prior to removal of the central hard-tissue core in type III demonstrating the main dens invaginatus (note alternate openings)
- B.** Length determination and lateral canals
- C.** Radiograph taken after the complete removal of the invaginatus
- D.** MTA plug was formed then the plasticised gutta percha obturation done and coronal seal was done with composite resin

TABLE 2: DENTAL ANOMALIES ASSOCIATED WITH DENS INVAGINATUS

DENTAL ANOMALIES	AUTHORS
Microdontia	Casamassimo et al. ⁷⁵ Desai et al. ⁷⁸
Macrodontia	Ekman-Westberg & Julin. ⁷⁶
Hypodontia	Hulsmann ⁷⁷
Oligodontia	Conklin ⁴⁹ , Ruprecht et al. ⁴¹
Taurodontism	Casamassimo et al. ⁷⁵
Germination and Fusion	Ruprecht et al. ⁴¹
Supernumerary teeth	Petz ⁷⁹ Beynon, ⁵⁹ Morfis ⁶⁰
Amelogenesis imperfect	Kerebel et al. ⁸⁰
Invagination in an odontome	Hitchin & McHugh ⁵⁸
Multiple odontomes	Robbins & Keene ⁸¹
Coronal agenesis	Hicks & Flaitz ⁸²
William's syndrome	Oncag et al. ⁸³
Mesiodens	Sannomiya et al. ⁸⁴
Talon cusp	Tiku et al. ⁸⁵
Dens evaginatus	Anthonappa et al. ⁸⁶
Crouzon and Apert syndromes	Melero et al. ⁸⁷

Type I and Type II

Once an invagination has been identified, base-line vitality test readings should be taken to get current pulpal status. Where pathological disease is absent the instigation of appropriate prophylactic measures should commence as soon as possible. There have been a wide variety of techniques advocated for prophylactic treatment. This has included the preparation of the invagination entrance and the placement of an amalgam restoration whilst more contemporary techniques have included the use of fissure sealant.^{74,88}

Where possible the use of magnification to open up the invagination entrance using a combination of fast hand piece burs and ultrasonic instruments should be considered to gain full access to the invagination.⁹⁴ Once the invagination is fully exposed, MTA can be used to obturate the invagination and access cavity will be sealed with composite. The tooth should be regularly monitored for vitality loss. If this arises, appropriate root canal treatment should be instigated.⁷⁴

Antiseptic control is usually achieved by intracanal medicaments such as calcium hydroxide most commonly used but recently introduced triple antibiotic (ciprofloxacin, metronidazole, minocycline) paste has also been used and open apex problem is overcome by forming apical plug either using calcium hydroxide or by MTA (mineral trioxide aggregate).^{6,95,100} When simple endodontic therapy fails then combination of nonsurgical and surgical treatment could be performed.⁹⁰

Type III

In a vital tooth associated with periradicular inflammation, the invagination should be treated endodontically in the same way as an normal root canal to preserve the pulp vitality.⁹⁶ A combined endodontic and surgical therapy in a vital tooth has also been reported.⁹¹ Pulp necrosis occurring in a tooth with the usual form of type III invagination is often successfully managed by endodontic therapy of root canal and the invagination alone, or by a combined endodontic and surgical therapy.^{97, 98} In some cases ultrasonic can be used for the complete removal of invagination to facilitate endodontic therapy.⁹⁴

As the morphology of these teeth is complex, if root canal treatment is not possible then extraction is usually recommended and prosthetic replacement is done.^{8,74}

The role of intentional replantation has also been reported in very complex forms of type III dens invaginatus.^{99,73}

The use of MTA in combination with gutta percha may be considered, where the post preparation apical portions are wide and blunder-buss in their formation.⁹ (Figures 10A, B, C & D)

REFERENCES

- 1 Alani A, Bishop K. Dens invaginatus. Part 1: classification, prevalence, aetiology. *Int Endod J* 2008; 41(12):1123-1136.
- 2 Zengin AZ, Sumer AP, Celenk P. Double dens invaginatus. *Eur J Dent* 2009; 3:67-70.

- 3 Hulsmann M. Dens invaginatus: aetiology, classification, prevalence, diagnosis and treatment considerations. *Int Endod J* 1997; 30:79-90.
- 4 Reddy YP, Karpagavinayagam K, Subbarao CV. Management of Dens invaginatus diagnosed by spiral computed tomography. *J Endod* 2008; 34:1138-1142.
- 5 Stamfeli J, Kansky AA, Gasperic D. Unusual variant of type 3 Dens invaginatus in a maxillary Canine: A rare case report. *J Endod* 2007; 33:64-68.
- 6 Er K, Kustarcia A, Ozan U, Tasdemir T. Non surgical endodontic treatment of Dens invaginatus in a Mandibular premolar with large Peri-radicular lesion: A case report. *J Endod* 2007; 33:322-324.
- 7 Steffen H, Splieth C. Conventional treatment of dens invaginatus in maxillary lateral incisor with sinus tract: one year follow-up. *J Endod* 2005; 31:130-3.
- 8 Demartis P, Disso C, Cotti M, Cotti E. Endodontic treatment and hypotheses on an unusual case of dens invaginatus. *J Endod* 2009; 35(3):417-21.
- 9 Silberman A, Cohenca N, Simon JH. Anatomical redesign for the treatment of dens invaginatus type III with open apices: a literature review and case presentation. *J Am Dent Assoc* 2006; 137(2):180-5.
- 10 Sedano HO, Ocampo-Acosta F, Naranjo-Corona RI, Torres-Arellano ME. Multiple dens invaginatus, mulberry molar and conical teeth. Case report and genetic considerations. *Med Oral Patol Oral Cir Bucal* 2009; 14(2):69-72.
- 11 Neville BW. Abnormalities of teeth. In: Neville B, Damm DD, Allen CM, Bouquot J. *Oral and maxillofacial pathology*. 2nd ed. Philadelphia: W.B. Saunders; 2002. p. 80-2.
- 12 BUSCH, F. 1897 über Verschmelzung und Verwachsung der Zähne des Milchgebisses und des bleibenden Gebisses, *Deut. Monatsschrift für Zahnheilkunde* 1900; 15, p. 469.
- 13 Hunter HA. Dilated composite odontome. *Oral Surg Oral Med Oral Pathol* 1951; 4:668-73.
- 14 Atkinson SR. The permanent maxillary lateral incisor. *Am J Orthodont* 1943; 29:685-698.
- 15 Kronfeld R. Dens in dente. *J Dent Research* 1934; 14:49-66.
- 16 Rushton MA. A collection of dilated composite odontomes. *Brit Dent J* 1937; 63:65-85.
- 17 Oehlers FAC. Dens invaginatus. Part I: variations of the invagination process and association with anterior crown forms. *Oral Surg Oral Med Oral Pathol* 1957; 10:1204-1218.
- 18 Brust P. Über die Entstehung des, Dens un dente, *Schweizer Monatsschrift für Zahnheilkunde* 1950; 60:534-542.
- 19 Sprawson EC. Odontomes. *Brit Dent J* 1937; 62:177-201.
- 20 Gustafson G, Sundberg S. Dens in dente. *Brit Dent J* 1950; 88:83-88, 111-122, 144-146.
- 21 Sapp JP, Eversole LR, Wysocki GP. *Contemporary Oral and Maxillo-facial Pathology*. 2nd ed. St Louis: Mosby. 2003:8-9.
- 22 Casamassimo PS, Nowak AJ, Ettinger RL, Schlenker DJ. An unusual triad: microdontia, taurodontia, and dens invaginatus. *Oral Surg Oral Med Oral Pathol* 1978; 45:107-12.
- 23 Shulze C. Developmental abnormalities of the teeth and the jaws In: Gorlin O, Goldman H. *Thoma's Oral Pathology*. 1970. St. Louis: Mosby. p. 96-183.
- 24 Ohazama A, Country JM, Sharpe PT. Rank and Rankl in tooth development: co-ordination of odontogenesis and osteogenesis. *J Dent Research* 2004; 83:241-44.
- 25 Kettunen P, Laurikkala J, Itaranta P et al. Association of FGF-3 and Fgf-10 with signaling networks regulating tooth morphogenesis. *Developmental Dynamics* 2000; 219:322-32.
- 26 Hallet GE. The incidence, nature and clinical significance of palatal invagination in the maxillary incisors teeth. *Proceedings of the Royal Society of Medicine* 1953; 46: 491-9.
- 27 Oehlers FA. The radicular variety of dens invaginatus. *J Oral Surg Oral Med and Oral Pathol Oral Radiol Endod* 1958; 11:1251-60.
- 28 Damm N, Bouquet A. *Oral and Maxillofacial pathology*. 3rd ed. Saunders 2009:90-93.
- 29 Schulze C, Brand E. Über den Dens Invaginatus (Dens in dente). *Zahntechnische Welt, zahnärztliche Reform, ZWR* 1972; 81:569-73, 613-20, 653-60, 699-703.
- 30 Muhlreiter E. Die Natur der anomalen Hohlenbildung im oberen Seitenschneidezahne. *Deutsche Vierteljahresschrift für Zahnheilkunde*. 1873; 13:367-72.
- 31 Boyne PJ. Dens in dente: report of three cases. *J Am Dent Assoc* 1952; 45:209-10.
- 32 Shafer WG. Dens in dente. *The New York Dental Journal* 1953; 19: 220-5.
- 33 Amos ER. Incidence of the small dens in dente. *J Am Dent Assoc* 1955; 51: 31-3.
- 34 Grahnen H, Lindahl B, Omnell K. Dens Invaginatus. I. A clinical, roentgen logical and genetical study of permanent upper lateral incisors. *Odontologisk Revy* 1959; 10:115-37.
- 35 Ulmanky M, Hermel J. Double dens in dente in a single tooth. *Oral Surg, Oral Med and Oral Patol Endod* 1964; 17: 92-7.
- 36 Poyton GH, Morgan GA. Dens in dente. *Dental Radiography and Photography* 1966; 39:27-33.
- 37 Miyoshi S, Fujiwara J, Nakata T, Yamamoto K, Deguchi K. Dens invaginatus in Japanese incisors. *Jap J of Oral Biol* 1971; 13:539-44.
- 38 Fujiki Y, Tamaki N, Kawahara K, Nabae M. Clinical and radiographic observations of dens invaginatus. *J Dentomaxillofac Radiol* 1974; 3:343-8.
- 39 Thomas JG. A study of dens in dente. *Oral Surg, Oral Med, and Oral Pathol* 1974; 38:653-5.
- 40 Gotoh T, Kawahara K, Imai K, Kishi K, Fujiki Y. Clinical and radiographic study of dens invaginatus. *Oral Surg, Oral Med, and Oral Patol* 1979; 48: 88-9.
- 41 Ruprecht A, Batniji S, Sastry K, El-Newehi E. The incidence of dental invagination. *The J Pedodont* 1986; 10: 265-272.
- 42 Ruprecht A, Sastry K, Batniji S, Lambourne A. The clinical significance of dental invagination. *J Pedodont* 1987; 11: 176-81.
- 43 Thongudomporn U, Freer TJ. Prevalence of dental anomalies in orthodontic patients. *Aust Dent J* 1998; 43:395-8.
- 44 Backman B, Wahlin YB. Variations in number and morphology of permanent teeth in 7-year-old Swedish children. *Int J Paediat Dent* 2001; 11:11-7.
- 45 Hamasha AA, Al-Omari QD. Prevalence of dens invaginatus in Jordanian adults. *Int Endod J* 2004; 37:307-10.
- 46 Ezoddini AF, Sheikhha MH, Ahmadi H. Prevalence of dental developmental anomalies: a radiographic study. *Community Dent Health* 2007; 24:140-4.
- 47 Cakici F, Celiekoglu M, Arslan H, Topcuoglu HS, Erdogan AS. Assessment of the prevalence and characteristics of dens invaginatus in a sample of Turkish Anatolian population. *Med Oral Patol Oral Cir Bucal* 2010; 15(6):e855-8.
- 48 Kirzioglu Z, Ceyhan D. The prevalence of anterior teeth with dens invaginatus in the western Mediterranean region of Turkey. *Int Endod J* 2009; 42:727-24.
- 49 Conklin WW. Bilateral dens invaginatus in the mandibular incisor region. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1978; 45:905-8.
- 50 Hartup GR. Dens invaginatus type II in a mandibular premolar. *General Dent* 1997; 45:584-7.
- 51 Swanson WF, McCarthy FM. Bilateral dens in dente. *Journal of Dental research* 1947; 26:167-71.
- 52 Eden EK, Koca H, Sen BH. Dens invaginatus in a Primary molar. *ASDC Journal of Dentistry for Children* 2002; 69:49-53.
- 53 Rabinowitch BZ. Dens in dente. primary tooth-report of a case. *Oral Surg Oral Med Oral Pathol* 1952; 5:1312-4.
- 54 Mann RW, Dahlberg AA, Stewart TD. Anomalous morphologic formation of deciduous and permanent teeth in a 5-year old 15th century child: a variation of the Ekman-Westborg-Julin syndrome. *Oral Surg, Oral Med, and Oral Pathol* 1990; 70:90-4.

- 55 Omnell KA, Swanbeck G, Lindahl B. Dens invaginatus. II. A microradiographical, histological and micro X-ray diffraction study. *Acta Odontologica Scandinavica* 1960;18: 303–30.
- 56 Piatelli A, Trisi P. Dens invaginatus: a histological study of undemineralized material. *Endodontics and Dental Traumatology* 1993;9:191–5.
- 57 Kronfeld R. Dens in dente. *Journal of Dental Research* 1934; 14:49–66.
- 62 Rushton MA. Invaginated teeth (dens in dente): Contents of the invagination. *Oral Surg, Oral Med, and Oral Pathol* 1958; 11:1378–87.
- 58 Hitchin AD, Mchugh WD. Three coronal invaginations in a dilated composite odontome. *British Dental Journal* 1954; 97:90–2.
- 59 Beynon AD. Developing dens invaginatus (dens in dente). A quantitative microradiographic study and a reconsideration of the histogenesis of this condition. *British Dental Journal*. 1982; 153:255–60.
- 60 Morfis AS. Chemical analysis of a dens invaginatus by SEM microanalyses. *The Journal of Clinical Pediatric Dentistry*. 1993; 17:79–82.
- 61 Bloch-Zupan A, Cousandier L, Hemmerle J, Obry-Musset AM, Maniere MC. Electron microscopical assessments (FDI abstract FC-11# 123). *Int Dent J* 1995; 45:306.
- 62 Sapp JP, Eversole LR, Wysocki GP. Contemporary Oral and Maxillo-facial Pathology. 2nd ed, 2003:8-9.
- 63 Patel S, Dawood DA, Ford TP et al. The potential applications of cone beam computed tomography in a management of endodontic problems. *Int Endod J* 2007;40:818-30.
- 64 NIK-Hussein NN. Dens invaginatus: Complications and treatment of non-vital infected tooth. *Journal of Clinical Pediatric Dentistry* 1994;18:303–6.
- 65 Green Field RS, Cambruzzi JV. Complexities of endodontic treatment of maxillary lateral incisors with anomalous root formation. *Oral Surg, Oral Med and Oral Pathol* 1986; 62: 82–8.
- 66 Chen RJ, Yang JF, Chao TC (1990) Invaginated tooth associated with Periodontal abscess. *Oral Surg, Oral Med and Oral Pathol* 1990;69:659.
- 67 Conklin WW. Double bilateral dens invaginatus in the maxillary incisor region. *Oral Surg, Oral Med and Oral Pathol* 1975; 39:949–52.
- 68 Mader C. Triple dens in dente. *Oral Surg, Oral Med and Oral Pathol* 1977;44:966.
- 69 Petz R. Beitrag zum 'Dens in dente'. *Deutsche Stomatologie* 1956; 6:100–5.
- 70 Augsburg RA, Brandebura J. Bilateral dens invaginatus with associated radicular cysts. *Oral Surg, Oral Med and Oral Pathol* 1978; 46:260–4.
- 71 Hulsmann M, Radlanski R. Möglichkeiten der konservativen Therapie des Dens invaginatus. *Deutsche Zahnärztliche Zeitschrift* 1994;49:804-8.
- 72 Shapiro. Dens in dente. *Oral Surg, Oral Med and Oral Pathol* 1970;30:782.
- 73 Arsenault M, Andreasen RD et al. Facial cellulitis secondary to dens invaginatus :a case report. *J Can Dent Association* 2010;76:a114.
- 74 Alani A. Dens invaginatus; a problem from the outside in. *Int Dent J* 2009;59(6):343-8.
- 75 Casamassimo PS, Nowak AJ, Ettinger RL et al. An unusual triad: microdontia, taurodontism, and dens invaginatus. *Oral Surg, Oral Med and Oral Pathol* 1978;45:107-12.
- 76 Ekman-Westborg B, Julin P. Multiple anomalies in dental morphology: macrodontia, multituberculism, central cusp, and pulp invaginations. *Oral Surg, Oral Med and Oral Pathol* 1974;38,:217–22.
- 77 Hulsmann M (1995c) Dens invaginatus: incidence, aetiology, diagnosis, and treatment options. Poster-presentation, 6th ESECongress, Tel Aviv, 1995.
- 78 Desai RS, Vanaki SS et al. An unusual combination of idiopathic generalized short roots anomaly associated with microdontia, taurodontism, multiple dens invaginatus, obliterated pulp chambers and infected cyst: a case report. *J Oral Patol, Oral med* 2006;35970:407-9.
- 79 Petz R. Beitrag zum 'Dens in dente'. *Deutsche Stomatologie* 1956; 6:100–5.
- 80 Kerebel B, Kerebel LM, Daculsi G, Doury J. Dentinogenesis-imperfecta with dens in dente. *Oral Surgery, Oral Medicine and Oral Pathology* 1983; 55:279–85.
- 81 Robbins IM, Keene HJ. Multiple morphologic dental anomalies. *Oral Surg, Oral Med and Oral Pathol* 1964; 17: 683–90.
- 82 Hicks MJ, Flaitz CM. Dens invaginatus with partial coronal agenesis: report of a case. *Journal of Dentistry for Children* 1985; 52:217–9.
- 83 Oncag A, Gunbay S, Parlar A. Williams Syndrome. *Journal of Clinical Pediatric Dentistry* 1995; 19:301–4.
- 84 Sannomiya EK, Asaumi J, Kishi K et al. Rare association of dens invaginatus and mesiodens. *Oral Surg, Oral Med and Oral Pathol and Oral Radiol* 2007;104:e41-4. 17:683.
- 85 Tiku A, Nadkarni UM, Damle SG. Management of two unusual cases of dens invaginatus and talon cusp associated with other dental anomalies. *J Indian Soc Pedod Pre Dent* 2004;22(3):128-33.
- 86 Anthonappa RP, Yiu CKY, King NM. A novel combination of dens evaginatus and dens invaginatus in a single tooth. Review of literature and a case report. *J Clin Pediatr Dent* 2008;32:239-42.
- 87 Melero SJ, Leite MM, de Carvalho IMM. Dental Anomalies in patients carrying the Apert syndrome and Crouzon syndrome. *Salusvita, Baruru* 2005;24:183-93.
- 88 Bishop K, Alani A. Dens invaginatus. part 2: Clinical, radiographic features and management options. *Int Endod J* 2008;41: 1137-54.
- 89 Aguiar CM, Ferreira JP, Câmara AC, de Figueiredo JA. Type 2 dens invaginatus in a maxillary lateral incisor: a case report of a conventional endodontic treatment. *J Clin Pediatric Dent*. 2008 winter; 33(2):103-6.
- 90 Ortiz P, Weisleder R, Villareal de Justus Y. Combined therapy in the treatment of dens invaginatus: case report. *J Endod* 2004; 30:672–4.
- 91 Nallapati S. Clinical management of a maxillary Lateral incisor with vital pulp and type III dens invaginatus; a case report. *J Endod* 2004;30:726-31.
- 92 Nedley MP, Power GK. Intentional extraction and reimplantation of an immature invaginated central incisor. *ASDC J Dent child* 1997;64:417-20.
- 93 de Sousa SM, Bramante CM. Dens invaginatus: treatment choices. *Endod Dent Traumatol* 1998;14:152-8.
- 94 Girsch WJ, Mc Clammy TV. Microscopic removal of dens invaginatus. *J Endod* 2002; 28:336–9.
- 95 Schmitz MS, Montagner F, Flores CB, Morari VHC et al. Management of dens invaginatus type I and open apex. Report of three cases. *J Endod* 2010;36:1079-1085.
- 96 Tsurumachi T. Endodontic treatment of an invaginated maxillary lateral incisor with a periradicular lesion and a healthy pulp. *Int Endod J* 2004;37:717-23.
- 97 Jung M. Endodontic treatment of dens invaginatus type III with three root canals and open apical foramen. *Int Endod J* 2004;37:205-13.
- 98 Carounandy U, Sathyanarayanan R. Dens invaginatus: two cases. *Endodontology* 2000;12:86-9.
- 99 Bansal M, Singh NN, Singh AP. A rare presentation of dens in dente in the mandibular third molar with extra oral sinus. *J Oral Maxillofac Pathol* 2010;14:80-2.
- 100 Kristofferson O, Nag OH, Fristad. Dens invaginatus and treatment options based on a classification system: report of a type II invagination. *Int Endod J* 2008;41:702-9.