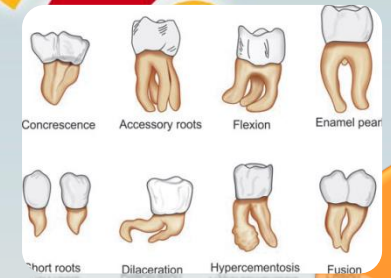

Good morning



TOOTH MORPHOLOGY

CONTENTS

- INTRODUCTION
- PULP CAVITY
- COMMON CANAL CONFIGURATIONS – Vertucci, weine, gulabivala & coworkers
- FACTORS AFFECTING INTERNAL ANATOMY.

ROOT CANAL ABERRATIONS

- Fusion & Gemination
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- ✓Prevalence
- ✓Etiology
- ✓Diagnosis
- ✓Management

CONTENTS

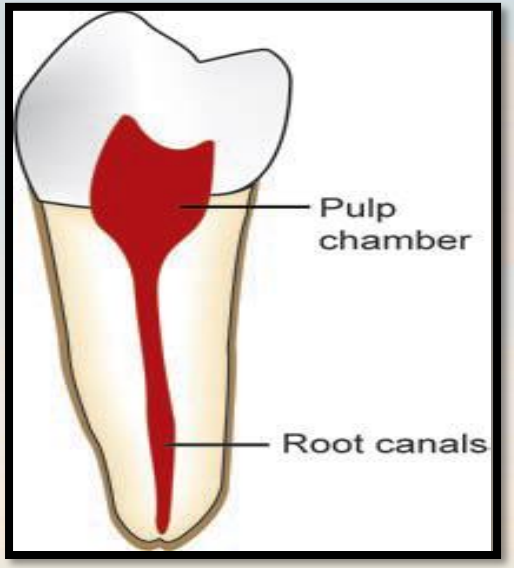
INTRODUCTION

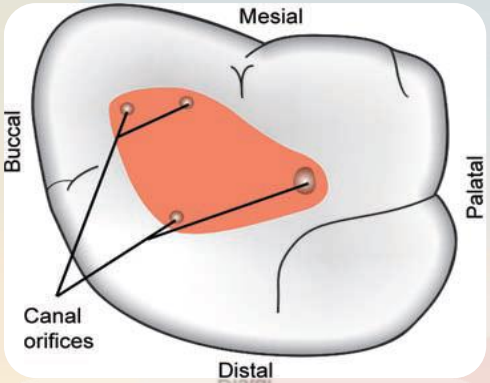
- Successful endodontic treatment involves accurate diagnosis, good understanding of the biological principles and excellent execution of the treatment.
- Knowledge of external and internal anatomy of a tooth and its variations is a key for the success of endodontic therapy.
- These anatomical variations in root canal play a vital role in the success of endodontic therapy.

INTRODUCTION

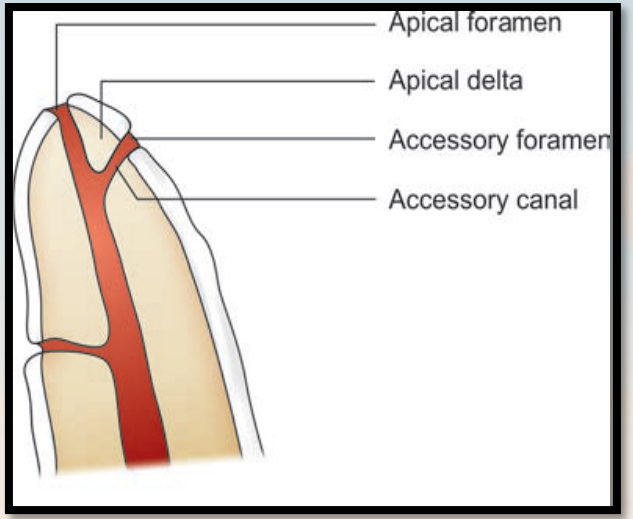
- For each tooth in the permanent dentition, there is a wide range of variation with respect to the frequency of occurrence of the number and the shape of canals in each root, the number of roots.
- Incomplete debridement and disinfection of root canal space as the most important factor in endodontic treatment failure.

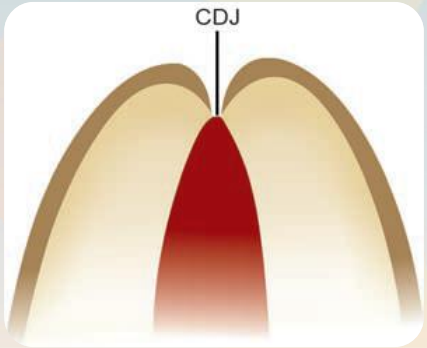
PULP CAVITY

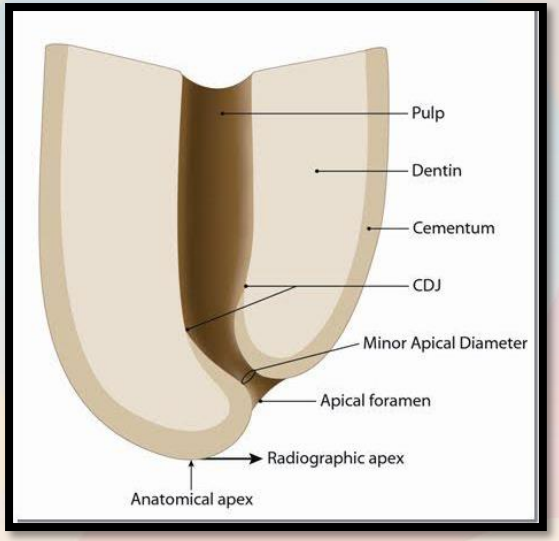

Pulp chamber
Root canals


Mesial
Buccal
Palatal
Canal orifices
Distal

APICAL ROOT ANATOMY



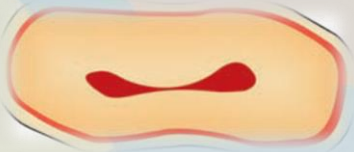




Significance

- The main problems associated with apical part of root are its variability and unpredictability.
- The root canal treatment of apical part of root is difficult sometimes because of presence of accessory and lateral canals, pulp stones, varying amounts of irregular secondary dentin and areas of resorption.

ISTHMUS



Methylene blue dye

An isthmus is a narrow, ribbon shaped communication between two root canals which can be complete or incomplete.

Hsu and Kin

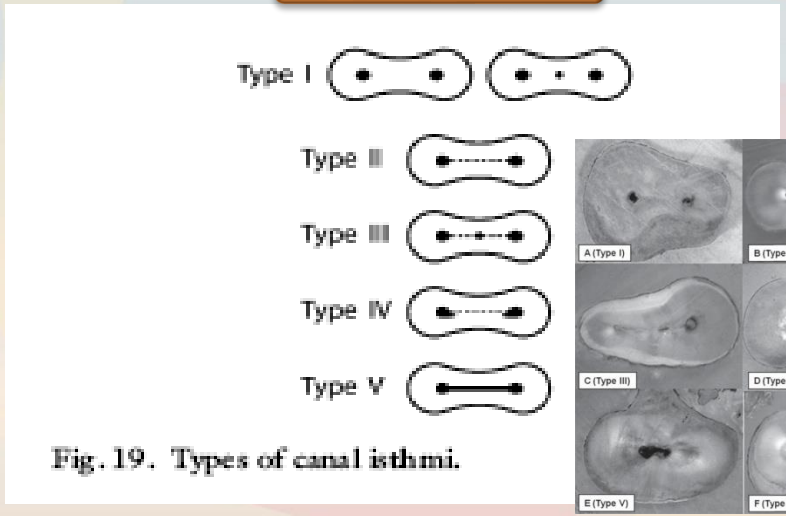


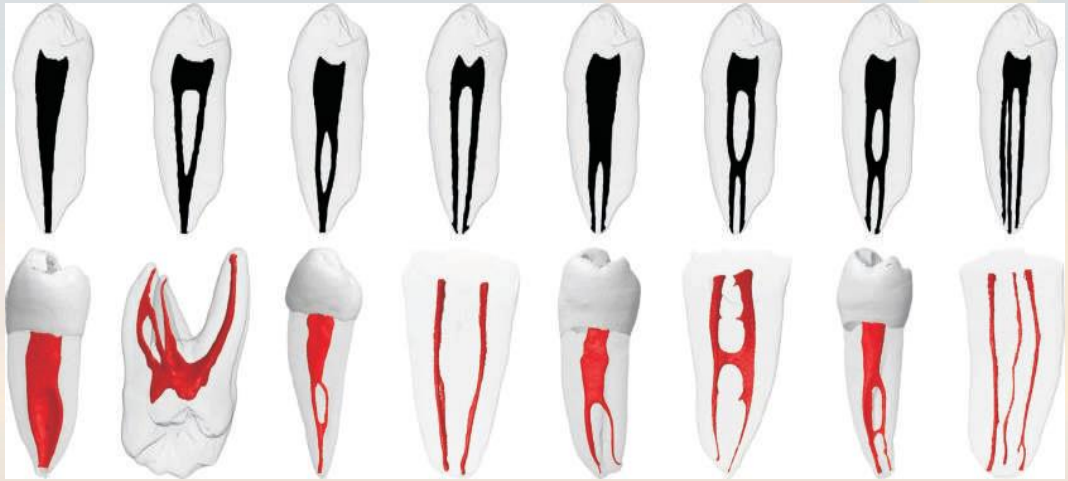
Fig. 19. Types of canal isthmi.

Clinical significance

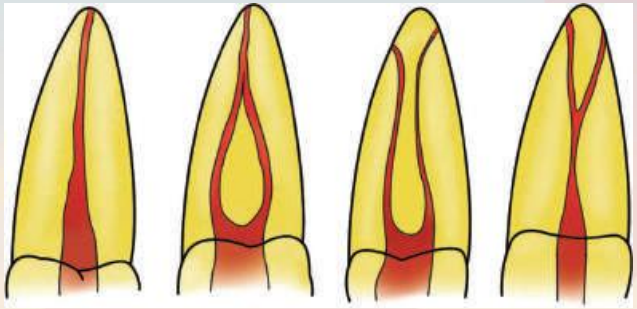
It is always mandatory to clean, shape and fill the isthmus area by orthograde or retrograde filling of root canals.

COMMON CANAL CONFIGURATIONS

Vertucci's classification

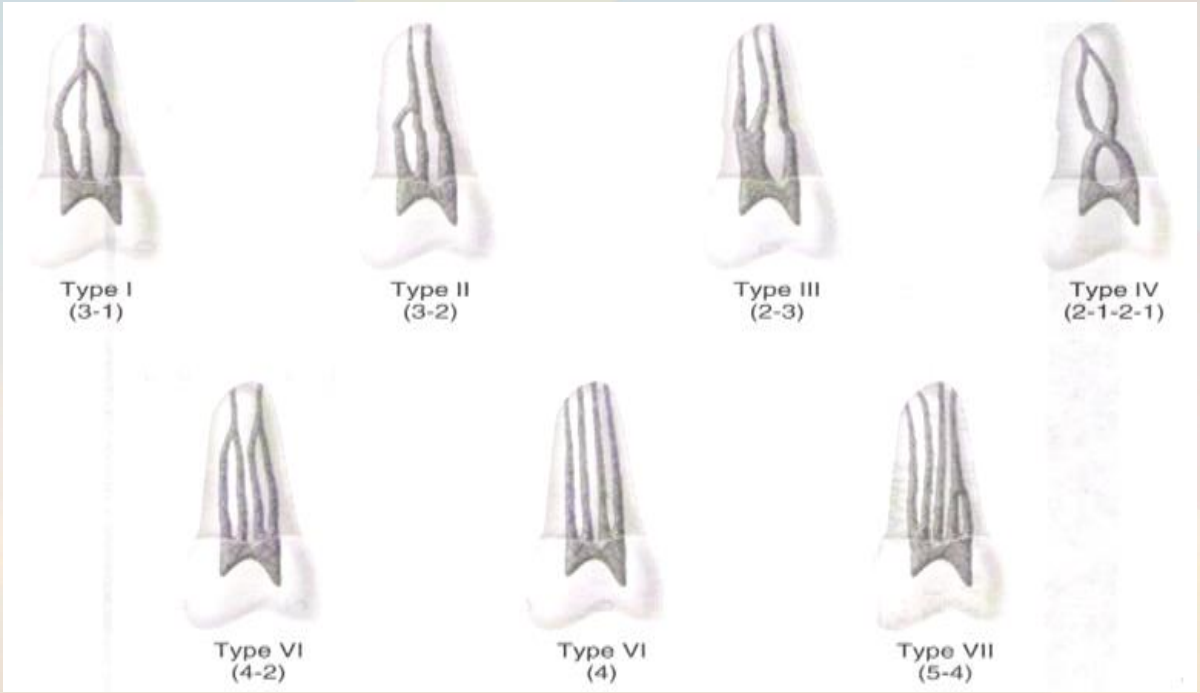


Weine's classification



COMMON CANAL CONFIGURATIONS

Gulabivala
& co workers

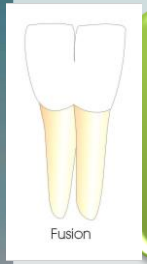


FACTORS AFFECTING INTERNAL ANATOMY

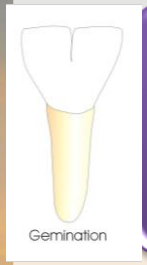
- **Age –** Continued dentin formation. Problem in locating pulp chamber & canals.
- **Irritants –** stimulate dentin formation at base of tubules – change in shape of pulp cavity.
- **Calcific metamorphosis –** trauma of recently erupted tooth.
- **Calcifications –** alter the internal anatomy, makes canal local difficult.
- **Resorption -** result in change of pulp cavity.

Double teeth
Connate teeth
Conjoined teeth

FUSION & GEMINATION



Fusion is defined as union of two normally separated tooth buds with the resultant formation of a joined tooth with confluence of dentin.



Gemination was defined as an attempt of a single tooth bud to divide, with the resultant formation of a tooth with a bifid crown and, usually, a common root and root canal.

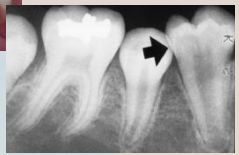
Prevalence

- Primary (0.5%-2.5%) & permanent dentition (0.3%-0.5%).
- Gemination – maxilla, Fusion – mandible.
- Anterior region.

Etiology: Remains unkonwn. Various factors such as pressure or physical force, local metabolic disturbances, viral infection during pregnancy, hypervitaminosis A, and genetic factors - causative agents.

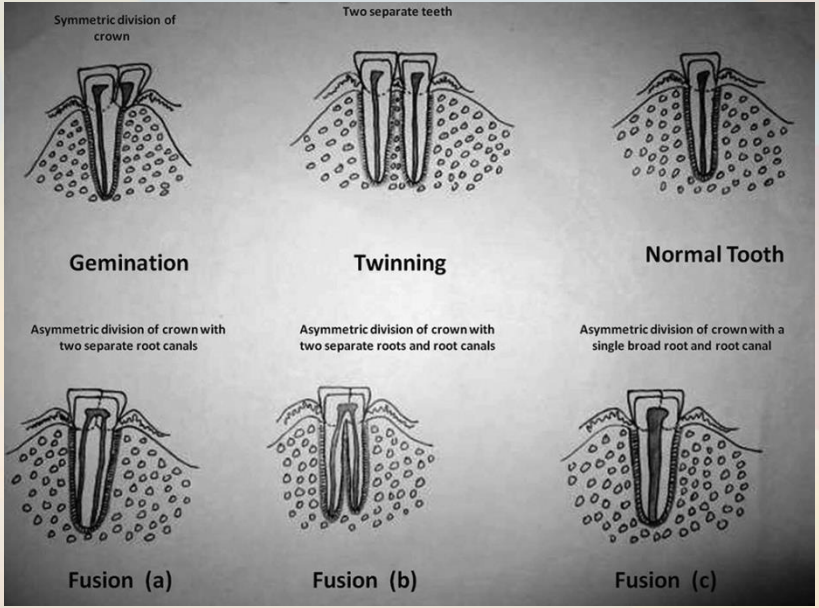
Sharma G, Mutneja AR, Nagpal A, Mutneja P. Dens evaginatus and dens invaginatus in a double tooth: A rare case report. Indian J Dent Res 2015;26:545-9.

FUSION & GEMINATION



Diagnosis

Characteristics	Gemination	Fusion between two normal set of teeth	Fusion between normal tooth and supernumerary tooth
Common location	Anterior maxilla	Anterior mandible	-
Dentition	Normal complement of teeth	Absence of adjacent teeth	Normal complement of teeth
Quadrant involvement	Unilateral	Unilateral	Unilateral
Clinical appearance	Bifid crown, each half symmetrical	Unsymmetrical; crooked appearance	Unsymmetrical; crooked appearance
Radiographic appearance	Single root with one canal	Mostly two separate pulp chambers and root canals	Variable



Sharma G, Mutneja AR, Nagpal A, Mutneja P. Dens evaginatus and dens invaginatus in a double tooth: A rare case report. Indian J Dent Res 2015;26:545-9.

FUSION & GEMINATION

Management

- In fusion, if the double teeth have separate pulps, hemisection may be successful without root canal therapy.
- The separation may be done intraorally or require extraction with extraoral sectioning if the union extends close to the apex.
- If extraction is necessary, immediate (within 5 minutes) replantation of the desirable half may result in preservation of vitality and long-term survival of the tooth.

FUSION & GEMINATION

Management

- In double teeth that share a common pulp, endodontic therapy is necessary if sectioning is considered.
- Selected shaping with or without placement of full crowns has been used in many cases.
- Other patients exhibit pulpal or coronal anatomic features that are resistant to reshaping and require surgical removal with prosthetic replacement.

Case reports

Khurana K et al reported a case of fused maxillary lateral incisor and supernumerary teeth & they managed by endodontic therapy and all ceramic restoration.





Uslu G et al reported a case of geminated maxillary lateral incisor & they managed by endodontic therapy.



Khurana k & Khurana P. Esthetic and endodontic management of fused maxillary lateral incisor and supernumerary teeth with all ceramic restoration after trauma. Saudi Endod J 2014; 4 (1): 23-7.
Uslu G & Taha O. Endodontic management of geminated maxillary lateral incisor: A case report . Int J Applied Dent Sci 2016; 2(3): 26-28 .

DENTINOGENESIS IMPERFECTA

Rare autosomal dominant disorder originating in the histodifferentiation stage of tooth development in which the dentin is abnormal in structure and is poorly attached to the enamel.

Hereditary opalescent dentin

Genes responsible for producing both dentinsialophosphoprotein (DSPP) and dentinsialoprotein (DSP) are located at 4q12-21.

Prevalence

- **1 in 6,000 to 8,000 people.**
- **Primary teeth are more severly affected than permanent teeth.**
- **Permanent incisors and first molars.**

DENTINOGENESIS IMPERFECTA

Diagnosis

- Blue-to-brown discoloration, often with a distinctive translucence .
- The enamel frequently separates easily from the underlying defective dentin.

- Bulbous crowns,
- Cervical constriction,
- Thin roots &
- Early obliteration of the root canals and pulp chambers

DENTINOGENESIS IMPERFECTA

Management

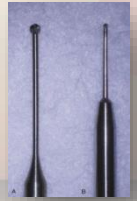
- Aim - to remove sources of infection or pain, restore aesthetics & protect teeth from wear.
- Treatment options include amalgams as dental fillings, veneers to fix the discoloration of teeth, crowns and bridges.
- Dentures or dental implants may be necessary if the majority of teeth are lost.
- Resin restorations and teeth bleaching.
- If symptomatic root canal therapy is performed for obliterated canals.

DENTINOGENESIS IMPERFECTA

Management of obliterated canals – location of canal orifice

- Pulp chamber is always located in the centre of the tooth at the level of th
- Various burs (LN, Mueller, Munce discovery burs) and ultrasonic tips.
- Dyes such as methylene blue may assist in locating the canal system und
- Sodium hypochlorite may also be used to assist, with the identification of a calcified canal being enhanced using the 'bubble' or 'champagne' test.

Start X™ # 3 ultrasonic tip
CPR 2D .
BUC 1 and 2 tips.
Endosuccess stellace ultrasonic tips.
VDW (CAVI) ultrasonic tips.

DENTINOGENESIS IMPERFECTA

Management of obliterated canals – Guidelines of negotiating calcified canals

Once the orifice has been located, a No. 8 K-file is penetrated into the canal to negotiate the canal.

Copious irrigation all times with 2.5 - 5.25 % NaOCl enhances dissolution of organic debris & lubricates the canal

Advance instruments slowly in calcified canals. Always clean the instrument on withdrawal.

When fine instrument reaches the canal length, take a radiograph.

Use of chelating agents to assist canal penetration. Flaring of canal orifice.

Well angulated bitewing & periapical radiographs.

Avoid anesthetizing the patient.

Avoid removing large amounts of dentin. Small round burs used to create a glide path to the canal orifice.

DENTIN DYSPLASIA

Dentin dysplasia-I - root less teeth, autosomal dominant. 1:1,00,000.

- Extreme tooth mobility and premature exfoliation, spontaneously or secondary to minor trauma.
- Strength of radicular dentin is reduced.

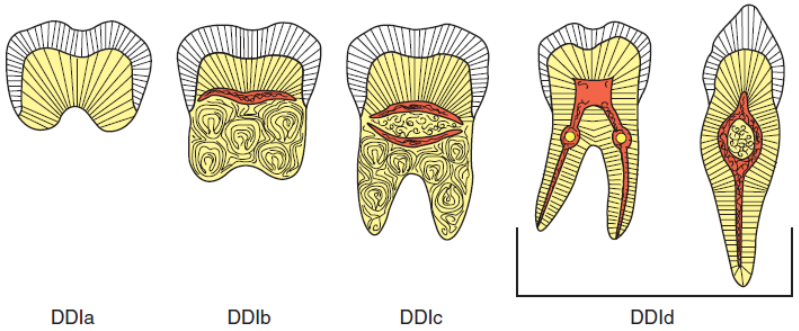
Dentin dysplasia -II – blue to-amber-to-brown translucence.

- In permanent teeth, radiographically pulp chambers exhibit significant enlargement and apical extension – "thistle tube–shaped or flame-shaped". Pulp stones develop in the enlarged pulp chambers.

DENTIN DYSPLASIA

• BOX 2-13 Subclassification of Dentin Dysplasia Type I

- DDIa: No pulp chambers, no root formation, and frequent periapical radiolucencies
- DDIb: A single small horizontally oriented and crescent-shaped pulp, roots only a few millimeters in length, and frequent periapical radiolucencies
- DDIc: Two horizontally oriented and crescent-shaped pulpal remnants surrounding a central island of dentin, significant but shortened root length, and variable periapical radiolucencies
- DDId: Visible pulp chambers and canals, near normal root length, enlarged pulp stones that are located in the coronal portion of the canal and create a localized bulging of the canal and root, constriction of the pulp canal apical to the stone, and few periapical radiolucencies



• **Fig. 2-109 Dentin Dysplasia Type I (DD-I).** Illustration demonstrating the variability of the radiographic appearance according to the degree of dentin disorganization within the root.

Neville – oral & maxillofacial pathology 4th ed.

DENTIN DYSPLASIA

Management

- Conventional endodontic therapy requires mechanical creation of canal paths and has been successful in teeth without extremely short roots.
- Teeth with short roots demonstrate pulpal ramifications that eliminate conventional endodontic treatment as an appropriate therapeutic option.
- Periapical curettage and retrograde amalgam seals have demonstrated short-term success.

CASE REPORT

- Jain P et al presented a case report of 40-year-old female reported to the department of conservative dentistry, with a chief complaint of food impaction and pain in the left upper molar region.

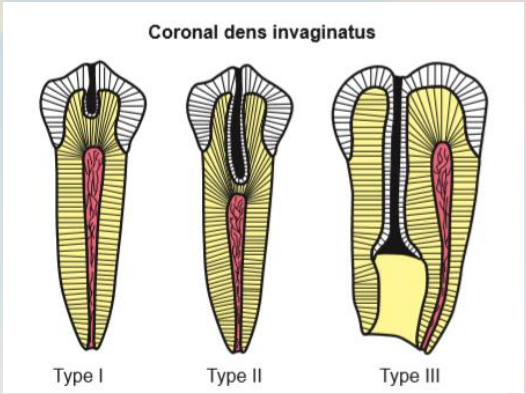
6 months

Jain P, Patni P, Hiremath H, Jain N. Successful removal of a 16 mm long pulp stone using ultrasonic tips from maxillary left first molar and its endodontic management. *J Conserv Dent* 2014;17:92-5.

DENS INVAGINATUS

Deep surface invagination of the crown or root that is lined by enamel.

is an odontogenic malformation resulting from deepening or an infolding of the enamel organ into the dental papilla during odontogenesis before the calcification process.



- PREVALENCE : 0.04% to 10%.
- Permanent lateral incisors, central incisors, premolars, canines, and molars.

Type I - exhibits an invagination that is confined to the crown.
Type II – invagination extends below the cementoenamel junction and ends in a blind sac.
Type III - extends through the root and perforates in the apical or lateral radicular area without any immediate communication with the pulp.

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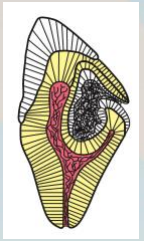
DENS INVAGINATUS

Type - II

Type - II

Type - III

DENS INVAGINATUS



- Radicular dens invaginatus is rare and thought to arise secondary to a proliferation of Hertwig root sheath, with the formation of a strip of enamel that extends along the surface of the root.
- Rather than protrude from the surface, the altered enamel forms a surface invagination into the dental papilla.
- Radiographically, the affected tooth demonstrates an enlargement of the root.
- Close examination often reveals a dilated invagination lined by enamel, with the opening of the invagination situated along the lateral aspect of the root.

DENS INVAGINATUS

Management

- In small type I invaginations, the opening of the invagination should be restored after eruption.
- In cases with obvious pulpal communication or signs of pulpal pathosis, both the invagination and the adjacent pulp canal require endodontic therapy.
- In teeth with open apices, apexification with calcium hydroxide or mineral trioxide aggregate often is successful followed by final obturation.
- Type III invaginations associated with periradicular inflammatory lesions require endodontic-like therapy of the perforating invagination.

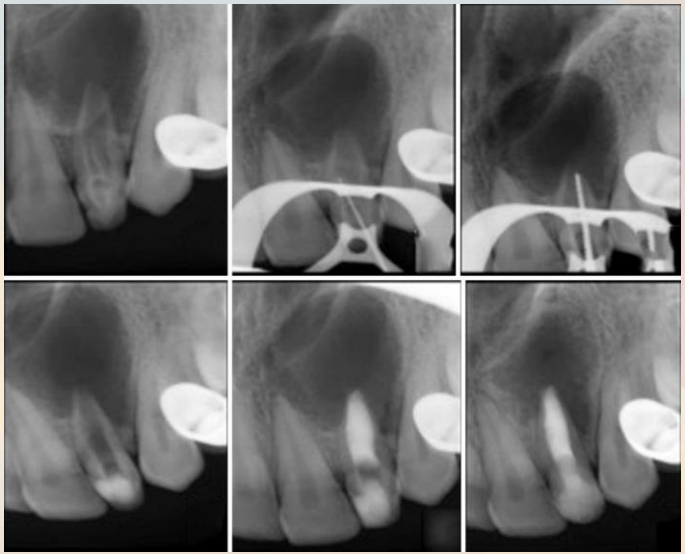
DENS INVAGINATUS

Management

- Once again before final obturation with gutta-percha temporary placement of calcium hydroxide helps to build dentinal bridges and maintain vitality of the adjacent pulp.
- If vitality is lost, endodontic therapy of the parallel root canal also becomes necessary.
- Some cases do not respond to conservative endodontic therapy and require periapical surgery and retrofill.
- Large and extremely dilated invaginations often have abnormal crowns and need to be extracted.

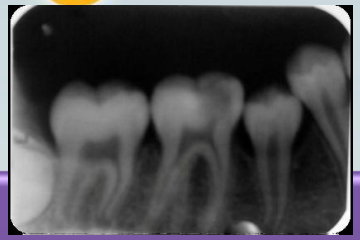
CASE REPORT

- Alenazy MS et al presented a case reports of 32 year old male & 20 year old female patients referred to department of conservative dentistry & endodontics for endodontic treatment of the left maxillary lateral incisor (#22).



Alenazy MS, Murwahi AE, Altwaijri SM, Mosadomi HA. Endodontic management of dens invaginatus of maxillary lateral incisor: Report of two cases. Saudi Endod J 2017;7:194-8.

EXTRA ROOT



"Radix entomolaris" - extra third root or disto lingual root in mandibular first molar. Carabelli in 1844.

"Radix paramolaris" - extra root buccally to the mesial root. Bolk in 1915

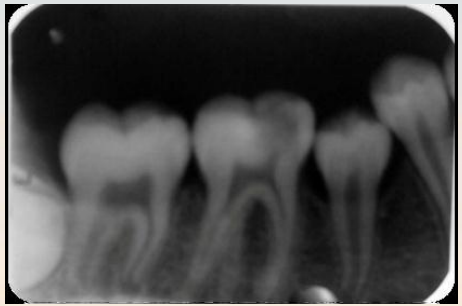
Prevalence

Africans - less than 3%
Caucasians - 4.2%
Eurasian and Asians - below 5%
Mongolians - more than 5%
Indian - 5.97%.

The exact etiology of RE/RP is still unknown. The external factors like racial genetic factors or penetration of an atavistic gene or involvement of polygenetic system during the processing of odontogenesis might be one of the causes for formation of supernumerary root.

CASE REPORT

- Chakraborty S et al presented a case report of 12 year old female patient reported to the Department of Pedodontics & Preventive Dentistry with chief complaint of pain in her lower right tooth back region of mouth since 2 months.

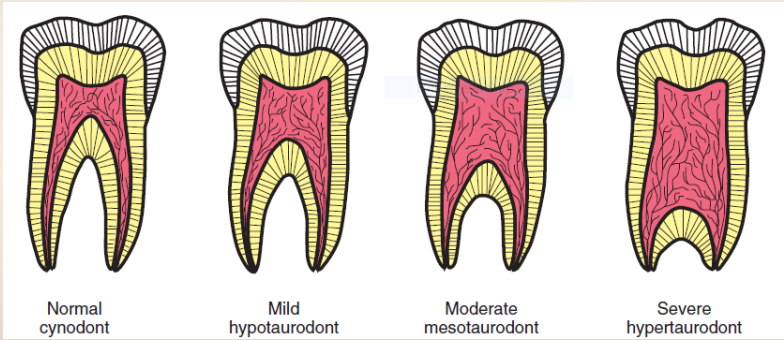



Chakraborty S, Rastogi P, Sharma S, Agali C. Root Canal Treated Mandibular Molar:Radix Entomolaris. Int J Oral Health Med Res 2015;2(1):36-38.

TAURODONTISM

- Taurodontism is an enlargement of the body and pulp chamber of a multirooted tooth, with apical displacement of the pulpal floor and bifurcation of the roots.
- Affected teeth tend to be rectangular and exhibit pulp chambers with a dramatically increased apico-occlusal height and a bifurcation close to the apex.

Chromosomal abnormalities may disrupt the development of the tooth's form and not the result of a specific genetic abnormality.



- 0.5% to 46%.
- Permanent teeth.
- unilateral /bilateral.

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TAURODONTISM

Management

- Patients with taurodontism require no specific therapy.
- Coronal extension of the pulp is not seen; therefore, the process does not interfere with routine restorative procedures.
- If endodontic therapy is required, then the shape of the pulp chamber frequently increases the difficulty of locating, instrumenting, and obturating the pulp canals.
- In addition, the presence of supernumerary roots and canals mandates careful exploration of all orifices and chamber grooves, with magnification being highly beneficial.

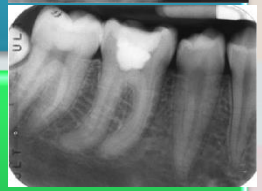
ROOT CANAL CURVATURES

Gradual curve

- Root canal gradually curves from orifice to the apical foramen.

Apical curve

- Root canal is generally straight but at apex it shows curve
- Commonly seen in maxillary lateral incisors and mesiobuccal root of maxillary molars.



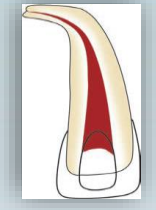
Bayonet-shaped Canal (s-shaped canal)

- 'S'shaped canal has two curves with the apical curve being very difficult to negotiate
- Chances of strip perforation are very high. Commonly seen in premolars.

Sickle-shaped Canals

- canal is sickle-shaped. Commonly seen in mandibular molars. Cross-section of this canal shows ribbon shape.

Tomes in 1848



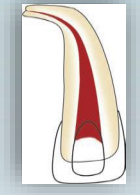
DILACERATIONS

deviation or bend in the linear relationship of a crown of a tooth to its root.
(or)
deformity of a tooth due to a disturbance between the unmineralized and mineralized portions of the developing tooth germ.

Prevalence

- **Mostly permanent teeth**
- **Posterior teeth**
- **Maxilla**
- **0.32% to 98%**
- **frequency of dilaceration in upper lateral incisors is 98%.**
- **No sex prediliction.**

Hamid J & Paul V. Dilaceration: Review of an Endodontic Challenge. J Endod 2007;33(9): 1025-30.



DILACERATIONS

ETIOLOGY

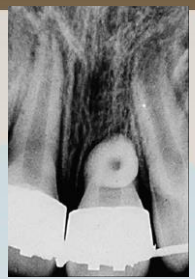
Mechanical trauma to the primary predecessor tooth, which results in dilaceration of the developing succedaneous permanent tooth.	**Contributing factors:** - scar formation - developmental anomaly of the primary tooth germ - facial clefting - advanced root canal infections - ectopic development of the tooth germ and lack of space - the effect of anatomic structures.	- the presence of an adjacent cyst, tumor, or odontogenic hamartoma - orotracheal intubation and laryngoscopy - mechanical interference with eruption - tooth transplantation - extraction of primary teeth - hereditary factors.

DILACERATIONS

Diagnosis

- The direction of root dilacerations should be considered in 2 planes, and they can be categorized as mesial, distal, labial/buccal, or palatal/lingual.
- If the roots bend mesially or distally, the dilaceration is clearly apparent on a periapical radiograph.
- However, when the dilaceration is toward the labial/buccal or palatal/lingual, the x-ray beam passes through the deflected portion of the root in an approximately parallel direction.

DILACERATIONS



Diagnosis

- The dilacerated portion then appears at the apical end of the unaltered root as a rounded opaque area with a dark "spot" in its center that is caused by the apical foramen of the root canal (bull's eye or a target).
- The periodontal ligament space around the dilacerated portion of the root might be seen as a radiolucent halo.
- Additional radiographs from different angles are recommended to assist with the diagnosis.

ROOT CANAL CURVATURES

Management

- Traditionally, canal shaping has been achieved using ISO- normed, 0.02-tapered stainless steel instruments.
- Sizes above #15 or #20 become inflexible and have a tendency to straighten.
- When carried out in curved canals, such procedure often results in iatrogenic damage to the natural shape of the canal, particularly in its apical third, resulting in errors like ledge, elbow or zipping of the canal.
- To avoid occurrence of such errors, even contact of the file to canal dentine should be there.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

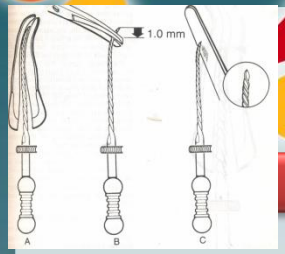
Management

- *Errors can be reduced by:*

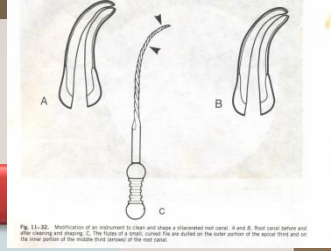
decreasing the restoring force by means of which straight file apt to bend against the curved dentine surface and

decreasing the length of the file which is aggressively cutting at a given span.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41



ROOT CANAL CURVATURES



Management – Decreasing the force can be done by:

Precurving the file - **A precurved file traverses the curve better than a straight file.**
Precurving is done in two ways:
- Placing a gradual curve for the entire length of the file.
- Placing a sharp curve of nearly 45° near the apical end of the instrument.

Extravagant use of smaller number files as they can follow canal curvature:
Because of their flexibility, they should be used until larger files are able to negotiate the canal without force.

Use of intermediate size of files:
It allows smoother transition of the instrument sizes to cause smoother cutting in curved canals, e.g. cutting 1 mm of No. 15 file makes it No. 17 file as there is an increase of 0.02 mm of diameter per millimeter of length.

Use of flexible files:
As they help in maintaining shape of the curve and avoid errors like ledge, elbow or zipping of the canal.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

Management - Decrease in length of actively cutting files is achieved by:

- Anti-curvature filing.
- Modifying cutting edges of the instrument by dulling the flute on outer surface of apical third and inner portion of middle third, which can be done by diamond file.
- Changing canal preparation techniques, i.e. use of crown-down technique.

❖ A significant advancement in root canal preparation with hand instruments was made with the introduction of balanced force movements of files.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

Management

- Balanced force movements of the file are:

A – clockwise 60°, so that it binds against the wall and advances apically.

B – anticlockwise 120° with apical pressure, so as to crush and break off the engaged dentinal wall.

C – clockwise 60° without apical advancement, allows flutes to be loaded with debris and removed from the canal.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

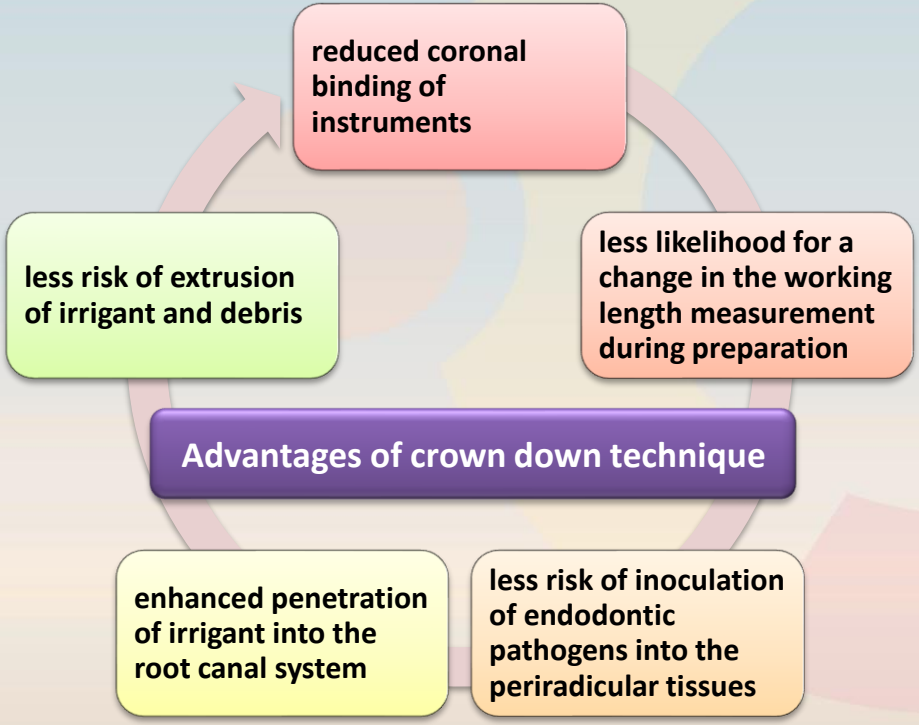
Management - **Motion of file in a root canal**

- Introduction of very flexible instruments made from nickel titanium alloy having a taper 2-6 times greater than the ISO standardized 0.02 files have revolutionarised the management of curved canal.
- They have the ability to pass around curves more readily.
- They are available as GT instruments and Protaper instruments.
- Hand NiTi instruments can also be selected instead of rotary instruments in teeth with difficult canal anatomy like severe curvature in apical third and problematic handpiece access.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

Management



Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

Management

- Outcome of root canal treatment will depend largely on complete biomechanical debridement of the canals and the elimination of microorganisms from the root canal system.
- The use of copious irrigation, file recapitulation, and further irrigation should be repeated more frequently in these severely curved canals.
- A multi-visit approach should also be followed, with the use of inter appointment intracanal medicaments to increase the predictability of the treatment.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

ROOT CANAL CURVATURES

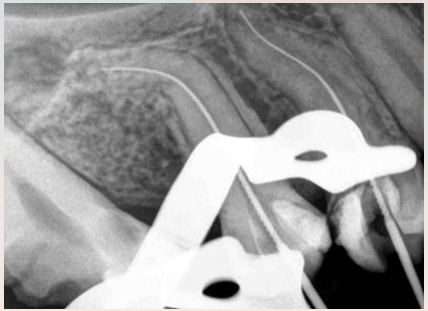
Management – Root canal filling

- Although lateral compaction of curved canals can be very effective in most teeth, this technique might be difficult and sometimes impossible in curved canals.
- If small, flexible spreaders cannot reach to within 1 mm of the working length, or the taper of the root canal preparation is less than that of the spreader, then lateral compaction is not the technique of choice.
- If the lateral compaction technique is chosen, then spreaders made from NiTi are highly recommended. Arc of movement of spreader should be limited to 90 degrees or even less.

Ansari I, Maria R. Managing curved canals. *Contemp Clin Dent* 2012,3:237-41

CASE REPORT

- NASIL S et al presented a case report of 19 years old female reported to the Department of Conservative Dentistry and Endodontics with pain in relation to upper right posterior teeth.

NASIL S, KHALEEL A, MALI G, SAM J, CHRISTALIN R. Management of Dilacerated and S-shaped Root Canals - An Endodontist's Challenge. J Clin & Diag Res 2014;8(6): ZD22-ZD24

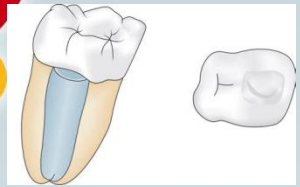
CASE REPORT

four cross-sections (2, 4, 6, and 8 mm from apex)

- Turkistani AK et al, evaluated and compared the shaping ability of HyFlex™ EDM (HFEDM) and ProTaper Next (PTN) rotary instruments in curved root canals by using micro-computed tomography (micro-CT) imaging.
- Compared to PTN, HFEDM showed significantly less mesiodistal canal transportation and improved centering ability in cross-section L6 ($p < 0.05$).
- The instruments showed similar increases in volume and surface area of the canals, with minor insignificant differences.
- HFEDM OneFile performed better at the vicinity of the danger zone in terms of mesiodistal canal transportation and centering ability.

Turkistani AK, Gomaa MM, Shafei LA, Alsofi L, Majeed A, AlShwaimi E. Shaping Ability of HyFlex EDM and ProTaper Next Rotary Instruments in Curved Root Canals: A Micro-CT Study. J Contemp Dent Pract. 2019 Jun 1;20(6):680-685.

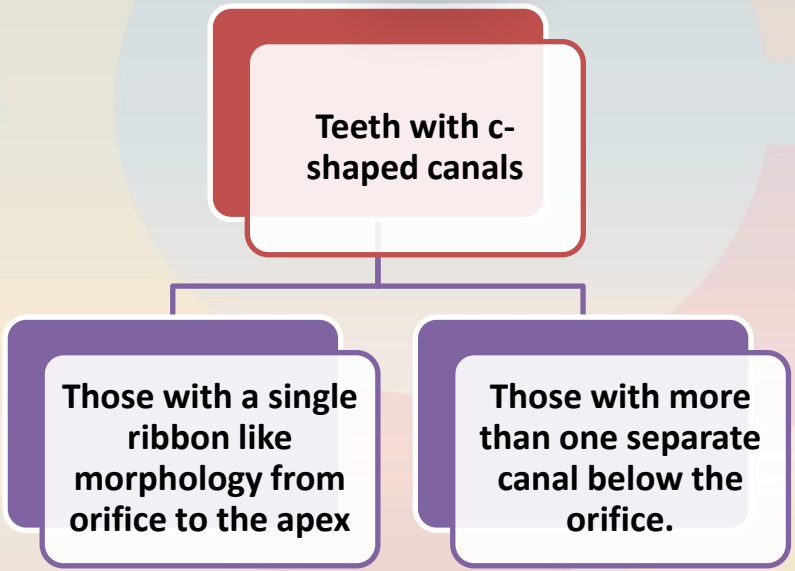
Cooke & Cox in 1979

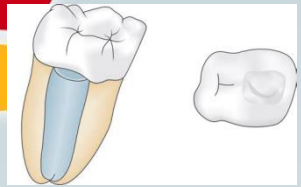


C-SHAPED CANALS

❖ C- shaped root canal system is a single, ribbon-shaped orifice with an arc of 180° or more.

❖ Root canal structure below the orifice shows wide range of anatomic variations with one, two, three or four separate canals.



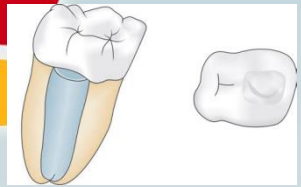


C-SHAPED CANALS

Prevalence

- Frequency varies from 2.7% to 8%.
- The teeth with C-shaped root canal configuration are usually mandibular second molars and rarely the mandibular first premolars, the maxillary first molars, mandibular third molars.
- The C-shaped configuration of the pulp chamber and the root canal system affects more often Asians than Caucasians with frequency of distribution up to 30%.
- The probability of finding C-shaped configuration in the contralateral tooth is up to 70%.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

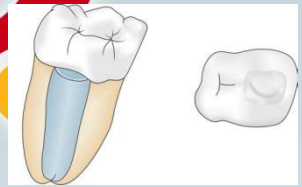


C-SHAPED CANALS

ETIOLOGY

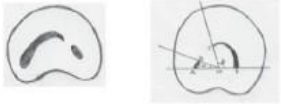
- Failure of the Hertwig's epithelial root sheath to fuse on the lingual or buccal root surface is the main cause of C-shaped roots, which always contain a C-shaped canal.
- The C-shaped root may also be formed by coalescence because of deposition of the cementum with time.
- C-shaped canals appear when fusion of either the buccal or lingual aspect of the mesial and distal roots occurs.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

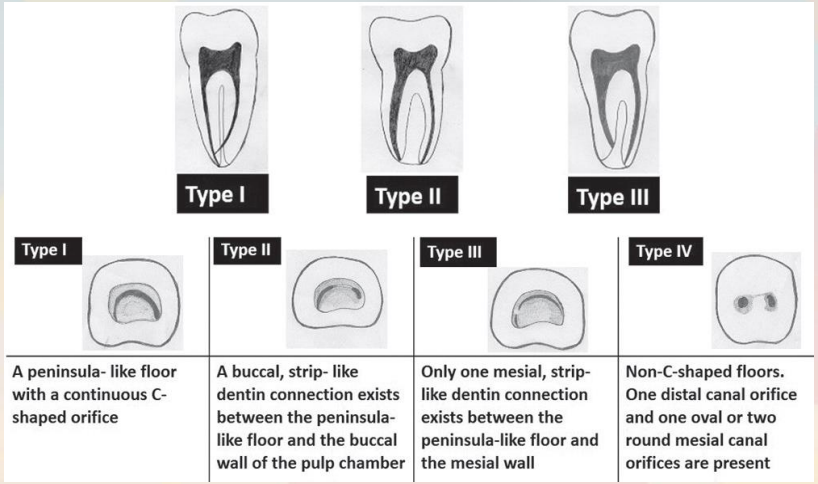


C-SHAPED CANALS

CLASSIFICATION

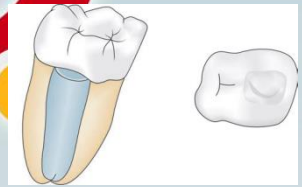
C1		The shape is an uninterrupted "C" with no separation or division
C2		The canal shape resembles a semicolon resulting from a discontinuation of the "C" outline, but either angle α or β should be no less than 60°
C3		Two or three separate canals and both angles, α or β are less than 60°
C4		Only one round or oval canal in that cross-section
C5		No canal lumen can be observed (which is usually seen near the apex only)

Fan et al anatomic classification

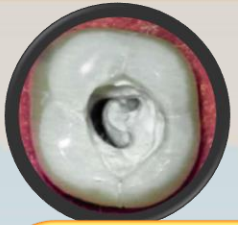


(a) Radiographic classification
(b) Classification of pulp chamber floor of teeth

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.



C-SHAPED CANALS

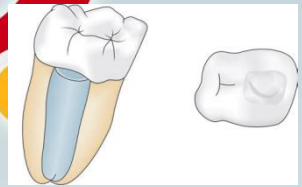


Diagnosis

Preoperative radiographic diagnosis:

- Four radiographic characteristics that can allow prediction of the condition:
  - radicular fusion,
  - radicular proximity,
  - a large distal canal
  - blurred image of a third canal in between.
- Hence, a C-shaped root in a mandibular second molar may present radiographically as a single-fused root or as two distinct roots with a communication.
- When the communication or fin connecting the two roots is very thin, it is not visible on the radiograph and may thus give the appearance of two distinct roots.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.



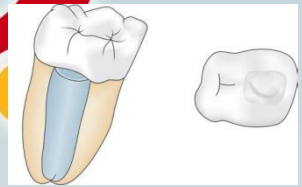
C-SHAPED CANALS

Diagnosis

Preoperative clinical diagnosis:

- The crown morphology of teeth with C-shaped anatomy does not present with any special features that can aid in the diagnosis.
- A longitudinal groove on lingual or buccal surface of the root with a C-shaped anatomy may be present.
- Such narrow grooves may predispose the tooth to localized periodontal disease, which may be the first diagnostic indication.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.



C-SHAPED CANALS

Diagnosis

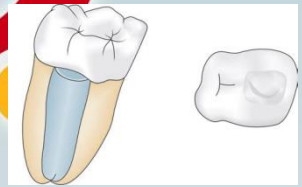
Clinical diagnosis following access cavity preparation:

- The pulpal floor in C-shaped teeth can vary from peninsula like with a continuous C-shaped orifice to non C-shaped floors.

Fan et al., stated that for mandibular second molar to qualify as having a C-shaped canal system, it has to exhibit all the following three features:

- Fused roots
- Longitudinal groove on buccal or lingual surface of root
- Atleast one cross-section of the canal belong to c1,c2 or c3

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.



C-SHAPED CANALS

Diagnosis

Clinical and radiographic diagnoses during working length determination:

- In a true C-shaped canal, (single canal running from the orifice to the apex) it is possible to pass an instrument from the mesial to the distal aspect without obstruction.
- In the semicolon type, (one distinct canal and a buccal or lingual C-shaped canal) whenever an instrument was inserted into any side of the C-shaped canal, it always ends in the distal foramen of the tooth and a file introduced in this canal could probe the whole extension of the C.
- When negotiating the C-shaped canal, instruments may be clinically centered.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management

- The high percentage of canal irregularities, such as accessory to lateral canals, and apical delta in a C-shaped canal makes it difficult to clean and seal the entire canal system adequately.
- Wide fins and small surface area of these canals preclude complete debridement using traditional hand instrumentation techniques, which can lead to failure of root canal therapy.
- Careful location and negotiation of the canals and the meticulous mechanical and chemical debridement of the pulp tissue should be carried out in order to successfully treat a C-shaped canal.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Location and negotiation of canals

Orifice	Number of canals	Insertion of files
continuous C-shape or arc like MesiobuccalDistal (MB-D)	One to three	3 initial files are inserted, one at either end and one in the middle.
oval or flat	One or two	two files are inserted, that is one file at each end of the orifice.
Round	one	one initial file is inserted

Exploration should be carried out with small size endodontic files i.e.,8,10,15 K-files with a small, abrupt apically placed curve.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Cleaning and shaping

- In order to access all the irregularities in the C-shaped canal system, the orifice portion of the slit can be widened with Gates Glidden drills.
- In narrow, interconnecting isthmus areas, Gates Glidden drills should not be used and cleaning should be carried out by using a size 25 instrument or smaller.
- Abou-Rass et al.,'s anti-curvature filing technique has been recommended to avoid danger zones that are frequently present at mesiolingual walls.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Cleaning and shaping

- Though nickel-titanium rotary instruments seem to be safe in such canals, further enlargement to an apical dimension greater than size 30 (0.06 taper) is not recommended.
- After instrumentation by NiTi rotary instruments, K-files or H-files could be passively introduced into the canal, and filling could be specifically directed towards the isthmus areas to obtain better debridement in clinical practice.
- The recently developed self-adjusting file (SAF) system has been reported to be more efficacious than the protaper system for shaping of C-shaped canals.

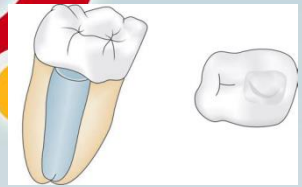
Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Cleaning and shaping

- Because of the large volumetric capacity of the C-shaped canal system housing transverse anastomoses and irregularities, continuous circumferential filing along the periphery of the C-shaped root walls with copious amounts of 3% to 6% NaOCl is often necessary to ensure maximum tissue removal and cessation of bleeding.
- If bleeding persists, then ultrasonic removal of tissue or placement of $Ca(OH)_2$ may be used between appointments to neutralize bacteria, enhance tissue dissolution, removal and control hemorrhage.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.



C-SHAPED CANALS

Management

- Ultrasonic instrumentation should be considered to remove tissue and debris in inaccessible areas.
- Over preparation of C-shaped canals should be avoided.
- In some cases, even with adequate local anesthesia, pain persists during canal enlarging and cleaning.
- Frequent administration of intrapulpal anesthesia may be necessary to keep the patient comfortable until all remnants of pulp tissue have been removed.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Obturation

- Obtaining a three dimensional fill of a C-shaped canal may prove to be a problem due to the various intricacies present within the root canal system.
- Studies have shown that following the cleaning and shaping, the remaining dentin thickness around the canals is usually 0.2 to 0.3 mm.
- The resultant forces of compaction during obturation can exceed the dentin canal resistance, which may result in root fracture and perforation of the root.
- In this regard, the thermoplasticized gutta-percha technique may prove to be more beneficial.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Obturation

- The aim of this technique is to move the gutta-percha and sealer into the root canal system under a hydraulic force.
- But in C-shaped canals the hydraulic forces can dramatically decrease and can seriously compromise the obturation quality due to the following reasons:

There are divergent areas that are frequently unshaped, which may offer resistance to obturating material flow

communications exist between the main canals of the C-shape through which the entrapped filling materials that should be captured between the apical tug back area and the level of condensation may pass from one canal to another.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

C-SHAPED CANALS

Management - Obturation

Walid's technique aimed to overcome these problems.

- This technique involves placing the master points simultaneously in the C-shaped canal.
- A large plugger is placed on one of the seated master points while the other master point is down packed with a smaller plugger.
- This increases the resistance towards the passage of obturating material from one canal to another.
- The smaller plugger is then held in place while the other point is down packed.
- This offers backpressure on entrapped filling materials and enhances the seal.

Fernandes M, de Ataide I, Wagle R. C-shaped root canal configuration: A review of literature. J Conserv Dent 2014;17:312-9.

CASE REPORTS

- Kadam NS et al presented case reports of 33 year old female & 26 year old male reported to the Department of Conservative Dentistry with a chief complaint of pain in the lower right back tooth region.

Kadam NS, Ataide IN. Management of C-shaped canals: Two case reports. *J Orofac Sci* 2013;5:37-41.

BLUNDER BUSS CANALS

Divergent & flaring root canal walls in which apex is funnel shaped and typically wider than the coronal aspect of canal.

ETIOLOGY

- The development of the root begins after the enamel and the dentin formation has reached the future cemento-enamel junction.
- At the time of tooth eruption root development is only 62-80%.
- If due to trauma or caries exposure occurs, pulp undergoes necrosis, dentin formation ceases and root growth is arrested.
- The resultant immature root will have an open apex – Blunder buss canal.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

Diagnosis

- Pulpal condition and stage of root development are the major factors in the selection of treatment plan.
- However with early diagnosis and intervention, pulp preservation strategies promote an environment for continued dentine apposition and root formation.
- Electric and thermal tests are of limited value due to their varied responses in permanent teeth with immature apex.
- laser Doppler flowmetry (LDF) for measurement of blood flow in traumatized teeth as this would provide more accurate readings

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

Diagnosis

- The pulse oximeter also offers accurate means of monitoring pulp vitality by recording the oxygenation of pulpal flow.
- Radiographic examination of teeth require good quality periapical and bitewing radiographs.
- These radiographs reveal the status of periapical tissues, presence and proximity of pulpal caries and stage of root development.
- The use of cone beam computed tomography should provide more accurate information regarding the condition of periapical tissues and root formation compared to 2-dimensional conventional radiographs.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

Management - teeth with vital pulp and open apices

- When pulp exposure occurs in immature tooth due to caries or trauma, the exposed pulp can heal if protected from further injury.
- Vital pulp therapies are the treatment of choice for traumatized and carious teeth with vital pulps and open apices.
- The approaches include indirect pulp capping in deep caries cavities and direct pulp capping or pulpotomy in cases of pulp exposure.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

APEXOGENESIS

- Apexogenesis is defined as "a vital pulp therapy procedure to encourage continued physiological development and formation of the root end".
- Only inflamed pulp tissue should be removed and bioactive material is placed over remaining healthy pulp tissue.
- The goals of apex genesis are:

Allow continued development of root length

Maintain pulp vitality, thus allow continued deposition of dentin.

Promoting root end closure, thus creating natural apical constriction.

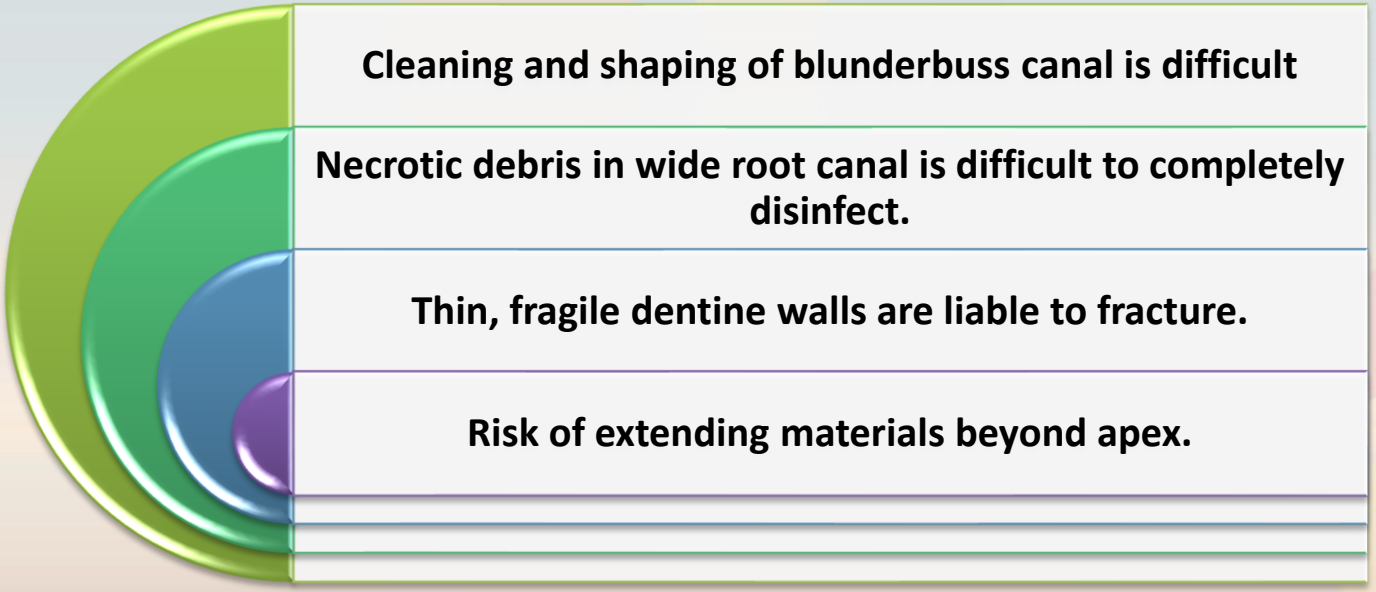
Generating dentine bridge at the site of pulpotomy.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

Management - teeth with necrotic pulp and open apices

- *Incomplete root development can provide a challenging clinical situation in treatments which include:*



Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

APEXIFICATION

- Apexification is defined as "method of inducing apical closure by the formation of osteocementum or a similar hard tissue or the continued apical development of the root of an incompletely formed tooth in which the pulp is no longer vital".
- The infected necrotic pulp is removed up to the apex by means of mechanical debridement and anti septic chemical irrigation.
- Apical hard tissue barrier formation following apexification is reparative process of the dentine-pulp complex.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

MTA APEXIFICATION

- MTA has been reported to produce equivalent amounts of apical hard tissue with no more inflammation than $Ca(OH)_2$ because of - good sealing ability
  - biocompatibility
  - good strength &
  - ability to induce cytokine release from bone cells.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

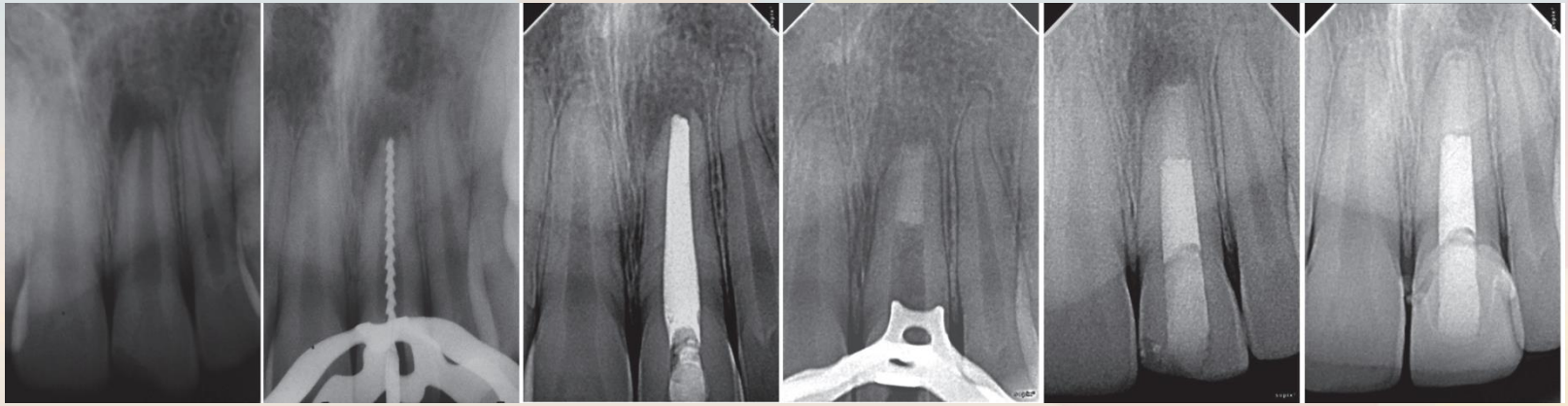
MTA APEXIFICATION

- After thorough debridement, the canal is medicated with $CaOH_2$ for 1 week for disinfection.
- On re-entry, canal is cleansed and rinsed with NaOCl.
- The canal is dried and a 3-4 mm plug of MTA is packed into the apical end with pluggers.
- The placement is confirmed radiographically and then a moist cotton pellet is placed against the MTA and access cavity is sealed for 4-6 hours to allow the material to harden.
- The canal is then obturated with gutta-percha.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

CASE REPORT

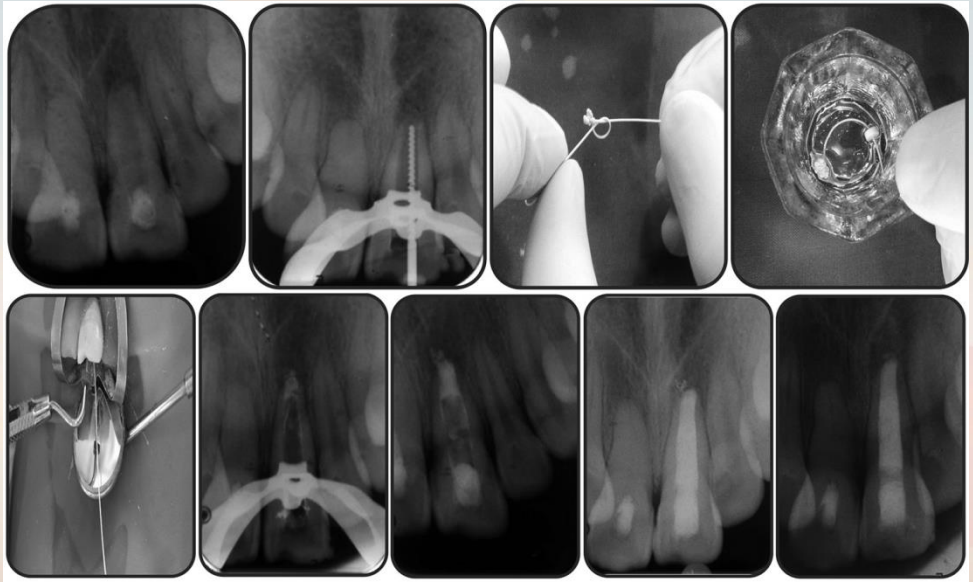
- Nayak G et al presented a case report of 20 year old male patient reported to the Department of Conservative Dentistry and Endodontics with a chief complaint of fractured and discoloured upper left front tooth.



Nayak G, Hasan M. Biodentine-a novel dentinal substitute for single visit apexification. *Restor Dent Endod* 2014;39(2):120-125

CASE REPORT

- Purra AR et al presented a case report of 16-year-old male patient reported with a chief complaint of discolored maxillary left central incisor.



Purra AR, Ahangar FA, Chadgal S, Farooq R. Mineral trioxide aggregate apexification: A novel approach. J Conserv Dent 2016;19:377-80.

BLUNDER BUSS CANALS

Revascularization

- Revascularization is the procedure to re-establish the vitality in a non vital tooth to allow repair and regeneration of tissues.
- The rationale of revascularization is that if a sterile tissue matrix is provided in which new cells can grow, pulp vitality can be re- established.

TECHNIQUE:

- The tooth is anesthetized and isolated with rubber dam.
- The canal is disinfected without mechanical instrumentation but with copious irrigation with 2.5% sodium hypochlorite.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

BLUNDER BUSS CANALS

Revascularization

- The triple antibiotic paste is placed in contact with necrotic pulp inside the root canal for up to 1 month before revascularization procedure.
- After one month, antibiotic is removed from canal by irrigation with 2.5% sodium hypochlorite and 17% ethylene diamine-tetracetic acid.
- Conditioning the dentin surface with ethylenediaminetetraacetic acid may enhance the adherence and differentiation of dental pulp stem cells during regeneration.

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BLUNDER BUSS CANALS

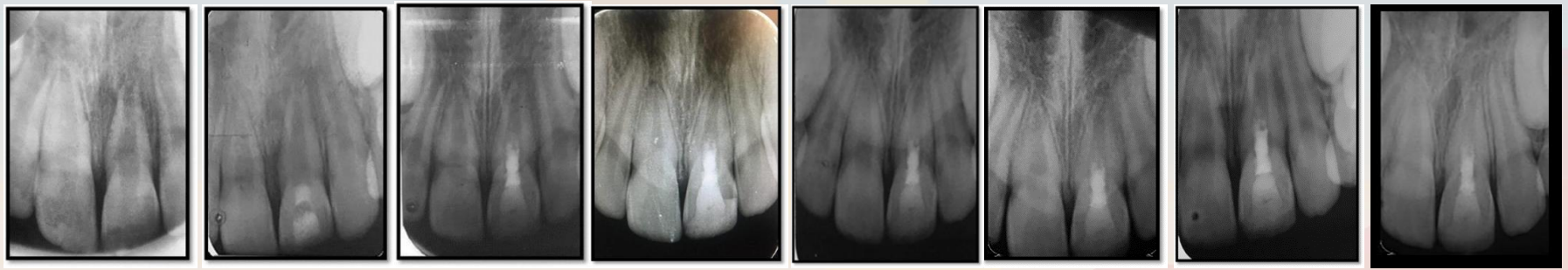
Revascularization

- Bleeding is induced till the level of canal orifice by passing a file beyond working length and causing irritation in periodical tissue.
- The bleeding is left for 15 minutes so that the blood would clot.
- Blood clot serves as a protein scaffold and permitting three dimensional in growth of tissue.
- MTA is placed over blood clot followed by moist cotton and well-sealed temporary restoration.
- After few days the cotton is removed and bonded restoration is placed over set MTA.

Kareem A M K, Rasha M A. Managements of Immature Apex: a Review. Mod Res Dent 2017;1(1):1-21

CASE REPORT

- Seraj B et al presented a case report of eight-year-old girl was reported to the Department of Pediatric Dentistry of Dental School of Dentistry for treatment of left maxillary central incisor.



PRE-OP | POST-OP | 1 MONTH | 3 MONTHS | 6 MONTHS | 12 MONTHS | 24 MONTHS | 3 YEARS

Seraj B, Sohrabi M, Shafizadeh M. Revascularization Treatment of Immature Permanent Tooth with Necrotic Pulp: A Case Report. *J Islam Dent Assoc Iran* 2018; 30(1):39-43.

VARIATIONS SEEN IN EACH TOOTH

MAXILLA

TOOTH	VARIATIONS
CENTRAL INCISOR	Double teeth, dens invaginatus, 2 roots, 2 or 3 canals.
LATERAL INCISOR	Dens invaginatus, gemination, fusion, dilaceration
CANINE	Dilaceration, dens invaginatus, 2 canals, 2 roots
1st premolar	Gemination, taurodontism, 3 roots, 3 canals
2nd premolar	Dens invaginatus, 3 canals, 3 roots
1st molar	C-shaped canal, taurodont, root fusion, single root, 2 palatal roots, 5 roots(2p,2MB,1DB)
2nd molar	4 roots (1p, 1MB, 2DB), taurodontism, single root.

VARIATIONS SEEN IN EACH TOOTH

MANDIBLE

TOOTH	VARIATIONS
CENTRAL INCISOR	Double teeth, dens invaginatus, 2 canals, dens evaginatus.
LATERAL INCISOR	Dens invaginatus, gemination, fusion, two roots (bifid)
CANINE	Dens invaginatus, gemination, 2 or 3 canals.
1st premolar	Gemination, dens invaginatus, 2 or 3 canals, 2 or 3 roots.
2nd premolar	Dens evaginatus, 4 or 5 canals in single root.
1st molar	Extra canal, taurodontism, c-shaped canal, supernumerary roots & canal.
2nd molar	C-shaped canal.

CONCLUSION

- Aberrant anatomy is far more common in today's endodontic specialist practice.
- Clinicians shall be constantly on the look out for 'occult' anatomy as successful outcome of any case depends on the complete debridement and disinfection of all canals.
- Thorough knowledge of the root canal anatomy and the consistent use of surgical operating microscope facilitate the location and treatment of aberrant anatomy

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Thank
You