Tooth Development and Eruption

Pediatric dentistry is a multidisciplinary branch of dentistry which encompasses many aspects of other dental specialties. It may provide a good overview of other sections in your preparation for the INDBE.

1 Odontogenesis

Tooth development is dependent on genetic control and environmental factors, such as - nutrition, trauma, infection, excess fluoride intake. It is composed of sequential events identified as initiation, bud, cap, bell, and erupted tooth stages.

Initiation Stage

The initiation stage begins 6 weeks in utero and is also referred to as the thickening stage. During this stage, the tooth development tissues are composed of the outer layer of oral epithelium, dental lamina, and ectomesenchyme.

All three of these tissue types are derived from the ectoderm. However, the ectomesenchyme is derived specifically from the neural crest cells of the ectoderm which has physiological characteristics which resemble mesenchymal origin.

- Oral Epithelium - superficial-most layer of developing mouth for both upper and lower arch forms
- Dental Lamina - row of thickened oral epithelium that will eventually become the developing teeth
- Ectomesenchyme - provides signal for oral epithelium to multiply into dental lamina.

Failure in this first step can lead to defects of congenitally missing or supernumerary teeth

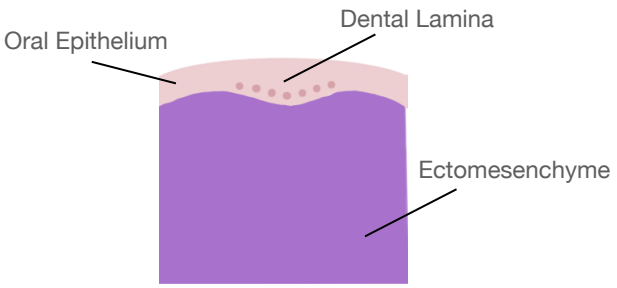

Figure 1.01 Initiation stage

Bud Stage

The bud stage begins **8 weeks in utero**. It is characterized by a quickly developing dental lamina which begins to invade the underlying mesenchyme. This results in the formation of a **dental placode** which histologically resembles the shape of a proliferating bud.

All primary teeth and permanent **molars** arise from the dental lamina. However, permanent incisors, canines, and premolars, arise from their primary predecessor when a secondary bud develops from the initial bud.

The continuous proliferation of the dental placode into the mesenchyme results in a condensing mesenchyme which is also a characteristic of the bud stage.

Failure in the bud stage also leads to congenitally missing teeth or supernumerary teeth.

INBDE Pro Tip: It is only the succedaneous permanent teeth which develop from a secondary bud of their primary predecessor.
The primary teeth and permanent molars are not replacing any teeth and thus develop from a primary bud.

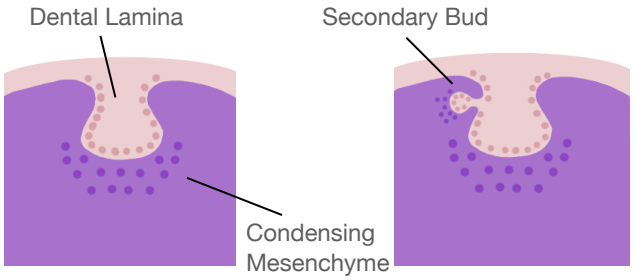

Figure 1.02 Bud stage

Non-succedaneous teeth develop from a single bud (Right). Succedaneous teeth develop from a secondary bud that arises from the primary bud of the developing primary tooth. (Left)

Cap Stage

The cap stage occurs **9 weeks in utero** when the bud continues to proliferate and begins to differentiate into various layers.
Each dental placode grows to form an **enamel organ** which will ultimately form the enamel.
The **enamel organ** consists of the outer enamel epithelium, inner enamel epithelium, stellate reticulum, and enamel knot.

- Outer Enamel Epithelium (OEE) - outermost cell layer
- Inner Enamel Epithelium (IEE) - cell layer underlying OEE
- Stellate Reticulum - star-shaped cells between the OEE and IEE
- Enamel Knot - thickened signalling centers of the developing tooth that will eventually form the cusp tips

The condensed mesenchyme will aggregate to form the **dental papilla** that will eventually form the dentin and pulp. Histologically, the enamel organ will resemble a cap over the dental papilla.
The **dental follicle** is defined as the surrounding sac of the dental papilla and enamel organ.
Early defects in this stage can lead to congenitally missing or supernumerary teeth. However, it is also likely to result in cysts, odontomas, gemination, fusion, or dens in dente.

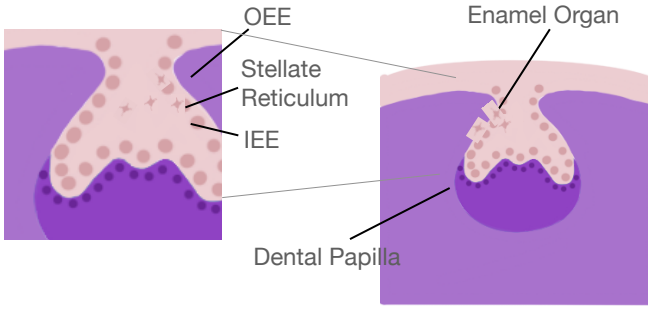

Figure 1.03 Cap stage

Bell Stage

The bell stage occurs **11 weeks in utero** and is characterized by two simultaneously occurring phases of histodifferentiation and morphodifferentiation.

Histodifferentiation:
In this phase, the tissues differentiate into distinct cell types which will be able to form the final tooth tissues.

- Inner Enamel Epithelium - differentiate into ameloblasts of tall columnar shape cells
- Dental Papilla - differentiate into odontoblasts of tall columnar shape cells

The interface between the ameloblasts and odontoblasts will form the **dentinoenamel junction (DEJ)**, as it is where the enamel and dentin will be secreted.

Defects in this stage can lead to amelogenesis imperfecta or dentinogenesis imperfecta.

Morphodifferentiation:
In this phase, the shape and size of the eventual crown is determined.
Defects in this phase can lead to size and shape abnormalities such as peg laterals or macrodontia.

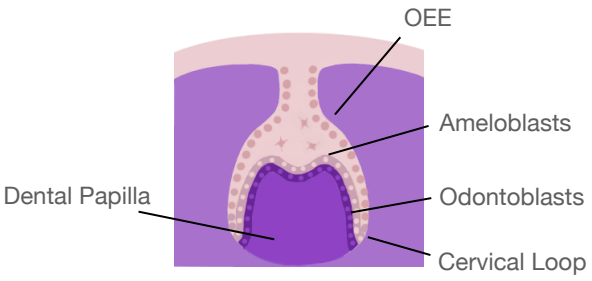

Figure 1.04 Early bell stage

Apposition

I. Apposition occurs **14 weeks in utero** and is defined by the deposition of initial tooth tissue matrices.
II. Odontoblasts begin to deposit dentin matrix of **collagen** that signals for ameloblast secretion.
    A. The remaining dental papilla will eventually form the pulp.
III. Ameloblasts will deposit enamel matrix of **amelogenin** which signals root development at the cervical loop.
IV. The cervical loop is the junction of the IEE and OEE which grows deep to form an extension called the **Hertwig's epithelial root sheath (HERS)**.
V. The HERS stimulates odontoblasts to secrete **radicular dentin** as part of the root.
    A. With continued development, the HERS will eventually disintegrates to form clusters of cells called the **epithelial rests of Malassez** which remain in the periodontal ligament of the final tooth.
VI. The stellate reticulum collapses to form the **reduced enamel epithelium** (REE) when the IEE and OEE combine. The REE lays along the superficial border of the forming enamel and protects the tooth during development.
    A. Post-eruption, the REE will form the **junctional epithelium.**

Disruptions in this stage through trauma or localized infection can lead to localized defects in the enamel called Turner's hypoplasia. Other defects may include enamel hypoplasia, enamel pearls, or concrescence.

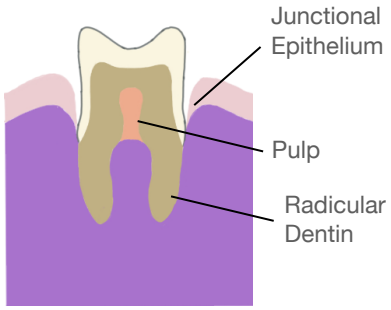

Figure 1.05 Apposition stage

Maturation

Maturation occurs **after 14 weeks in utero at various time points for different teeth** and is the longest stage. It is also referred to as calcification or mineralization. During this stage, the final deposition of enamel and dentin occurs.

The calcification process begins at the cusp tips and incisal edges at the previous enamel knots and proceeds in a cervical direction.
Calcification takes **2 years** to complete for a **primary tooth crown** and **4-5 years** to complete for a **permanent tooth crown**, without including the time required for complete root formation.

Disturbances in this stage are more common as the critical time period is much longer for the maturation stage. Some of them include - enamel hypomineralization, fluorosis , tetracycline.

Fluorosis is a common defect occurring with systemic fluoride ingestion >1ppm that disturbs ameloblasts. It leads to enamel matrix defects that can lead to a mottled enamel appearance. It commonly affects children from their second trimester (14 weeks in utero) through 8 years old, while their teeth are forming.

Tetracycline is an antibiotic which can cause intrinsic staining. It binds calcium and is eventually incorporated into hydroxyapatite of the dentin. It also affects children from their second trimester (14 weeks in utero) through 8 years old, while their teeth are forming.

INBDE Pro Tip: The later the disturbance occurs along the developmental process, the more minor the defect is.

Summary

Tooth Germ	Cell Type	Tissue
Enamel Organ	Ameloblast	Enamel
Dental Papilla	Odontoblast	Dentin
	Central Cell	Pulp
Dental Follicle	Cementoblast	Cementum
	Osteoblast	Alveolar Bone
	Fibroblast	Periodontal Ligament

2 Calcification Dates

Calcification of primary tooth roots are completed at 3-4 years of age.

Tooth		Calcification Start Date of Crown
Primary Teeth	Central Incisors (A)	14 weeks in utero
	First Molars (D)	15 weeks in utero
	Lateral Incisors (B)	16 weeks in utero
	Canines (C)	17 weeks in utero
	Second Molars (E)	18 weeks in utero
Permanent Teeth	First Molars (6)	Birth
	All anterior teeth except maxillary laterals (1, L2, 3)	6 months
	Maxillary Laterals (U2)	12 months
	First Premolars (4)	18 months
	Second Premolars (5)	24 months
	Second Molars (7)	30 months

INBDE Pro Tip: Primary teeth begin calcification in the order of:

A, D, B, C, E

beginning at **14 weeks** in utero at **1 week intervals**.

Permanent teeth begin calcification at **6 month intervals from birth**. The sequence of calcification occurs in the order of:

6, (1, L2, 3), U2, 4, 5, 7

3 Eruption Dates

The eruption times for teeth exist within a range. It is accepted that eruption will occur within a 6 month window of the provided dates. However, the order of eruption is more important for development than the dates themselves.

**All eruption times are from the ADA website

Primary Teeth

Tooth	Eruption Time
Mandibular Central Incisor (A)	6 months
Maxillary Central Incisor (A)	8 months
Maxillary Lateral Incisor (B)	9 months
Mandibular Lateral Incisor (B)	10 months
Maxillary Primary First Molar (D)	13 months
Mandibular Primary First Molar (D)	14 months
Maxillary Canine (C)	16 months
Mandibular Canine (C)	17 months
Mandibular Primary Second Molar (E)	23 months
Maxillary Primary Second Molar (E)	26 months

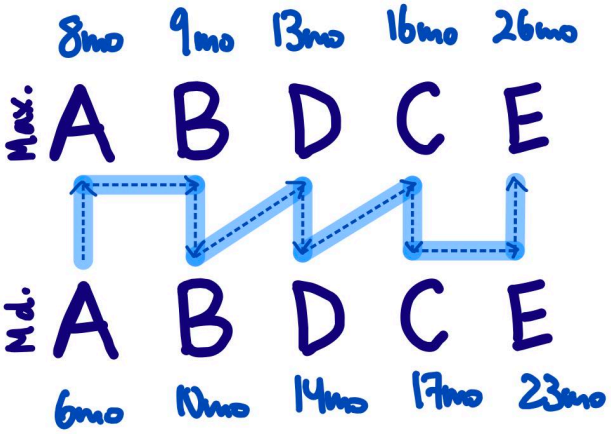

Figure 1.06 Eruption order of primary teeth

This figure is a useful visualization for memorizing the eruption sequence of primary teeth. The teeth are represented by their orthodontic designations and their order of eruption by the arrows in blue.

Permanent Teeth

For the permanent teeth, it is generally accepted that the mandibular teeth erupt before the corresponding maxillary teeth. Additionally, the corresponding teeth generally erupt earlier for females than in males.

The eruption of teeth often occurs symmetrically in that the eruption on one side will usually be followed by the eruption of the same tooth on the opposite side within a few months. If this does not occur, it may be suspected that the tooth is impacted or missing.

Tooth	Eruption Time
Maxillary/Mandibular 1st Molar (6), Mandibular Central Incisor (1)	6 years old
Maxillary Central Incisor (1), Mandibular Lateral Incisor (2)	7 years old
Maxillary Lateral Incisors (2)	8 years old
Mandibular Canine (3)	9 years old
Maxillary/Mandibular 1st Premolar (4)	10 years old
Maxillary 2nd Premolar (5)	10.5 years old
Maxillary Canine (3), Mandibular 2nd Premolar (5), Mandibular 2nd Molar (7)	11 years old
Maxillary 2nd Molar (7)	12 years old
Maxillary/Mandibular Molar (8)	17 years old

2-3 Rule

The 2-3 rule refers to the **⅔ of the root** that is developed in erupting teeth. After initial eruption, the root takes **2-3 year**s to complete its development.

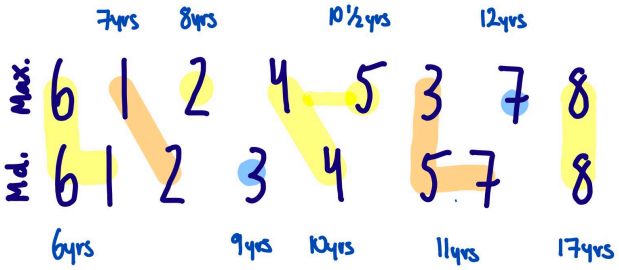

Figure 1.07 2-3 Rule

This figure is a useful visualization for memorizing the eruption sequence of permanent teeth. The teeth are represented by their orthodontic designations and are grouped by colour if they erupt at the same time.

Developmental Disturbances

1 Tooth Number Anomalies

Disturbances resulting in missing or supernumerary teeth occurs in the initiation or bud stages.

Supernumerary Teeth

Supernumerary teeth refers to teeth that are present in addition to the typical set of teeth. They may require removal as they may block the normal eruption of permanent teeth.

Incidence: 3% of population
Most commonly affected: Mesiodens
Mesiodens are extra teeth which develop close to the midline. They are often found palatally.

Congenitally Missing Teeth

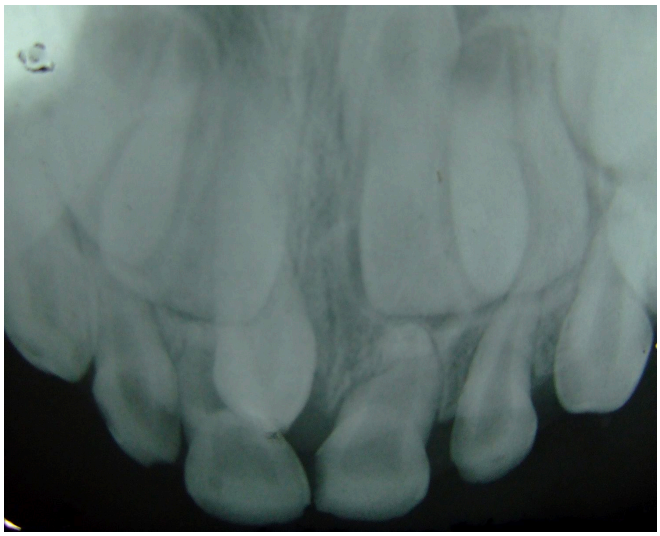

Figure 1.08 Supernumerary Teeth (Mesiodens)
Albert, Public domain, via Wikimedia Commons.

Commonly Affected Perm Teeth *(most to least)*: third molars, mandibular second premolars, maxillary laterals, maxillary second premolars

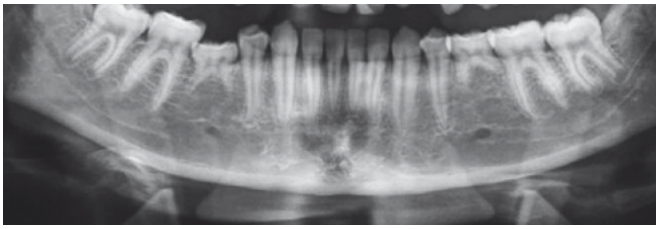

Figure 1.09 Missing Second premolars
2015 Medio et al. Licensed CC BY 4.0.

INBDE Pro Tip: The order of most commonly congenitally missing teeth is a frequently appearing concept in the INBDE.

Commonly Affected Primary Teeth: Primary Maxillary Lateral Incisor

Missing teeth are addressed depending on the tooth missing and whether it is missing uni- or bilaterally.

A missing lateral incisor can be replaced with canine substitution or prosthetic replacement. If a second premolar is missing unilaterally, the second premolar may be extracted on the opposite side and closed with orthodontic treatment to provide symmetry.

Figure 1.10 Missing Second premolars
2015 Medio et al. Licensed CC BY 4.0.

2 Tooth Size Anomalies

Anomalies of size can occur due to disturbances in multiple stages of tooth development. Microdontia and macrodontia occur as a result of disturbances in the bell stage, whereas fusion and gemination occur due to disturbance in the cap stage.

Microdontia

Microdontia refers to the presence of small teeth and can either be generalized or localized in nature.

- Generalized: commonly seen with down syndrome, pituitary dwarfism, ectodermal dysplasia
- Localized: most common form

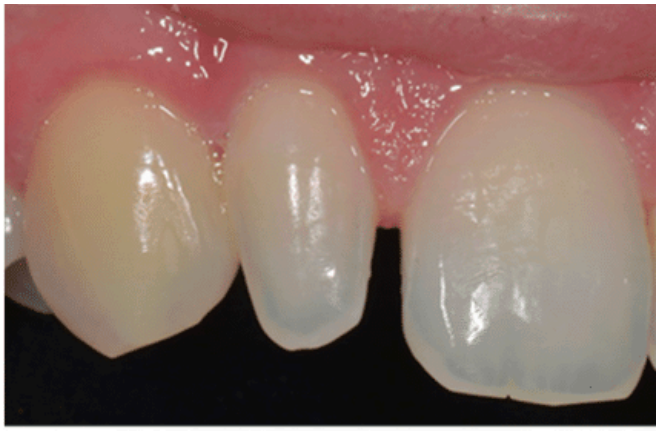

Figure 1.11 Localized Microdontia (Peg-Shaped Lateral Incisor)
Adapted from 2020 by Zafar S.A, et al. Licensee MDPI, Basel, Switzerland CC BY 4.0

Peg-shaped lateral incisors are a common form of localized microdontia. It is an autosomal dominant trait which may vary in severity.

Macrodontia

Macrodontia refers to big teeth but do not include fusion or gemination traits. Like microdontia, it can also be generalized or localized in nature.

- Generalized: commonly seen with pituitary gigantism, pineal hyperplasia with hyperinsulinism
- Localized: commonly seen with hemifacial hyperplasia

Fusion

Fusion occurs when two adjacent developing teeth merge together in the cap stage. When this occurs, the tooth count is one less than a typical set of teeth. Although the two teeth are fused, they each contain their own separate root canal system.

Commonly Affected Teeth: Primary teeth of anterior region

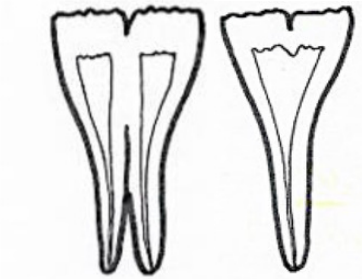

Figure 1.12 Diagrammatic Representation of Fusion (Left) and Gemination (Right)
Adapted from 2021, Pandya-Sharpe et al. Licensed CCBY 4.0

Gemination

Gemination occurs when one developing tooth develops two crowns with a shared root canal system. Although it may clinically resemble a fused tooth, the tooth count is normal despite the two seemingly-conjoined crowns.

INBDE Pro Tip: Take note of the differences in fusion and gemination:

- Fusion results in a decreased tooth count while gemination does not alter the tooth count.
- Fused teeth each contain their own separate root canal system, while gemination results in a shared root canal system.

3 Tooth Shape Anomalies

Taurodontism

Taurodontism refers to a tooth with short roots and an enlarged pulp chamber and elongated crowns.This trait is commonly linked to type IV amelogenesis imperfecta.

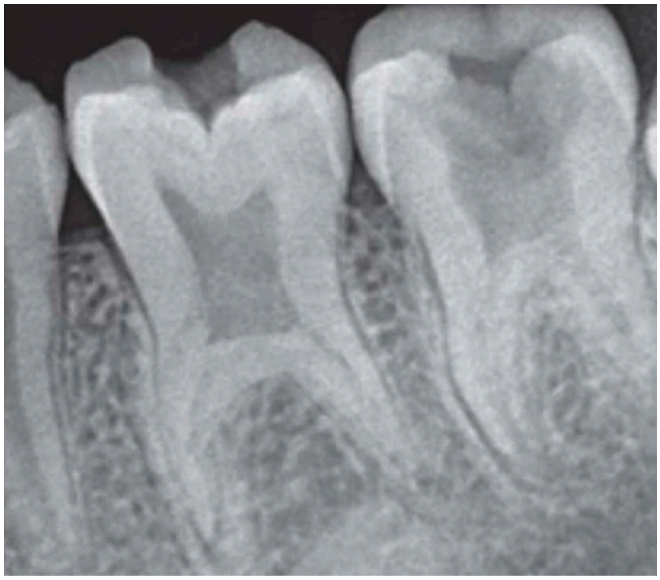

Figure 1.13 Taurodontism
Adapted from 2021 Chetty M., et al. Licensed CCBY 4.0

Dens Evaginatus

Dens evaginatus refers to the presence of an extra cusp containing enamel, dentin, and pulpal tissue. This is an important aspect to consider during operative dentistry in order to avoid pulpal encroachment.

Dens evaginatus may also be referred to as a **talon cusp** in anterior teeth.

Figure 1.14 Talon Cusp
2020 Rafael Alberto dos Santos Maia et al. Licensed CCBY 3.0

Dens Invaginatus (Dens in Dente)

Dens invaginatus is caused by an invagination of inner enamel epithelium (IEE) during tooth development.

After invagination, the IEE continues its normal differentiation into ameloblasts which secrete enamel in their invaginated state. This often results in the formation of a tunnel into the internal structure of the tooth which facilitates bacterial penetration and caries development. It must be diagnosed radiographically.

Commonly Affected Teeth: Permanent Maxillary Lateral Incisors

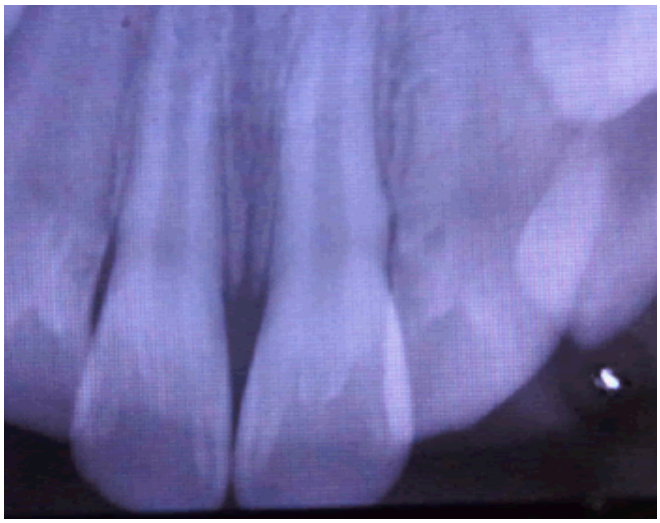

Figure 1.15 Dens Invaginatus
2015 Nagaveni NB, et al. Licensed CCBY 4.0

Dilaceration

Dilaceration refers to an abnormal bend in the tooth root that commonly occurs due to trauma of the primary tooth affecting development of

Figure 1.16 Dilacerated Lateral Incisor
2018, Pauly G., et al. Licensed CCBY 4.0

4 Tooth Structural Anomalies

Enamel Hypoplasia

Enamel hypoplasia is a form of underdeveloped enamel tissue following a disturbance in the apposition stage of tooth development.

Turner's Hypoplasia
A type of enamel hypoplasia following an infection or trauma induced inflammatory response to the primary tooth.

This results in a disturbance to the ameloblasts of the developing permanent tooth and thus only affects the permanent dentition.

This may be visualized as a brownish tinge on the enamel of permanent teeth.

Congenital Syphilis
Congenital syphilis in the fetus of mothers infected with syphilis can be commonly associated with enamel hypoplasia defects such as Hutchinson's incisors and Mulberry molars.

This condition develops in utero and thus affects both primary and permanent teeth.

- Hutchinson's Incisors: Hypoplastic triangular notch on incisal edges
- Mulberry Molars: globular rounded enamel cusps seen on occlusal surfaces of molars

Enamel Hypocalcification

Enamel hypocalcification occurs with a failure in maturation stage of tooth development. It is often clinically present as white spot lesions of abnormal mineralized enamel of teeth.

Amelogenesis Imperfecta (AI)

This condition consists of an alteration of enamel that has an autosomal dominant, recessive, or X-linked expression pattern of a disturbance in the bell stage.

This results in little to no enamel in both primary and permanent teeth, while the dentin and pulpal tissues remain unchanged.

Treatment options in these cases may include full-coverage crowns for aesthetic purposes.

Dentinogenesis Imperfecta (DI)

This condition consists of an alteration of dentin in a autosomal dominant expression pattern by affecting the bell stage of development.

Dentinogenesis imperfecta results in all teeth from both primary and permanent dentitions to have short roots, bell-shaped or bulbous crowns, constricted DEJ, and obliterated pulps. Extra-orally, it may also be accompanied by blue sclera and is commonly linked to osteogenesis imperfecta.

Treatment options for this condition consists of full-coverage crowns for aesthetic purposes.

INBDE Pro Tip: AI and DI are common concepts in the INBDE.

Amelogenesis Imperfecta	Dentinogenesis Imperfecta
• Affects enamel • Autosomal dominant, recessive, or X-linked expression	• Affects dentin • Autosomal Dominant expression
• Affects bell stage • Affects all teeth in both dentitions	

Regional Odontodysplasia

Regional odontodysplasia is a condition affecting all dental tissues in a quadrant of teeth in both primary and permanent dentition.

Affected teeth are often referred to as **ghost teeth** because they display short roots, open apices and enlarged pulp chambers.

Treatment includes supporting eruption to promote healthy alveolar bone and extracting affected teeth once erupted.

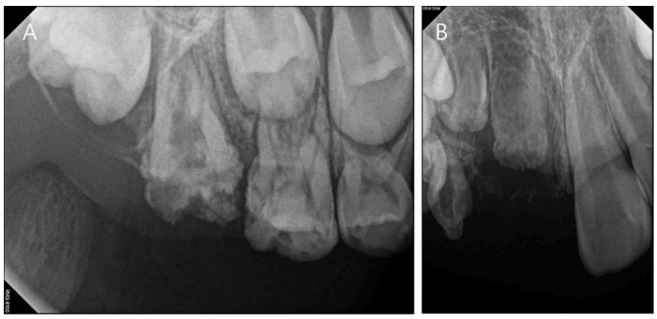

Figure 1.17 Regional Odontodysplasia
Adapted from 2014 by Song. CC BY 3.0

Concrescence

Concrescence occurs when there is a union of two adjacent teeth by cementum. It is commonly linked to hypercementosis and may result in difficulties with eruption of extraction of the affected teeth.

Most Commonly Affected: Maxillary Molars

Enamel Pearl

An enamel pearl is a piece of enamel found on the root surface which consequently blocks the attachment of Sharpey's fibres to the tooth. This results in periodontal pocketing in the patient and cannot be removed with scaling.

Most Commonly Affected: Molars

Dentin Dysplasia

Dentin dysplasia (DD) is an autosomal dominant condition leading to an alteration of dentin. It is often clinically presented in all teeth from both dentitions in two types:

Type I: Radicular Dentin Dysplasia
Type I DD affects the radicular dentin of teeth, resulting in short roots and chevron shaped pulps. This is often accompanied by premature mobility and exfoliation of the teeth.

Type II: Coronal Dentin Dysplasia
Type II DD affects the coronal enamel and is clinically determined by its thistle-shaped pulps, bulbous crowns, thin root. It can also be considered a form of dentinogenesis imperfecta.

Treatment options for this condition is limited as these teeth are not well suited for restoration.

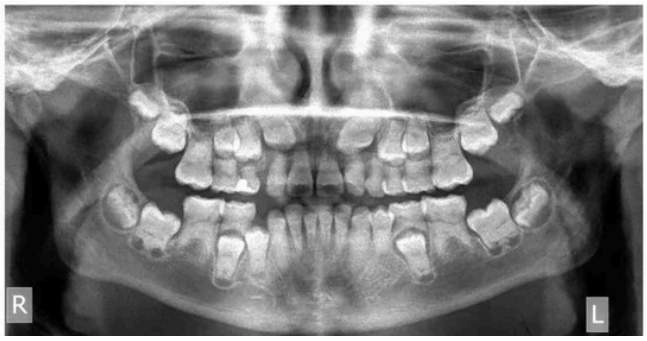

Figure 1.18 Type I Radicular Dentin Dysplasia
Adapted from 2021 by Papagiannis A, et al. Licensee MDPI, Basel, Switzerland CC BY 4.0

INBDE Pro Tip: The types of dentin dysplasia are high yield topics.To remember the types of dentin dysplasia, remember that type I results in short roots since it is a lower (or shorter) number than 2.

Primary Tooth Anatomy

1 General Characteristics

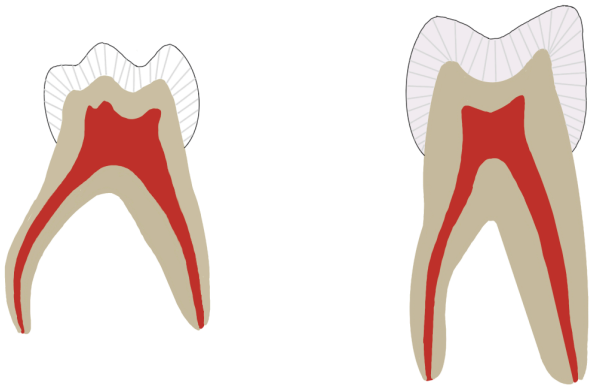

Figure 1.20 Cross Section of Primary Tooth (Left) and Permanent Tooth (Right)

Mineralized Layers

The enamel and dentin layers are relatively **thinner** in primary teeth than in permanent teeth. The enamel thickness in primary and permanent teeth are on average 1mm and 2mm, respectively.

Additionally, the enamel thickness is relatively uniform in primary teeth. In permanent teeth the enamel thickness varies depending on the region of the tooth.

As a result of the thinner mineralized layers, primary teeth are more prone to tooth wear, caries, and faster caries progression.

Pulp Space

Primary teeth also have **relatively larger pulp systems** than permanent teeth. This makes them more prone to pulp involvement with caries progression, as well as pulp exposure with mechanical preparations.

Colour

Primary teeth are **whiter** than permanent teeth due to their thinner enamel.

Tooth Shape

Primary teeth have clinical crowns with a larger width to height ratio. This means that they are **wider mesio-distally and shorter inciso-cervically** relative to their successors.

Enamel Rod Orientation

In permanent teeth, the enamel rods are perpendicular to the DEJ and orient apically within the cervical third of the crown. In primary teeth, the enamel rods are uniformly facing **occlusal in direction**.

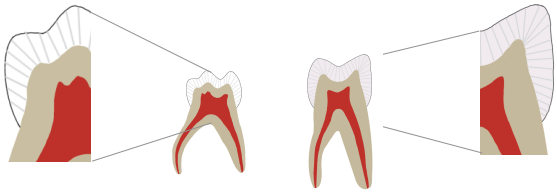

Figure 1.21 Enamel Cross Section of Primary Tooth (Left) and Permanent Tooth (Right)

Cervical Bulge

Primary teeth have a **cervical bulge or ridge** which is most prominent at the primary first molar.

Root Shape

The roots of primary teeth are **more divergent** than those of permanent teeth, as they are required to accommodate the succedaneous teeth. Permanent teeth have roots of varying morphologies, including straight and convergent.

Additionally, the roots of primary teeth have **small or absent root trunks**. This means that the bifurcation of the roots occurs immediately or shortly after the CEJ of the tooth.

2 Maxillary Tooth Characteristics

***Only INBDE high-yield facts have been included in this section*

Primary Maxillary Central Incisor

Dimensions

The maxillary central incisors are the **widest** anterior teeth in the **mesio-distal dimension** for both **primary and permanent dentitions**.

The primary maxillary central incisor is the only anterior tooth with a **width greater than its height**.

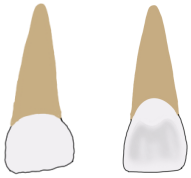

Figure 1.22 Primary Maxillary Central Incisor from Labial View (Left) and Palatal View (Right)

Morphological Features

The primary maxillary central incisor also displays:

- Prominent labial and lingual cervical ridges

Primary Maxillary Lateral Incisors

Figure 1.23 Primary Maxillary Lateral Incisor

***no high yield facts are seen in the INBDE*

Primary Maxillary Canine

Dimensions

The primary maxillary canine is the **widest** anterior tooth in the **facial-lingual dimension**.

The cusp of this tooth is also **longer and sharper** than the mandibular canine and permanent maxillary canine.

Morphological Features

The **mesial cusp ridge is longer** than the distal cusp ridge, similar to as seen in the maxillary first premolar. Consequently, the **cusp tip is offset distally** from the midline.

Figure 1.24 Primary Maxillary Canine

Primary Maxillary First Molar

Morphological Features

The crown of the primary maxillary first molar resembles the crown of the permanent maxillary first premolar with a slight distal extension. The crown also demonstrates a prominent **mesio-facial cervical bulge** that is accompanied by a prominent mesio-facial cervical ridge occlusally. This results in a CEJ that is more apically located on the mesial portion of the tooth.

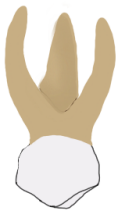

Figure 1.25 Primary Maxillary First Molar

Root Form

The root form of this tooth resembles that of the permanent maxillary molars. In the primary maxillary first molar, there is a palatal, mesio-buccal, and disco-buccal root.

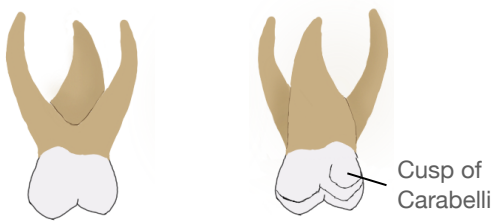

Figure 1.26 Primary Maxillary Second Molar from Buccal view (Left) and Palatal View (Right)

Primary Maxillary Second Molar

The primary maxillary second molar is the **last** primary tooth to erupt.

Dimensions

The primary maxillary second molar is the **widest** primary tooth in the **facial-lingual dimension.**

Morphological Features

The primary maxillary second molar is the only primary tooth demonstrating a **cusp of Carabelli, oblique ridge**, and **disto-lingual groove.** If present, the cusp of Carabelli is located palatal to the mesio-lingual cusp tip. These features make the crown resembles that of the permanent maxillary first molar and not of its successor.

3 Mandibular Tooth Characteristics

***Only INBDE high-yield facts have been included in this section*

Primary Mandibular Central Incisor

Dimensions

The primary mandibular central incisor is the **smallest** primary tooth in the **facial-lingual dimension.**

Morphological Features

As in the permanent dentition, the mandibular central incisor of primary dentition is the **most symmetrical.**

Figure 1.27 Primary Mandibular Central Incisor

Primary Mandibular Lateral Incisor and Canine

***no high yield facts are seen in the INBDE*

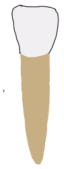

Figure 1.28 Primary Mandibular Lateral Incisor

Primary Mandibular Canine

***no high yield facts are seen in the INBDE*

Figure 1.29 Primary Mandibular Canine

Primary Mandibular First Molar

The primary mandibular first molar is the most unique tooth in the entire human dentition. It is often said to resemble a combination of a mandibular first premolar mesially and a mandibular second premolar distally.

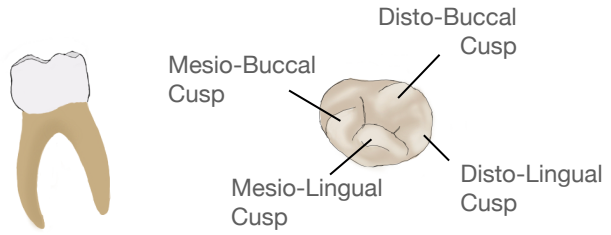

Figure 1.30 Primary Mandibular First Molar from Buccal View (Right) and Occlusal View (Left)

Morphological Features

The primary mandibular first molar has the most prominent **mesio-facial cervical bulge** that is accompanied by an **S-shaped CEJ** that is more cervically located on the mesial side.

The **transverse ridge** is also the most distinct on this primary tooth. This is neighboured by a **distal triangular ridge** and **4 cusps** with 4 coinciding pulp horns.

The mesio-lingual cusp is **cone-shaped** and is the **highest** and sharpest cusp of the tooth. However, the **mesio-buccal cusp** is the **largest** in size.

INBDE Pro Tip: Although the mesio-lingual cusp is the highest and sharpest, it is the mesio-buccal cusp that is the largest.

Root Form

Similar to the permanent mandibular molars, the primary mandibular molars have a mesial and buccal root.

Primary Mandibular Second Molar

Dimension

The primary mandibular second molar is the **widest** primary tooth in the **mesio-distal dimension.**

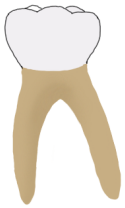

Figure 1.31 Primary Mandibular Second Molar

Morphological Features

The crown resembles a permanent mandibular first molar. However, in the primary mandibular second molar, the mesio-buccal, disto-buccal, and distal cusps are relatively **equal in size.** The primary mandibular second molar has **5 cusps.**

Root Form

Similar to the permanent molars, the primary mandibular second molar has a **two root form.** The **mesial root is bigger** than the distal root and also contains **two root canals**.

4 Natal and Neonatal Teeth

Natal and neonatal teeth are commonly the primary mandibular incisors which are expected to erupt at 6 months of age. These teeth may cause nursing difficulties.

Natal teeth: refer to teeth present at birth
Neonatal teeth: refer to teeth that erupt within the first 30 days

Riga-Fede Disease
This disease refers to natal or neonatal teeth induced ulcerations on the ventral surface of the tongue. Treatment may include smoothing of the incisors or extractions.

INBDE Pro Tip: Riga-Fede ('feed') can cause difficulties with feeding.

Primary Tooth Treatment

Primary teeth have features which make them more susceptible to decay and rapid decay progression. Treatment options in pediatrics are unique to address these characteristics.

1 Early Childhood Caries (ECC)

Early childhood caries are a form of widespread caries of primary teeth which occur in infants or young children. It is diagnosed when **any dmft** is seen on a patient **<6 years of age.**

Caries in ECC patients are often seen on the **labial** surfaces of the maxillary **incisors**, as well as the **lingual and buccal** surfaces of maxillary and primary **molars**.

Causes

ECC is also referred to as baby bottle syndrome because it commonly affects children who sleep with their bottle. For this reason, bottle or breastfeeding before bed should be stopped after the first primary tooth erupts.

Other causes may include excessive fruit juice consumption following constipation, or chronic high-sucrose antibiotic use with ear infections.

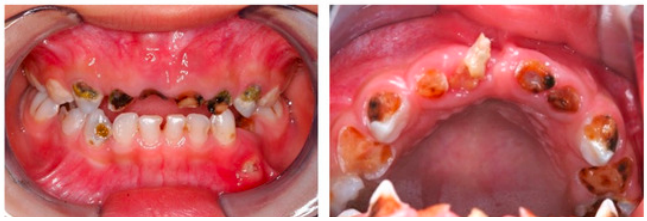

Figure 1.32 Severe Early Childhood Caries
Adapted from 2020 Chai H.H, et al., CCBY 4.0

Prevention

Caries risk can be mitigated by implementing **cup drinking** and a **first dental visit** by the **age of 1.** Additionally, toothpaste should be introduced at **age 2** as a smear and increased to a pea size between the **ages of 3 and 6.**

INBDE Pro Tip: Pediatric patients should visit a dentist early, as primary teeth are more susceptible to caries. To remember this, utilize the phrase:

First tooth, First birthday = First (Dental) Visit.

Fluoride for Children

Fluoride supplementation is only used for children at risk for caries and living in non-fluoridated areas on a prescription only basis. The method and dosage depends on age and regular exposure to fluoride.

Fluoride Drops

Recommended for children **≤3 years old** to mitigate chewing and swallowing of tablets.

Fluoride Tablets or Lozenges

Recommended for children between the ages of **3 and 6 years old.**

Fluoride Mouth Rinse

Recommended for children over the **age of 6** to minimize the chances of ingestion. Fluoride rinses are available in daily solutions at 0.05% NaF and weekly solutions of 0.2% NaF.

2 Restoration Options

Amalgam Restorations

The cavity preparation for amalgam restorations in primary teeth should be conservative in depth, but made **at least 1.5mm deep.**

In primary teeth, the cavity preparations should be extended into susceptible pits and fissures. They must have rounded line internal line angles, smooth and flat pulpal floor, and 90˚ cavosurface margins.

For proximal caries, the isthmus width must be **⅓ of the intercuspal distance** of the facial and lingual cusps.

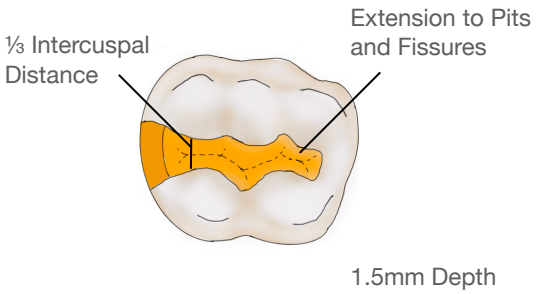

Figure 1.33 Amalgam Preparation in Primary Tooth

Composite Resin Restorations

Composite resin restorations allow for more conservative preparations as they provide **micro-mechanical retention** through etch, prime, and bond systems. However, they require dry, isolated operating fields which may be difficult to achieve in pediatric patients.

The moisture sensitive technique makes composite resin restorations more susceptible to an inadequate marginal seal. The **gingival margin** is the most susceptible to failure.

Stainless Steel Crown

Stainless steel crowns are an effective restorative options for primary teeth with **extensive caries** or caries past the axial line angle. They are also the restoration of choice following a **pulpotomy**, **pulpectomy**, or **fractured primary crown.** However, they are ineffective as long-term restorations for permanent teeth.

After removal of defects, the crown preparation is conservative with **1mm occlusal reduction** and rounded reduction adequate enough to **break contacts** with adjacent teeth. It is important to maintain the cervical bulge of the primary tooth as it provides retention for the stainless steel crown.

The pre-formed or modified stainless steel crown can be snapped onto the prepared tooth that allows it to function **temporarily** until exfoliation.

Figure 1.34 Stainless Steel Crown (Left) and Preparation (Right)
Left: Trikkelle, CC BY 3.0

Strip Crown

Strip crowns are an aesthetic restorative option for primary anterior teeth with inter-proximal caries and potential incisal edge involvement. However, it requires adequate remaining tooth structure for bonding.

Preparations generally require a **1mm incisal reduction** and **breaking contacts** with adjacent teeth. They are largely dictated by preparation design and caries involvement.

Strip crowns are fabricated using a **celluloid crown form** that is filled with composite resin after being trimmed and modified with a vent hole.

Figure 1.35 Anterior Strip Crown Placement
Adapted from Jeong M., *et al. 2013, CCBY 3.0*

3 Endodontic Treatment

Signs and Symptoms

The clinical signs and symptoms important to determining the need for endodontic therapy often overlap with normal physiologic changes in primary teeth.

Pain and Sensitivity

Pain and sensitivity is a symptom of endodontic involvement of a tooth. The pain or sensitivity may be triggered by hot or cold stimuli, or may be spontaneous. However, mild sensitivity may occur in primary teeth approximate to their exfoliation.

Furcation Radiolucency

Furcation radiolucency is a sign of pulp necrosis that is **specific** to primary teeth. Pulp necrosis in permanent teeth manifests as a periapical radiolucency around the apices of roots.

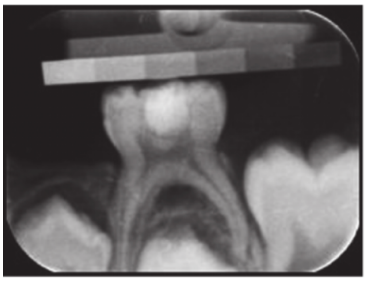

Figure 1.36 Primary Mandibular Second Molar with Furcation Involvement
Adapted from Arikan V., *et al. 2016, CCBY 3.0*

A similar radiolucency may also present when the successor permanent tooth approximates the primary tooth. To eliminate this as a differential diagnosis, it is important to consider additional signs and symptoms indicating endodontic treatment.

INBDE Pro Tip: Furcation radiolucency is a common INBDE topic, as it is an endodontic symptom specific to primary teeth.

Mobility
Mobility may present as a clinical symptom indicating endodontic therapy, but may also present as primary tooth roots resorb and prepare for exfoliation.

Fistula or Abscess
Fistula or abscesses are specific to true infections as they are clinical manifestations of pus accumulating in the periodontal tissues. This sign **does not overlap** with regular physiologic growth and development of dentition.

Root Resorption
Root resorption may present pathologically with extensive caries or physiologically as a part of the exfoliation process.

Physiologic root resorption is regulated by the **dental follicle** and **stellate reticulum** of the successive permanent tooth. The mineralization of the permanent roots is accompanied by the activation of **clast cells** that resorb bone and primary roots to create an eruption path. This process occurs t**wo to three years prior** to exfoliation and eruption.

INBDE Pro Tip: Unlike indirect and direct pulp cap methods, calcium hydroxide is not indicated in pulpotomy as it is an irritant that may induce internal root resorption in primary teeth.

Indirect Pulp Cap

Indirect pulp caps are a treatment option for deep caries approximating the pulp. During the preparation, a thin layer of dentin is maintained to prevent healthy pulp exposure.

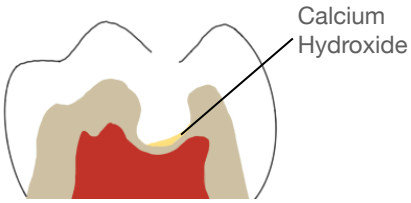

Figure 1.37 Indirect Pulp Cap

This thin layer of dentin is reinforced with **calcium hydroxide** or **resin-modified glass ionomer** prior to restoration with an appropriate material. This process promotes the formation of **tertiary dentin**.

Direct Pulp Cap

Direct pulp caps are indicated for **pinpoint** pulp exposures caused by a trauma within 24 hours, or by a carious of mechanical exposure less than 2mm.
Calcium hydroxide is placed directly on the healthy exposed pulp and reinforced by **resin-modified glass ionomer** prior to restoration with an appropriate material.

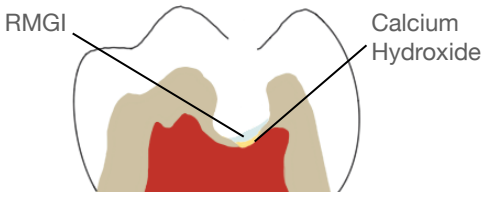

Figure 1.38 Direct Pulp Cap

Although this process is intended to promote tertiary dentin formation, it is uncommonly performed as it may cause **internal root resorption** in primary teeth.

Pulpotomy

A pulpotomy is indicated for pulp exposures in **healthy, vital primary teeth** with adequate tooth structure. A shallow section of the exposed pulp is removed while maintaining the remaining healthy pulp.

Once dry cotton pellets are utilized to stop the bleeding, **formocresol** is applied for 5 minutes before restoration with Zinc-Oxide Eugenol (ZOE) and a stainless steel crown. Ferric sulfate and MTA are other agents that are less toxic and more successful, respectively.

The pulp tissue in direct contact with the formocresol forms a **fixed zone** that is non-susceptible to enzymatic breakdown. This is superficial to the zone of **coagulation necrosis** which contacts **vital tissue** at the apex of the root canals.

Pulpotomy is often not indicated for permanent teeth as they may induce calcification in the root canals.

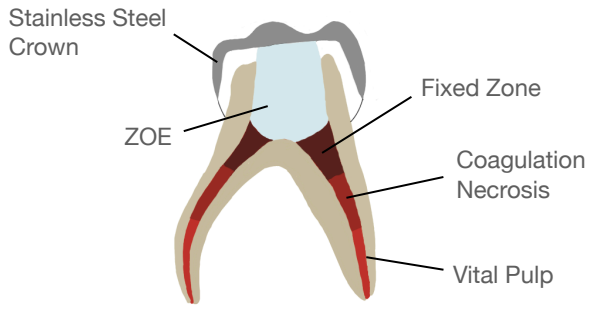

Figure 1.39 Formocresol Pulpotomy

Pulpectomy

A pulpectomy is indicated for **necrotic** teeth that have adequate tooth structure for restorability. However, it is **c**ontraindicated in primary first molars due to their extensive accessory canals.

In primary teeth, a pulpectomy involves the **complete removal** of pulpal tissue that is then replaced with Zinc-Oxide Eugenol (**ZOE**) material. They are then reinforced with a stainless steel crown.

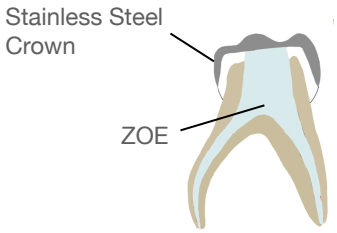

Figure 1.40 Pulpectomy

Extraction

Extractions followed by space maintenance are indicated for necrotic teeth which are non-restorable, have root resorption, or are primary first molars. Depending on the age and development stage of the patient, they may also be indicated for restorable necrotic teeth that are close to exfoliation.

Primary second molars with mild to moderate root resorptions may be an exception for extraction in young patients. In these cases, they may be treated by endodontic therapy via pulpotomy or pulpectomy and utilized as a space maintainer. Primary second molars are crucial to **maintaining the leeway space** and guiding the eruption of the permanent first molar.

Summary

To determine the need for endodontic therapy, the operator must consider:

Furcation Involvement

If furcation involvement is absent but other endodontic symptoms persist, the tooth is indicated for **pulpotomy**.

Primary First Molar *(with Furcation Involvement)*

If the tooth is a primary first molar, the tooth must be **extracted** and followed by space maintenance due to the presence of extensive accessory canals.

Primary Second Molar *(with Furcation Involvement)*

If the tooth is a primary second molar, a **pulpectomy** is indicated.

Restorability *(with Furcation Involvement)*

If the tooth is not restorable, an **extraction** is indicated.

Pathologic Root Resorption

If root resorption is absent, a **pulpectomy** is indicated.

If root resorption is present, an **extraction** is indicated.

Space Management

Crowding is a discrepancy between the arch dimension and tooth dimension. In space management, the space discrepancy between primary and permanent dentition is utilized to limit crowding.

1 Physiologic Spaces of Primary Teeth

Primary teeth provide masticatory and phonetic function, but also play a crucial role in maintaining space for the permanent dentition. Premature loss of primary teeth can lead to **mesial drifting** of the permanent first molars which can cause problems such as crowding or ectopic eruption. To prevent this, space must be artificially maintained upon premature exfoliation or tooth loss.

Primate Space

The primate space is a naturally occurring **1.5mm** width of space that is **mesial to the upper canines** and **distal to the lower canines**.

It is naturally lost in **early mesial shift** with the eruption and mesial shift of the **permanent first molars** at around **6 years of age**.

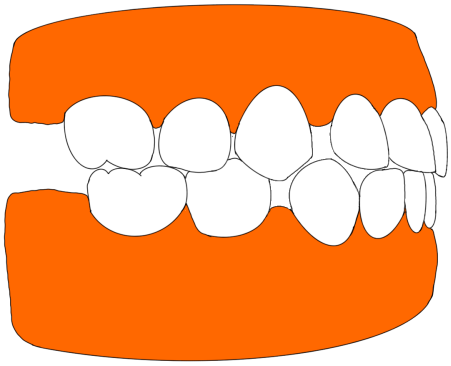

Figure 1.41 Primate Space

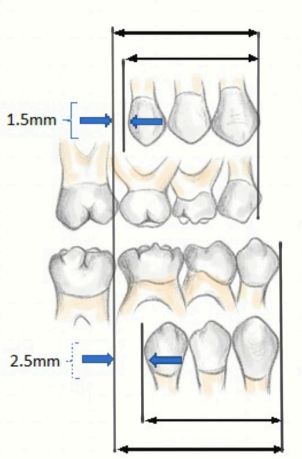

Figure 1.42 Leeway Space
Rjmedink, CCBY 4.0, via Wikimedia Commons

Leeway Space

Leeway space refers to the cumulative space discrepancy in mesio-distal width of the primary canine and molars and the permanent canine and premolars.

The primary canine is thinner in mesio-distal dimension in comparison to the permanent canine, while the primary molars are wider than the permanent premolars. This results in a Leeway space of:

- **1.7-2.5mm per sid**e on the mandibular arch
- **0.9-1.5mm per side** on the maxillary arch

The Leeway space is eventually lost in **late mesial shift** at around **11-12 years of age.** The Leeway space can also be referred to as the **E space** as their closure is dependent on the exfoliation of the primary second molars (E) and mesial shift following the eruption of the permanent second molars.

Interdental Space

Interdental spaces are seen between the anterior permanent teeth during development. This is a normal physiological space as a result of arch expansion during growth. If interdental space is not seen, it may be an indicator for future crowding in the full permanent dentition.

Interdental spaces are said to be present during the "**ugly duckling stage"** and effectively close with the eruption of the maxillary canines between **7 to 11 years of age.**

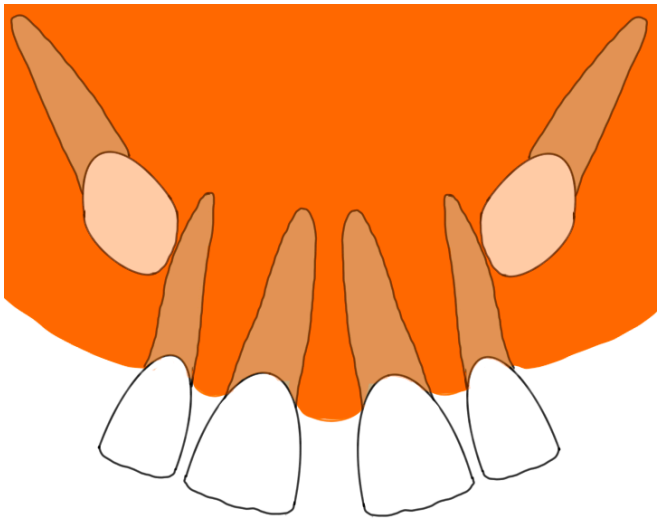

Figure 1.43 Interdental Space and Incoming Permanent Canines

INBDE Pro Tip: The Primate space is the first, or Primary space to close at 6 years old.

The Leeway space is the Later space to close at 11-12 years old.

Interdental spaces close between (inter) these two age frames at 7-11 years old.

2 Space Management

Space management can be defined by the timing of intervention. Earlier interventions are often simpler and allow for more favourable treatment outcomes.

Space Management

Space management is a **proactive** intervention that is implemented prior to the loss of Leeway space. This maintains arch perimeter for as long as possible.

Space Maintenance

This is a **reactive** intervention used to maintain space after premature primary tooth loss. This prevents drifting of permanent teeth and loss of the arch perimeter.

Space Regaining

Space regaining to a maximum of 3mm is a **retroactive** intervention after the premature loss of a primary tooth has lead to drifting and loss of arch perimeter.

Primary Incisor Loss

Premature loss of primary incisors are uncommon as they are the first teeth to be exfoliated in the developmental process.

Their premature loss may result in localized space loss that may be addressed with **kiddie partials** that also aid with speech and esthetics.

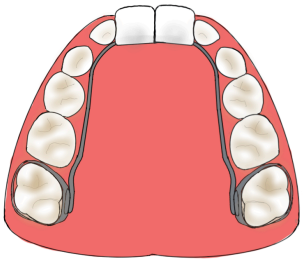

Figure 1.44 Kiddie Partial for Central Incisor Loss

Primary Canine Loss

The primary canines are important to maintaining the **arch length**. The arch length is the distance along the midline from the mesial contact point of the central incisors and the mesial contact point of the permanent first molars.

Premature loss of the canines causes **lingual tipping** or collapse of the incisors and eventual loss of arch length.

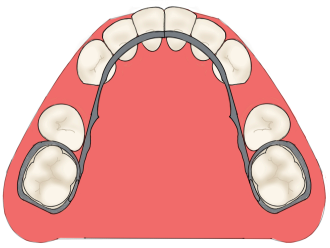

Figure 1.45 Lower Lingual Holding Arch

Intervention methods include **lower lingual holding arch (LLHA) or Nance holding arm** that are stabilized by the permanent first molars. Both of these appliances have an anteriorly extending **strong wire** to prevent lingual tipping of the incisors. However, the Nance is indicated for the maxillary arch as it features an **acrylic pad** on the wire for placement on the palate. Since the Nance is partially tissue borne, some argue it is not as effective as a lingual holding arch.

The permanent incisors must erupt before appliances are banded to prevent **trapping** the incisors which may erupt lingually.

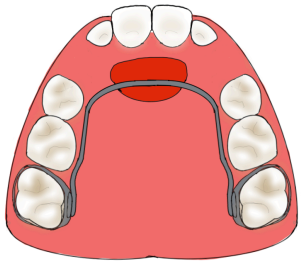

Figure 1.46 Nance Holding Arm

Primary First Molar Loss

Premature loss of primary first molars are not critical to the space maintenance of primary dentition. However, appliances such as a **band and loop**, **lower lingual holding arch,** or **Nance** can be utilized to maintain space. All of these appliances utilize a strong wire originating from the banded abutment tooth to maintain the exfoliated tooth space.

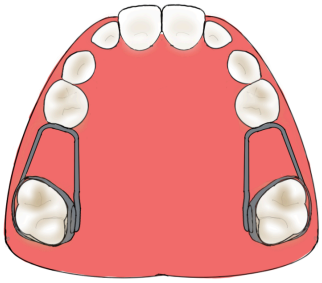

Figure 1.47 Band and Loop

Primary Second Molar Loss

The primary second molars (E)'s are said to be the key's to the Leeway space. Premature loss can be critical to **crowding** and early intervention is recommended.

A common appliance utilized for this purpose is the **distal shoe** featuring a banded primary first molar that extends subgingivally to guide the unerupted permanent first molar. If the permanent first molar is already erupted, a **lower lingual holding arch** or **Nance** can be utilized.

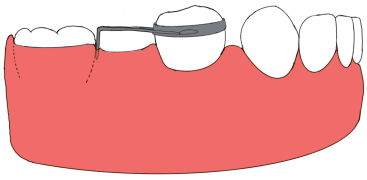

Figure 1.48 Distal Shoe

3 Variables in Space Management

Eruption Pattern Variations

The eruption pattern and timing is generally conserved between individuals. However, variations can lead to spacing problems.

Permanent Lower Second Molar

If the permanent lower second molar erupts **before** the **second premolar**, a loss of leeway space for the second premolar will occur. This may lead to second premolar impaction that can be prevented by using a space maintainer.

Permanent Upper Canine

If erupted before or alongside the first premolar, the canine may be forced **labially**.

Asymmetrical Eruption

After eruption, the same tooth on the opposite side of the dental arch can be expected to erupt **within 6 months**. If this does not occur, extraction of the primary tooth may be indicated to **maintain the midline**.

Root Development

After the permanent tooth crown completes calcification, the root development and eruptive movement begins. At this point, the **clast cells** become activated and the bone remaining between the primary tooth and permanent tooth begins to get resorbed. On average, the tooth pierces **bone** and **gingiva** with **⅔ root formation** and **¾ root formation**, respectively.

Space maintenance is not necessary if there is **no bone** remaining between the primary tooth and underlying permanent tooth because it indicates the permanent tooth is close to eruption

Rule of Seven

Premolars are expected to erupt between the **ages of 10-11.** This indicates that the root resorption of the overlying primary molars must occur 2-3 years prior to eruption, between the ages of **7-9 years old.**

Following this information, the rule of seven states that:

- A primary molar lost **before the age of 7** will lead to a **delay** in premolar eruption
- A primary molar lost **after the age of 7** will lead to an **accelerated eruption** of the premolar

INBDE Pro Tip: The rule of seven is a high yield topic for the INBDE.

Space Closure

Space closure mostly occurs within the **first 6 months** following tooth loss. The **first 4-8 weeks** demonstrate the most movement and **tipping** of neighbouring teeth due to the activated inflammatory mediators.

Additionally, active eruption of a neighbouring tooth increases the space loss.

4 Ectopic Eruption

Ectopic eruption refers to the eruption of permanent teeth along their unintended path. This may occur due to several reasons and may vary in severity.

Ectopic Eruption of Incisors

Lingual eruption of the incisors may lead to a **double row of teeth** during development. This problem generally resolves with continued growth, unless the primary incisors become over-retained.

Lateral eruption of teeth may occurs due to **early exfoliation** of the **primary lateral incisor**. If this premature exfoliation was unilateral, the contralateral primary lateral must be extracted to avoid **midline deviation.**

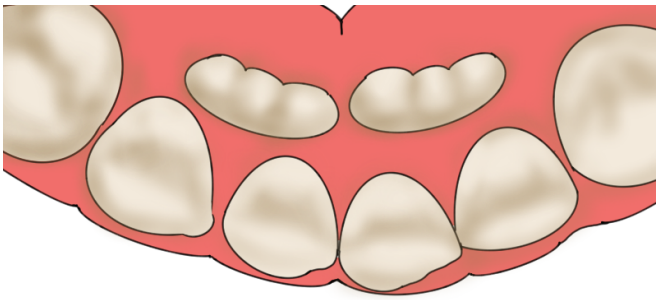

Figure 1.49 Lingual eruption of Incisors

Ectopic Eruption of Premolars

Distal eruption occurs most commonly with the **mandibular second premolar** that may only resorbs the distal root of the primary second molar. This leads to prolonged exfoliation of the primary second molar which deviates the eruption pathway of the second premolar.

Buccal or lingual eruption is also very common and must be managed by extraction of the primary molar, if it is not ready to exfoliate within a few weeks.

Ectopic Eruption of Molars

Mesial eruption of permanent molar eruptions is very common, with the maxillary first molar being most susceptible. Mesial eruption may lead to the permanent molar getting impacted underneath the distal of the primary second molar.

If the level of impaction is less than 1mm, an **elastomeric spacer** may be inserted between the primary second molar and permanent first molar to promote distal movement of the impacted tooth.

However, if the impaction is more severe a **Halterman appliance** may be indicated to shift the permanent first molar distally and re-create the lost space. It may also be indicated to extract the primary second molar and maintain the newly created space with a space maintaining appliance, such as a **Nance**.

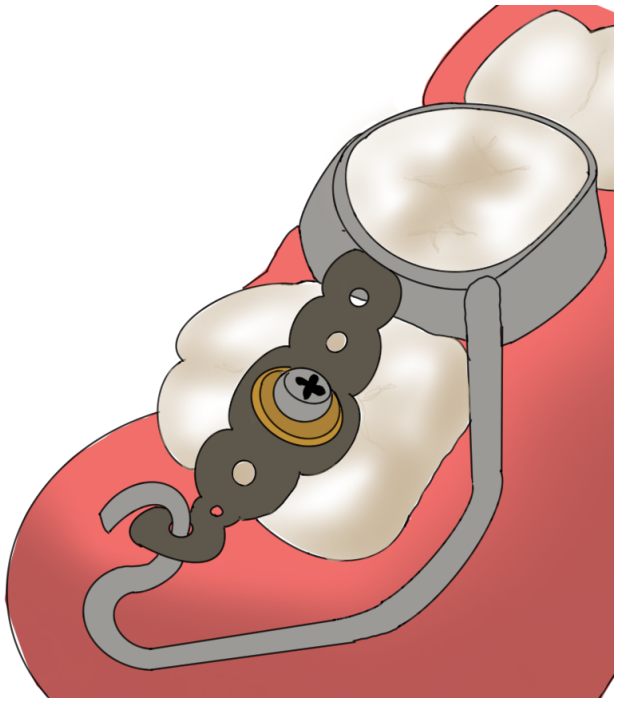

Figure 1.50 Halterman Appliance

5 Ankylosis of Primary Molars

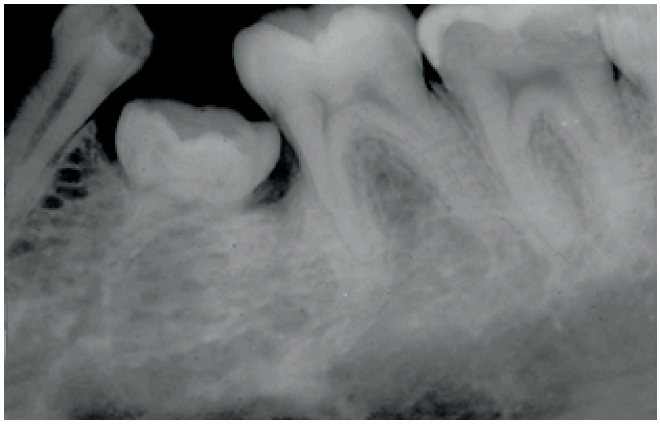

Figure 1.51 Ankylosed Primary Molar
2019 Lopes RDC, et al. CCBY 4.0

Ankylosis occurs when teeth become histologically fused to the underlying bone.

Prevalence

- *Ethnicity*: African-American (1%), Caucasian (4%)
- *Dental Arch*: more common in mandible
- *Teeth:* **Mandibular first primary molars** most common
  - More common in primary first molars than primary second molars

Diagnosis

A critical clinical sign of ankylosed molars are when the crowns are **infra-occluded** and below the plane of occlusion.

Additional signs include:

- Lack of **mobility**
- **Hollow sound** upon tapping
- Radiographic loss of **periodontal ligament space**

Treatment

Treatment is often unnecessary. However, if neighbouring teeth begin to drift, **extraction and space maintenance** may be indicated.

Pediatric Soft Tissue

1 Healthy Gingiva Features

Healthy gingiva in children differ from adults as the physiologic changes of the oral cavity that occur during growth also occur in the soft tissue.

Figure 1.52 Healthy Pediatric Gingiva
2019 Valletta R, et al. Licensee MDPI, Basel, Switzerland. CCBY 4.0

Colour

Children

Gingiva in children are **more red** in colour. This is because the epithelium is thinner, less keratinized, and receives greater blood supply.

Adults

The gingiva is a **coral pink** colour.

Contour

Children

The gingiva in children have **rounded, rolled margins**. This is due to the prominent c**ervical ridges** of the crowns, as well as the **edema** and **activated inflammatory mediators** which are present during eruption.

Adults

The gingival margins of adults are often **knife-edge** in health.

Consistency

Children

In children, the gingiva is **flabby** and less dense due to the **lower density** of fibres and **lack of organized collagen** in the connective tissue.

Adults

In adults, the gingiva is **firm and resilient.**

Texture

Children

The gingiva texture in children is **smooth** and lacks stippling because of the **shorter and flatter dental papilla.**

Adults

In adults, the gingiva texture is **stippled** and resembles an "orange-peel."

Sulcus

Children

The sulcus in children are **deeper** because the less resilient soft tissue is easier to separate from the tooth.

Adult

In adults, the sulcus are **more shallow** with good periodontal health.

Figure 1.53 Healthy Adult Gingiva
2007 Crawford J. CCBY 3.0, via

2 Soft Tissue Pathology

Gingivitis

Gingivitis affects up to 70% of children over **age 7**. It is frequently seen in **adolescents.**

The presence of **plaque** is a required precursor to developing gingivitis. However, it may be exacerbated by mouth breathing, crowded teeth, erupting teeth, and braces.

In **adolescents,** hormones may contribute to the gingival inflammation and lead to **adolescent gingivitis** at the labial papilla. This form of gingivitis peaks at puberty.

It is recommended that **parental help** with oral hygiene continues until the **age of 8** or **adequate manual dexterity** is developed to ensure proper plaque removal.

Acute Necrotizing Ulcerative Gingivitis

Acute necrotizing gingivitis is most commonly seen in adults, but may also be seen in children.

The symptoms may include **painful, inflamed, and bleeding gums** which are accompanied by **fever**, **necrotic tissue, pseudomembrane** on the marginal gingiva, **blunted papilla**, and **fetid breath**.

Treatment may include **debridement**, **oxidizing mouth rinses,** and **antibiotics.**

Figure 1.54 Acute Necrotizing Ulcerative Gingivitis in Adult
2017 Malek R., et al. CCBY 3.0

INBDE Pro Tip: Each term in acute necrotizing ulcerative gingivitis refers to a group of symptoms of the condition.
Acute: refers to pain, fever
Necrotizing: refers to necrotic tissue, fetid breath
Ulcerative: refers to the pseudomembranous gingival margins,
Gingivitis: refers to the bleeding, inflamed gums and blunted papilla

Reduced Attached Gingiva

Attached gingiva is an important component of the periodontium that is firmly attached to the alveolar bone. It is more robust than the free gingiva and oral mucosa.

Reduced attached gingiva is diagnosed under the criteria that the band of attached gingiva is **less than 2mm wide.** It is most commonly caused by labial eruption of the tooth, but can also be caused by proclination of teeth, or gingival recession.

For reduced attached gingiva caused by labially positioned or proclined teeth, **orthodontics** can be utilized to lingually reposition the teeth and restore the attached gingiva. However, in some cases orthodontics can also exacerbate the condition.

Although treatment is not always necessary, intervention may include **orthodontics**, as well as a **free gingival or connective tissue graft**.

Figure 1.55 Reduced Attached Gingiva in Adult
2018 Nemcovsky C.E., et al. CCBY 4.0

Eruption Cyst

An eruption cyst is a bump on the crest of the alveolar ridge at the expected position of a tooth. It is most common in **children** around the **incisors** and **mandibular first molars.**

Treatment is usually **not indicated**. However, diagnosis can be confirmed with a **radiograph** and excised surgically if symptomatic.

Figure 1.56 Eruption Cyst in Adult
Edelweiss Publications CCBY 4.0

High Frenum

A high frenum is defined by a frenum that is attached towards a more coronal aspect of the alveolar bone.

A high frenum may apply additional apical forces on the neighbouring gingiva and subsequently cause **gingival recession**. They may also be accompanied by a **notch** in the alveolar bone at the point of insertion, as well as a **diastema**.

Treatment indicates closure of the diastema **prior** to frenectomy. This is important because a frenectomy can heal with **scar tissue** that may provide elastic **rebound** to the teeth even after orthodontic correction of the diastema.

Figure 1.57 High Frenum
2018 Monnet-Corti V., et al. CCBY 4.0

Periodontitis

Periodontitis is characterized by the loss of attachment and bone in the periodontium. It is less common in children.

Localized Aggressive Periodontitis

This form of periodontitis often involves the **first permanent molars** and **permanent incisors.**

It is often accompanied by increased **aggregatibacter actinomycetemcomitans (a.a)** bacterial counts and is most commonly seen in **African-American children.**

Treatment includes **surgical intervention** and **antibiotics.**

Generalized Aggressive Periodontitis

This form of periodontitis involves the **entire dentition** and is often associated with increase **plaque** and **calculus**. It is uncommon in children.

Treatment options include **surgical intervention** and **antibiotics**.

Pre-Pubertal Periodontitis

This form of periodontitis is localized to the **primary molars**. It is most commonly seen in **African-American children.**

Treatment options include **debridement** and **antibiotics**.

Dental Trauma

1 Dental Trauma

Dental trauma refers to any injury of the teeth, periodontium, or oral soft tissue.

Prevalence
- More common in **boys** than girls
- Most common in **maxillary anteriors**
- More common with increased **overjet of >6mm**

Ellis and Davey Classification of Fractures

The Ellis and Davey classification is commonly used in endodontics to specify the extent of dental trauma. The classification system has been generally summarized in the table below.

Class	Description	Trauma Type
Class I/II	Simple or extensive fracture of crown involving considerable to no dentin, but no pulp.	Minor
Class III/IV	Extensive fracture of crown involving dentin and pulp; potentially leading to loss of vitality.	Moderate
Class V to VIII	Fracture of root or full crown, loss of teeth, or displacement of tooth.	Major

2 Major Injuries

Major injuries often require extensive and high-cost interventions with a multi-displinary and specialty approach. These teeth often have a poor prognosis and require a long term follow-up.

Luxations - *Intrusion, Extrusion, Lateral Luxation*

Intrusion

Intrusion is a type of luxation in which the tooth is forced apical into the periodontal tissues.

Due to the **labial positioning** of primary anterior teeth, intrusion injuries may be pushed against the successor teeth. The potential damage to underlying permanent teeth is dependent on the stage of tooth development during which the injury occurs.
Damages may include **hypoplasia**, **hypocalcification**, and **dilaceration** if injury occurs during the apposition, calcification, and

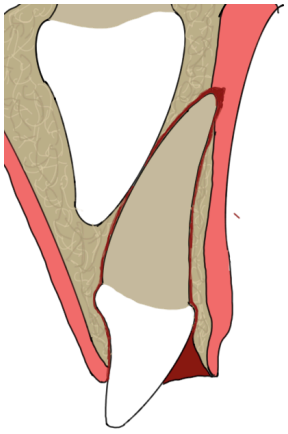

Figure 1.58 Intrusion Luxation

Treatment
No treatment is recommended for intrusions as spontaneous re-eruption may occur with healing. Follow-ups are recommended.

Extrusion
Extrusion injuries refer to the coronal displacement of teeth. The severity and luxation distance of the injury determines the possibility of severing the blood supply to the tooth and subsequent pulpal necrosis.

INBDE Pro Tip: Extraction is not required to be followed by space maintenance if the permanent successor is close to eruption.

Treatment
If the extrusion is more than **3mm**, the tooth must be **extracted** and space maintained. However if the patient is seen before **formation of a blood clot** apically, the tooth may be carefully repositioned and splinted for 1-2 weeks prior to necessary endodontic treatment. Follow-ups are also recommended.

Figure 1.59 Extrusion Luxation
2021 Di Giorgio, G., et al. MDPI, Basel, Switzerland. CCBY 4.0

Avulsion
Avulsion occurs when a tooth is completely displaced from the socket.

Treatment
Previously, replantation of the avulsed primary tooth was recommended if the **extra-alveolar dry time** (time out of mouth and appropriate solution) was **less than 30minutes**. In this scenario, replantation and splinting for 1-2 weeks on a soft diet and antibiotics was indicated prior to endodontic treatment.

Currently, it is recommended to **not replant the tooth** as replanting can cause damage to the permanent successor.

Figure 1.60 Total Avulsion
Damdent, CC BY 3.0, via Wikimedia Commons

Alveolar and Crown-Root Fracture
Root fractures are **rare** in pediatric patients, as their alveolar bone is malleable. This makes apical root fractures less likely than those occurring in the coronal half.

Treatment
If the root fracture occurs in the apical half, **no treatment** is indicated and the root segment is left to undergo physiological resorption. However if the fracture occurs in the coronal half, a **rigid splint** or **extraction** is required.

Root Resorption - *Review*
Root resorption can be a pathological response to dental trauma which may occur after root fracture.

Internal root resorption occurs when the odontoblastic layer in the pulp is damaged, while external root resorption occurs when the cementoblastic layer in the periodontal ligament is damaged.

External root resorption can occur in various forms:
- Surface - occurs in small areas
  - occurs when periodontal ligament is relatively normal
- Replacement - leads to ankylosis
  - long-term splinting may increase risk
- Inflammatory - may be visualized as radiolucency
  - replacement of root with granulation tissue
- Cervical Root Resorption - pink spot in biological width area
- Apical Root Resorption
  - often caused by orthodontic forces

3 Moderate Injuries

Moderate injuries require more complex and higher-cost interventions which may require a multi-disciplinary approach. They have a moderate prognosis and require a longer term follow up.

Subluxation
Subluxation refers to direct damage of the periodontal ligament which may cause mobility.

Treatment
No treatment is recommended. However, patients may be recommended a soft diet and provided with oral hygiene instruction. Follow-ups may be conducted.

INBDE Pro Tip: Teeth with open apices are more likely to remain vital after trauma.

Extensive Tooth Structure Involvement
Crown fractures involving more tooth structure and pulp are more likely in primary teeth due to their large pulp spaces.

Treatment
For vital primary teeth, a **pulpotomy** is indicated.
For non-vital teeth, a **pulpectomy** is indicated.
In the more severe case where pathologic root resorption is observed, the tooth may be indicated for extraction and space maintenance.

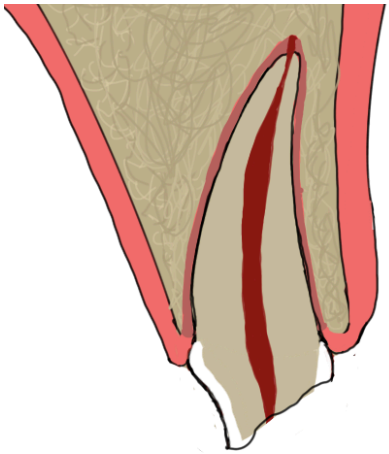

Figure 1.61 Extensive Crown Fracture

4 Soft Tissue Pathology

Minor injuries are require simpler, low-cost treatments and minor procedures. They have a good prognosis and short term follow up.

Concussion

Concussion refers to tenderness caused by inflammation of the periodontal ligament following a dental injury.

Treatment

Similar to subluxation injuries, no treatment is recommended for concussion injuries. Patients may be recommended a soft diet and continued oral hygiene.

Craze Lines and Enamel Fractures

Fractures limited to the enamel can be smoothed for patient comfort.

Enamel and Dentin Fractures

Fractures including enamel and dentin without pulpal involvement are indicated for minimal preparation and restoration to functional and esthetic demand.

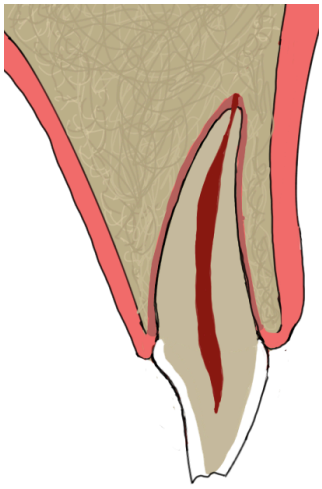

Figure 1.62 Enamel and Dentin Fracture

5 Dental Trauma Management

Medical History

For all trauma patients, information regarding the medical history must be obtained to ensure the safety of the patient.

Coagulation Disorders

Information of coagulation disorders must be obtained as they can alter the course of intervention.

Tetanus Coverage

Tetanus coverage is important to ensure the patient is not at risk of active tetanus infection.

Active immunization through the **tetanus, diphtheria, pertussis (Tdap) vaccine** can be obtained by receiving:

- 3 dosages in the first year
- Boosters at 1.5 years, 3 years, 6 years, followed by every 4-5 years

Dated coverage can be updated with a booster dosage upon injury, but if uncovered patients must receive the **tetanus anti-toxin.**

Possibility of Head Injury

Dental trauma can be associated to serious head injuries. Neurological assessment of **drowsiness**, **amnesia**, **vomiting,** and **blurred vision** must be conducted prior to dental management in order to mitigate risk.

Radiographs

Radiographs are helpful diagnostic tools that must be taken at the incident, and **follow-ups of 1, 2, and 6 months after**, depending on the severity of the injury.

Prevention

Mouthguards

Mouthguards are an appliance utilized to prevent the frequency and severity of dental trauma injuries. They are highly recommended for contact sports.

Type	Fit and Fabrication	Availability
Stock	• Fit is un-customizable - available in a single size	• Available at sporting goods stores • low cost
Mouth Formed: Boil and Bite	• Soften in hot water for molding to teeth	• Available at sporting goods stores • low cost
Mouth Formed: Shell	• Firm outer shell and soft inner liner (ethyl methacrylate)	• Available at sporting goods stores • moderate cost
Custom	• Fit is completely customized • Formed via vacuum form or pressure-lamination	• Custom made from impression in dental office • High cost

Child Abuse and Neglect

Dental trauma is a possible indicator for child abuse and neglect. Children of the **ages 0-3** are most commonly abused or neglected.

Types of abuse may be occurring as:

- Physical - intentional injuries
- Emotional - denial of affection, isolation
- Neglect - negligence to provide basic necessities

INBDE Pro Tip: It is legally required for dentists to report suspected child abuse and neglect with or without evidence.

Child Behaviour and Management

1 Child Behaviour

Pediatric Behaviour Types

The major pediatric behaviour types are:

- cooperative
- avoidant
- defiant
- fearful or anxious
- uncontrolled
- tense-cooperative
- whining

Cooperative Patients

Cooperative patients are communicative, comprehending, and willing in the operative chair. They have minimal apprehension.

Potentially Cooperative Patients

These patients demonstrate appropriate behaviour but may be disruptive based on various factors during dental care. These patients are further subdivided into categories which may be dependent on age.

- Avoidant - avoiding operator
- Defiant (all ages) - spoiled, stubborn patients who dislike instruction
- Uncontrolled (3-6 years old) - may throw tantrums
- Timid (3-6 years old) - may demonstrate fear by hiding behind caregivers (**shielding)** or become uncontrolled when uncomfortable
- Tense-Cooperative (7+ years old) - patient attempts to cooperate but may be stiff, show white knuckles, and tense in fear
- Whining - continuous whining but usually no tears

Uncooperative or Uncontrolled Patients

These patients may be uncommunicative, non-comprehending, and unwilling to demonstrate appropriate behaviour. These types of children are more commonly seen in infants, as well as certain groups of disabled children.

Frankl Rating Scale

The Frankl rating scale is based on a study published in 1962 which ranks child behaviour. Children generally increase in rank over time and with positive interactions.

Rank	Description
1 - Definitely Negative	Children which demonstrate refusal, forceful crying, and unwillingness to cooperate.
2 - Negative Resistance	Children may demonstrate reluctance, generally uncooperative, but less pronounced pessimism.
3 - Positive Acceptance	Children demonstrate some acceptance, cooperation, and willingness to cooperate.
4 - Definitely Positive	Children who are interested, cooperative, and enthusiastic.

2 Behaviour Disorders

Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is an inattentive and hyperactive disorder that is more common in **boys** and most commonly diagnosed from **ages 3 to 6.**

Patients may be undergoing treatment with psychostimulant medications with side effects including nausea, xerostomia, hypertension.

INBDE Pro Tip: The most common medications for ADHD are methylphenidate (Ritalin), Atomoxetine (Straterra), Amphetamine (Adderall).

Autism Spectrum

Autism is a spectrum disorder arising from differential brain development that leads to differences in perception and socialization.

Although there are a wide range of symptoms, some common symptoms may include **repetitive behaviour,** or **heightened sensitivity** to light and sound.

3 Domains of Pediatric Patient Management

Physical Domain

This includes physical restraints such as papoose boards, belts, and tape.

Pharmacological Domain

Anesthetics, sedatives, and nitrous oxides may be options for patient management. Mild behavioural issues may require nitrous oxide, while more severe issues may require IV sedation or general anesthesia.

Reward-Oriented Domain

This utilizes reinforcement to optimize cooperation.

Aversive Domain

This domain utilizes punishment as a management strategy. This is not recommended for timid or tense-cooperative patients.

Linguistic Domain

Linguistic domain rely on communication to increase patient willingness.

4 Management Strategies

***The following management strategies are provided in a general order from most to least conservative.*

Anticipatory Guidance

Anticipatory guidance refers to providing counselling that is age appropriate and focused on prevention of disease. This may include anticipatory guidance on dental development, age-appropriate oral hygiene instruction, and diet counselling.

The first dental visit should take place after the **first tooth** eruption or **first birthday**, depending on the earlier event.

Thumbsucking

This is a very common, normal habit that does not require intervention up to **age 3**. However, it may result in i**ncreased overjet, anterior open bite, maxillary constriction,** or **posterior crossbite** if the habit is of high intensity, duration, and frequency.

Intervention with appliances is recommended if the habit continues to **age 5 or 6**, including **cribs** or **bluegrass** which act as reminder appliances in the anterior palate.

INBDE Pro Tip: Thumbsucking appliance therapy is only effective with patient compliance.

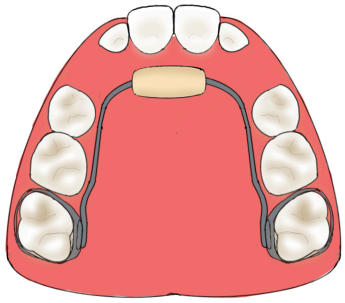

Figure 1.63 Bluegrass Appliance

Familiarization

This strategy is a dental visit without dental intervention, but rather introducing the setting and instruments to mitigate fear. It is best recommended for patients who are uncooperative, tense-cooperative, or timid.

Functional Inquiry

A functional inquiry refers to any form of **questioning** with the caregiver to provide information on the chief complaint and allow for estimation of behaviour in the dental setting.

Pre-Visit Imagery

This strategy involves providing positive **visual cues** around the dental office to increase positive association to dental care. It is indicated for any patient and may be implemented as a part of familiarization or as an intervention visit.

Sensory-Adapted Dental Environments

Adaptations can be made to a dental clinic to reduce fear in patients with dental anxiety or autism. This may include a blanket or dimmed lighting.

Animal Assisted Therapy

Trained animals may be introduced in the dental setting to reduce anxiety. However, it must be avoided in patients with allergies to animals, lack of interest or fear of animals.

Knee-to-Knee Exam

This strategy is often implemented for infants below the **age of 2**. It refers to an examination in which the dentist and caregiver sit knee-to-knee with the patient's head in the dentist lap. This allows the caregiver to aid in the process while providing emotional support.

INBDE Pro Tip: The knee-to-knee is exam is an important high yield fact.

Systematic Desensitization

This technique involves **gradual and more frequent exposures** to components of dental procedures to minimize anxiety. This is very helpful for patients with dental anxiety or people with autism.

Direct Observation

Direct observation may include watching a video about the procedure, or explaining the procedure as it is performed on a **positive role model.**

Tell-Show Do

This technique involves providing a verbal **explanation**, **demonstration**, and **execution** of the procedure at hand. It allows patients to become familiar with the tools which may be especially helpful for patients with behavioural disorders.

Distraction

This technique utilizes attempts to divert the patient's attention from potentially fearful situations. This may include music, virtual reality eyeglasses, or other methods.

Picture Exchange Communication System (PECS)

This strategy utilizes picture cards to facilitate **communication** with visual representations. It is indicated for non communicative patients.

Behaviour Shaping

This refers to slowly working towards a goal by providing **immediate** and **specific positive** feedback specific to the desired behaviour.

For example, directing the patient to turn their head while providing reinforcement as they are convinced to continue turning.

Treatment Deferral

Treatments may be concluded early if patients demonstrate uncontrolled behaviour with non-urgent care. **Deferral until cooperation** can be achieved is contraindicated if there are signs of active infection, pain, or trauma.

For example, silver diamine fluoride or interim therapeutic restorations can be utilized to safely defer the treatment.

Protective Stabilization

This strategy includes restricting patient movement under the consent of the caregiver. It is indicated if physical restraint is required for safe completion of urgent care treatment. However, it must be avoided in patients with respiratory conditions or for non-urgent care.

Passive restraints stabilize the patient, such as a papoose board. **Active restraints** rely on other individuals to restrict movement.

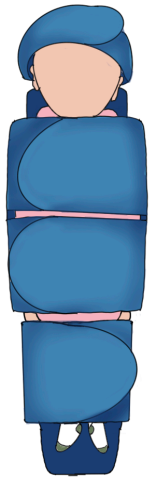

Figure 1.64 Papoose Board

Aversive Conditioning

This strategy utilizes punishment to cease or improve uncooperative behaviour.

Voice Control

This technique relies on changing the voice to a firm tone to achieve compliance. It is indicated for defiant or avoidant patients.

Hand Over Mouth Exercise (HOME)

The hand-over-mouth involves gently placing the hand over the mouth. This strategy is largely **not recommended**. It is not included in new AAPD guidelines.

5 Levels of Sedation

Minimal Sedation - *Anxiolysis*

Anxiolysis is achieved when the patient experiences less dental anxiety while their ability to respond, respiration, and cardiac function are **unaffected**.

It can be achieved through light nitrous oxide sedation (≤50%) or sedating medications, such as benzodiazepines.

Indications: dental anxiety, patients with special health care needs, ineffective local anesthesia, gag reflex, long procedures

Contraindications: children <3 years old, non-communicative patient, respiratory conditions, sickle cell, bleomycin sulfate use

Moderate Sedation - *Conscious Sedation*

This level is achieved when the patient's ability to respond is purposeful yet limited to verbal and tactile stimuli. Their respiration may be slowed.

It is achieved through **higher concentrations of nitrous oxide (>50%) alone** or in combination with other **sedating medication**.

Indications: dental anxiety, uncooperative patients due to lack of maturity or understanding

Contraindications: patients with ASA class III or higher, elective care

Deep Sedation - *IV Sedation*

Deep sedation greatly **impairs** the patient's consciousness and limits response to repeated or painful stimuli. It often requires airway intervention while cardiac function is maintained.

Substances may include midozalam, propofol, ketamine, and dexmedetomidine. This level of sedation is often indicated for third molar extractions.

Indications: patients with dental anxiety or special health care needs requiring **extensive dental intervention**

Contraindications: cooperative patients, patients with ASA class III or higher, porphyria, hepatic insufficiency, minimal dental needs, or finances

General Anesthesia

Patients in this level **cannot produce any response**. It requires airway intervention and cardiac function may be impaired.

This can be achieved through a combination of inhaled and IV substances, including propofol, ketamine, thiopental, methohexital, etomidate, sevoflurane, desflurane, and isoflurane.

Indications and Contraindications are the same as for deep sedation.

6 Pharmacological Management

Nitrous Sedation

Nitrous sedation is indicated in patients with mild behaviour disorders. The minimum alveolar concentration (MAC) or concentration required to induce immobility in 50% of patients is 105% for nitrous oxide.

Contraindications include **infants under 2 years old**, uncooperativeness, or susceptibility wheezing episodes. Mild to moderate asthma is **not** considered a contraindication.

INBDE Pro Tip: Nausea is the most common complication of nitrous sedation

Protocol

1. Place hood on the patient's nose with a bag full of oxygen. The flow rate must be **4-6L/min.**
2. Continue to increase nitrous in **increments of 10%** for up to 30%.
3. After the procedure, provide patients with 100% oxygen for 3-5 minutes to prevent diffusion hypoxia.

Diffusion hypoxia refers to the phenomenon in which the lungs fill with nitrous after stopping the flow of nitrous in the air.

Four Plateaus of Stage I Anesthesia

The consecutive plateaus of stage I anesthesia are observed with nitrous sedation.

1. Paresthesia - tingling
2. Vasomotor - increased warmth
3. **Drift (Target Plateau)** - floating sensation
4. Dream - patients demonstrate closed eyes and jaw sag

After the first two plateaus, drift and dream can be maintained for **several hours**.

Local Anesthesia

Local anesthesia in children differs due to anatomy, metabolic capabilities, and size.

Dosage

The maximum recommended dose of anesthetic for children is **4.4mg/kg**.

Innervation of Primary Teeth

All mandibular teeth are innervated by the **inferior alveolar nerve.**

For the maxillary teeth, the molars are innervated by the **posterior superior alveolar nerve** and the anterior teeth by the **anterior superior alveolar nerve.**