Development of Dentition

Prenatal Development of Dentition

The embryonic oral cavity is lined by stratified squamous epithelium called the *oral ectoderm*, which is visible around 28-30 days of intrauterine life.

The first sign of tooth development appears late in the 3rd embryonic week when the epithelial lining begins to thicken on the inferior border of the maxillary process and the superior border of the mandibular process which join to form the lateral margins of the oral cavity.

At 6 weeks, four maxillary odontogenic zones coalesce to form the dental lamina and the two mandibular zones fuse at the midline. The dental lamina is the foundation for the future dental arches. Tooth formation begins with invagination of the dental lamina epithelium into the underlying mesenchyme at specific locations. The dental lamina gets demarcated into ten knoblike structures namely the tooth bud/germ.

A tooth bud **(Fig. 1)** consists of an enamel organ, which is derived from the oral ectoderm, a dental papilla and a dental sac, both of which are derived from the mesenchyme. Each of these swellings of the lamina proliferates and differentiate, passing through various histological and morphological differentiation stages namely bud, cap and bell stages.

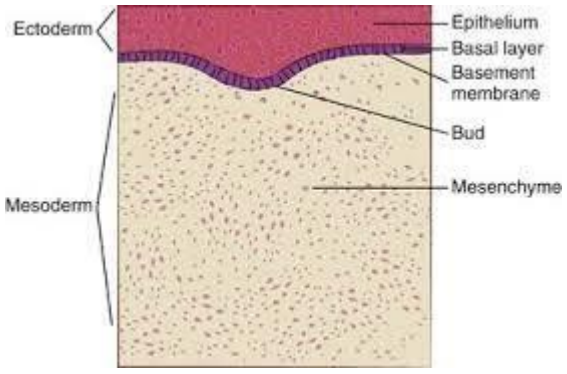


Figure 1: tooth bud.

Stages of Tooth Bud Development

1. *Initiation*: This is the first epithelial incursion into the ectomesenchyme of the jaw. The tooth bud is the primordium of the enamel organ. Histologically it consists of peripheral low columnar cells and centrally located polygonal cells. The area of ectomesenchymal condensation subjacent to the bud is the dental papilla. The dental sac surrounds the tooth bud and the dental papilla. The dental papilla later on forms the dentin and pulp whereas the dental sac forms cementum and the periodontal ligament. Initiation takes place as follows:

• Deciduous dentition: 2nd month *in utero*.

• Permanent dentition: Growth of the free distal end of dental lamina gives rise to the successional lamina, which initiates the permanent dentition; starts from 5th month *in utero*.

• Dental lamina elongates distal to the second deciduous molar and gives rise to the permanent molar tooth germs.

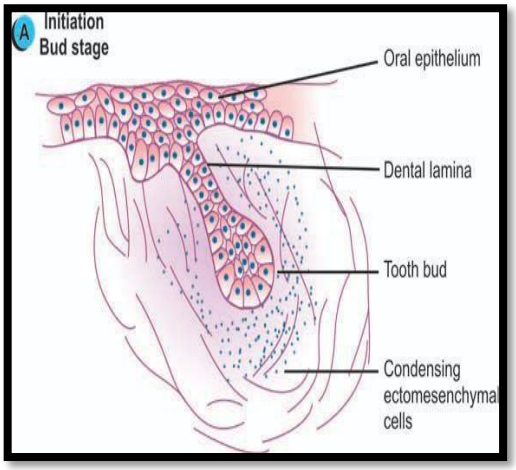


Figure 2: Initiation stage

2. *Proliferation*: Unequal growth in different parts of the bud produces a shallow invagination on the deep surface of the bud to produce a cap shaped structure. Histologically it is made up of the outer enamel epithelium (cuboidal cells) at the convexity of the cap and the inner enamel epithelium

(tall, columnar cells) at the concavity of the cap. Between the above 2 layers Polygonal cells are located which is known as the stellate reticulum. These cells assume a branched reticular network as more intercellular fluid is produced.

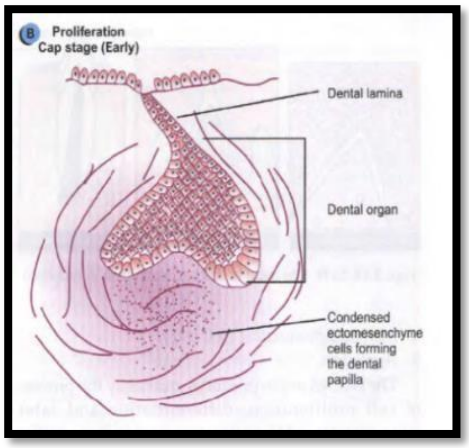


Figure 3: Proliferation stage

3. ***Histo-differentiation***: The enamel organ now assumes a bell shape as the invagination of the cap continues and the margins grow longer. Four different layers are seen. The inner enamel epithelium (IEE) cells remain tall columnar cells. The outer enamel epithelium flatten to low cuboidal cells. The stellate reticulum expands further and the cells become star shaped. A new layer of cellsknown as Stratum Intermedium whose function is to provide nutrition to IEE cells appears between inner enamel epithelium and stellate reticulum.

4. Morpho-differentiation (bell stage)

5. Apposition

The enamel organ produces enamel by the process of cell proliferation, differentiation and later mineralization. Mineralization commences in the deciduous dentition around the 14th week of intrauterine life and occurs first in the central incisors. The permanent tooth buds appear around the fourth to fifth month of intrauterine life and their mineralization is initiated at birth, beginning with the first permanent molar.

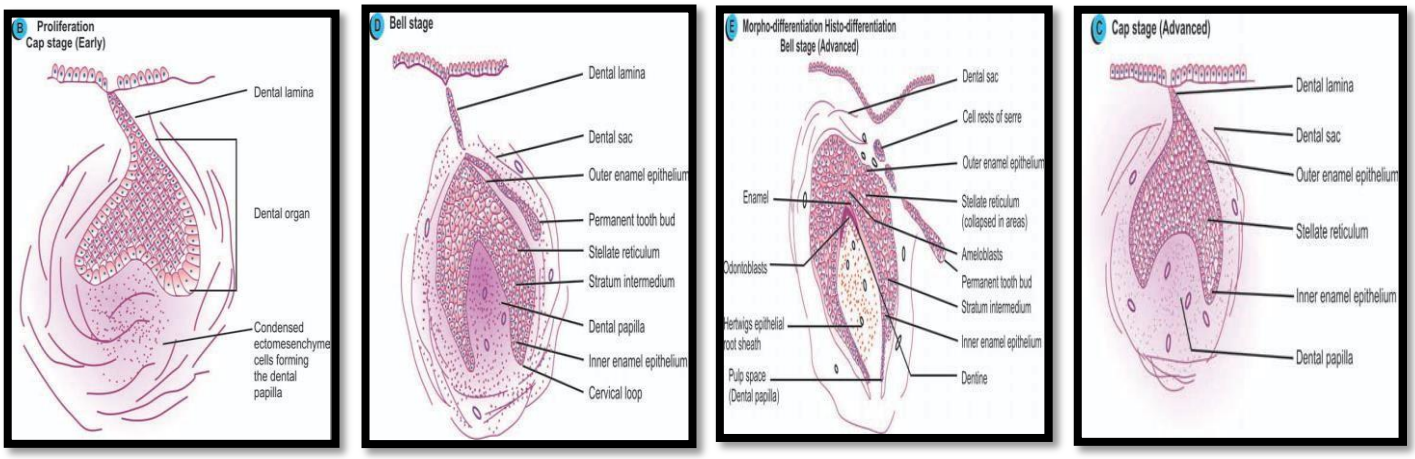


Figure 4: A to H: Life cycle of tooth

Eruption

Eruption is the developmental process that moves a tooth from its crypt position through the alveolar process into the oral cavity and to occlusion with its antagonist. During eruption of succedaneous teeth:

- Primary tooth resorbs
- Roots of the permanent teeth lengthen
- Increase in the alveolar process height
- Permanent teeth move through the bone.

Teeth do not begin to move occlusally until crown formation is complete. It takes 2-5 years for posterior teeth to reach the alveolar crest following crown completion and 12-20 months to reach occlusion after reaching alveolar margin.

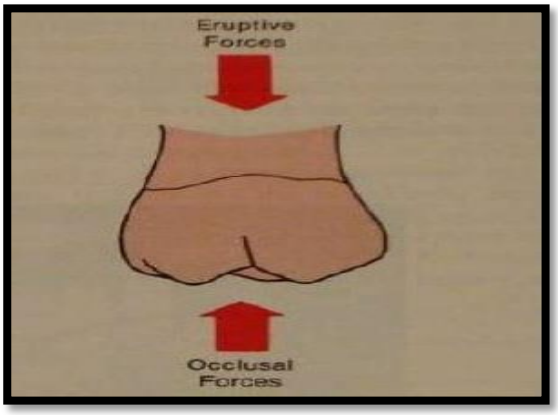


Figure 5: Eruption

Factors Determining Tooth Position during Eruption

Tooth passes through four distinct stages of development:

1. *Pre-eruptive* Initially position of tooth germ is dependent on heredity

2. *Intra-alveolar* Tooth position is affected by:-

• Presence or absence of adjacent teeth

• Rate of resorption of primary teeth

• Early loss of primary teeth

• Localized pathologic conditions.

3. *Intraoral stage* Tooth can be moved by lip, cheek, tongue muscles or externalobjects and drift into spaces.

4. *Occlusal stage* Muscles of mastication exert influence through interdigitation of cusps. The periodontal ligament disseminates the strong forces of chewing to the alveolar bone.

Developmental Disturbances affecting the Teeth

Disturbances during Initiation of Tooth Germs

1. ***Ectodermal dysplasia*** Complete or partial anodontia of both the dentitionsalong with the presence of malformed teeth.

2. ***Anodontia*** Absence of 1 or more teeth due to failure of tooth bud initiation. Most commonly missing teeth are third molars followed by mandibular second premolars, maxillary lateral incisor and maxillary second premolars.



Figure 6: Anodontia

3. ***Supernumerary and supplemental*** *teeth:* teeth in excess of the normal complement of teeth. The difference between the two is that supplemental teeth resemble normal teeth whereas supernumerary teeth do not, e.g. of supernumerary teeth:

• *Mesiodens:* between maxillary central incisors.



Figure 7: Supernumerary teeth Mesiodens

• *Peridens :* located buccal to the arch

• *Distomolar :* distal to the third molar.

• *Paramolar:* located buccal or lingual to molars.

4. ***Natal and neonatal teeth****:* These may be either supernumerary or deciduousteeth.

5. ***Pre deciduous dentition****:* Aborted structures with caps of enamel and dentine.

6. ***Post permanent dentition****:* Teeth erupt after the loss of the permanent dentition, usually impacted accessory teeth.

Disturbances during Morphodifferentiationof Tooth Germs

1. **Hutchinson's incisors**: Screwdriver shaped notched incisors, e.g. incongenital syphilis.



Figure 8: Hutchinson's incisors

2. **Mulberry molars**: Occlusal surface is narrower than the cervical margin and is made up of agglomerate mass of globules; seen in congenital syphilis.



Figure 9: Mulberry molars.

3. ***Peg shaped laterals:*** Proximal surfaces of the crown converge giving the tooth aconical shape.



Figure 10: Peg shaped laterals

4. **Macrodontia Teeth:** larger than normal. It may be true or relative generalized.



Figure 11: *Macrodontia* Teeth

5. ***Microdontia* Teeth**: smaller than normal. It may be true or relativegeneralized; most commonly the lateral incisor and third molars.

Figure 12: *Microdontia* Teeth



6. ***Dens in dente**:* Tooth invaginates before calcification, e.g. permanent maxillary lateral incisor.

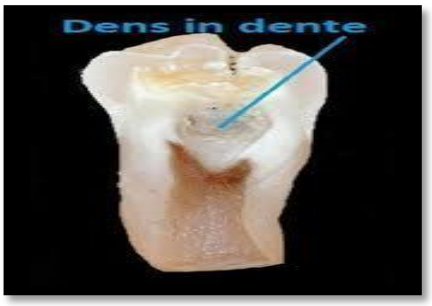


Figure 13: Dens in dente.

7. ***Dens evaginatus:*** A tubercle or protruberance from the involved surface of the affected tooth; occurs due to proliferation or evagination of part of the inner enamel epithelium into the stellate reticulum. Seen in premolars.

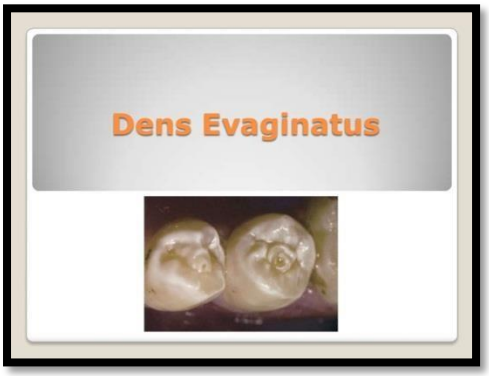


Figure 14: Dens evaginatus

8. ***Gemination*** Single tooth germ splits into partially or fully separated crowns but with a common root and root canal.
9. ***Fusion*****Two** tooth germs unite to form a single large crown with two root canals; seen in incisors.

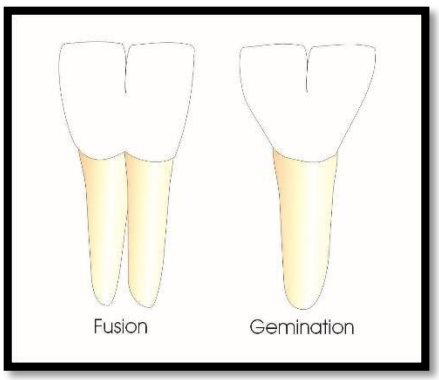


Figure 15: Gemination and Fusion

10.***Dilaceration****:* Twisting, bending or distortion of a root.



Figure 16: Dilaceration

11.***Taurodontism****:* Enlargement of the body and pulp chamber of a multi-rooted tooth with apical displacement of the pulpal floor and bifurcation of the root

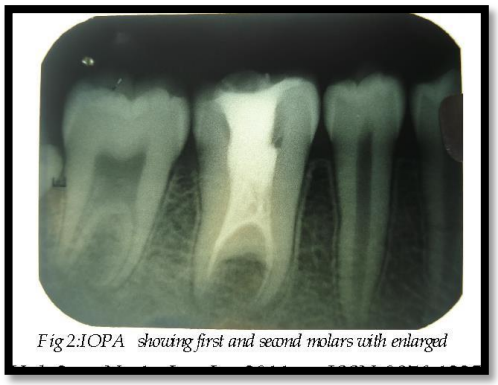


Figure 17: *Taurodontism*.

Disturbances during Apposition of Hard Tissues

1. ***Enamel hypoplasia****:* Reduction in the amount of enamel formed.



Figure 18: Enamel hypoplasia

• *Local enamel hypoplasia* Periapical infection or trauma (Turner's tooth)

• *Systemic enamel hypoplasia* Rickets, German measles, fluoride ingestion.

• *Hereditary enamel hypoplasia* Tooth appears yellow due to reduced enamelthickness.

2. ***Amelogenesisimperfect****: Hereditary disorder wherein the quality and quantity of enamel formed is altered. Three types:*



Figure 19: Amelogenesisimperfect

• *Hypoplastic* Defective matrix formation

• *Hypocalcification* Defective mineralization of matrix.

• *Hypomaturation* Immature enamel crystals.

3. ***Dentinogenesis imperfect****:* Hereditary developmental disorder of the dentine. The dentine appears grey to brownish violet, enamel frequently separates from the defective dentine, roots become short, canals get obliterated, and rapid attrition is seen.



Figure 20: Dentinogenesis imperfect

4. ***Dentinal dysplasia*** premature loss of teeth, short roots.

5. ***Shell teeth*** Roots fail to form, pulp chambers are wide.

6. ***Odontodysplasia (Ghost teeth)*** Enamel and dentine is defective and very thin.

7. Pigmentation of enamel and dentine

• Erythroblastosis fetalis: enamel is green/blue.

• Porphyria: red to brownish

• tetracycline's brownish

8.*Cemental hypoplasia* Reduced rate of cementum formation, e.g. hypophosphatasia.

9. *Enamel pearls* Attached to the furcation area of maxillary molars.

Disturbances during Calcification of Hard Tissue

1. ***Enamel hypocalcification*** Calcification is subnormal. It may be local,systemic or hereditary.
2. ***Interglobular dentine*** Areas of partially calcified dentine.

Disturbances during Eruption of Teeth

1. ***Concrescence:*** Cemental union of two teeth.

2. ***Retarded eruption:*** Due to endocrine disturbances, vitamin deficiencies, localcauses.

3. ***Ankylosed teeth:*** Teeth fail to erupt to the occlusal level as they are fused tothe bone.



Figure 21: Ankylosed teeth

Dimensional Changes in the Dental Arches

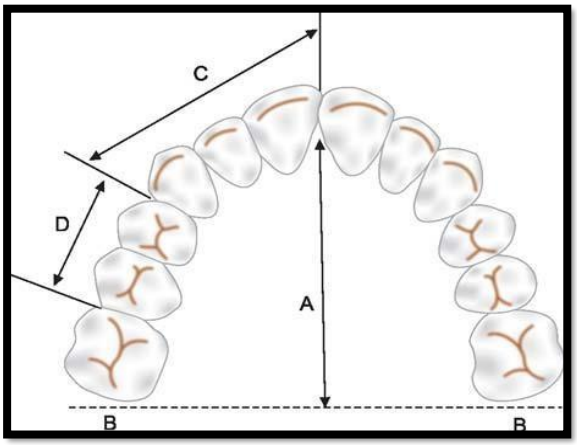


Figure 21: Dimensional Changes in the Dental Arches

The usual arch dimensions measured are:

1. **Widths** of the canines, primary molars (premolars) and first permanent molars:

a. Dimensional increase in width involves alveolar process growth almosttotally, since there is little skeletal width increase at this time.

b. Clinically significant differences exist in the manner and magnitude of width changes in the maxilla and mandible. Width increase correlates highly with vertical alveolar process growth. Maxillary alveolar processes diverge while mandibular alveolar processes are more

Parallel. Thus, maxillary width increases more and can be easily altered in treatment.

c. The only significant increase in mandibular inter-canine width occurs during eruption of

Incisors when primary cuspids are moved distally into primate spaces and does not increase significantly thereafter.

d. Maxillary arch width increase is timed with periods of active eruption of teeth. Eruption of maxillary permanent canines is an important factor in widening of the arch.

e. Maxillary premolar width increase is coincidental with vertical growth whereas mandibular premolar width increase occurs because of further buccal placement of premolar crowns.

2. Length or depth: Arch length or depth is measured at the midline from a point midway between central incisors to a tangent touching distal surfaces of second primary molars or premolars. Any changes in arch length are coarse reflections of changes in perimeter.

3. Arch circumference or perimeter: Measured from distal surface of second primary molar or mesial surface of first permanent molar around the arch over contact points and incisal edges in a smoothened curve to the distal of second primary molar or mesial surface of first permanent molar of the opposite side. The reduction in mandibular arch circumference during transitional and early adolescent dentition is a result of:

a. Late mesial shift of first permanent molar as "Leeway space" (**Fig. 22)** is pre-empted.

b. Mesial drifting tendency of posterior teeth throughout life.

c. Slight interproximal wear of teeth.

d. Lingual positioning of incisors.

e. Original tipped position of incisors and molars.

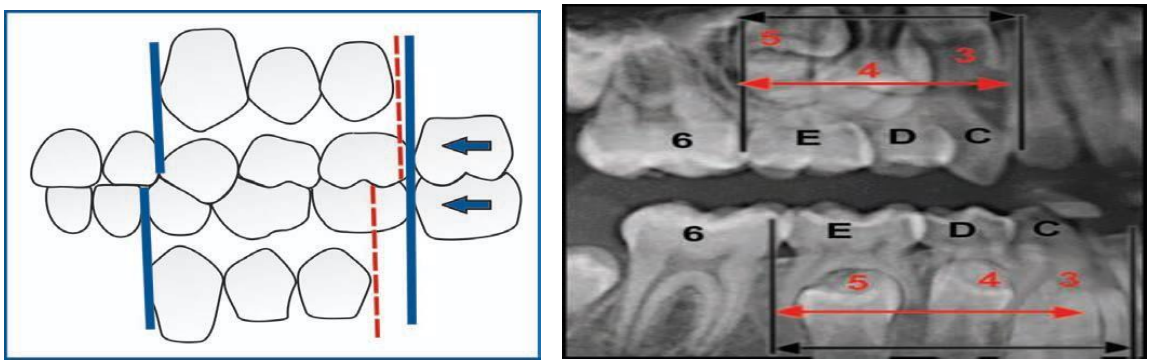


Figure 22: Leeway space