DEVELOPMENT OF DENTITION AND OCCLUSION

Malocclusion is a reflection of disturbances that might have occurred during the normal process of occlusal development. Functional disturbances of the masticatory system may have their beginning during the development of occlusion, a period when the position of the tongue, swallowing habits, chewing patterns, etc. are established. Thus, it is imperative to understand the development of dental occlusion in order to recognize and intervene in case of any abnormal development and also to treat an already existing malocclusion.
It is also important to note that certain occlusal irregularities, observed during the developing stages of occlusion are transient and thus do not require treatment.

DEVELOPMENT OF THE DENTITION

Humans have two sets of dentitions namely, deciduous and permanent, which contain 20 and 32 teeth respectively. The formation and eruption of these teeth follow a definite pattern and fairly consistent timetable.
The primitive oral cavity or stomatodeum is lined by stratified squamous epithelium called oral ectoderm. The underlying connective tissue is called the ectomesenchyme, as these cells are formed by migration of the neural crest cells derived from the ectoderm to the head region. The primitive oral cavity establishes a connection with the foregut at 4th week of gestation when the buccopharyngeal membrane, which is limiting the stomatodeum, ruptures.
The first indication of tooth formation is seen at about 6th week of gestation when oral ectoderm proliferates into the underlying ectomesenchyme to form horseshoe-shaped dental lamina at the future upper and lower dental arches. The primary teeth develop directly from the dental lamina; while the permanent successor teeth develop from a lingual extension of the dental lamina called successional lamina. The permanent molars, which do not have deciduous predecessors develop from a distal extension of the dental lamina.
Development of tooth occurs by a series of epithelial-mesenchymal interactions along the dental lamina. The ectoderm in certain areas of dental lamina proliferates into the underlying ectomesenchyme to form an enamel organ. Each enamel organ surrounds a local portion of ectomesenchyme called the dental papilla. Condensed ectomesenchyme that limits the dental papilla and surrounds the enamel organ is called a dental follicle/sac. The enamel organ forms enamel, the dental papilla forms dentin, and the pulp and dental sac form the supporting tissues—periodontal ligament and alveolar bone.
The enamel organ, dental papilla and dental sac together constitute a tooth bud or tooth germ. Ten such tooth germs arise in each dental arch to form the primary dentition.

Stages of Tooth Development

Bud Stage

The enamel organ at first resembles a small bud, which is surrounded by the condensation of ectomesenchymal cells. During bud stage, the enamel organ consists of peripherally located low columnar cells and centrally located polygonal cells (Fig 1 A).

Cap Stage

The enamel organ then proliferates to form a cap over the dental papilla. The dental papilla and dental sac become well defined. The enamel organ differentiates to form three epithelial layers namely (Fig 1 B).

i. Inner dental/inner enamel epithelium
ii. Stellate reticulum and
iii. Outer dental/outer enamel epithelium.

Early Bell Stage

The enamel organ acquires a bell shape due to uneven proliferation of its cells, resulting in deepening of the undersurface of the epithelial cap. Another cell layer forms between the inner dental epithelium and the stellate reticulum called stratum intermedium. Thus, the enamel organ at bell stage exhibits four different types of epithelial cells.

The inner dental epithelium differentiates into tall columnar cells called ameloblasts, which later secrete enamel. The peripheral cells of the dental papilla differentiate into odontoblasts under the organizing influence of inner dental epithelium, which later form dentin (Fig 1 C).

Advanced Bell Stage

First, odontoblasts form a layer of dentin and then the ameloblasts begin to secrete enamel matrix. The deposition of enamel and dentin continues until the crown formation is complete (Fig 1 D).

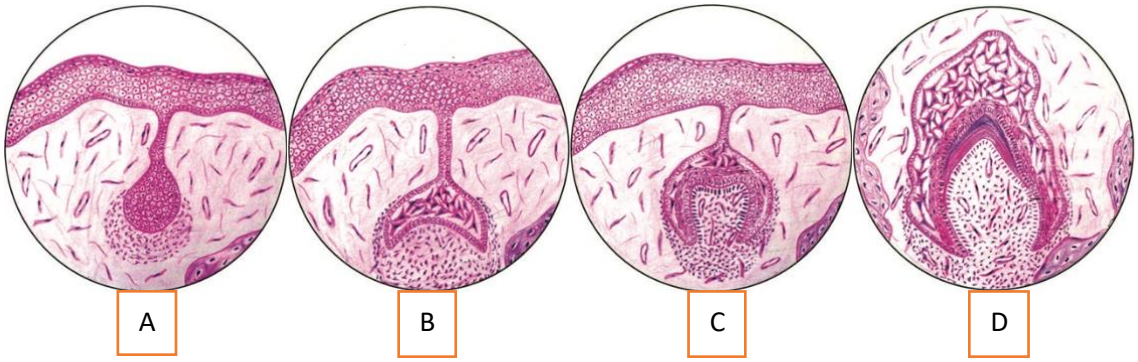


Figure 1 shows the stages of tooth development: a: bud stage: cap stage: early bell stage,D: late bell stage.

Root Formation

Root formation begins once the dentin and enamel reach the future cementoenamel junction. The cervical portion of the enamel organ gives rise to Hertwig's epithelial root sheath, which molds the shape of the roots and initiates radicular dentin formation. Eruption of a tooth generally begins when two-thirds of the root is formed. Root formation is usually completed 1–3 years after the eruption of the tooth.

Overlapping on these morphologic stages of tooth development are a series of physiological processes that occur in a sequential manner.

These physiological processes are:

- Initiation—dental lamina and bud stage
- Proliferation—bud and cap stage
- Histodifferentiation—early bell stage
- Morphodifferentiation—advanced bell stage
- Apposition—formation of enamel and dentin matrix.

Mineralization begins around the 14th week of gestation in primary dentition and occurs first in the central incisors. The permanent tooth germs begin to form around the 4th– 5th month of intrauterine life and their mineralization commences at birth, beginning in the first molars.

Radiographic studies of tooth formation consider three basic stages:

I. Beginning of calcification.

II. Crown completion

III. Root completion

Nolla (1960) described the tooth development in 10 stages (Fig 2).

Crown

1: Absence of crypt.

2: Initial calcification

3: 1/3 of crown completed

4: 2/3 of crown completed

5: Crown almost completed

6: Crown completed.

root

7- 1/3 of root completed

8- 2/3 of root completed

9- root almost completed

10- apical end of root completed

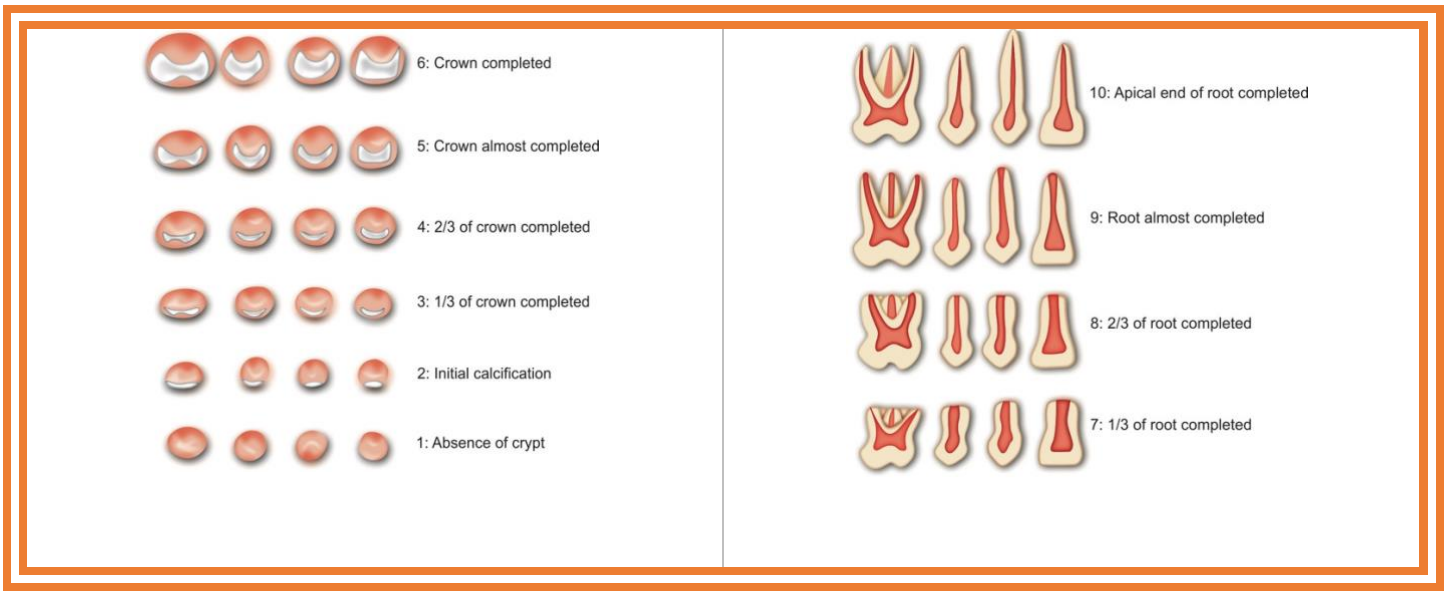


Figure 2 shows the radiographic stages of tooth development.

DEVELOPMENT OF OCCLUSION

Dental occlusion undergoes significant changes from birth until adulthood and beyond. This continuation of changes in the dental relationship during various stages of the dentition can be divided into four stages:

I. Gum pads stage: 0–6 months
II. Deciduous dentition: 6 months–6 years
III. Mixed dentition: 6–12 years
IV. Permanent dentition: 12 years and beyond.

Gum Pad Stage (0–6 Months)

Usually, jaws are devoid of teeth at birth. The gum pad stage extends from birth up to the eruption of the first primary tooth, usually the lower central incisors at around 6 months of age. The gum pads are pink in color and firm in consistency. The maxillary gum pad is horseshoe shaped and the mandibular gum pad is U/square shaped (Figs 3).

The gum pads develop in two portions, buccal and lingual, which are separated by the dental groove. The gum pads in both arches show certain elevations and grooves that outline the portion of various primary teeth, which are still developing in the alveolar ridges. These are called

transverse grooves. The prominent transverse groove separating the canine and first deciduous molar segments in both arches is called the lateral sulcus. The lateral sulci are often used to judge the interarch relationship at a very early stage. The gingival groove separates the maxillary and mandibular gum pads from the palate and floor of the mouth, respectively.

Characteristic Features of Gum Pad Stage

Infantile open bite: Usually, the anterior segment of the upper and lower gum pads do not approximate each other with a space created between them, while the posterior segments occlude with each other at the molar region (Fig. 4). The tongue is positioned in this space between the upper and lower gum pads during suckling. This infantile open bite is transient and gets self-corrected with the eruption of deciduous incisors.

Complete overjet: The maxillary gum pad is usually larger and overlaps the mandibular gum pad both horizontally and vertically with a complete overjet all around. In this way, the opposing surface of the pads provides an efficient way of squeezing milk during breastfeeding.

Anteroposterior relationship: In general, the mandibular lateral sulci are more posterior to the maxillary lateral sulci (Fig. 4).

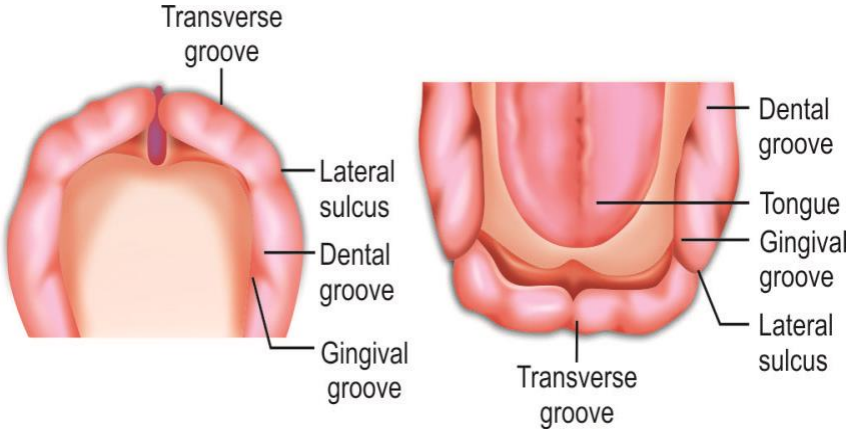


Figure 3 A and B: The gum pads: (A) Maxillary; and (B) Mandibular

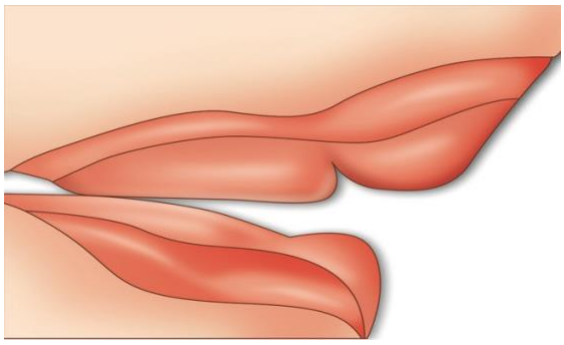


Figure 4 Relationship between upper and lower gum pads: infantile open bite seen at birth. Also note that mandibular lateral sulcus is posterior to maxillary lateral sulcus

Precocious eruption of primary teeth—Natal and neonatal teeth: Usually jaws are devoid of teeth at birth. However, occasionally infants are born with one/ two erupted teeth, usually, the mandibular incisors.

Such teeth present at birth are called natal teeth (Fig5). Teeth that erupt within 30 days of life are called neonatal teeth. Familial tendency is observed in this condition and such premature eruption of teeth may cause problems during feeding. It is advised to retain them unless they are too mobile.





Figure 5 shows natal teeth.

Deciduous Dentition Stage (6 Months–6 Years)

The deciduous dentition stage spans from the time of eruption of primary teeth until the eruption of the first permanent tooth around 6 years of age.

Eruption Chronology

Eruption of the primary teeth begins by 6 months of age when primary mandibular incisors erupt into oral cavity. Eruption of all the primary teeth is usually complete by two and half years by which age the deciduous dentition is in full function. Root formation of primary teeth is usually completed by three years of age.

Although considerable variation is seen in the eruption timing of deciduous teeth, there appears to be no significant gender differences. The chronology of primary teeth is presented in the Table 1 .

Table 1: Chronology of deciduous dentition

Tooth	*First evidence of calcification*	*Amount of enamel formed at birth*	*Crown completed*	*Eruption*	*Root completed*
Primary Dentition					
Maxillary					
Central incisor	4 months *in utero*	Five-sixths	1½ months	7½ months	1½ years
Lateral incisor	4½ months *in utero*	Two-thirds	2½ months	9 months	2 years
Cuspid	5 months *in utero*	One-third	9 months	18 months	3¼ years
First molar	5 months *in utero*	Cusps united	6 months	14 months	2½ years
Second molar	6 months *in utero*	Cusp tips still isolated	11 months	24 months	3 years
Mandibular					
Central incisor	4½ months *in utero*	Three-fi fths	2½ months	6 months	1½ years
Lateral incisor	4½ months *in utero*	Three-fi fths	3 months	7 months	1½ years
Cuspid	5 months *in utero*	One-third	9 months	16 months	3¼ years
First molar	5 months *in utero*	Cusps united	5½ months	12 months	2¼ years
Second molar	6 months *in utero*	Cusp tips still isolated	10 months	20 months	3 years

The sequence of eruption of primary teeth may also show some variation. However, in most of the cases, the lower central incisors are the first teeth to erupt, followed by the upper central incisors. Usually, the lateral incisor, first molar and canine tend to erupt earlier in the maxilla than in the mandible.

Deciduous dentition generally shows the following order of eruption:

1. Central incisors
2. Lateral incisors
3. First molars

ABDCE _____
ABDCE

4. Canines
5. Second molars

By 3 years of age, the occlusion of deciduous dentition is completely established, and dental arches remain relatively constant with no significant changes up to 6 years of age.

Characteristics of Occlusion

Interdental Spacing

Interdental spacing, when present in permanent dentition is considered abnormal. However, presence of interdental spacing is an important and normal feature of deciduous dentition, which is required for the accommodation of larger permanent teeth at a later stage.

Spaces present between deciduous teeth are often referred to as physiologic or developmental spaces (Fig. 6). Sufficient interdental space is needed for the permanent teeth to erupt into an uncrowded position and for the establishment of their proper alignment. Malocclusion, with crowding of teeth, can be expected in case of unspaced primary dentition (Fig. 6).

Physiologic/developmental spacing in deciduous dentition includes:

- Generalized spacing between teeth.
- Primate spaces.

Generalized Spacing

According to Foster (1982), generalized spacing occurs in almost 75% of the individuals in the primary dentition stage. Generalized spacing between the teeth is seen in both the dental arches and helps in the accommodation of larger successor teeth.

Primate Spaces

In addition to the generalized spacing, localized spacing is often present mesial to the upper canine and distal to the lower canine. Such spaces, originally described by Lewis and Lehman (1929), are a normal feature of the permanent dentition in the higher apes (primates) and are present in the human primary dentition. Thus, these are usually referred to as the anthropoid spaces. Anthropoid spaces appear to be a more constant feature of deciduous dentition (Fig 6 A).

Significance: Following the eruption of primary first molars, when canine teeth erupt and reach occlusion, the primate spaces facilitate proper interdigitation of the opposing canines into class I canine relationship.

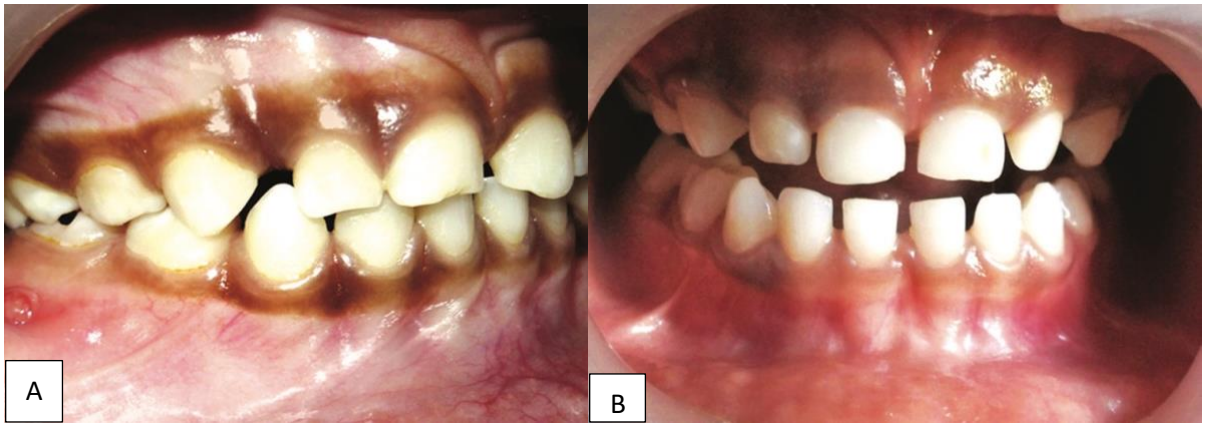


Fig. 6: A: Primate spaces, B: physiological spacing

Incisor Relationship

Incisor relationship in deciduous dentition normally show:

- Increased overbite (deep bite)
- Increased overjet

Deep Bite

An increased overbite is usually seen in the initial stages of development with the deciduous mandibular incisors contacting the cingulum area of the deciduous maxillary incisors in centric occlusion (Fig. 7). Deep bite may be due to the fact that the primary incisors are more vertically placed than the permanent incisors.

The ideal position of the deciduous incisors has been described as being more vertical than the permanent incisors, with a deeper incisal overbite.



Fig. 7: Deep bite is a normal feature of deciduous dentition

A deep bite is a normal feature of deciduous dentition This deep bite later gets self-corrected by:

Attrition of incisors

Eruption of deciduous molars

Differential growth of the alveolar processes of the jaws.

Increased Overjet

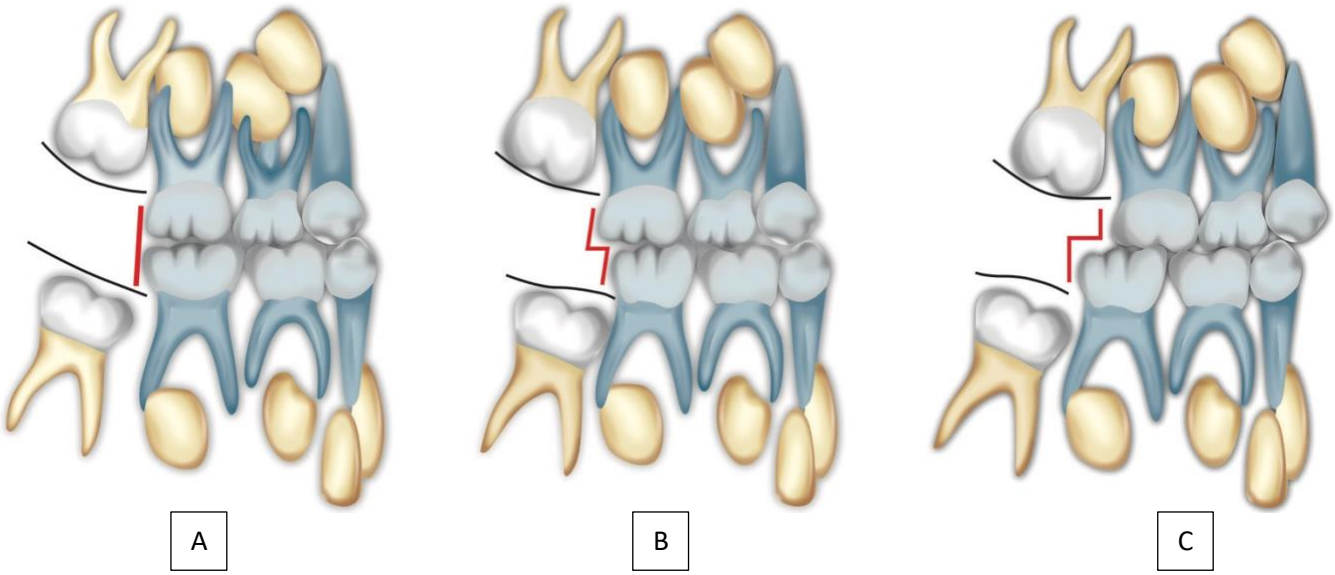
Excessive incisal overjet is often observed in deciduous dentition. 72% of children exhibited an increased overjet in a study conducted by Foster. Excessive overjet usually gets corrected later by the forward growth of the mandible.

Molar Relationship

The anteroposterior molar relationship in the deciduous dentition is described in terms of the terminal planes. Terminal planes are the distal surfaces of the maxillary and mandibular second primary molars.

Moyers described three possible kinds of primary molar relationships (Figs8):

1. Straight/Flush terminal plane
2. Mesial step
3. Distal step.



Figs 8 A to C: Terminal plane relationships: (A) Flush/straight terminal plane; (B) Mesial step; (C) Distal step

Flush Terminal Plane

In the straight/flush terminal plane, the distal surfaces of the maxillary and mandibular second deciduous molars are in the same vertical plane (Fig8A).

It is of significance to note that the mandibular second primary molar has a greater mesiodistal diameter than the maxillary second molar. This difference in the dimensions makes the distal surfaces of both maxillary and mandibular deciduous second molars fall in the same vertical plane in centric occlusion. Such an arrangement is called a "flush terminal plane." The flush terminal plane is considered to be the ideal kind of molar relationship in the primary dentition.

Mesial Step

In this terminal plane relationship, the distal surface of the mandibular deciduous second molar is more mesial to the distal surface of the maxillary deciduous second molar (Fig 8 B).

Distal Step

Here, the distal surface of the mandibular deciduous second molar is more distal to the distal surface of the maxillary deciduous second molar. In other words, the maxillary second deciduous molar is ahead of the mandibular second deciduous molar (Fig. 8 C).

GOOD LUCK