

ORTHODONTICS

✚ Development of Dentition (Part I)

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❖ Introduction

Dentition is defined as type, number and arrangement of teeth or it refers to all upper and lower teeth collectively. The upper and lower arches are functional unit made up of specific components, i.e. the teeth. The mammalian dentition goes back 75 million years. The dental formula of early primates consisted of 2 incisors, 1 canine, 4 premolars and 3 molars.

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 consistent timetable. The chronology of human dentition is given in Tables 1 and 2 based on radiographic studies of tooth formation that considers three basic stages.

- I. Beginning of calcification
- II. Crown completion
- III. Root completion

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 <i>in utero</i>	Five sixths	1 ½ months	7 ½ months	1 ½ years
Lateral incisor	4 ½ months <i>in utero</i>	Two thirds	2 ½ months	9 months	2 years
Cuspid	5 months <i>in utero</i>	One-third	9 months	18 months	3 ¼ years
First molar	5 months <i>in utero</i>	Cusps united	6 months	14 months	2 ½ years
Second molar	6 months <i>in utero</i>	Cusp tips still isolated	11 months	24 months	3 years
Mandibular					
Central incisor	4 ½ months <i>in utero</i>	Three fifths	2 ½ months	6 months	1 ½ years
Lateral incisor	4 ½ months <i>in utero</i>	Three fifths	3 months	7 months	1 ½ years
Cuspid	5 months <i>in utero</i>	One-third	9 months	16 months	3 ¼ years
First molar	5 months <i>in utero</i>	Cusps united	5 ½ months	12 months	2 ¼ years
Second molar	6 months <i>in utero</i>	Cusp tips still isolated	10 months	20 months	3 years

Table 2: Chronology of permanent dentition

Tooth	First evidence of calcification	Amount of enamel formed at birth	Crown completed	Eruption	Root completed
Permanent Dentition					
Maxillary					
Central incisor	3-4 months	—	4-5 years	7-8 years	10 years
Lateral incisor	10-12 months	—	4-5 years	8-9 years	11 years
Cuspid	4-5 months	—	6-7 years	11-12 years	13-15 years
First bicuspid	1 ½ - 1 ¾ years	—	5-6 years	10-11 years	12-13 years
Second bicuspid	2-2 ¼ years	—	6-7 years	10-12 years	12-14 years
First molar	At birth	Sometimes a trace	2½-3 years	6-7 years	9-10 years
Second molar	2 ½ - 3 years	—	7-8 years	12-13 years	14-16 years
Third molar	7-9 years	—	12-16 years	17-21 years	18-25 years
Mandibular					
Central incisor	3-4 months	—	4-5 years	6-7 years	9 years
Lateral incisor	3-4 months	—	4-5 years	7-8 years	10 years
Cuspid	4-5 months	—	6-7 years	9-10 years	12-14 years
First bicuspid	1½-2 years	—	5-6 years	10-12 years	12-13 years
Second bicuspid	2¼-2 ½ years	—	6-7 years	11-12 years	13-14 years
First molar	At birth	Sometimes a trace	2½-3 years	6-7 years	9-10 years
Second molar	2½-3 years	—	7-8 years	11-13 years	14-15 years
Third molar	8-10 years	—	12-16 years	17-21 years	18-25 years

❖ Evolution:

The jaws and teeth in the humans have undergone evolutionary changes over several years to reach their present form. Reptilian dentition was polyphyodonty (many sets of teeth) which evolved to diphyodont (only 2 sets of teeth) in mammals. Also, the dentition evolved from homodont (all teeth same) to heterodont (different types of teeth) in the present-day humans. To develop a functional occlusion, it became necessary for the teeth and bones to develop synchronously. Over a period of time there was loss or fusion of cranial and facial bones, the number of bones has reduced, and dental formula has also undergone changes.

❖ THEORIES OF ORIGIN OF MAMMALIAN TEETH

1. THEORY OF CONCRESCENCE

Mammalian dentition was produced by the fusion of two or more primitive conical teeth and each tubercle with its root originated as simple reptilian tooth.

2. THEORY OF TRITUBERCULY

Each of the mammalian tooth was derived from a single reptilian tooth by secondary differentiation of tubercles and roots.

3. THEORY OF MULTI-TUBERCULY

Mammalian dentition is a result of reduction and condensation of primitive multi-tuberculate teeth. In terms of evolution, teeth are said to have developed from lobes or primary centrals. Incisors, premolars and maxillary molars developed from 4 lobes whereas mandibular molars developed from 5 lobes.

❖ CHARACTERISTICS OF HUMAN DENTITION

✓ MODE OF ATTACHMENT

Teeth may be attached to the jaws in the following ways:

- Acrodont Teeth attached to the jaw by a connective tissue.
- Pleurodont Teeth are set inside the jaws.
- Thecodont Teeth inserted in a bony socket.

✓ NUMBER OF SUCCESSIVE TEETH

- Polyphyodont Teeth replaced throughout life, e.g. shark
- Diphyodont Two sets of teeth, e.g. humans
- Monophyodont Single set of teeth, e.g. sheep.

✓ SHAPE OF TEETH

- Homodont Single type of teeth.
- Heterodont Teeth of different shapes, e.g. incisors, molars, etc. as in humans.

❖ 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 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 proliferate and differentiate, passing through various histological and morphological differentiation stages namely bud, cap and bell stages.

Stages of Tooth bud Development

- **Bud Stage:** The enamel organ at first resembles a small bud, which is surrounded by the condensation of ectomesenchymal cells (Figure 1) peripherally located low columnar cells and centrally the enamel organ then proliferates to form a cap over located polygonal cells.

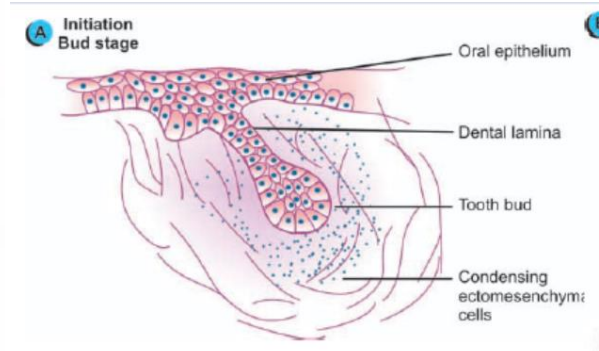


Figure 1: Bud stage

- **Cap stage:** The enamel organ then proliferates to form a cap over located the dental papilla. The dental papilla and dental sac become well defined (Figure 2). The enamel organ differentiates to form three epithelial layers namely,
 - i. Inner dental/inner enamel epithelium
 - ii. Stellate reticulum and
 - iii. Outer dental/outer enamel epithelium.

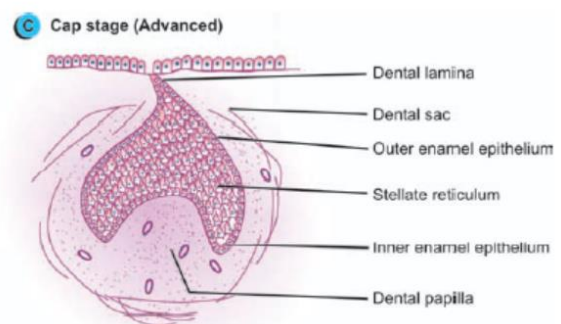
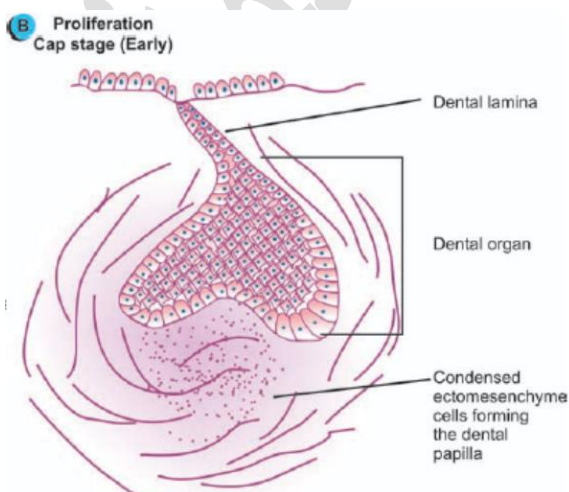


Figure 2: Cap stage

- **Early Bell Stage:** The enamel organ acquires a bell shape (Figure 3) due to uneven proliferation of its cells, resulting in deepening of the under surface 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.

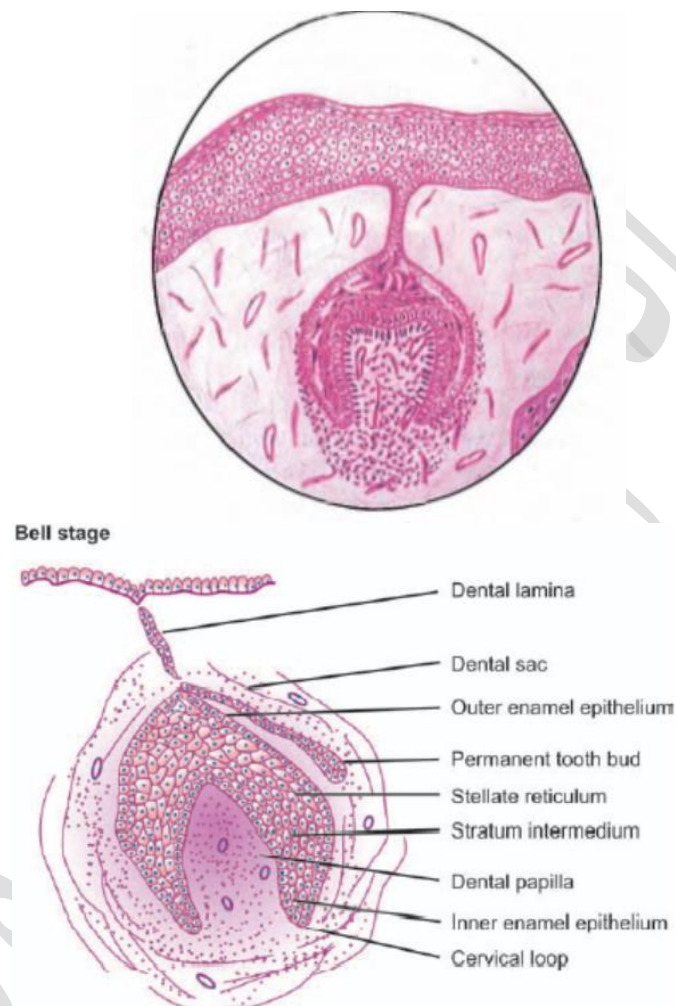


Figure 3: Early bell stage

- **Advanced Bell Stage:** (Figure 4) 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.

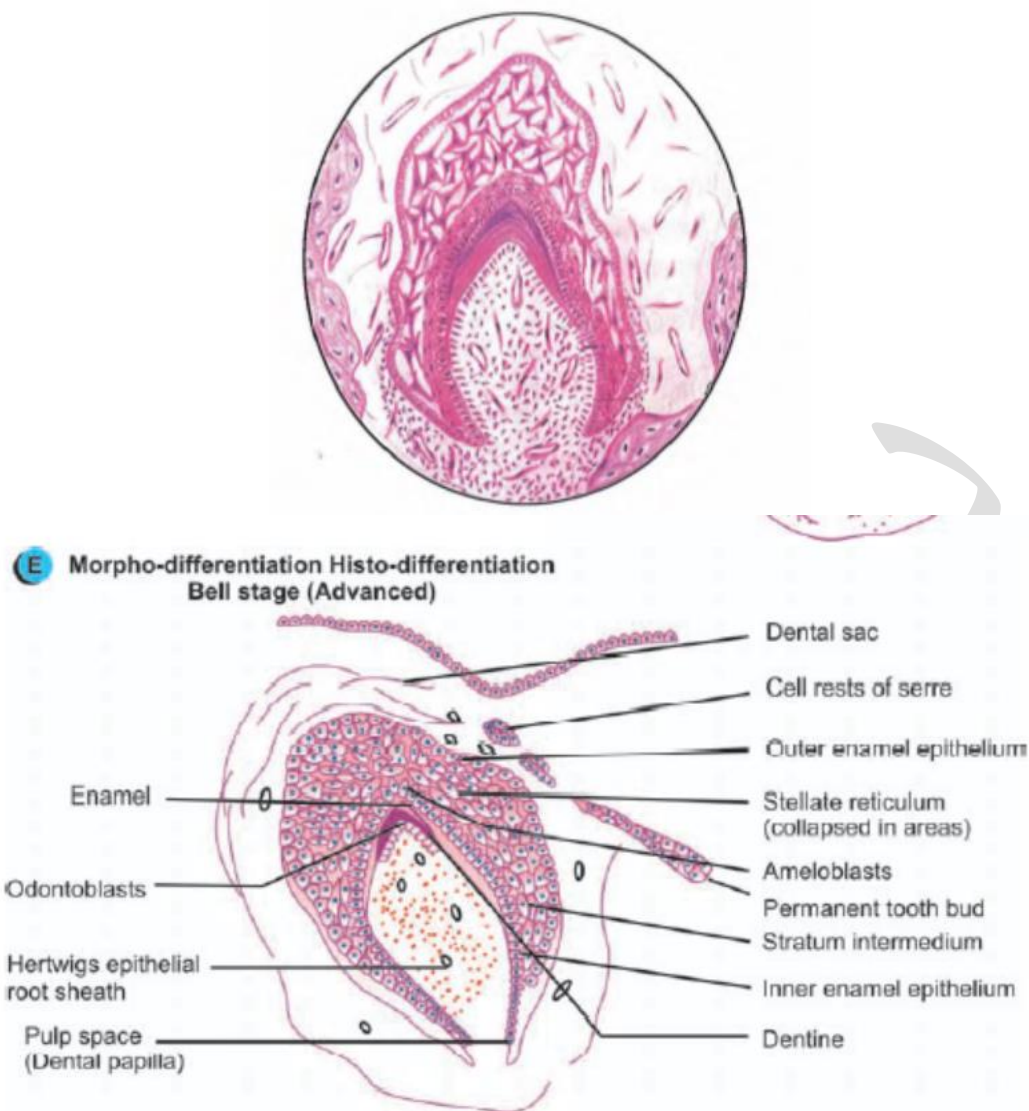


Figure 4: Advanced bell stage

- ❖ 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:** 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 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.

- **Proliferation—bud and cap stage:** 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.
- **Histodifferentiation—early bell stage:** 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 flattens to low cuboidal cells. The stellate reticulum expands further and the cells become star shaped. A new layer of cells known as Stratum Intermedium whose function is to provide nutrition to IEE cells appears between inner enamel epithelium and stellate reticulum.
- **Morpho differentiation—advanced bell stage**
- **Apposition—formation of enamel and dentin matrix:** 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. Mineralization begins around 14th week of gestation in primary dentition and occurs first in the central incisors. The permanent tooth germs begin to form around 4th-5th month of intrauterine life and their mineralization (calcification) commences at birth, beginning in the first molars and then for the other permanent teeth after few months to years of birth as mentioned in Table 2.

❖ 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 alveola margin.

PROCESS OF TOOTH ERUPTION

Tenacate divided tooth eruption into the following 3 stages:

1. **Pre-eruptive tooth movement:** Movement of tooth germs within the jaw before they begin to erupt.

2. **Eruptive tooth movement:** Tooth movement from its position within the jaws to its functional position.
3. **Post-eruptive tooth movement:** Maintaining the position of erupted tooth in occlusion while the jaws continue to grow.

Tooth eruption can also be divided into:

1. **Pre-emergent eruption:** During the stage of crown formation, there is very slow labial or buccal drift of the tooth follicle within the bone. However, there is no eruptive movement. Two processes are necessary for a tooth to erupt intra-osseously:

- Resorption of bone and primary tooth roots overlying the crown of the erupting tooth.
- Eruption mechanism itself must move the tooth in the direction where the path has been cleared. Resorption is the rate-limiting factor in pre-emergent eruption.

2. **Post-emergent eruption:** Once a tooth emerges into the mouth, it erupts rapidly (about 4 mm in 14 weeks) until it approaches the occlusal level and is subjected to the forces of mastication. This stage of relatively rapid eruption is called as the post emergent spurt. This is followed by a phase of Juvenile Occlusal Equilibrium, i.e. after teeth reach the occlusal level; eruption becomes almost imperceptibly slow although it definitely continues. After the teeth are in function, they erupt at the same rate as the vertical growth of the mandibular ramus unless there is occlusal wear, or the antagonist tooth is lost at any age in which case additional eruption occurs. When the pubertal growth ends, a final phase of tooth eruption takes place known as adult occlusal equilibrium.

❖ **Root Formation:**

Root formation begins once the dentin and enamel reach the future cemento-enamel junction. The cervical portion of the enamel organ gives rise to the 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 2-3 years after the eruption of permanent tooth and 12-18 months after eruption of primary tooth.

❖ **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 external objects 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.

- **SEQUENCE OF ERUPTION**

There is wide variability in the sequence of arrival of teeth in the mouth.

Maxilla 6-1-2-4-3-5-7 or 6-1-2-4-5-3-7 (most common)

Mandible 6-1-2-4-5-3-7 or 6-1-2-3-4-5-7 (most common)

Dental age 6: First stage of eruption

- Eruption of mandibular central incisor and permanent first molar
- Mandibular molar eruption precedes maxillary molar.

Dental age 7:

- Eruption of maxillary central and mandibular lateral incisor.
- Root formation of maxillary lateral incisor well advanced.
- Crown completion of canines and premolars.

Dental age 8:

- Eruption of maxillary lateral incisor.
- Delay of 2-3 years before any further teeth erupt.

Dental age 9

- One-third root formation of mandibular canine and first premolar is complete.
- Root development of mandibular second premolar begins.

Dental age 10

- One-half root formation of mandibular canine and first premolar is complete.
- Significant root development of maxillary and mandibular second premolar as well as maxillary canine.
- Root completion of mandibular incisors and near completion of maxillary laterals.
- According to Moyers, mandibular canine erupts between 9 and 10 years.

Dental age 11

- Eruption of mandibular canine, mandibular first premolar and maxillary first premolar.
- Maxillary first premolar erupts ahead of canine and second premolar.

Dental age 12

- Remaining succedaneous teeth erupt.

- Second permanent molars nearing eruption.
- Early beginnings of third molar.

Dental age 13,14,15

- Completion of roots of permanent teeth.
- Third molars apparent on the radiograph .

Notes:

- Change in eruption sequence is a reliable sign of disturbance in normal development of the dentition.
- Certain normal variations with important clinical significance:
 - Eruption of second molars ahead of premolars in the mandibular arch. This decreases the space for second premolars, which get partially blocked out.
 - Eruption of maxillary canines ahead of premolars will cause the canines to be forced out labially.
 - Asymmetries in eruption between the right and left sides occurs when there is lack of space to accommodate erupting teeth due to different pattern of mechanical obstruction, decreased space on one side compared to the other.