CHAPTER 8

Development of Dentition

INTRODUCTION

Development of the dentition is a very important phase of life. The teeth start developing in the jaw bones in utero. They start erupting in the oral cavity at around 6 months of age. Eruption of first tooth of an infant is always eagerly awaited by the parents. From an orthodontist's point of view, the teeth act as "functional matrices" for the growth of alveolar processes of both the jaws. The absence of one or more teeth leads to deficient growth of the alveolar process in that area.

Development of the dentition can be broadly studied in four phases:

1. Gum pads
2. Primary dentition phase
3. Mixed dentition phase
4. Permanent dentition phase.

The Self-correcting Anomalies

Before discussing the various stages of dentition, we should know the normal features of the dentition. There are certain features observed during the development of dentition, which appear abnormal at that time. But these are the natural stages and are essential features of development at that time, and resolve automatically with the advancing development of dentition. These features should not be disturbed by any intervention, but a close and regular check-up must be done. Following are some of the features noted as self-correcting features.

Gum Pads Stage

Open bite; increased overjet; tongue in between gum pads; skeletal class II relationship.

Primary Dentition Period

Deep bite; primate spacing; small mandible; more upright incisors; primary spacing; FTP; skeletal class II relationship; whiter teeth.

Mixed Dentition Period

End-on molars; ugly-duckling stage; spacing between maxillary incisors; less than 2 mm of lower incisors crowding; lingual eruption of incisors.

Incipient Malocclusion

These are certain features which give an idea of expected space problems in future. Sometimes, if growth is favorable, they get resolved naturally. But if proper growth is not there, they contribute to crowding of teeth. These are, the lack of interdental spacing in primary dentition, crowding in permanent incisors in MDP and premature loss of primary canines especially mandibular due to erupting lateral incisors which cause root resorption of canines, if arch length is deficient in the mandibular arch.

GUM PADS (Fig. 8.1)

The alveolar processes/ridges from the time of birth till the eruption of first tooth are known as the gum pads. They are pink, firm and are covered by fibrous perriosteum. They are of somewhat horse shoe-shaped.

Grooves in Gum Pads

Dental Groove

Each gum pad is divided into two parts by a groove (called as dental groove), i.e. labiobuccal part and the lingual part. The former forms the major part of the gum pad, and has the deciduous teeth. The lingual portion is of relatively small size, and it loses its identity by merging with the tissue on the lingual aspect with eruption of the deciduous teeth. The dental groove is due to the invagination of oral epithelium into underlying connective tissue; and with eruption of the deciduous teeth, the dental groove disappears.

Lip Groove

Lip groove is on the external aspect of the arch and is not well defined.

Transverse Grooves

Each gum pad is divided into 10 small segments by grooves called as transverse grooves. These 10 parts correspond to the 10 developing primary teeth.

Lateral Sulcus

Transverse groove between canine and first molar region is called as lateral sulcus. They help in determining the interjaw relations at young age. Since the lower jaw is smaller than the upper jaw at birth, the lateral sulcus of lower arch lies distal to that of upper arch.

Gingival Groove

Gingival groove separates the gum pad from palate or the floor of mouth.

Most of the sulci and grooves present in gum pads at birth disappear with eruption of teeth.

Characteristics of Gum Pads

1. **Shape:** Both gum pads are almost similar to each other. The upper gum pad is U-shaped, while lower gum pad is horse shoe-shaped.
2. **Occlusal contact:** They touch in future primary first molar region only. It leads to the presence of anterior open bite (so it is a self-correcting malocclusion condition which does not require any treatment), which helps in anterior tongue positioning and making the lip seal during suckling (Fig. 8.2).
3. **Overjet:** Upper gum pad is wider and longer than the lower gum pad. When in occlusion, it covers the lower gum pad from all around, thus having a positive overjet in anterior and posterior regions.
4. **Skeletal class II effect:** Also, anterior overjet is more than normal, thus giving a skeletal class II effect, and thus a convex profile. It is due to smaller mandibular jaw as compared to upper jaw. The overjet diminishes markedly with age due to growth of lower jaw in accordance with

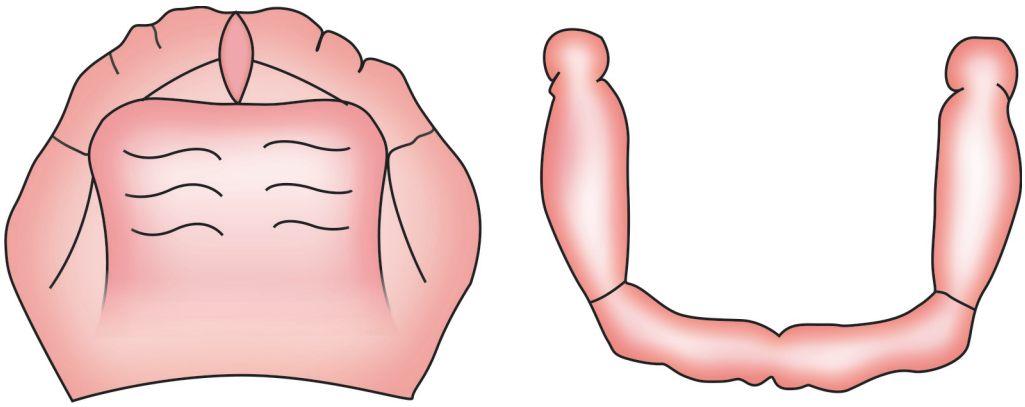

Fig. 8.1: Upper and lower gum pads

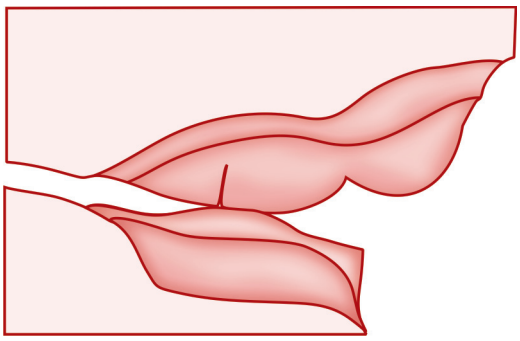

Fig. 8.2: Upper and lower gum pads occluding in future premolar region, with anterior open bite, and increased overjet.

the anteroposterior changes associated with cephalocaudal gradient of the skeletal growth.

5. **Neonatal jaw relationships:** Although the upper and lower gum pads touch in future primary first molar area, a precise bite or jaw relationship cannot be seen. Indeed at birth there is variability in the upper and lower gum pads, and so it can't be used as a diagnostic criterion for reliable predictions of subsequent occlusion in primary dentition.
6. **Anterior open bite:** The gum pads contact in the region of future primary first molar only, thus giving an anterior open bite. This helps in forward movement of tongue and making a tongue-lip seal during suckling. The mandible is controlled by the muscles of face, especially orbicularis oris, mentalis, etc. supplied by facial nerve. However, with the eruption of incisors, the child learns gradually to control the mandible with the masticatory muscles supplied by branches of mandibular nerve.

The space between the anterior segments of the gum pads has been classified as follows:

Class A: The maxillary and mandibular anterior segments lie in their respective planes.

Class B: In the maxillary, the incisor segments are higher than the canine segments, while in the mandibular, the anterior segments are in the same plane.

Class C: In the maxillary, the incisor segments are higher than the canine segments, while in the mandibular the canine segments are higher.

Class D: In the maxillary, the anterior segments are in the same plane, while in the mandibular, the canine segments are higher.

However, it has been found by studies that the anterior space between the gum pads at birth bears no relationship to future open-bite.

According to Leighton, the size of gum pads at birth may be affected by one of the following factors:

- The state of maturity of the infant at birth
- The size at birth as expressed by birth weight
- The size of the developing primary teeth
- Genetic factors.

Prematurely Erupted Primary Teeth

Natal teeth (i.e. present at birth), neonatal teeth (i.e. erupted during the first month), and pre-erupted (i.e. erupting during 2nd or 3rd months) may be present in some children. Teeth are generally the mandibular incisors. Familial tendency for these conditions also exists. They cause the problem during suckling. But, they should not be extracted without proper diagnosis, as they may be the normal primary teeth.

PRIMARY DENTITION PERIOD

It starts with the eruption of first primary tooth, usually the mandibular central incisors, at approx. 6 months of age; and extends upto 6 years of age till the eruption of first permanent tooth, usually mandibular first permanent molars (Fig. 8.3).

Sequence of Eruption

The sequence of eruption of primary teeth is ABDCE. Primary teeth start developing at 6th weeks of IU life. The first primary tooth erupts at approx. 6 months of age; and by 2½–3 years age, all primary teeth are present in the oral cavity. The lower teeth erupt before their upper counterparts, and females are ahead of males in eruption.

Fig. 8.3: Place for first permanent molar eruption.

Neuromuscular Consideration

The neuromuscular regulation of jaw relationship is important during the development of primary occlusion. During suckling before the eruption of incisors, the main jaw movement is forward and is supported by the facial muscles. After eruption of incisors, the mandibular movement is controlled mainly by masticatory muscles. As the new teeth erupt in oral cavity, the muscles learn to effect the necessary functional occlusal movements. First occlusal contact appears with eruption of D's. The teeth are guided into their occlusal position by the functions of muscles during active growth of facial skeleton. The low cusp height and occlusal wear also contribute to the adaptability of primary occlusion, with ensuing growth.

Before the incisors eruption, the mandible is moved in a forward direction for suckling. At this time, the articular eminence is flat, thereby allowing the forward movement of mandible. With growth, and with the eruption of incisors, the articular eminence also starts taking shape, and the incisal guidance is introduced by incisors. This IG is parallel to the height of articular eminence (which in turn provides the condylar guidance (CG). With further growth, and with eruption of permanent incisors, the articular eminence, CG and IG also increases, e.g. in class II division 2 cases, the IG and thus CG is longer due to deep bite.

During 3–4 years age, the dental arches are quite stable, with little or no changes observed. But at 5–6 years of age, size of dental arches changes due to eruption of first molars.

Characteristic Features of Primary Dentition

a. Shape of dental arches
b. Primary/developmental spaces
c. Primate spaces: These are the spaces found mesial to the maxillary cuspids and distal to the mandibular cuspids.
d. Deep bite due to upright incisors
e. Molar relationships.

Primary Dental Arch

Most primary arches are ovoid and show less variation in shape as compared to the permanent arches. In the early stages of development, the tongue plays an important role in the shaping of dental arches.

Occlusal Relation

At birth when the gum pads are in contact, the mandibular arch is posterior to the maxillary arch giving rise to **a skeletal class II relationship**. This difference reduces progressively with age, due to a cephalocaudal gradient of growth, leading to more growth of mandible than maxilla and thus reducing the skeletal class II effect. However, this skeletal class II relationship is a normal feature of dentition and no attempt should be performed to intervene with the nature at this stage.

First Occlusal Contact

The posterior occlusion/the intercuspation in primary dentition is first established by eruption and contact of primary first molars.

Molar Relation in Primary Dentition (Fig. 8.4)

According to Baume's classification of occlusion in primary dentition, there are 3 relations: according to the relation of distal surfaces of upper and lower primary second molars, as follows:

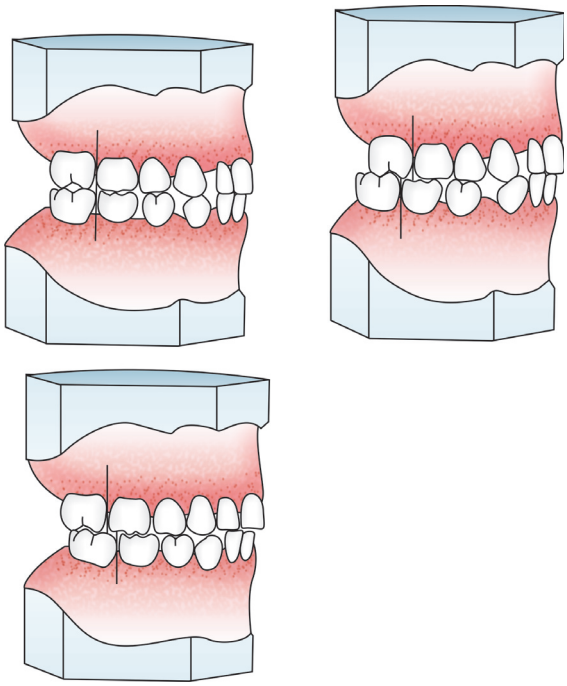

Fig. 8.4: Relation of upper and lower primary second molars: flush terminal plane; distal step; and mesial step relation.

1. Flush terminal plane	76% (to be observed most critically)
2. Mesial step	14%
3. Distal step	10%

Flush terminal plane: When the distal surfaces of upper and lower primary second molars are in the same plane, it is the flush terminal plane (FTP). The mesiolingual cusp of maxillary molars occludes in the central fossa of mandibular molars. The mesiodistal width of the mandibular 2nd primary molar is more than the maxillary, giving rise to, "*flush terminal plane*". Thus, the flush terminal plane relation is a normal relation of the developing dentition, and should not be disturbed with the treatment. The difference in the sizes of second primary molar and the second bicuspid is known as the **E-space**. This is greater in mandible than the maxilla, which is due to the fact that the size of mandibular second primary molar is large than the maxillary second primary molar.

When the terminal plane is straight, the first permanent molars are guided into an initial **"end-on" relationship** by the distal surfaces of primary second molars.

Mesial step: In mesial step, distal surface of lower second molar is mesial to that of upper second molar. It gives rise to skeletal class III tendency.

Distal step: In distal step, distal surface of lower second molar is distal to that of upper second molar. It gives rise to skeletal class II tendency.

Significance of the Primary Molar Relationships (Fig. 8.5)

They give an indication of future occlusion relation, and guide to achieve the permanent molar relationship in future.

Flush terminal plane:

- Change to end-on, if minimum growth differential is there.

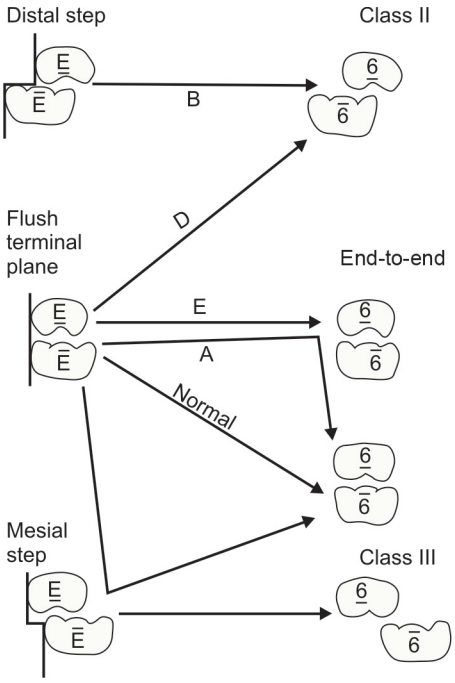

Fig. 8.5: Effect of deciduous molars relation on the relation of permanent first molars *(Redrawn from McDonald's).*

- Change in class I due to loss of leeway space of mandibular E.
- Change in class II if maxillary E is lost before mandibular E.
- It can change to class I if lower second molar is lost before upper.
- Chances of change in class I are also achieved with the growth of mandible.

Distal step:

- It almost changes to Angle's class II molar relation. It is due to the already locked inclined plane relationship of primary molars in distal step fashion, that they guide the permanent molars in Angle's class II relation.
- Change to class II, if minimum growth differential is there.
- Change in end-on, by loss of leeway space and forward mandibular growth.
- Rarely, it can change to class I, if lower second molar is lost before upper.

Mesial step

- It almost changes to Angle's class III molar relation. It is due to the already locked inclined plane relationship of primary molars in mesial step fashion, that they guide the permanent molars in Angle's class III relation.
- It rarely changes to class I if upper second molar is lost before lower.
- It can also change to class I if minimum growth differential of jaws is there.
- Mostly, it changes to Angle's class III, due to loss of leeway space and forward mandibular growth.

Local Factors

Interproximal caries, sucking habits, or a skeletal pattern may produce a "*step*" rather than a flush terminal plane. In people with coarse diets, occlusal surfaces of primary teeth wear to a great extent. The removal of these cuspal interferences permits mandible to move forward as it is growing faster than the maxilla. It also helps in correction of skeletal class II relation. But if there is no natural occlusal wear, a functional retraction of the mandible may occur during closure due to inclined plane effect of the cusps, which then maintains the mandible in skeletal class II relation.

Spacing in Primary Dentition (Figs 8.6a and b; 8.7)

It is a normal and important feature which helps in proper alignment of permanent teeth in the arches. Following types of spacing can be observed.

Primary Spacing/Physiological/ Developmental Spacing

It is a normal developmental sequence, a self-correcting anomaly; and is an important

(a)

(b)

Figs 8.6a and b: Spacing in the primary dentition is important for alignment of permanent teeth in the dental arches because permanent teeth are bigger in MD size than primary teeth and need more space.

Fig. 8.7: An ideal condition of developmental spaces in primary dentition, which is important for alignment of the permanent teeth in arches.

Fig. 8.9: Closed primary dentition, and mild crowding in lower incisal region. Crowding in primary teeth is a sure sign of future crowding in permanent dentition.

requirement for proper development of dentition. It appears due to active skeletal growth. It helps in proper alignment of permanent teeth which are wider than primary teeth. It occurs 70% of time in maxilla and 63% in mandible. Spaces are more in maxillary arch than the mandibular arch.

Open Dentition and a Closed Dentition
(Figs 8.8 and 8.9)

If developmental spacing in deciduous dentition is present, it is known as open dentition. If there is no spacing, it is known as a closed dentition. Mean increase in the intercanine width is more in closed dentition as compared to open dentition, so that there is no excessive space for erupting incisors.

Fig. 8.8: Physiological spaces in both arches. It is known as open dentition.

Primate/Simian/Anthropoid Spaces
(Figs 8.10 and 8.11)

These are found mesial to primary maxillary canines and distal to primary mandibular canines; named so as it is found in primates, i.e. between BC/CD. They help in proper interdigitation of canines, because of larger MD size of upper canine than lower, and presence of more I/D spaces in upper than the lower arch.

Fig. 8.10: Developmental and primate spacing in primary teeth which is a normal and necessary condition.

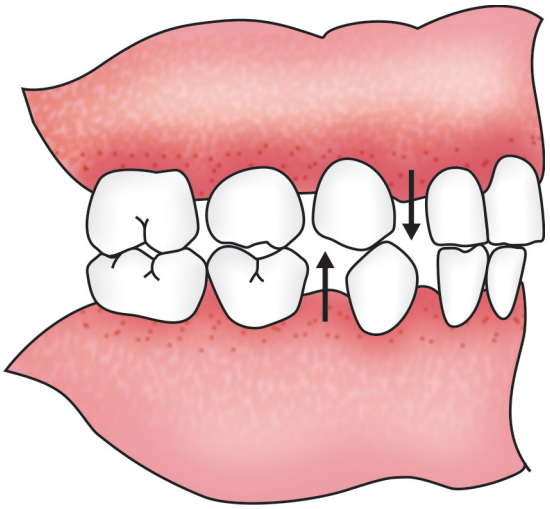

Fig. 8.11: Primate spaces in both arches, which are found mesial to canines in upper arch, and distal to canine in lower arch.

Fig. 8.12: Crowding in the primary dentition implies the space deficiency and a future crowding in the permanent dentition.

Importance of Spacing in the Primary Dentition (Fig. 8.12)

It helps in proper alignment of permanent teeth in the arches, since the size of permanent teeth are larger than the primary teeth. Given below in the table are the possibilities of crowding in permanent dentition depending on the amount of spacing present in the deciduous dentition.

Class	*In deciduous teeth*	*Crowding chances in permanent teeth*
I	Crowded	10 in 10
II	No spaces	7 in 10
III	< 3 mm spacing	5 in 10
IV	3–6 mm spacing	2 in 10
V	> 6 mm spacing	None

Deep Bite in the Primary Dentition

A relative deep bite exists in incisal region, which is due to more upright/vertical position of the incisors. It is due to a larger interincisal angle (170°) than in the permanent incisors (130°). It decreases due to attrition of primary incisors, eruption of primary molars and by forward mandibular growth (Fig. 8.13).

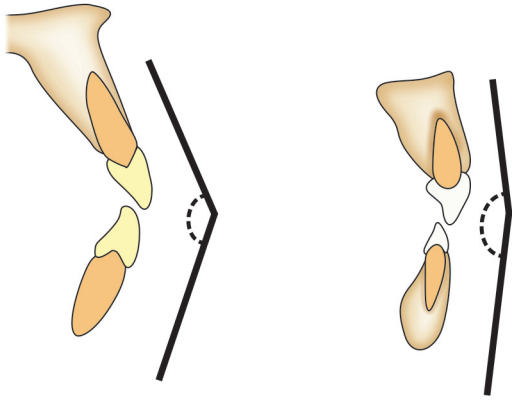

Fig. 8.13: Interincisal angle in permanent teeth is less than that in primary teeth, i.e. primary incisors are more upright in position.

Bite depth in permanent dentition is less than in primary dentition. It is due to decreased interincisal angle, due to forward eruption of permanent incisors. Also they are not that upright on their basal bone.

Since in orthodontics, bite depth is generally considered as the percentage of the overlap of lower incisors (by the upper incisors) to the total height of crowns of lower incisors. So, although the overlap in mili-meters in primary dentition may be less than in permanent dentition, the percentage of overlap in primary dentition is more than the permanent dentition.

Self-correcting Anomalies

There are certain features of the dentition which are naturally present in developing dentition at various stages, they look abnormal features at that age, but are naturally-occurring and essential features of development of occlusion. They should be known to every dentist and should not be interfered with treatment procedures. The worried parents should also be comforted by proper explanation.

The following normal signs of primary dentition should be noted:

- Spaced anteriors
- Primate spaces
- Straight terminal plane
- Almost vertical inclination of anterior teeth
- Small mandible, convex profile.

Why a class III relationship is very rare in primary dentition period? Normally, in primary dentition, an equivalent of class III is never/very rarely seen, due to growth pattern of mandible, which lags behind the maxilla. Also C2D2 is not seen in primary dentition. However, abnormal growth can lead to such problems even in primary dentition (Figs 8.14 and 8.15).

Fig. 8.14: Concave profile due to mandibular prognathism in a small child.

Fig. 8.15: Anterior crossbite and mesial step of primary E's.

THE MIXED DENTITION PERIOD

It is the period of dentition when a few primary and permanent teeth are present in the mouth. It begins with the eruption of first permanent molars at 6 years of age, generally in end-on relationship. It also marks the stage I of natural bite opening.

Natural Bite Opening (Fig. 8.16)

It is the decrease in the overbite due to eruption of the permanent molars in the oral cavity. It occurs three times in the life of an individual, i.e. at the time of eruption of first, second and third permanent molars. So, the permanent molars are called as natural bite openers.

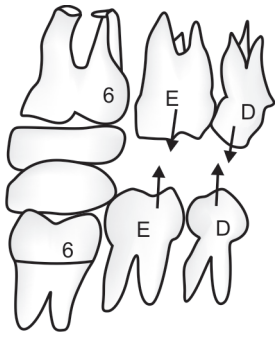

Fig. 8.16: Extrusion of primary teeth and thus correction of deep bite when the soft tissues on erupting permanent first molars lead to some occlusal gap in which primary teeth erupt.

Mechanism of Natural Bite Opening

When the molars erupt, the soft tissue overlying the molars is swollen and it comes in contact during mastication or swallowing and causes pain. So, the patients learn to keep the contact away from it. It causes a gap in the area anterior to molar region and leads to supraeruption of the teeth, and thus the bite opening.

Occlusal changes in the mixed dentition: The mixed dentition can be divided into three phases.

- First transitional period
- Intertransitional period/rest period
- Second transitional period.

Fig. 8.17: Early mixed dentition stage showing lower incisal crowding.

First Transitional Period (Fig. 8.17)

It is also called as early mixed dentition period (MDP). It is characterized by emergence of first permanent molars and incisors teeth in lower and upper arches. Mostly, the lower teeth erupt before upper teeth. This phase is seen during 6–8 years of age. Here, we can see the three relations of permanent first molars, viz. end-on, class II, and class III, depending on the relation of primary second molars. Correction of end-on relation to class I occurs by utilization of physiologic space, leeway space and differential forward growth of the mandible (Figs 8.18 and 8.19).

Emergence of First Permanent Molars (Figs 8.20 and 8.21)

The mandibular first molar is generally the first permanent tooth to erupt at around 6 years. The first permanent molars are guided into the dental arch by the distal surfaces of the second deciduous molars. As discussed before, the mesiodistal relationship between the distal surfaces of the upper and lower second deciduous molars can be of three types:

1. **Flush terminal plane** (Fig. 8.22): The distal surfaces of the upper and lower deciduous molars is in one vertical plane

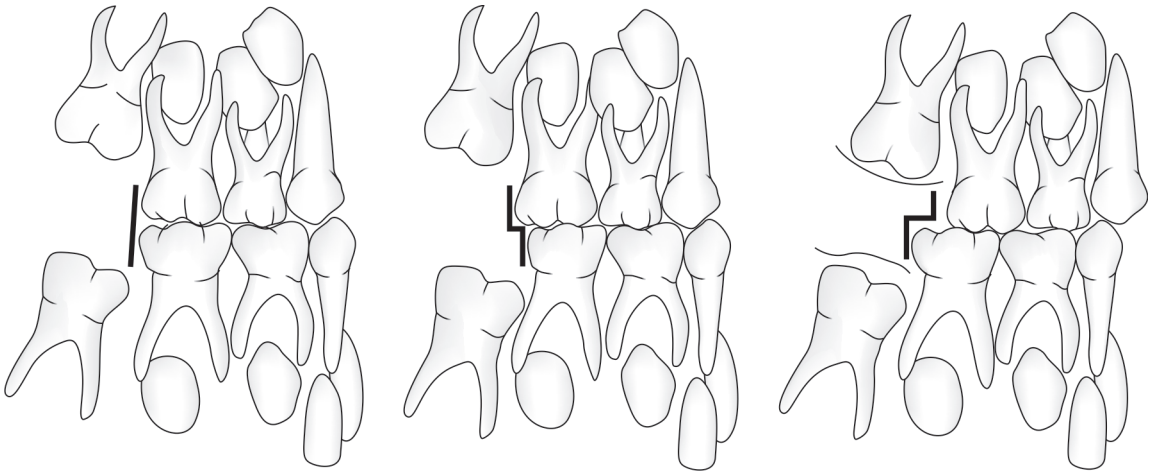

Fig. 8.18: Different molar relationships in primary dentition, and their effect on the eruption of permanent first molars relation *(Redrawn from Graber and Swain)*.

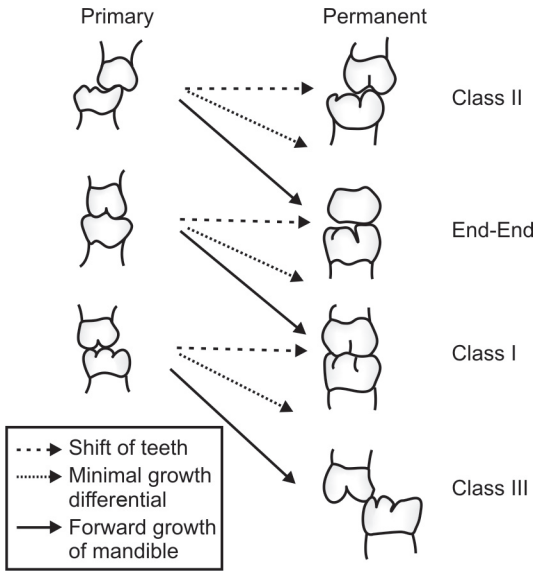

Fig. 8.19: Molar relation of primary teeth and the ensuing effect of growth on the final relation of permanent molars *(Redrawn from Proffit and Fields)*.

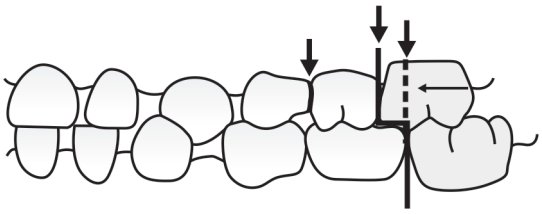

Fig. 8.20: How the distal caries on upper primary second molar leads to space loss with mesial migration of permanent first molar and thus a change in occlusal relation toward Angle's class II *(Redrawn from Graber and Swain)*.

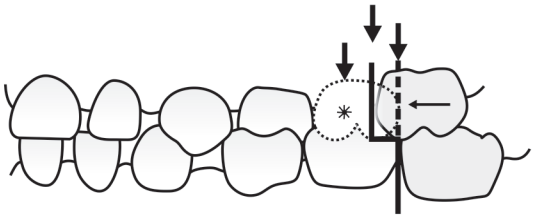

Fig. 8.21: How the early loss of upper primary second molar leads to space loss with mesial migration of permanent first molar and thus a change in occlusal relation toward Angle's class II*(Redrawn from Graber and Swain)*.

called as flush or vertical terminal plane, thus the erupting permanent first molars are in end-on relationship. For them to end in class I molar relation, the lower molar has to move forward by 3–5 mm relative to upper molar. This occurs by utilization of physiological spaces and leeway spaces in lower arch and by differential forward growth of the mandible. The shift of lower molar from a flush terminal plane to class I relation, occurs by early and late shift.

Early mesial shift (Fig. 8.23): It is a phenomenon which is observed in open dentition at 6–7 years of age, and it occurs due to closure of primate spaces by pressure of erupting permanent molars. It leads to conversion of FTP relation into class I relationship. However, it is not a good feature as per the development of dentition, as it leads to a future space crunch in the arches, and generally leads to the development of crowding. An observant parent and an orthodontist can save this space loss by cementing proper appliance at a proper timing so as to avoid mesial movements of the permanent molars, e.g. lingual holding arch, Nance palatal arch, etc.

Late mesial shift: It occurs in closed dentitions at 10–11 years age (Fig. 8.24). First permanent molars shift mesially due to closure of leeway spaces after shedding of primary second molars. It also leads to loss of E-space, which may be utilised for alignment of teeth by the orthodontist. So, a close watch should be kept during this period and if possible and required, this space should be preserved by putting appropriate space managing appliances in the dental arches.

Since, the orthodontist has to be very vigilant regarding the maintenance of spaces during the mixed dentition period, this period can also be termed as space-age.

Many children lack the primate spaces. In these cases, the permanent

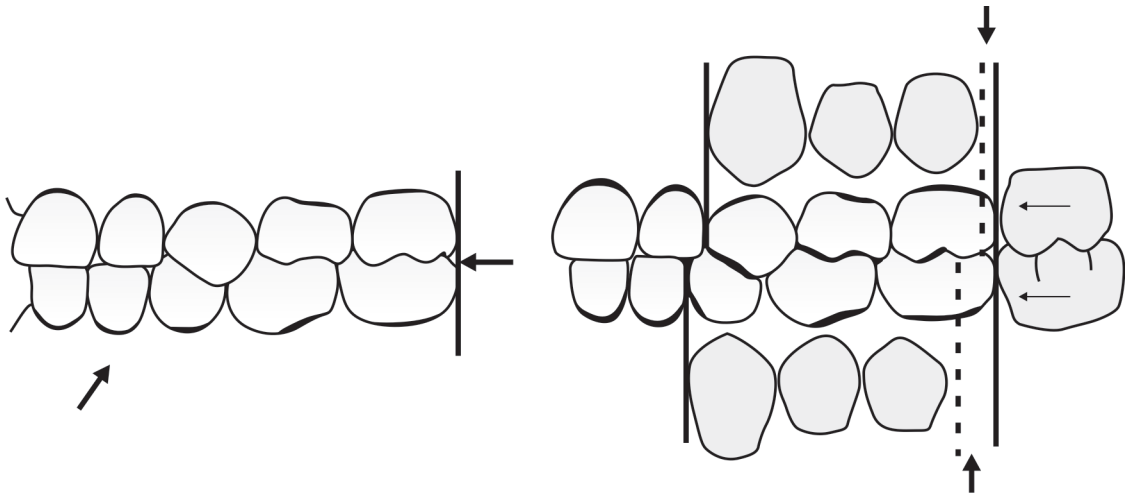

Fig. 8.22: Edge-on relation of permanent first molars when primary molars are in flush terminal plane relation. It gets converted in Angle's class I relation later on when leeway space is utilized *(Redrawn from Graber and Swain)*.

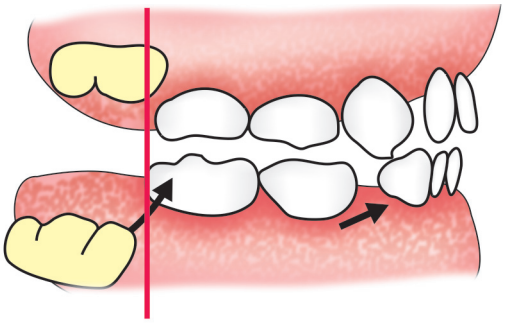

Fig. 8.23: Early mesial shift in the lower primate space.

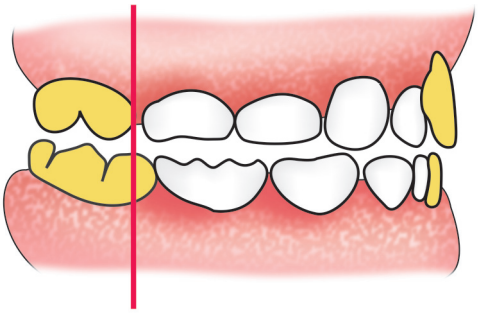

Fig. 8.24: Closed dentition, in which late mesial shift will take place when primary second molar will be lost

molars drift mesially utilizing the leeway space. This occurs in the late mixed dentition period.

2. **Mesial step terminal plane:** Here, the distal surface of lower primary 2nd molar is mesial to that of the upper. The permanent molars erupt directly into Angle's class I relation. It occurs due to early forward growth of mandible. If this differential growth of the mandible in a forward direction persists and is more, it can lead to skeletal and dental class III malocclusion.
3. **Distal step terminal plane:** It is characterized by the distal surface of the lower 2nd deciduous molar being distal to that of the upper. The erupting permanent molars generally are in class II relation.

The Exchange of Incisors

Incisal liability: The mandibular central incisors generally are first to erupt at 6–7 years. The permanent incisors are of larger width than the deciduous teeth. So, they require more space for alignment. This difference between the amount of space needed for the accommodation of permanent incisors and the amount of space available is called as incisal liability. It is 7.6 mm for the maxillary and 6.0 mm for the mandibular arch approximately.

The incisal liabilty exists in one of the three forms:

1. The favorable incisor liability is when primary spaces of the spaced dentition are sufficient to allow for the eruption of the permanent incisor without any crowding.
2. It is precarious when some amount of primary spacing is present in primary dentition. And then the individual must rely on secondary spacing to create sufficient space for the permanent incisors to erupt without crowding.
3. A difficult situation exists when the incisor liability is of such kinds that the growth and development will never be able to meet the space demands required by the permanent incisors, which leads to severe crowding and irregularities.

Naturally, the incisal liablity is overcome by following factors, known as **Warren Mayne's principles** (Table 8.1, Fig. 8.25).

1. Utilization of interdental spaces in the primary dentition.
2. Increase in the intercanine width
3. Change in incisor inclination.

Interdental spacings appear in both arches, especially in anterior region, with the ensuing growth. It occurs especially due to the transverse growth of jaw bases (remember, the sequence TSV). Sagittal growth mainly occurs distal to the molars, and does not contribute to any spacing in anterior region. It can also be seen that at this age, the transverse growth is more rapid, and also the growth in the transverse plane is first to be completed in the jaws.

Increase in intercanine width occurs more in males as compared to females, M > F, and more in upper arch as compared to lower arch, U > L. So, the girls have greater liability to incisor crowding.

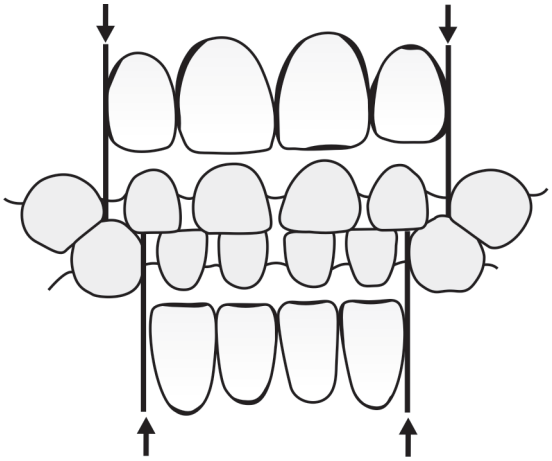

Fig. 8.25: Physiological spaces in incisal regions, and the compensation of incisal liability in both the arches. Note that how the presence of upper primate spaces helps in accommodation of bigger permanent incisors in the arch *(Redrawn from Graber and Swain)*.

By the age of eruption of lateral incisors, the intercanine width in each arch is gained by 3 mm. Also, an increase of 1.5 mm in upper arch is also attained with the eruption of upper canines. So, the primary canines should not be restricted by any clasps or space maintainer during this time.

Intercanine width in mandibular arch does not increase after 9 years of age in both the sexes. But in maxillary arch, it increases upto 16 years in males and upto 12 years in females. Thus, expansion of maxillary arch should be commenced in females at early age to take advantage of growth. In mandible, the arch expansion by natural development is possible till 9 years of age. It can be achieved by oral screen appliances or other passive/myofunctional appliances. Once the width of lower arch is established, it cannot be increased mechanically. Any attempt to increase the width needs

Table 8.1: Incisal liability

Method	*Maxilla*	*Mandible*
I/D spacing	0–10 mm, average 4 mm	0–6 mm, average 3 mm
Increase in intercanine width	4.5 mm	3.0 mm
Incisor position	2.2 mm	1.3 mm

a permanent retainer, otherwise it gets relapsed.

Forward position/eruption of incisors: It also contributes to some spaces in arches. The permanent incisors buds are positioned lingual to the primary incisors, but their erupt on more labially inclined, i.e. they are not that much upright as the primary teeth. Thus they acquire a wider arc of the circle and a larger perimeter (Fig. 8.26).

Repositioning of primary mandibular canines occurs distally, in the primate spaces when mandibular lateral incisors erupt and push the mandibular primary canine there, which also give approx. 1 mm space. But, this phenomenon does not occur in maxillary arch, as primate space is already between B and C there.

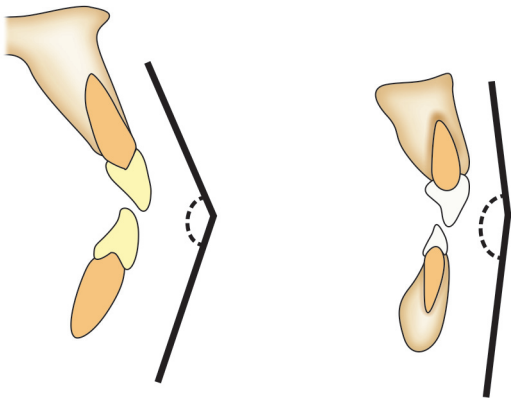

Fig. 8.26: Interincisal angle in permanent and primary dentition.

Secondary Spacing (Fig. 8.27)

It occurs in closed dentition with eruption of lower incisors, which pushes primary mandibular canine laterally. It creates space for proper eruption of maxillary lateral incisors. It helps to increase the intercanine width in both arches and increase in arch circumference in maxilla.

Normally, the lower incisors erupt in mild crowding stage. Crowding of upto 2 mm gets resolved by natural growth and alignment of teeth under tongue pressure. More crowding does not resolve by itself. Also, if any crowding does not resolve itself by the age of 8 years, it is highly unlikely to be resolved by any other natural process after this age, and will need some interceptive or corrective procedures later in life.

Also, the primary maxillary canines should not be extracted at an earlier age, esp during serial extractions. It is because erupting permanent canines help in increasing the intercanine width in maxilla. If primary maxillary canines are extracted at an earlier age, the stimulus of eruption of permanent canines is lost, which may lead to their impaction or deflection in their path of eruption. Also, the maxillary intercanine width increase is not proper. In some cases, if crowding is there, then it is better to slice the mesial surfaces of the primary canines, so as to provide some space for proper eruption/alignment of the erupting incisors.

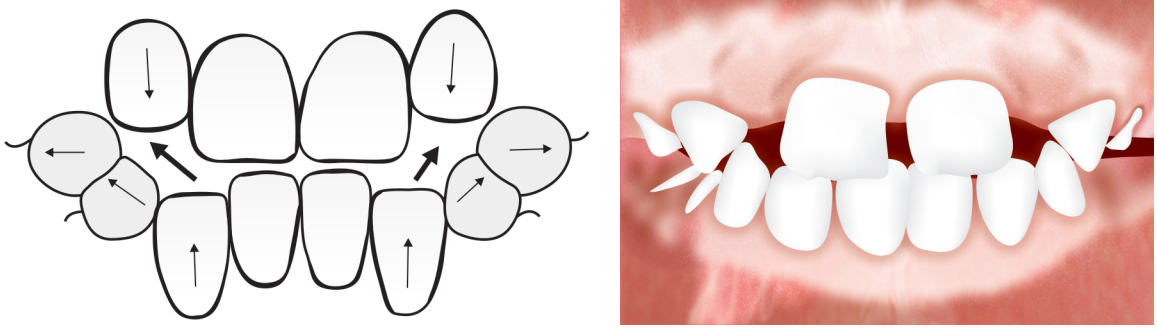

Fig. 8.27: Phenomenon of secondary spacing when erupting lower lateral incisors push the primary canines distally to gain space for alignment *(Redrawn from Graber and Swain)*.

Intertransitional Period

This is the phase when no change in status of dentition is observed, but only growth of the jaws is taking place. Thus, it can be considered as a stable phase or a **period of rest**. However, continuing skeletal growth helps in increasing the width and length of basal bones, which is to be subsequently used for the alignment of other succedaneous teeth. It generally extends in 8–9 years of age.

Second Transitional Period

It is also called as late mixed dentition period. It is characterized by replacement of deciduous molars and canines by their successors. It generally starts after 9 years of age with the eruption of mandibular permanent canines. This is an important phase of development, as the changes in dentition and jaw growth are rapid and going on simultaneously. It is the age of prepubertal growth spurt when basal jaw growth in length and width take place. According to Graber, the main growth spurts seen in children are as follows.

Spurt	*Females*	*Males*
Childhood	3 years	3 years
Juvenile	6–7 years	7–9 years
Prepubertal	11–12 years	13–15 years

The sequence of growth completion in face is WDH, i.e. width completes first, then the depth and then the height in the last. The jaws follow the same sequence as face, i.e. general growth curve. So, the treatment of expansion should be done at an early age to take advantage of the ensuing growth in width. The expansion should best be done in the age range of 8–10 years, followed by period of retention. In cranium, the sequence of growth completion is WHD, i.e. width completes first, then the height and then the depth in the last. The cranium follows the neural growth curve.

The following features are noted during this stage:

1. Ugly-duckling stage
2. Conversion of first molar relationship, by the use of leeway space of Nance.
3. Late mesial shift
4. Growth of jaws and reduction of bite depth, skeletal convexity, etc.

Leeway Space of Nance

The combined mesiodistal width of permanent canines and premolars is usually less than that of the deciduous canines and molars. The surplus space is called as leeway space of Nance. It is 1.8 mm in the maxillary (0.9 mm per side) and 3.4 mm (1.7 mm per side) in the mandibular arch. It is more in lower arch because the size of lower primary second molar is larger than upper. The difference in the size of primary second molar and the second premolar is called the **E-space**. It is bigger in lower than in upper arch. This space is utilized by the mesial drift of the permanent molars, more for mandibular molars, to establish an Angle's class I molar relation from flush terminal plane relation (Fig. 8.28).

Importance of this space: This space is generally gets used during eruption by mesial drift of permanent first molars after the loss of primary second molars. In certain cases, the conservation of this space becomes very important during the development of dentition, as an interceptive procedure. This preserved space can be used for alignment of teeth in the arches, when erupting 2nd premolars drift distally giving space for teeth anterior to them.

Indications of preservations: Certain conditions, e.g. closed dentition; cases of mild lower incisors crowding; loss of space due to premature loss of primary tooth especially in maxillary primary second molar region; cases requiring maxillary molar distalization to correct molar relationship, etc. The decision depends on the clinical accumenship of the orthodontist. But, conservation of this space can be very useful in future orthodontic treatment and can help convert an extraction case to a nonextraction case, and also helps in conservation of the anchorage.

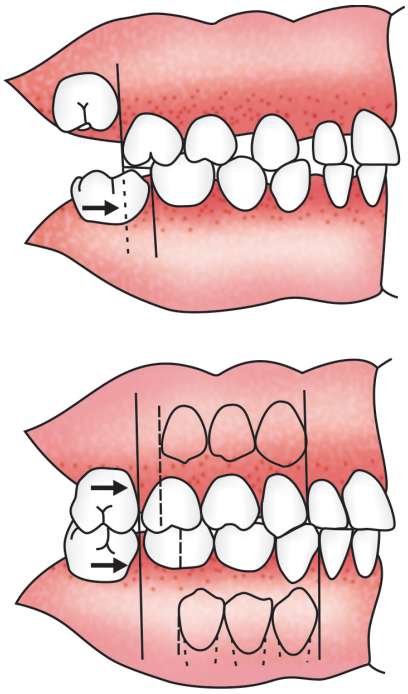

Fig. 8.28: Eruption of lower first molar in mesial position when there is mesial step. Second fig showing leeway space of Nance in upper and lower buccal regions. Note upper leeway space is less than lower.

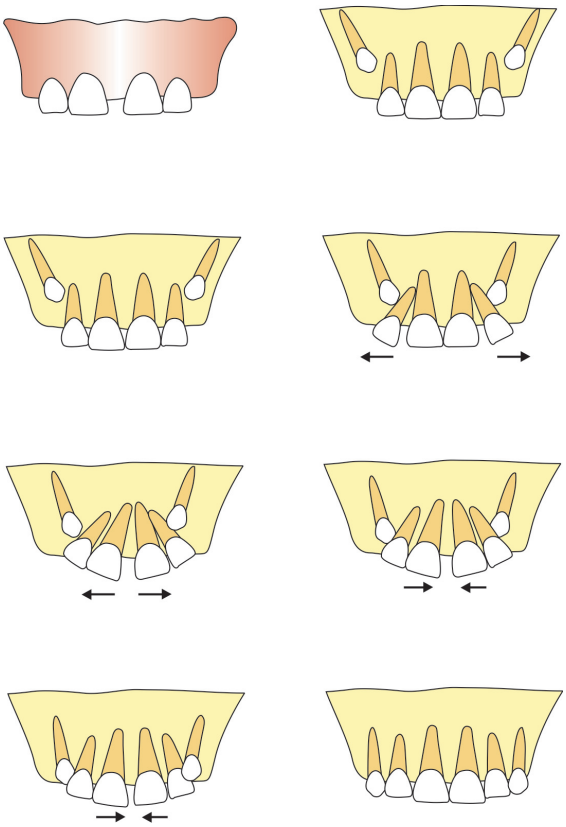

Fig. 8.29: Ugly-duckling stage: Note that the erupting permanent canines, while sliding along the roots of lateral incisors, lead to root crowding of incisors and flaring of crowns distally thus creating spaces. Later on, when canines slide along the crowns of lateral incisors, apply mesial forces thus closing the spaces and uprighting the crowns. Thus, it is a self-correcting anomaly.

Appliances needed: Certain appliances, e.g. transpalatal arch, Nance's palatal arch, lingual holding arch, etc. can be used to preserve this space. During fixed appliance therapy, this space can be preserved by making bent-in stop loops in the arch wires; by using open coil spring; by using arch sleeves; headgear, etc. which do not allow the molars to drift forward.

THE UGLY-DUCKLING STAGE (Fig. 8.29)

It is a transient or self correcting condition which starts in the maxillary incisor region between 8 and 9 years, when the permanent canines start their eruptive movements within the bone. Maxillary canines are generally the last succedaneous teeth to erupt in oral cavity as they have to traverse a very long path of eruption from their initial position near the floor of maxillary sinuses. As they erupt, they apply physiological forces and displace the roots of upper lateral incisors mesially. It results in transmitting the forces on roots of central incisors also, which also get displaced mesially, creating a **root-crowding**. In reciprocation, the crowns of incisors move distally, thus opening the spaces between them. This resultant divergence of crowns of incisors and spacing has been called by Broadbent as the ugly-duckling stage (Fig. 8.30).

Do not Disturb this Condition

This condition corrects itself when the canines erupt and the pressure of canines is transferred from the root to the coronal area of

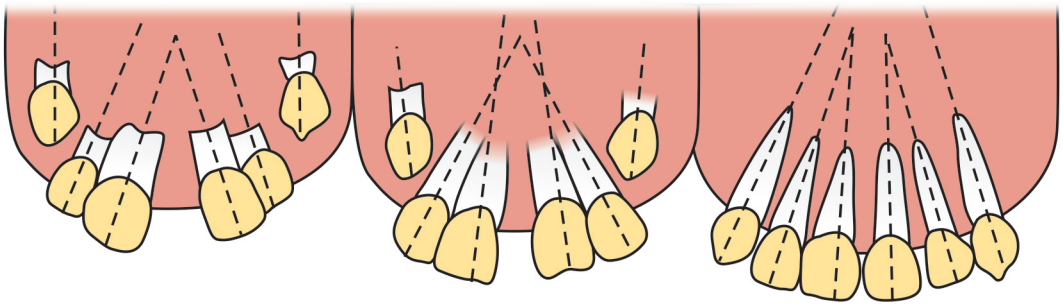

Fig. 8.30: Various phases of ugly-duckling stage.

incisors. It is very important to know here that this stage should not be disturbed by any orthodontic intervention, (unless the spaces present are more than normal, and inhibit the eruption of canines). If an attempt is done to close these spaces, it may cause root resorption of lateral incisors, which strike the canines during their orthodontic tipping movement. They may also cause deflection of path of eruption of canines leading to their impaction or malalignment.

A midline space between central incisors may also be present due to lower attachment of labial frenum. The frenum normally gets receeded due to growth of alveolar height with eruption of incisors. This space should not be attempted to close and we should wait till eruption of canines. Sometimes, it gets closed itself by the pressure of incisors causing pressure atrophy of frenum, thus removing the resistance/cause. But, if this space is larger due to some other factor, e.g. supernumerary tooth, or larger basal bone size, etc. and if it is expected to cause ectopic eruption of adjacent teeth, then it needs orthodontic intervention to close some part of the space.

Eruption of Permanent First Molars

It occurs at around 6 years of age, and the lower molar erupts before the upper molar. In majority of children, the first permanent molars erupt prior to the central incisor. The occlusal relationship that the first permanent molars initially obtain with each other is determined by the terminal plane relationship of the primary second molars which is generally end-on. During formation, the crowns of the maxillary molars face distally rather than occlusally. As the maxilla grows forward, space is created posteriorly, permitting the growth of maxillary tuberosity. It helps the first molar to rotate and by the time the crown pierces the gingiva, it is facing more occlusally.

Eruption of Incisors

Lower incisors generally erupt before upper incisors. In mandible, although the incisors erupt after permanent molars, they reach their clinical crown height earlier. The permanent incisors develop lingual to the roots of the primary incisors, causing their root resorption on lingual side, forcing them to get exfoliated. But, they erupt in a labially inclined direction in a larger perimeter as compared to the primary incisors. Also the interincisal angle of permanent incisors is less than the primary incisors. It helps in accommodating some incisal liability.

When the primary central incisors get exfoliated, their successors move labially under the influence of tongue pressure. The balance of forces of tongue and the buccolabial musculature help to attain a proper arch form. Sometimes, the primary incisors do not exfoliate but permanent incisors appear lingual to them, thus creating rotations and crowding. If this situation is allowed to progress, then it leads to development of crossbite of the tooth/teeth. The primary incisors should be extracted as soon as possible to pave way for permanent teeth to take their aligned position.

There are certain criteria which help to determine whether the permanent incisors will appear crowded or not are: size difference

of primary and permanent teeth; amount of physiologic spacing in the arches; and the size of perimeter of dental arches.

Generally, the lower incisors erupt in a state of crowding, which is considered normal upto 2 mm. It gets resolved itself due to ongoing skeletal jaw growth and under the influence of tongue pressure. More than 2 mm crowding does not resolve itself. If this crowding is not resolved by the time the lateral incisors have completely erupted, i.e. 7–8 years of age, then it will need orthodontic intervention.

During eruption, the mandibular lateral incisors push the primary lateral incisors labially but also move the cuspids distally and laterally. It leads to closing the primate spaces, and helps to create some space (known as secondary spacing) for alignment of lower incisors.

When the mandibular primary cuspids are prematurely lost, the lower incisors may get tipped lingually under the influence of hyperactive mentalis, leading to increased overjet. It leads to a loss of space in dental arch from the anterior side, and is a strong indication of future crowding. It warrants a closer and regular follow-up of the case for a proper and timely guidance of eruption or serial extractions and may need LHA for prevention of lingual tipping. Lingual tipping of incisors also leads to labial eruption of permanent cuspid. A premature loss of primary canines occurs due to small arch or jaw size; and is an indication of future crowding.

The maxillary anterior dental segment is supported by the mandibular, providing functional stops against which the maxillary incisors erupt. The maxillary permanent incisors erupt with a more labial inclination than their predecessors and in a larger arch perimeter, thus reducing the incisal liability.

Safety Valve Mechanism

It is the nature's attempt to maintain a proper occlusion during growth. The intercanine width in mandible is completed at 9 years in females, and at 10 years in males. In maxilla, it is completed at 12 years in girls and at 18 years in boys. This delay in the increase in intercanine width of maxilla serves as the safety valve during the pubertal growth spurt for the mandible. The amounts of horizontal increments of maxilla and mandible are different during pubertal growth spurt, in accordance with the cephalocaudal gradient of growth. The horizontal increments of mandible are more than the maxilla. So when the mandible comes forward during growth spurt (mandible's forward growth being more than maxilla) and for long-time, its wider posterior part comes in approximation with a narrower anterior part of maxillary arch. If this relation gets maintained, it will lead to crossbite situation. Here, the maxillary intercanine width comes as a savior, and an increasing intercanine width helps in gaining a width of maxillary arch. This helps in adjusting the broader part of forwardly-moved mandibular arch to the maxillary arch, when mandible comes forward during growth.

Eruption of Canines and Premolars (Fig. 8.31)

Normal development of occlusion depends on factors like a favorable sequence of eruption; normal tooth size–arch size ratio without any discrepancy; a normal molar relationship with minimal loss of leeway space; and a favorable buccolingual relationship of the alveolar processes.

Mandibular Arch

The most favorable sequence of eruption in mandibular arch is 61234578. The cuspids erupt at 9 years of age and lead to a final gain in intercanine width. They help in maintaining the anterior arch perimeter and prevent the lingual tipping of incisors. On the contrary, if primary canines get lost prematurely, and there is time for eruption of permanent canines, the lower incisors tip lingually under the pressure of lower lips. It leads to the loss of their centric stops with maxillary incisors. Thus, they overerupt until they find the occlusal stops, either with upper teeth or the palatal mucosa, leading to deep bite. If first premolars erupt before the

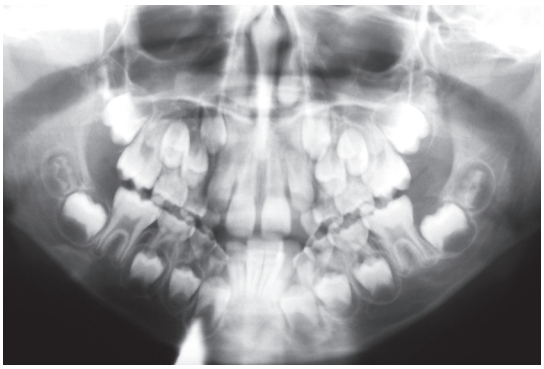

Fig. 8.31: OPG showing normal development of teeth.

canine/s, they take up some of the space meant for canines, and cause them to erupt into labioversion/labially blocked out situation.

Second bicuspid is the last tooth to erupt in lower arch. If space needed has been lost partially or completely (by gross caries or by premature extraction of primary 2nd molars without space maintainers, etc.), then there will be a shortening of the arch perimeter by mesial movement of permanent first molar. Then the said premolar gets either deflected buccally or lingually, or gets impacted. So it is necessary to maintain the arch space/perimeter by using space maintainer. All attempts should be done to maintain primary 2nd molars to avoid their extraction, or proper space maintainers should be given. It should be remembered that the primary teeth are the best space maintainers. In many cases, lower 2nd bicuspids are congenitally missing. There the primary 2nd molars may/may not be maintained depending on the crowding; need and consent of the patient/parents.

Maxillary Arch

The normal sequence of dental eruption in maxilla is either 61245378, or 61243578. Leeway space in upper arch is less than the lower arch due to difference in the size of primary 2nd molars. This leeway space is required for accommodation of the wider permanent teeth. Canines erupt generally at 11½–12 years age, and they help in increase in intercanine width during eruption. intercanine width is also gained by basal jaw growth during this age, as the adolescent growth spurt is active at this age. It helps in providing space for accommodation of canines. There should be no space loss during this phase; and also the permanent first molars must not be allowed to rotate and tip mesially. If space loss occurs, the cuspid is likely to be labially blocked out of the arch.

Maxillary anterior segment is easily displaced labially by thumb sucking, tongue thrusting, or a hyperactive mentalis muscle causing lower lip trap. And such displacement affects the eruptive pattern of the cuspid and bicuspid.

Eruption of Second Molars

The second permanent molars should erupt after eruption of canines. But, if permanent second molars erupt before second bicuspids but after the loss of primary second molar, they will force first molars to shift mesially. It leads to loss of leeway space and thus crowding/palatal eruption of second bicuspids. This condition should be recognised early and proper space maintainer should be given to prevent space loss.

The mandibular second molar appears before the maxillary and both of them generally appear after all teeth have erupted in the mouth. The eruption of maxillary second molar prior to the mandibular is symptomatic of developing Angle's class II malocclusion.

PERMANENT DENTITION PERIOD

When all the primary teeth have been lost, and the oral cavity has only the permanent teeth, this stage is called as permanent dentition period. Normally, it starts with the loss of either maxillary second primary molar or the canines, which are the last erupting permanent tooth. It generally starts at 11½–12 years of age.

Eruption of Second Molars

It starts erupting at around 12 years of age. The space distal to first permanent molars is

created by continuing growth of maxillary tuberosity, and by resorption of anterior border of ramus. Generally, the lower molars erupt before the upper; and teeth in females erupt before males.

Dentition of Young Adults

Third molar eruption: They show great variability in calcification and eruption. Normally, they erupt in 18–25 years age. Their eruption has also been linked to crowding of mandibular incisors during late teen period, but has now been largely disapproved. Incisor crowding is more common in men than women. This late lower arch crowding has been found to be associated with the late mandibular growth phenomenon.

They get impacted also due to lack of space. It can be due to evolutionary trend of small size of mandible due to the use of soft food in modern civilisation, to use of softer foods and thus loss of functional stimulation for the growth of mandible. Also there is less proximal attrition and mesial shifting of teeth. Thus, space for third molar is not created.

Dimensional Changes

Maxillary and mandibular arch widths do not show appreciable changes. Once established, the mandibular intercanine width cannot be changed. The arch length also does not increase, but shows a continued shortening of arch perimeter due to attrition and mesial shifting of teeth from posterior side; and by lingual tipping of lower incisors under the influence of late mandibular growth.

Occlusal Changes

Both overjet and overbite decrease throughout the 2nd decade of life, probably due to forward growth of mandible. Natural bite opening effects are seen at the time of eruption of first, second and third permanent molars.

Conclusion

The development of dentition is a very important phase during the growth of individual. The teeth are directed in the arches under the influence of growth and muscular forces. The teeth act as functional matrices for the alveolar bone growth. The dentition passes through various phases which need to be monitored carefully to take the best advantages of growth of jaws, the spaces and eruption sequence of the teeth. With the help of proper appliances and monitoring, the developing malocclusions can be intercepted timely to reduce the severity or to completely eliminate the developing conditions. A proper knowledge of the normal features of developing dentition is very important, which should not be interfered. However, any mechanical interference in normal path of eruption should be removed timely for normal eruption of teeth and development of dental arches.

VIVA VOCE QUESTIONS

1. **How much mesial movement of the permanent first molar is required for attaining class I relation from the FTP?**
   Approx. 3.5 mm of movement of mandibular first molar forward with respect to maxillary first molar is required for smooth transition to class I relation in permanent dentition (i.e. a one-half cusp transition in molar relation).

2. **What is intertransitional period?**
   It is a quite period, at 8–10 years of age; here no change is seen in dentition. No teeth erupt during this time period.

3. **What is late mixed dentition/second transitional period?**
   It is the period of dentition in the age of 10–12 years when there is eruption of 3,4,5; Transition in chewing pattern develops in conjunction with eruption of permanent canines at age 12 years.

4. **What is leeway space of Nance?**
   It is the difference between MD sizes of CDE and 3,4,5; it is 1.8 mm in maxilla and 3.4 mm in mandible; it is mostly due to primary mandibular second molar size ka E-space (2–3 mm), helps in late mesial shift to achieve class I molars.

5. **What is E-space?**
   It is the space provided by the primary mandibular second molar when the second premolar erupts after its shedding. It is approx. 3 mm.

6. **What is space age?**
   It is the mixed dentition period (MDP). This is the most important phase of dentition development and should be very critically observed.

7. **Why the attrition is considered important in the primary dentition and mixed dentition period?**
   Pronounced attrition in MDP is observed to help in-decrease in deep bite, prevent interlocking of the cusps by flattening them and thus paving way for unhindered forward growth of mandible.

8. **How does the deep bite decreases during transition of dentition?**
   It occurs by eruption of permanent molars, attrition of incisors and forward movement of mandible due to growth.

9. **What is meant by secondary spacing?**
   It occurs in closed dentition with eruption of lower incisors, which pushes primary mandibular canine laterally. It creates space for proper eruption of maxillary lateral incisors. It helps to increase the intercanine width in both arches and increase in arch circumference in maxilla.

10. **What do you mean by tertiary spacing?**
    It is the spacing created due to extraction, etc.

11. **What is ugly-duckling stage of Broadbent?**
    In maxillary arch, at 8–9 years age, canines press the roots of laterals and so root crowding occurs, crowns move distally, spaces develop b/w crowns of incisors. It should not be disturbed till eruption of canines, as it is a self-correcting anomaly.

12. **How does the arch length change from mixed dentition period (MDP) to the permanent dentition period (PDP)?**
    It decreases by 2–3 mm when MDP changes to PDP, both from anterior and posterior sides. The anteriors erupt in upright situation and with growth of mandible. Also posterior teeth move mesially throughout life due to attrition, loss of leeway space and anterior component of force of occlusion. Also the arch width does not increase b/w 2½–6 years of age; and the arch perimeter does not increase b/w 2½–6 years of age.

13. **When is the largest arch length available in the dentition?**
    It is before eruption of first permanent molar.

14. **What are the signs of incipient malocclusion?**
    These are: the lack of interdental spacing in primary dentition, crowding in permanent incisors in MDP and premature loss of primary canines especially mandibular due to the eruption of lateral incisors which cause root resorption of canines if arch length is deficient in the mandibular arch.

15. Which are the self-correcting anomalies?

Gum pads stage	Primary DP	Mixed DP
Open bite	Deep bite	End-on molars
Increased overjet	FTP	Ugly-duckling stage
Tongue in between gum pads	Primary spacing incisors	< 2 mm of lower crowding
	Primate spacing	
	Small mandible	
	More upright incisors	

16. How does the chewing pattern of child differ from that of an adult?

The adults open the mouth straight and then moves it laterally during chewing, while the child moves laterally.

17. What are various features of development of dentition?

18. What is natural bite opening phenomenon?

Natural bite opening occurs at 6, 12, 18 years of age, with eruption of permanent molars. There are 3 periods of natural bite opening according to Schwarz. At 6 years, when First molar erupts; at 12 years when 2nd molar erupts; at 18 years when 3rd molar erupts.

19. What are some other important features of dentition?

- U/L permanent incisors erupt lingual to primary teeth and move forward under the tongue pressure as they erupt.
- 7–8 years age = critical period
- Sudden change during the eruption of the CI and LI is shown by = 1.5 mm crowding in both M and F. Average female recovers slightly better than males.
- No great relief of crowding in incisor region is expected after full eruption of LI.
- Most crowding is generally seen in lower anterior segment.
- Occlusal contact is only 2–6% in 24 hours period.
- Primary incisors are more vertical and interincisal angle is greater causing deep bite.
- Mandibular CI, LI seem to erupt from lingual
- Maxillary LI = no labial gingival bulge. It is because the position of lateral incisor lingual to the central incisors.
- Maxillary second molar erupts D and F.
- Maxillary third molar erupts D and B and outward.

20. How does the apical inclinations of upper and lower teeth differ?

Axial inclination of maxillary teeth tend to converge apically especially at the end of the arch and mandibular axes tend to diverge following the curve of Spee. Crowns of maxillary posterior teeth and canines and of all mandibular teeth are lingually inclined, (labial root torque), whole of maxillary incisors are labially inclined (labial crown torque).

SELF-ASSESSMENT QUESTIONS

1. What are different types of crowdings?
2. What is the eruption sequence of primary and permanent teeth?
3. What is the eruption age of various permanent teeth?
4. Define chronologic age, dental age and skeletal age? Which is most reliable?
5. What do you mean by self-correcting anomalies?
6. What are the natal and neonatal teeth?
7. What do you mean by mixed dentition period (MDP)?
8. What is the natural bite opening?
9. What is mechanism of natural bite opening?
10. What is meant by first transitional period/ early mixed dentition period (MDP)?
11. What is meant by Early mesial shift?
12. What do you mean by late mesial shift?
13. What is incisal liability?