ORTHODONTICS

Development of Occlusion

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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)

The alveolar arches of an infant at the time of birth are called Gum Pads. These are greatly thickened oral mucous membrane of the gums, which soon become segmented, and each segment is a developing tooth site. Jaws are devoid of teeth at birth. Gum pad stage extends from birth up to the eruption of first primary tooth, usually the lower central incisors at around 6 months of age. The gum pads are pink in colour and firm in consistency. The maxillary gum pad is horseshoe shaped and the mandibular gum pad is U/square shaped (Figure 1). The gum pads develop in two portions, labial/buccal and lingual, which are separated by the dental groove (it starts at the incisive papilla, extends backward to touch the gingival groove in the canine region and then moves laterally to end in the molar region in the upper gum pad and this dental groove joins gingival groove in the canine region in the lower gum). The gum pads in both the 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 as transverse grooves (Transverse grooves separate the gum pads into 10 segments). The prominent transverse groove separating canine and first deciduous molar segments in both the arches is called the lateral sulcus. The lateral sulci are often used to judge the inter-arch 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.

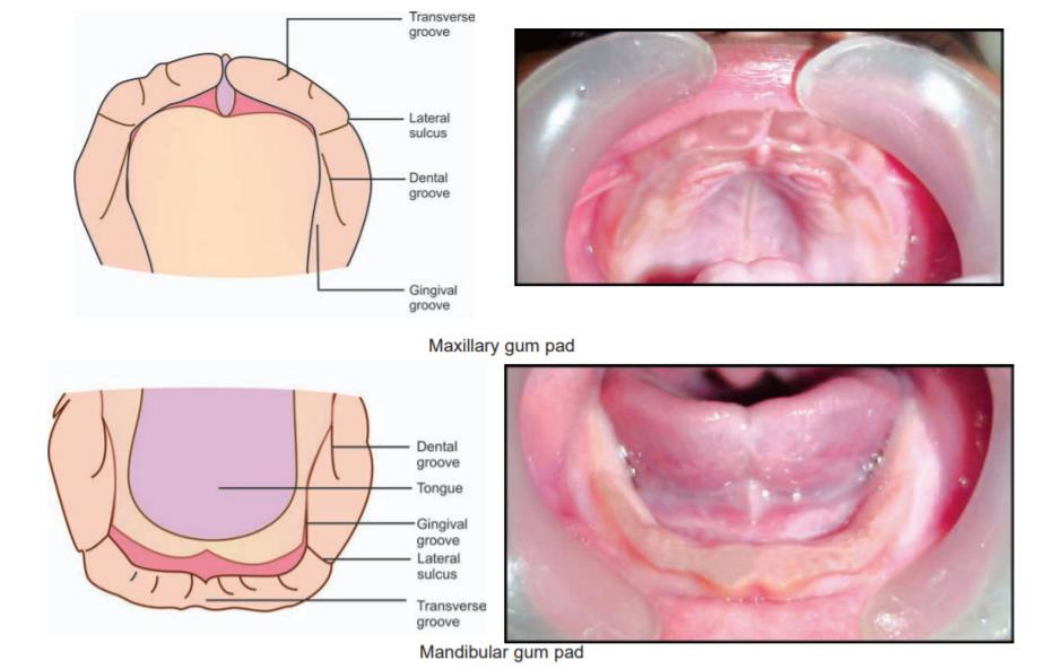


Figure 1: Gum pads (a) Maxillary (b) Mandibular

- **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 segment occlude with each other at the molar region (Figure 2). 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.

✓ Class II pattern with the maxillary gum pad being more prominent.

✓ Mandibular functional movements are mainly vertical and to a little extent anteroposterior. Lateral movements are absent.

✓ Anteroposterior relationship: In general, the mandibular lateral sulci are more posterior to the maxillary lateral sulci (Figure 2).

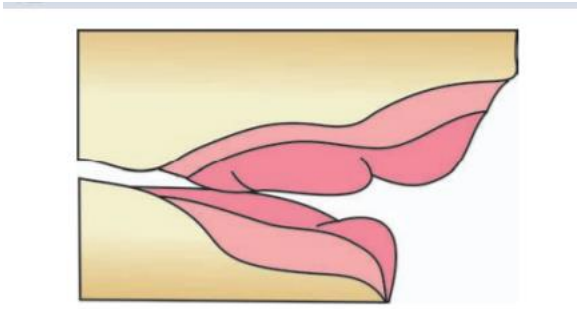


Figure 2: Relation between upper and lower gum pads at birth

- ✓ 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 as natal teeth (Figure 3). Teeth that erupt within 30 days of life are called as 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.

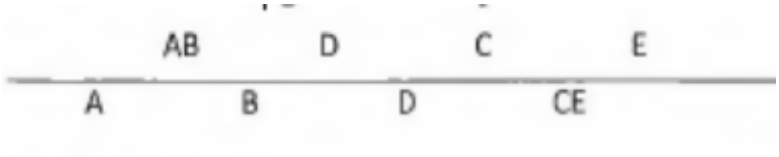
Figure 3: Natal tooth seen in a newborn

➢ 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 of Primary Teeth**

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 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

4. Canines

5. Second molars

Characteristics of Occlusion of Deciduous Dentition

✓ 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 (Figure 4). 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. Physiologic/ developmental spacing in deciduous dentition include Generalized spacing between teeth and Primate spaces.

Figure 4: Spacing in deciduous dentition

- 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 are seen in both the dental arches and helps in accommodation of larger successor teeth.

- Primate spaces/Anthropoid spaces/Simian 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 (Figure 5).

Significance of anthropoid spaces: Following 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.

Figure 5: Primate spaces

✓ 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 (Figure 6). 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. 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 forward growth of the mandible.

Figure 6: Increased overbite (deep bite) is a normal feature of deciduous dentition. It may be due to the fact that the primary incisors are more vertically placed than the permanent incisors

✓ Molar Relationship

The anteroposterior molar relationship in deciduous dentition is described in terms of the terminal planes. Terminal planes are the distal surfaces of the maxillary and mandibular second primary molars. Determining the terminal plane relationship in the primary dentition stage is of great importance because the erupting first permanent molars are guided by the distal surfaces of the second primary molars as they erupt into occlusion. Thus, the terminal plane relationship of primary dentition largely determines the type of molar relationship in the permanent dentition.

Moyers described 3 possible kinds of primary molar relationships (Figure 7):

1. Straight/Flush terminal plane

2. Mesial step

3. Distal step

Flush terminal plane: In straight/ flush terminal plane, the distal surfaces of the maxillary and mandibular second deciduous molars are in the same vertical plane. 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 to fall in same vertical plane in centric occlusion. Such an arrangement is called as "flush terminal plane." 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.

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.

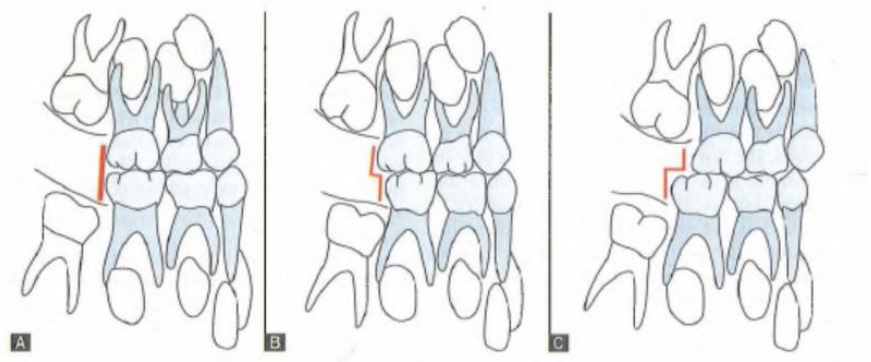


Figure 7: Terminal plane relationships: (A) Flush/straight terminal plane (B) Mesial step (C) Distal step

➢ Mixed Dentition Stage (6-12 Years)

Mixed dentition stage is a transition stage when primary teeth are exfoliated in a sequential manner, followed by the eruption of their permanent successors. This stage spans from 6 years to 12 years of age, beginning with the eruption of the first permanent tooth, usually, a mandibular central incisor or a first molar. It is completed at the time the last primary tooth is shed.

Significant changes in occlusion are seen in mixed dentition period due to the loss of 20 primary teeth and eruption of their successor permanent teeth. Most malocclusions are developed at this stage. Mixed dentition stage can be divided into the following phases:

- Early/1st.transitional period
- Inter-transitional period
- Late/2nd transitional period.

- Early/1st. Transitional Period (6-8 Years):

Early transitional period is concerned with the replacement of the primary incisors by their successors and the addition of four first permanent molars to the dentition. This usually occurs in the age range of 6 to 8 years.

- Emergence of the First Permanent Molars

The first permanent molars erupt at 6 years of age with mandibular molar preceding the maxillary molars in most cases. The first molars are considered to play an important role in the establishment of occlusion in the permanent dentition and class I molar relationship is considered as the normal anteroposterior molar relationship. The location and relationship of first permanent molars is influenced by the presence of interdental spacing and the terminal plane relationship of the primary dentition. The erupting first permanent molars are guided by the distal surfaces of the second primary molars as they erupt into occlusion. Thus, the terminal plane relationship of primary dentition largely determines the type of molar relationship in the permanent dentition, among other factors. The effects of terminal plane relationships are described in Figure 8.

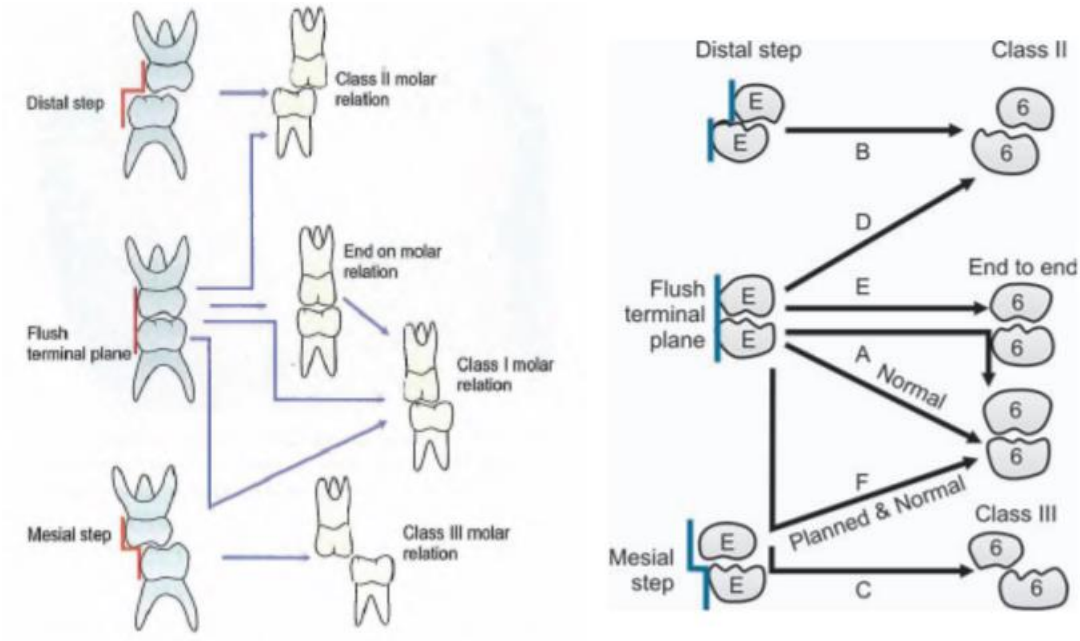


Figure 8: The possible effects of terminal plane relationship on permanent dentition

❖ Effects of flush terminal plane

Flush terminal plane usually develops into class I molar relationship in the permanent dentition. Some cases of flush terminal plane may also develop into class II molar relationship if forward mandibular growth is not sufficient. In the presence of flush terminal plane, the first permanent molars initially assume a cusp-to-cusp or end-on molar relationship, as they erupt distal to the second primary molars. The lower first permanent molar has to move 2-3 mm anteriorly in relation to the upper first permanent molar in order to transform the end-on relation to class I molar relation. This transformation from end-on to class I molar relation occurs in two ways:

a. Early mesial shift

b. Late mesial shift

a. Early mesial shift: Early mesial shift of lower permanent first molar occurs by utilization of the physiologic spaces present between primary incisors and the primate spaces. The eruptive force of permanent molars pushes the deciduous molars forward into the spaces, there by establishing class I molar relationship. As this change occurs in early mixed dentition, the shift is called the "early mesial shift" (Figure 9).

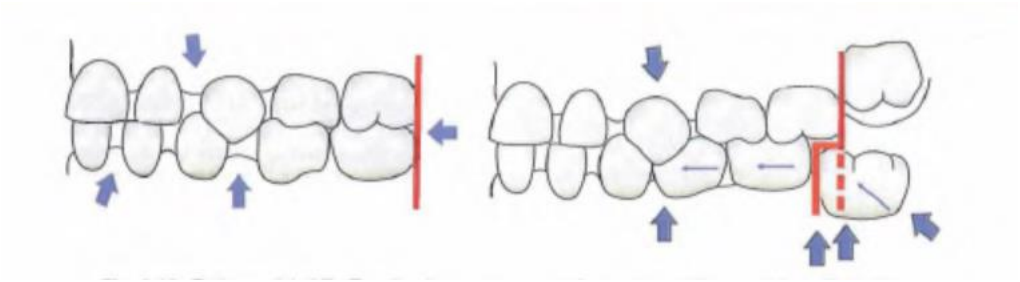


Figure 9: Early mesial shift: Erupting lower permanent first molars shifts mesially, utilizing the primate spaces in early mixed dentition period to establish class I molar relationship

b. Late mesial shift: In the absence of sufficient developmental spaces in primary dentition, the erupting permanent first molars may not be able to establish class I relationship in early mixed dentition period. In such cases, class I molar relationship can be established following the exfoliation of primary second molars; by utilizing Leeway space. As this occurs in late mixed dentition, it is called as the “Late mesial shift" (Figure 10).

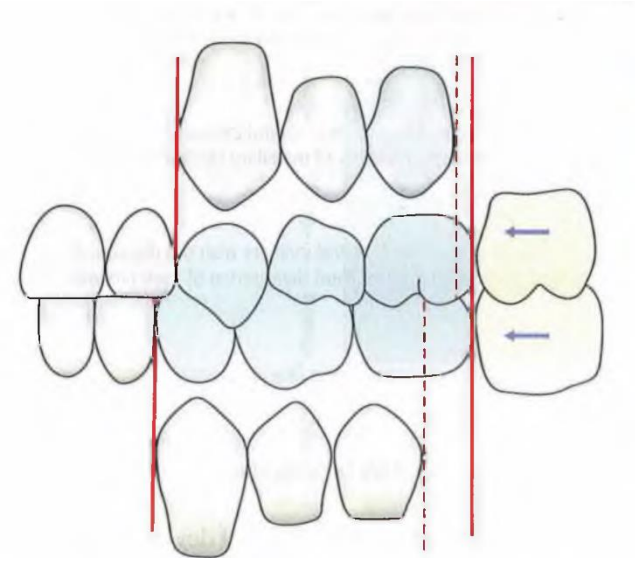


Figure 10: Late mesial shift: In case of primate space deficiency, class I molar relationship can be achieved in late mixed dentition period following exfoliation of primary second molars, utilizing the Leeway space

- Effects of mesial step

When deciduous second molars are in mesial step, the first permanent molars directly erupt into class I molar relationship. Few cases may also progress to class III molar relations, if forward growth of the mandible persists.

- Effects of distal step

Distal step in primary dentition usually leads to Angle's class II molar relationships in the permanent dentition. A few cases may go into class I molar relationship.

- Eruption of Permanent Incisors

Permanent incisors erupt lingual to the primary incisors and mandibular central are often the first to erupt. How the larger permanent incisor teeth are accommodated is described below:

A. Incisal liability

It can be readily appreciated that the mesiodistal crown dimensions of permanent incisors is considerably greater than that of the primary incisors. This difference in the mesiodistal crown dimension between the primary and permanent incisors is termed as incisal liability by Warren Mayne (Incisal liability in maxillary arch is about 7.6 mm—i.e. the maxillary permanent incisors are larger than their predecessors by 7.6 mm, while incisal liability in mandibular arch is about 6.0 mm i.e. mandibular permanent incisors are 6.0 mm larger than their predecessors). Thus, the amount of space available in the arch following exfoliation of the primary incisors is far less than the amount of space needed for accommodation of their permanent successors. Some degree of transient crowding may occur due to incisal liability at about 8-9 years of age and persist until the emergence of canines when the space for teeth may again become adequate. During the course of mixed dentition period, nature makes some adjustments to achieve the fit and maintain the dynamic balance. The incisal liability is overcome by the following factors:

1. Utilization of interdental spacing between primary anteriors:

Incisal liability is partly compensated by the developmental spaces that exist in the primary dentition (interdental physiologic spacing in the primary incisor region: 4 mm in maxillary arch; 3 mm in mandibular arch). Anterior crowding of permanent dentition may develop in the absence of interdental spacing.

2. Increase in the inter-canine arch width:

Continuing growth of the jaws often results in an increase in the inter-canine arch width during the mixed dentition period. This may significantly contribute to accommodation of the bigger permanent incisors in the arches.

B. Change in incisor inclination:

The deciduous incisors are more vertically positioned than the permanent incisors. Permanent incisors exhibit a more labial inclination. This means decreasing the inter-incisal angle from about 150° in the deciduous dentition to 123° in the permanent dentition, which tends to increase the dental arch perimeter. The change in the labiolingual inclination of incisors also contributes to overcome the incisal liability by adding 2-3 mm to the arch.

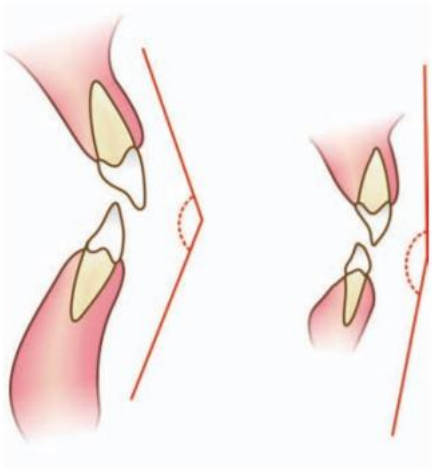


Figure 11: Comparison of the angulation of the permanent and primary teeth

- Ugly duckling stage (Broadbent's Phenomenon (7-14 years))

Around the age of 8 years, a midline diastema is commonly seen in the upper arch, which is usually misinterpreted by the parents as a malocclusion. Crowns of canines in young jaws impinge on developing lateral incisor roots, thus driving the roots medially and causing the crowns to flare laterally. The roots of the central incisors are also forced together, thus causing a maxillary midline diastema. The period from the eruption of lateral incisor to canine is termed as the Ugly Duckling stage (Figure 12). It is an unesthetic metamorphosis, which eventually leads to an aesthetic result. With eruption of canines, the impingement from the roots shifts incisally, thus driving the incisor crowns medially, resulting in closure of the diastema.

Figure 12: Ugly duckling stage

- Inter-transitional Period

After first permanent molars and incisors establish occlusion, there is an interim period of 1-2 years before the commencement of second transitional period in which little changes in the occlusion is seen. This phase of mixed dentition stage is relatively stable with only minor changes taking place and is referred to as inter-transitional period.

- Late/ 2nd. Transitional Period (10-13 Years)

The second transitional period involves replacement of molars and canines by the premolars and permanent canines respectively and the emergence of second permanent molars. Exfoliation of mandibular primary canine at around 10 years of age usually makes the beginning of second transitional period.

- Eruption of permanent canines

Mandibular canines erupt following the eruption of the incisors at around 10 years, while the maxillary canines usually erupt after the eruption of one or both the premolars, at around 12-13 years.

- Eruption of the premolars

The important portion of the dental arch in the development of occlusion is the premolar segment. This is because the erupting premolars are significantly smaller in mesiodistal dimension than the primary molars which they replace. Thus, major changes in occlusion are observed during the premolar emergence.

Eruption of permanent canines and premolars usually occurs after a pause of 1-2 years following incisor eruption. The first posterior teeth to erupt are the mandibular canine and first premolar (9-10 years) followed by maxillary premolars and canine around 11-12 years. Most common eruption sequence is 4-5-3 in the maxilla and 3-4-5 in the mandible. Favourable occlusion in this region is largely dependent on:

• Favourable eruption sequence.

• Satisfactory tooth size- available space ratio.

• Attainment of normal molar relation with minimum diminution of space available for bicuspids

- Leeway space of Nance

In general, the combined mesiodistal crown dimension of the primary canine and primary first and second molars is greater than the combined mesiodistal crown dimension of their successors namely permanent canine and first and second premolars. The amount of space gained by this difference in the posterior segments is termed as the Leeway space of Nance and is present in both the arches (Figure 13). Leeway space of Nance is the combined mesiodistal widths of deciduous canine, first and second molars is more than that of the combined mesiodistal width of permanent canine, first and second premolar. The difference between the two is called the Leeway space.

Maxilla 0.9 mm/segment = 1.8 mm total

Mandible 1.7 mm/segment = 3.4 mm total.

Significance of Leeway Space of Nance

- ❖ Presence of excessive leeway space is a favourable feature, which provides for the mesial movement of the permanent molars.
- ❖ Leeway space in the mandibular arch is more than that of the maxillary arch. This is because the primary mandibular molars are wider than the primary maxillary molars. The leeway space differential between the two arches causes the mandibular first molar to move mesially relatively more than the maxillary first molar. Such an arrangement causes a change in the molar relationship from end-on in the early mixed dentition period to class I relation at the late mixed dentition period (late mesial shift).
- ❖ Leeway space deficiency may be seen in some individuals when size of unerupted premolars and permanent canine are larger than the space available.

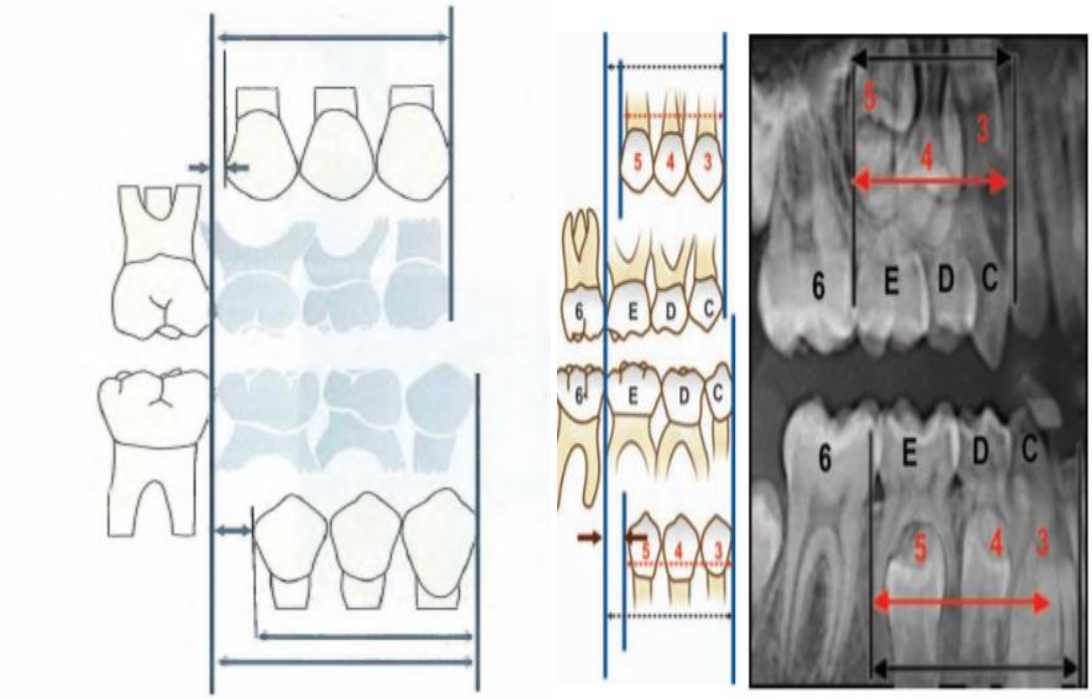


Figure 13: Leeway space of Nance

- Eruption of Permanent Second Molars

Emergence of second permanent molars ideally should follow the eruption of the premolars. If the second molars erupt before the premolars erupt fully, a significant shortening of the arch perimeter occurs, and malocclusion may be more likely to occur.

- Change in the Anteroposterior Molar Relationship in Mixed Dentition

To begin with, the newly erupted permanent first molars occlude in a cusp-to-cusp relation, especially when deciduous dentition exhibit flush terminal plane. Cusp to-cusp/end-on molar relationship, which is considered normal in early mixed dentition stage, changes into class I molar relationship, which is considered normal in permanent dentition stage by the following factors:

1. Leeway space of Nance

2.Differential mandibular growth.

Differential Mandibular Growth

During growing period, both the maxilla and the mandible grow downward and forward. However, the mandible grows relatively more forward than the maxilla during this developmental stage. Such differential mandibular growth is thought to contribute to the transition from end-on to class I molar relationship.

➢ Permanent Dentition Stage (12 Years and Beyond)

Permanent dentition stage is well established by about 13 years of age with the eruption of all permanent teeth except the third molars. Permanent successors develop from lingual extension of the dental lamina (successional lamina) and the permanent molar develop from the posterior extension of the dental lamina. The permanent incisors develop lingual to the primary incisors and move labially as they erupt. The premolars develop below the divergent roots of the primary molars. Permanent dentition begins to form at birth, at which time, calcification of the first permanent molars becomes evident. Sequence of eruption of permanent dentition is more variable than that of the primary dentition. In addition, there are significant differences in the eruption sequences between the maxillary and the mandibular arch.

Most Common Eruption Sequence in Maxilla
6-1-2-4-3-5-7-8
or
6-1-2-4-5-3-7-8

Most Common Eruption Sequence for Mandibular Arch
(6-1)-2-3-4-5-7-8
or
(6-1)-2-4-3-5-7-8

These are also the most favourable sequences for the prevention of malocclusion. It must be noted that there is a difference in eruption timing of the canines in the two arches. In the mandibular arch, the canines erupt before the premolars whereas in the maxillary arch, the canines generally erupt after the eruption of premolars. When second molars erupt before the premolars are fully erupted, significant shortening of the arch perimeter occurs due to mesial migration of permanent molars increasing the likelihood of malocclusion.

- Characteristics of Occlusion in Permanent Dentition

Some of the characteristics of the normal occlusion in the permanent dentition stage are listed below:

✓*Overlap*

The maxillary teeth overlap the mandibular teeth, both in labial and buccal segments in centric occlusion (Figure 14).

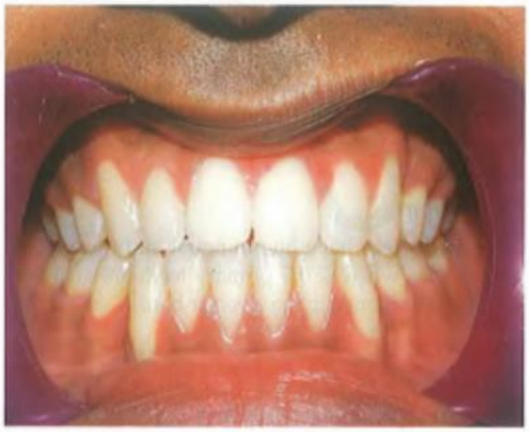


Figure 14: Maxillary teeth overlap mandibular teeth in labial, as well as buccal segments in centric occlusion

✓*Intra-arch Tooth Contacts*

With the exception of the maxillary third molars and mandibular central incisors, each permanent tooth occludes with two teeth from the opposite arch. In other words, each permanent tooth has two antagonistic teeth.

✓*Angulations*

Permanent teeth have buccolingual and mesiodistal angulations, whereas the primary teeth are generally vertically positioned in the alveolar bone.

✓*Arch Curvatures*

The anteroposterior curvature exhibited by the mandibular arch is called the curve of Spee (Figure 15). It refers to the anteroposterior curvature of the occlusal surfaces, beginning at the tip of the lower cuspid and following cusp tip of the bicuspids and molars continuing as an arc through to the condyle. If the curve were extended, it would form a circle of about 4 inches diameter. The corresponding curve in the maxillary arch is called the compensating curve.

Figure 15: The curve of Spee: A line from the tip of the canine touching the tips of the buccal cusps of the posterior teeth

✓*Incisor Relationship*

The vertical overlap between maxillary and mandibular incisors is called **overbite** and is about **1-3** mm and the horizontal overlap called the **overjet** is generally between **2-4** mm (Figure 16).

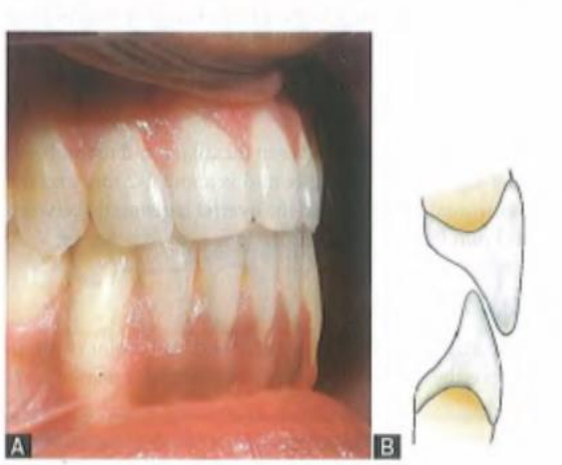


Figure 16: Normal incisal relationship: (A) overbite; (B) overjet

✓*Molar Relationship*

In permanent dentition stage, the class I molar relationship is the ideal relationship. In class I molar relationship, the mesio-buccal grove of the mandibular first molar is in the mesio-buccal cusp of the maxillary first molar. (Figure 17).

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Figure 17: A and B: Normal molar relationship