Orthodontics: Is that branch of dentistry concerned with facial growth; development of the dentitions and occlusion; diagnosis; interception and treatment of occlusal anomalies. Orthodontics" is derived from the Greek orthos ("correct", "straight") and -odont- ("tooth").

According to British society of orthodontics (1922) “Orthodontics includes the study of growth & development of the jaws & face particularly, & the body generally as influencing the position of the teeth; the study of action & reaction of internal & external influences on the development & the prevention & correction of arrested & perverted development.

According to American Board of orthodontics “Orthodontics is that specific area of dental practice that has as its responsibility the study and supervision of the growth and the development of the dentition and its related anatomical structures from birth to dental maturity, including all preventive and corrective procedures of dental irregularities requiring the repositioning of teeth by functional or mechanical means to establish normal occlusion and pleasing facial contours”.

In 1911 Noyes defined orthodontics as “The study of the relation of the teeth to the development of the face and correction of arrested and perverted development “.

In 1907 Angle stated that the objective of the science of orthodontics is “The correction of malocclusion of the teeth”.

Aims & objectives of orthodontic treatment: Aims & objectives of orthodontic treatment have been summarized by Jackson as the Jackson’s Triad.

1. Functional Efficiency.
2. Structural Balance.
3. Esthetic Harmony.

Functional Efficiency Many malocclusions affect normal functioning of the stomatognathic system. The orthodontic treatment should thus aim at improving the functioning of the orofacial apparatus.

Structural Balance The oro-facial region consists of the dentoalveolar system, the skeletal tissue and the soft tissue including musculature. Stable orthodontic treatment is best achieved by maintaining a balance between these three tissue systems.

Esthetic Harmony By far the most common reason for seeking orthodontic care is to improve the appearance of the teeth & face. Many malocclusions are associated with unsightly appearance of teeth & can thus affect the individual's self-image, wellbeing & success in society. Thus, the orthodontic treatment should aim at improving the esthetics of the individual.

Orthodontics can improve the following:

1- Dental health:
   - a- Dental caries: Mal-alignment of the teeth may reduce the potential for natural teeth –cleansing and increase the risk of decay.
   - b- Periodental disease: Irregular teeth reduce effective brushing, in addition to that, crowding may force one or more teeth to be squeezed buccally or lingually out of their investing bone reducing periodontal support and finally traumatic occlusion may lead to increase loss of periodontal support (e.g.: anterior crossbite).
   - c- Trauma to anterior teeth: Researches have shown that overjet more than 3 mm had more than double the risk of traumatic injury.
   - d- Impacted teeth: Impacted (unerupted) tooth may affect normal position and health of adjacent teeth in addition to the loss of function of the impacted tooth itself.

2- Function:
   - a- Masticatory function: Patients with open bites; markedly increased overjet (Class II) or reversed overjet (Class III) often complain difficulties with eating, particularly incising food.
   - b- Speech: Crowding may have little effect on normal speech.
   - c- Tempro-mandibular joint: There is no clear association between malocclusion and the TMJ.

3- Psychosocial -wellbeing: Unattractive dento-facial appearance does have a negative effect on expectations of teachers and employers.

Scope of orthodontic treatment:

1. Alteration in tooth position.

2. Alteration in skeletal pattern.

3. Alteration in soft tissue pattern.

Definitions:

Occlusion: Any position or relationship in which the upper and the lower teeth come together.

Ideal Occlusion: A theoretical concept of an ideal arrangement of the teeth within the dental arches, combined with an ideal inter-arch relationship, which concentrates optimal esthetic, function, and stability of the dentition and supporting structures. But it is almost never found in nature.

Normal occlusion: That occlusion which satisfies the requirements of function and esthetic but in which there are minor irregularities of individual teeth.

6 keys of normal occlusion:

1: Molar relation: The distal surface of the distobuccal cusps of the upper first permanent molar made contact and occluded with the mesial surface of the mesiobuccal cusps of the lower second molar, the mesiobuccal cusp of the upper first permanent molar fell within the groove between the mesial and middle cusps of the lower first permanent molar. (The canines and premolars enjoyed a cusp-embrasure relationship).

2: Crown angulation "The mesiodistal tip", The term angulation refers to angulation (or tip) of the long axis of the crown not to angulation of the long axis of the entire tooth. The gingival portion of the long axis of each crown was distal to the incisal portion varying with the individual tooth type, the long axis of the crown for all teeth except molars is identified to be the mid developmental of ridge which is the most prominent part and center most vertical portion of the labial or buccal surface of the crown.

The long axis of the molar crown is identified by the dominant vertical groove on the buccal surface of the crown.

3: Crown inclination (Labiolingual or buccolingual inclination):
Crown inclination refers to the labiolingual or buccolingual inclination of the long axis of the crown not to the inclination of the long axis of entire tooth. The inclination of all the crowns has a consistent scheme:
a- Anterior teeth (Central and lateral incisors)
The labial inclination of upper and lower anterior crown is sufficient to resist over eruption of anterior teeth and sufficient also to allow proper distal positioning of the contact points of the upper teeth in their relationship to the lower teeth, permitting proper occlusion of the posterior teeth.
b-Upper posterior teeth (Canines through molars)
A palatal crown inclination existed in the upper posterior crown was a constant and similar from the canines through the second premolar and was slightly more pronounced in the molars.
c-Lower posterior teeth (Canines through molars)
The lingual crown inclination in the lower posterior teeth progressively increases from the canine through the second molar.
4: Rotation: There are no undesirable rotations**.** Rotated molar and bicuspid occupy more space than normal while rotated incisors occupies less space than normal

5: Spaces: there were no spaces with tight contact point.

6: Occlusal planes: the plane of occlusion varied from generally flat to a slight curve of spee (which measured from most prominent cusp of lower second molar to the lower central incisor), no curve deeper than 1.5 mm is accepted from a stand point of occlusal stability.

Recently the authors believe that the correct crown diameter represents the seventh key to normal occlusion this key (the seventh key) had to be present in Andrews non-orthodontic normal study models.

Malocclusion
Defined as any deviation from the normal or ideal occlusion.

Risks of orthodontic treatments:

1- Root resorption: During 2- years of fixed orthodontic treatment it is inevitable to find 1mm of root resorption, however the use of excessive orthodontic force may lead to un-accepted amount of root resorption and hence devitalization of affected tooth or teeth.
2- Loss of periodontal support: Caused by poor oral hygiene during orthodontic treatment.
3- Demineralization: May occur during fixed orthodontic treatment specially, as a result of plaque accumulations in case of un-cooperative patient (poor oral hygiene).
4- Soft tissue damage: Traumatic ulceration may occur specially in fixed orthodontic treatment.
5- Pulpal injury: Excessive orthodontic force may lead to pulp injury and death especially for the teeth with a history of trauma.

Orthodontic definitions:

Incisal overjet: The horizontal distance between the upper and lower incisors in occlusion, measured at the tip of the upper incisor (Fig. 1).
It is dependent on the inclination of the incisor teeth and the antero-posterior relationship of the dental arches. In most people, there is a positive overjet, i.e. the upper incisor is in front of the lower incisor in occlusion (normally 2-4 mm), but the overjet may be reversed (in case of Class III), or edge-to-edge (Fig. 1).

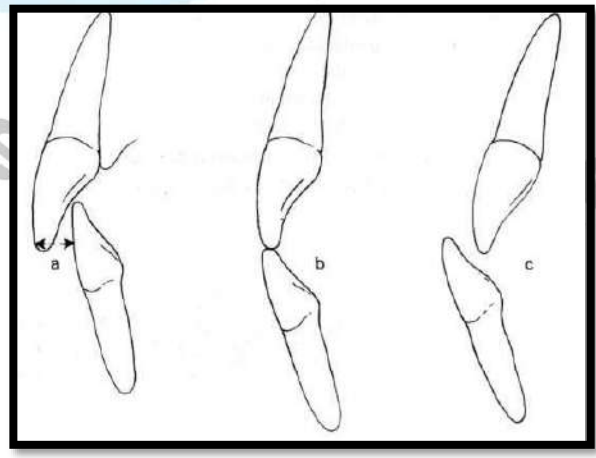


Fig. 1: Incisal overjet: (a) The ideal overjet relationship, (b) Edge to edge incisal position,
(c) Reversed overjet.

Incisal overbite: The overbite is the vertical distance between the tips of the upper and lower incisors in occlusion (Fig.2).
It is governed by the degree of vertical development of the anterior dento-alveolar segments. Ideally, the lower incisors contact the middle third of the palatal surface of the upper incisors in occlusion (2-4 mm), but there may be excessive overbite (deepbite), or there may be no incisal contact, in which case the overbite is described as *incomplete overbite* when the lower incisors are above the level of the upper incisal edges, or *anterior open bite,* when the lower incisors are below the level of the upper incisal edges in occlusion.

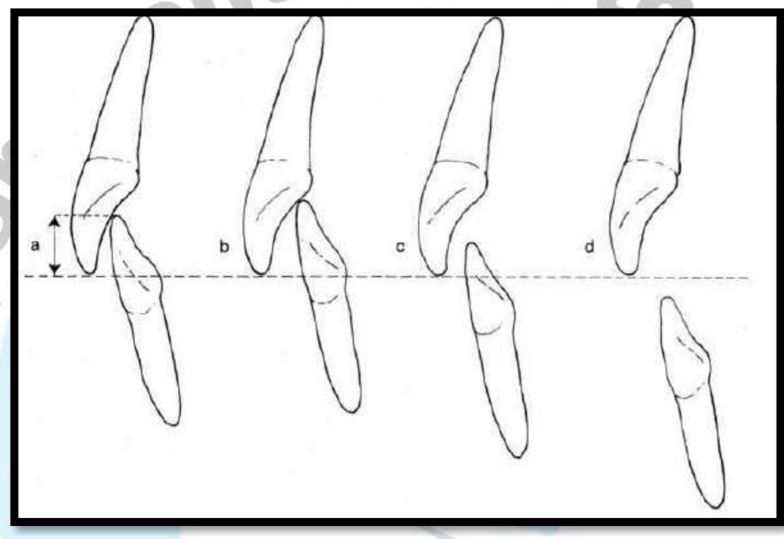


Fig.2: Incisal overbite: (a) Ideal overbite relationship, (b) Excessive incisal overbite (deepbite), (c) Incomplete overbite, (d) Anterior open bite.

Acknowledgement: I would like to thank Prof. Dr. Dhiaa J. Nasir Al-Dabagh, for helping me completing and presenting the lecture.

Orthodontic Definition

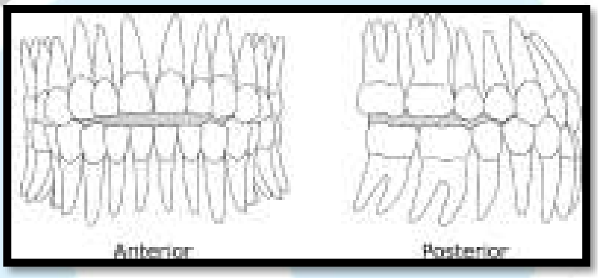
Open bite (Negative overbite):

Inherited, developmental or acquired malocclusion, whereby no vertical overlap exists between maxillary and mandibular anterior teeth (anterior open bite), or no vertical contact is exhibited between maxillary and mandibular posterior teeth (posterior open bite).

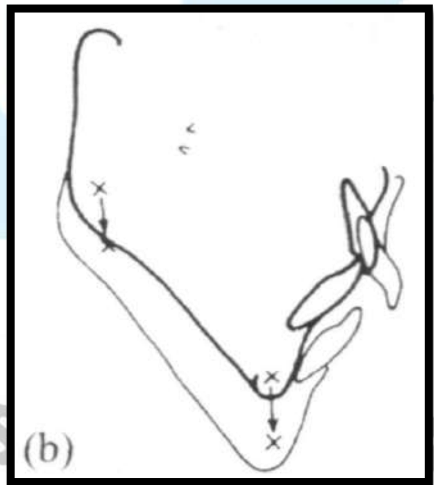
Subdivided to:

1- Dental open bite: A localized openbite that involves only a few teeth due to a digit-sucking habit or other local factors.

2- Skeletal open bite: Caused by divergence of the skeletal mandibular or / and maxillary planes leading to increased facial height as in case of posterior rotational growth of the mandible (Fig. b).



a-Anterior and posterior dental openbite



b-Posterior rotational growth of the mandible

Deep bite (Excessive overbite): Type of malocclusion in which the vertical overlap of the anterior teeth is increased beyond the ideal relationship (more than the normal range which is 2-4 mm); it is frequently associated with decreased vertical facial dimensions, subdivided into;

1- None traumatic deepbite: In which the deepbite still associated with teeth–teeth relation.

2- Traumatic deepbite: in which the deepbite associated with the Impingement of the mandibular incisors in the mucosa palatal to the maxillary incisors commonly is seen in malocclusions with extremely deep bite as in sever Class II malocclusion.

3- Bi-traumatic deepbite: usually seen in some Class II, Division 2 malocclusions with minimal overjet, the retroclined maxillary incisors may impinge in the keratinized tissue labial to the mandibular incisors, causing gingival recession at the same time there is a trauma to palatal mucosa caused by lower incisors.

Buccal overjet:

The distance between the buccal surfaces of the maxillary posterior teeth and the buccal surfaces of their mandibular antagonists. An unofficial term sometimes used to indicate whether or not there is a tendency for a posterior crossbite.

Crossbite:

An abnormal relationship of one or more teeth to one or more teeth of the opposing arch, in the buccolingual or labiolingual direction. A crossbite can be dental or skeletal in etiology. [Note: The appropriate type of crossbite can be specified by identifying the teeth or jaws that deviate the most from their ideal position (e.g. when a crossbite is mainly due to a narrow maxillary arch the correct term is "maxillary posterior lingual crossbite" as opposed to "mandibular posterior buccal crossbite" which indicates wider mandibular arch).

Classification of crossbite:

Based on Location

1. ANTERIOR CROSS BITE:
   - According to no. of teeth involved:
     A. Single tooth Cross bite. B. Segmental Cross bite.
2. POSTERIOR CROSS BITE:
   - According to no. of teeth involved:
     A. Single tooth Cross bite. B. Segmental Cross bite.
   - According to side involved:
     A. Unilateral. B. Bilateral.

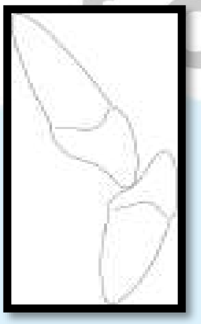
- According to extent:

A. Single posture Cross bite. B. Buccal Non-occlusion (Scissor bite).
C. Lingual Non-occlusion (Buccal crossbite).

Based on the Etiologic Factor

1. Skeletal crossbite.
2. Dental crossbite.
3. Functional crossbite.

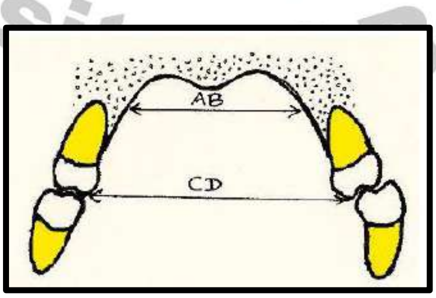
Anterior crossbite: If the one or more of the lower incisors are in front of the upper incisors, the condition is called reverse overjet or anterior crossbite.



Posterior crossbite: A crossbite due to buccal displacement of the affected posterior tooth (or group of teeth) from its (their) ideal position relative to its (their) antagonist(s). Subdivided into:

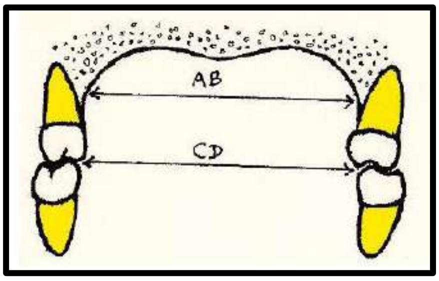
1- Unilateral posterior: Affect only one side of the dental arch, and can be either:
a-True unilateral posterior crossbite: Caused by the asymmetry present in the dental arch and usually does not associated with deviation of the mandible.
b- False unilateral posterior crossbite: caused by narrowing of the maxilla or widening of the mandible leading to cusp –cusp relation then the patient tries to get maximum intercuspation by deviation of the mandible to one side leading to unilateral crossbite.
2- Bilateral posterior crossbite: Caused by sever maxillary collapse or/ and mandibular widening, there is no mandibular deviation during closure.

Skeletal crossbite: It is a crossbite with a skeletal basis (constricted maxilla and/or wide mandible).



Palatal arch width (AB) is inadequate and quiet less than dental arch width (CD)

Dental crossbite: It is caused by distortion of the dental arch where the jaws are of normal proportions.

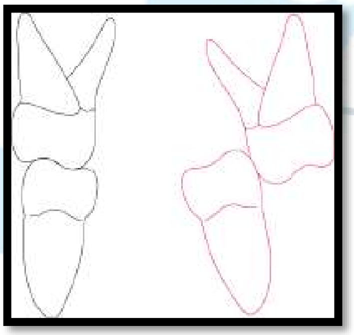


Palatal arch width (AB) is adequate and nearly equal to dental arch width (CD)

Functional crossbite (False): It is a crossbite due to a functional shift of the mandible, it should be treated early if recognized, because if uncorrected, true crossbite may result by modification of growth.

Scissors-bite:

Situation in which several adjacent posterior teeth overlap vertically in habitual occlusion with their antagonists, without contact of their occlusal surfaces. The deviation of the affected teeth from their ideal position could occur either in maxillary buccal or mandibular lingual direction, where mandibular dentition are completely contained within the maxillary dentition in habitual occlusion.



Spacing of the dentition: A dental arch with spacing of more than accepted range (2 mm or more), it is either:

a- Localized: Localized in one position like median Diasthema that caused by abnormal frenal attachment.

b- Generalized: Affect the whole dental arch mostly caused by abnormal soft tissue function like tongue thrust.

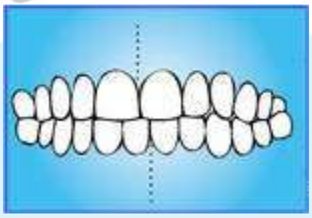
Crowding of the dentition: A dental arch with crowding of more than accepted rang (2 mm or more), either caused by local factor like early extraction of deciduous teeth or general factor like collapsed maxillary arch that lead to crowding of the whole arch.

Imbrication: The overlapping of incisors and canines in the same arch, usually due to crowding.

Midline shift (deviation): Occurs when the upper and lower dental midline are not coinciding, and subdivided into:

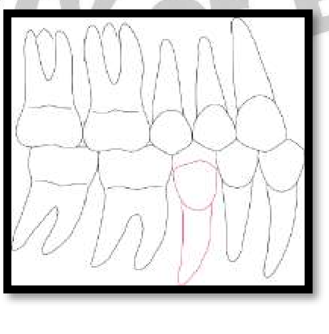
1- Associated with mandibular deviation during closure as in case of premature occlusal contact.

2- Not associated with mandibular deviation during closure as in case of unilateral missing of the teeth or crowding.

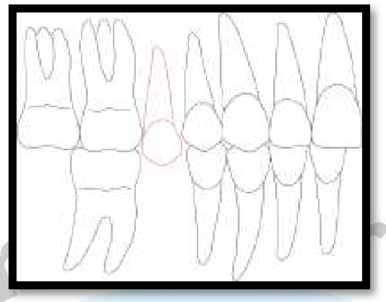


Midline shift may be due to shift of upper or lower teeth or some time may both of them and it is very important to determine that during diagnosis and treatment planning specially to choose a tooth or teeth to be extracted, in addition to that it is important to differentiate between midline shift of the dentition and the face because we may see one of them or some time both of them.
Midline shift of the face mostly caused by abnormal skeletal factor (like unilateral hyperplasia of the mandible) or deviation of the nose.
Midline shift of the dentition mostly associated with unilateral extraction or congenital missing or impaction of a tooth.

Infraposition (Infraocclusion):
A situation in which a tooth or group of teeth is positioned below the occlusal plane; commonly due to a deleterious habit or to ankylosis.



Overeruption (Supraeruption, Supraposition, Supraocclusion):
The situation whereby an unopposed or non-occluding tooth extends beyond the occlusal plane.



Dental retrusion:
Posterior position of a tooth or group of teeth but keeping their long axis with normal inclination.

Dental retroclination:
Posterior positioning of a tooth or group of teeth but their long axis are tipped labio-lingually.
[Note: A tooth can be retrusive without being retroclined, if it is positioned too far posteriorly but has a normal inclination.]

Dental proclination:
Anterior positioning of a tooth or group of teeth but their long axis are tipped labially.

Dental protrusion:
Anterior positioning of a tooth or group of teeth but keeping their long axis with normal inclination.

Impaction of teeth:
Occurs when eruption is completely blocked by other teeth due to crowding, it tends to affect the last teeth to erupt in each segment (as in case of canine).

Rotation of teeth:
A type of malocclusion in which there is a rotation of a tooth about its long axis, most evident when viewing the tooth from an occlusal perspective mostly, caused by crowding and sub divided into:

1- Mild (less than 90°): Can be treated easily by removable orthodontic appliance using couple force system.

2- Sever (more than 90°): Must be treated by Fixed orthodontic appliance only

Displacement of tooth:

Abnormal position of the tooth (crown and root) in the dental arch

Overlapping of teeth:

Abnormal position of the crown of the tooth in the dental arch while there is normal position of root in the jaw.

Acknowledgement: I would like to thank Prof. Dr. Dhiaa J. Nasir Al- Dabagh, for helping me completing and presenting the lecture.

Classification of malocclusion

Angle classification

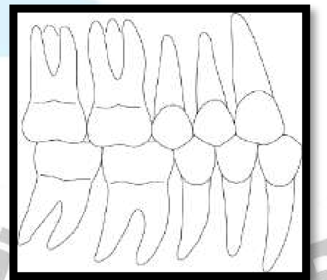
A classification of malocclusion introduced by E. H. Angle, based on the anteroposterior relationship of the maxillary and mandibular first permanent molars. Angle's assumption when formulating this classification was that the maxillary first permanent molar always is in the physiologically correct position and the variability comes from the mandible.

Angle's classification, which is still widely popular, only can serve as a framework, as it does not take into account many other important relationships in the anteroposterior (e.g. overjet, canine relationship), transverse (e.g. buccolingual crossbites), or vertical (e.g. overbite) planes of space. It also does not identify intra-arch problems, such as crowding, spacing, rotations, missing or impacted teeth.

Angle's classification subdivided into:

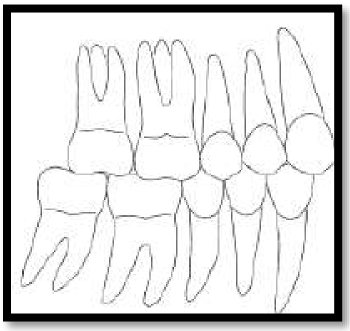
• Class I malocclusion (Neutroclusion)

A malocclusion in which the buccal groove of the mandibular first permanent molar occludes with the mesiobuccal cusp of the maxillary first permanent molar. The term "Class I" is sometimes used incorrectly as a synonym for normal occlusion, although in reality, it only signifies a normal relationship of maxillary and mandibular first molars in the sagittal plane.



•Class II malocclusion (Distoclusion, Postnormal occlusion):

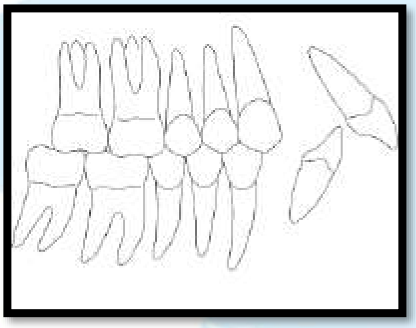
A malocclusion in which the buccal groove of the mandibular first permanent molar occludes posterior (distal by at least half cusp) to the mesiobuccal cusp of the maxillary first permanent molar. The severity of the deviation from the Class I molar relationship usually is indicated in fractions (or multiples) of the mesiodistal width of a premolar crown ("cusp" or "unit").



Subdivided into:

• Class II malocclusion, Division 1:

A Class II malocclusion with proclined maxillary incisors, resulting in an increased overjet with normal or mostly deepbite.



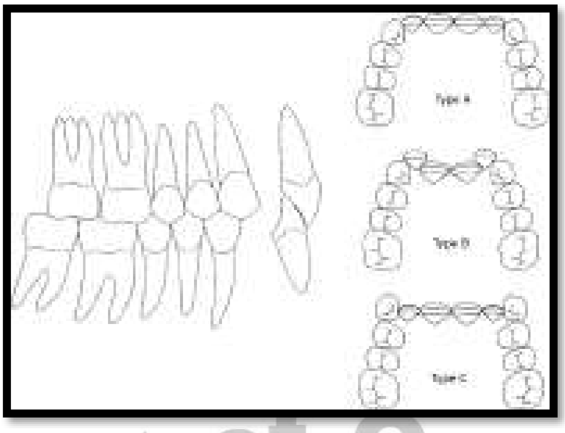
• Class II malocclusion, Division 2:

A Class II malocclusion typically with the maxillary central incisors tipped palatally, a short anterior lower face height, an excessive overbite and normal or decreasing overjet. Three types of Class II Division 2 malocclusion can be distinguished, based on differences in the spatial conditions in the maxillary dental arch:

Type A: The four maxillary permanent incisors are tipped palatally, without the occurrence of crowding.

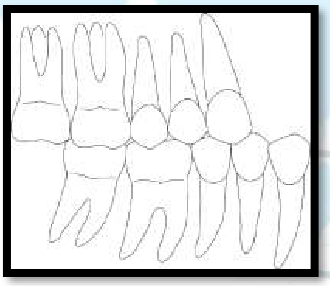
Type B: The maxillary central incisors are tipped palatally and the maxillary laterals are tipped labially.

Type C: The four maxillary permanent incisors are tipped palatally, with the canines labially positioned.



• Class III malocclusion (Mesioclusion, Prenormal occlusion):

A malocclusion in which the buccal groove of the mandibular first permanent molar occludes anterior (mesial by at least half cusp) to the mesiobuccal cusp of the maxillary first permanent molar. The same conventions as described before are used to indicate the severity of deviation from a Class I molar relationship.



Important notes:

1-Usually when we talk about angles classification we talk about first permanent molar relation (and some time we notice that this relation not symmetrical in both side).

2- When there is missing of the first permanent molar or there is drifting as a result of an early loss of deciduous molars so we shift to another classification which is canine classification ,and if there is no canine or impacted canine or severly malposed canine so we shift to another classification which is incisor classification.

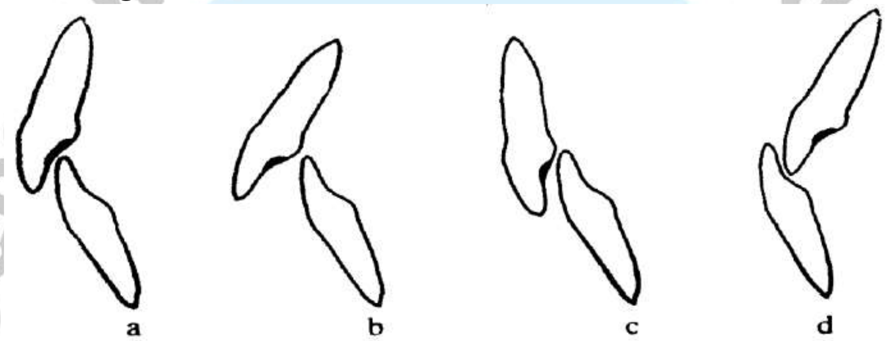
Canine classification:

Class I: It is a normal canine relation, when the tip of the upper canines located in the embrasure area between lower canine and first premolar (or the mesial slope of the upper canine coincide with the distal slop of lower canine) in occlusion.

Class II: Abnormal canine relation in which the lower canine will be more backward from normal canine relation in occlusion.
Class III: Abnormal canine relation, when the lower canine will be more forward than from normal canine relation.

Incisor classification

The incisor relationship does not always match the buccal segment relationship. Since much of orthodontic treatment is focused on the correction of incisor malrelationships, it is helpful to have a classification of incisor relationships. The terms used are the same but this is not Angle's classification, although it is a derivation.
In clinical practice the incisor classification is usually found to be more useful than Angle's classification.



Incisor classification: (a) Class 1: (b) Class II Division 1: (c) Class II Division 2; (d) Class III.

Class I. The lower incisor edges occlude with or lie immediately below the cingulum plateau (middle part of the palatal surface) of the upper central incisors (a).

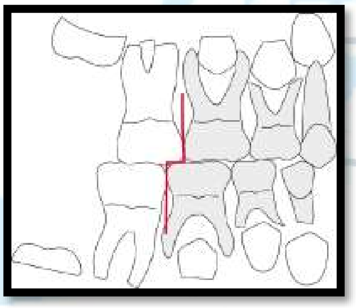
Class II. The lower incisor edges lie posterior to the cingulum plateau of the upper incisors.
There are two divisions to Class II malocclusion:
Division 1. The upper central incisors are proclined or of average inclination, with an increased overjet (b).
Division 2. The upper central incisors are retroclined (less than 105° to the maxillary plane). The overjet is usually of an average amount but may be increased (c),o.b mostly increased(deep bite)

Class III. The lower incisor edges lie anterior to the cingulum plateau of the upper incisors (d). The overjet may be either reduced or reversed.

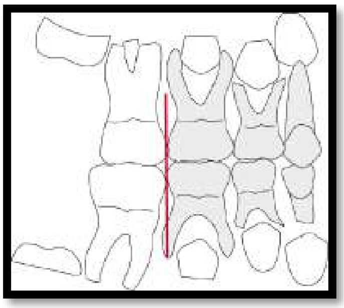
Classification of deciduous teeth: Depend on the relation between terminal plane present in the maxillary and mandibular deciduous posterior teeth.

Terminal plane:
The distal proximal surface of the maxillary and mandibular second deciduous molars (being the distal terminal plane of the deciduous dentition). The relationship between the maxillary and mandibular terminal planes in the early mixed dentition is thought to determine, to a degree, the eventual relationship between the (at the time still unerupted) maxillary and mandibular first permanent molars.

Distal step:
A situation in which the terminal plane of the mandibular second deciduous molar is situated posteriorly to that of the maxillary second deciduous molar. This situation is thought to be predisposing to, but not necessarily predictive of, a Class II relationship of the (at the time, still unerupted) first permanent molars.

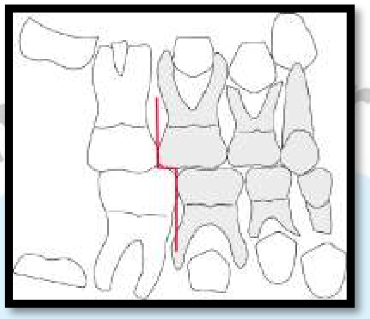


• Flush terminal plane
An end-to-end relationship between the distal proximal surfaces of the maxillary and mandibular second deciduous molars, usually leading to a Class I or Class II relationship between the (at the time, still unerupted) maxillary and mandibular first permanent molars.



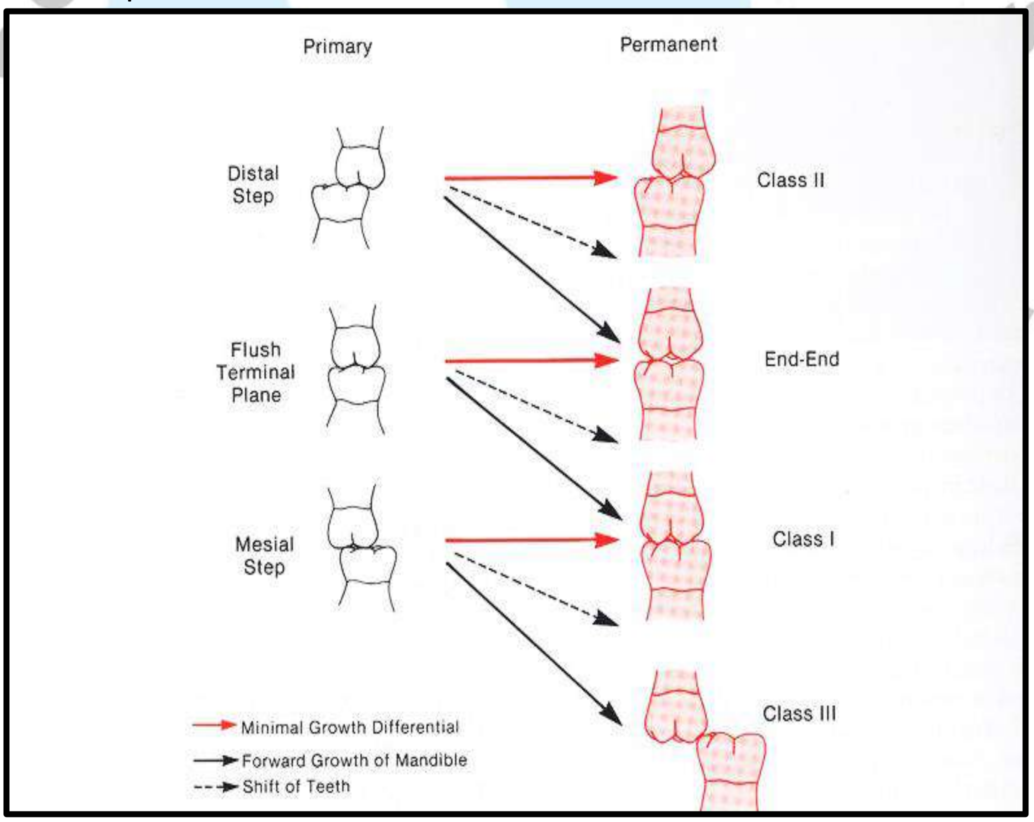
• Mesial step:

A situation in which the terminal plane of the mandibular second deciduous molar is situated anteriorly to that of the maxillary second deciduous molar. Depending on the severity of the mesial step, this relationship is thought to predispose to (but is, strictly speaking, not predictive of) either a Class I or a Class III relationship of the (at the time, still unerupted) maxillary and mandibular first permanent molars.



Clinical implications and variations:

The first permanent molars may erupt into one of the following occlusal relationships



Acknowledgement: I would like to thank Prof. Dr. Dhiaa J. Nasir Al- Dabagh, for helping me completing and presenting the lecture.

Growth and development

The term *growth* usually refers to an increase in size or number while the term *development* will be used to refer to an increase in complexity. Growth is largely an anatomic phenomenon, whereas development is physiologic and behavioral, which means a progress toward marurity.

Why should a dentist or orthodontist be interested in growth and development?

1. Knowledge of general and facial growth provides a background to the understanding of the aetiology and development of malocclusion, playing an important part of the diagnosis and treatment planning process.

2. At regular intervals of the growing child all dentists should be able to identify abnormal or unusual patterns of skeletal growth (posterior rotational growth of the mandible may lead to skeletal openbite)..

3. The dentist should be able to identify abnormal occlusal development at an early stage in order to undertake suitable interceptive orthodontic treatment (premature contact may lead to sever skeletal class III)

4. Poorly timed extractions performed by the dentist during growth may have unfortunate consequences on the developing occlusion.(serial extraction in dished in face)

5. Many malocclusions are, at least in part, due to skeletal discrepancies between the jaws (maxilla and mandible). Such discrepancies are usually due to differences in the comparative growth of the jaws.

6. Orthodontic treatment may make use of growth spurts (maximum growth period) and other trends. The timing of treatment in relation to these may be important. So understanding of the kinetics of facial growth is necessary.

7. Most orthodontic treatments are performed in the actively growing child or adolescent. Some are dependent on favourable growth and these treatments may have an effect on the hard and soft tissues of the area, however others treatment may have limited result by unfavourable growth pattern.

8. In some treatments, for example where surgery is being considered, it is important to be able to identify when the majority of facial growth has been completed.(above the age of 17th years)

9. Growth effects can have long-term effects on the stability of the occlusion after treatment. This needs to be considered when a retention regime is planned.(Class III needs long retention period because there is a continuous possibility of mandibular growth till 20 years of age while maxillary growth usually stopped earlier.)

Control of cranio-facial growth

Three major theories in recent years have attempted to explain the determinants of craniofacial growth as followings:

1- Bone, is the primary determinant of its own growth.

2-Cartilage is the primary determinant of skeletal growth, while bone responds secondarily and passively.

3-The soft tissue matrix in which the skeletal elements are embedded is the primary determinant of growth, and both bone and cartilage are secondary followers.

The major difference in the theories is the location at which genetic control is expressed.

The first theory implies that genetic control is expressed directly at the level of the bone, and therefore, its locus should be the periosteum. However this theory has been largely discarded from 1960.

The second, or cartilage, theory suggests that genetic control is expressed in the cartilage, while bone responds passively to being displaced, this theory still controversy till now. This indirect genetic control is called *epigenetic.*

The third theory assumes that genetic control is mediated to a large extent outside the skeletal system, and that growth of both bone and cartilage is controlled epigenetically, occurring only in response to a signal from other tissues (as it proposed that growth of cranium occurs as a result to growth of brain).

If neither bone nor cartilage was the determinant for growth of the craniofacial skeleton, it would appear that the control would have to lie in the adjacent soft tissues. This point of view was put formally in the 1960s by Moss, in his "functional matrix theory" of growth, and was reviewed and updated by him in the 1990s, his theory holds that neither the cartilage of the mandibular condyle nor the nasal septum cartilage is a determinant of jaw growth. Instead, he theorizes that growth of the face occurs as a response to functional needs and is mediated by the soft tissue in which the jaws are embedded. In this conceptual view, the soft tissues grow, and both bone and cartilage react.

Moss theorizes that the major determinant of growth of the maxilla and mandible is the enlargement of the nasal and oral cavities, which grow in response to functional needs.

The theory does not make it clear how functional needs are transmitted to the tissues around the mouth and nose, but it does predict that the cartilages of the nasal septum and mandibular condyles are not important determinants of growth, and that their loss would have little effect on growth if proper function could be obtained.

From the view of this theory, however, absence of normal function would have wide-ranging effects on normal growth. This theory considered as most acceptable one now a day.

GROWTH: PATTERN, VARIABILITY AND TIMING

1-Pattern: In studies of growth and development, the concept of pattern is an important one. In a general sense, pattern reflects proportionality, usually of a complex set of proportions rather than just a single proportional relationship, because it refers not just to a set of proportional relationships at a point in time, but to the change in these proportional relationships over time. In other words, the physical arrangement of the body at any one time is a pattern of spatially proportioned parts. But there is a higher level pattern, the pattern of growth, which refers to the changes in these spatial proportions over time.

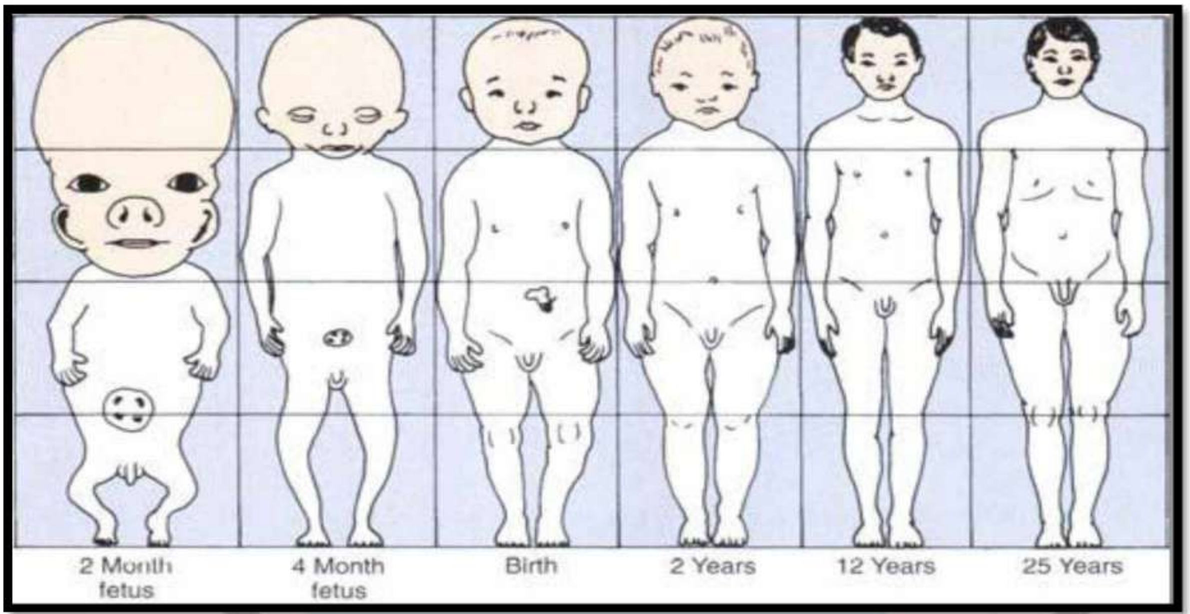


Fig. 1: Proportional growth change during life.

Figure 1 illustrates the change in overall body proportions that occurs during normal growth and development.

In fetal life, at about the third month of intrauterine development, the head takes up almost 50% of the total body length. At this stage, the cranium is large relative to the face and represents more than half the total head. In contrast, the limbs are still rudimentary and the trunk is underdeveloped.

By the time of birth, the trunk and limbs have grown faster than the head and face, so that the proportion of the entire body devoted to the head has decreased to about 30%. The overall pattern of growth thereafter follows this course, with a progressive reduction of the relative size of the head to about 12% of the adult.

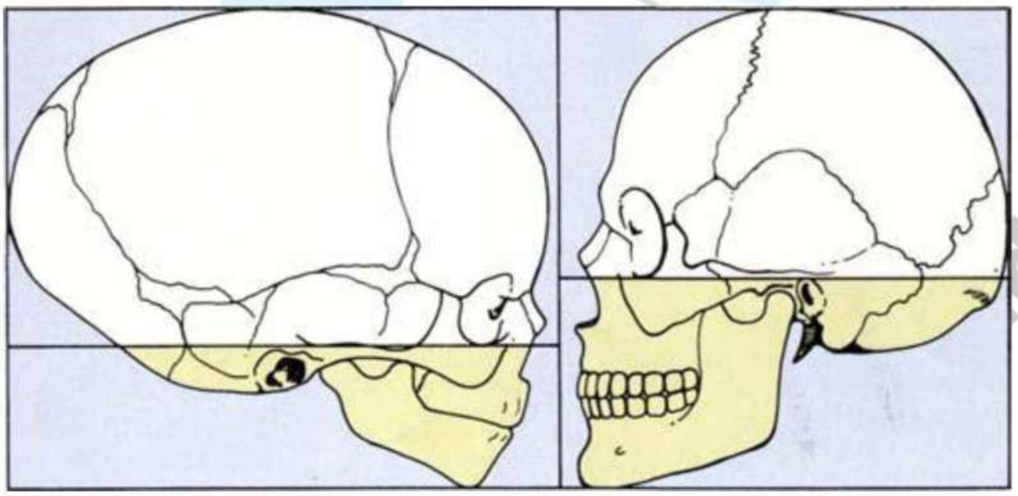
At birth, the legs represent about one third of the total body length, while in the adult, they represent about half.

As Figure (1) illustrates, there is more growth of the lower limbs than the upper limbs during postnatal life. All of these changes, which are a part of the normal growth pattern, reflect the "cephalocaudal gradient of growth." This simply means that there is an axis of increased growth extending from the head toward the feet.

As the face enlarges it grows downward and forwards away from the craniaum, the growth of the face involving many growth processes in the mandible, mid face, cranial base, all of these are going on at the same time, and the overall pattern of growth result from the interplay between them.

Even within the head and face, the cephalocaudal growth gradient strongly affects proportions and leads to changes in proportion with growth, so when the skull of a newborn infant is compared proportionally with that of an adult (fig. 2), it is easy to see that the infant has a relatively much larger cranium and a much smaller face.

This change in proportionality, with an emphasis on growth of the face relative to the cranium, is an important aspect of the pattern of facial growth. When the facial growth pattern is viewed against the perspective of the cephalocaudal gradient, it is not surprising that the mandible, being farther away from the brain, tends to grow more and later than the maxilla, which is closer, and this is considered as advantage in treatment of skeletal Class II and disadvantage in treatment of skeletal Class III .



Fig, 2: Changes in proportions of the head and face during growth. At birth, the face and jaws are relatively underdeveloped compared with their extent in the adult. As a result, there is much more growth of facial than cranial structures postnatally

Another aspect of the normal growth pattern is that not all the tissue systems of the body grow at the same rate (Figure 3).

Different systems of body have different growth patterns in terms of rate and timing and four main types are recognized:

1- Lymphoid growth

2- Genital growth

3- Neural growth: Determined by the growth of the brain, and the calvarium follows this pattern of growth, in other words the bones grows in response to the growth of another structure. There is rapid growth of cranium in the early years of the life, but this slows until about 8 years, growth is almost complete. The orbits follow the neural growth pattern.

4- Somatic growth: Is that followed by most of body structures. It is seen in the long bones leading to increase in the body height, This growth is fairly rapid in the early years but slows in the pr-pubertal period, while the pubertal growth spurt (11years in girls, 13 years in boys) is a time of very rapid growth, which followed by further slower growth.

The maxilla and mandible follow a pattern of growth that is intermediate between neural and somatic growth, with the mandible following the somatic growth curve more closely than the maxilla, which has a more neural growth pattern . Thus different parts of the skull follow different growth patterns, with much of the growth of the face occurring later than the growth of the cranial vault. As a result the proportions of the face to the cranium change during growth, and the face of the child represents a much smaller proportion of the skull than the face of the adult

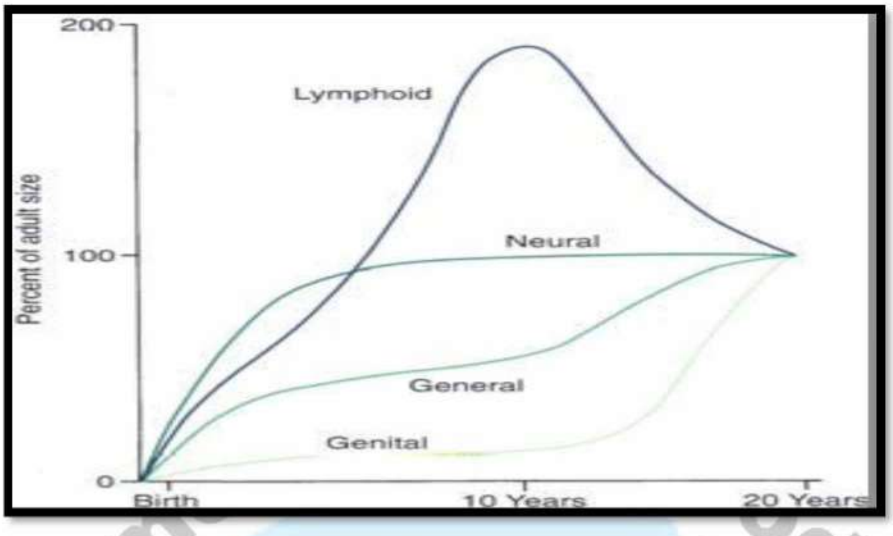


Fig. 3 Scammon's curves for growth of the four major tissue systems of the body. As the graph indicates, growth of the neural tissues is nearly complete by 6 or 7 years of age. Genera body tissues, including muscle, bone, and viscera, show an S shaped curve, with a definite slowing of the rate of growth during childhood and an acceleration at puberty. Lymphoid tissues proliferate far beyond the adult amount in late childhood, and then undergo involution at the same time that growth of the genital tissues accelerates rapidly.

CLINICAL SIGNIFICANCE OF THE GROWTH SPURTS

1-To differentiate whether growth changes are normal or abnormal.

2- Treatment of skeletal discrepancies (e.g. Class II) is more advantageous if carried out in the mixed dentition period, especially during the growth spurt.

3- Pubertal growth spurt offers the best time for majority of cases in terms of predictability, treatment direction, management and treatment time**.**

4-Orthognathic surgery should be carried out after growth ceases.

5-Arch expansion is carried out during the maximum growth period.

2- variability:

Obviously, everyone is not alike in the way that they grow, as in everything else. It can be difficult, but clinically very important, to decide whether an individual is merely at the extreme of the normal variation or falls outside the normal range. Rather than categorizing people as normal or abnormal, it is more useful to think in terms of deviations from the usual pattern and to express variability quantitatively.

One way to do this is to evaluate a given child relative to peers on a standard growth chart which can be used in two ways to determine whether growth is normal or abnormal.

a-The location of an individual relative to the group can be established.
b-More importantly, growth charts can be used to follow a child over time to evaluate whether there is an unexpected change in growth pattern

3- Timing:

Variation in timing arises because the same event happens for different individuals at different times—or, viewed differently, the biologic clocks of different individuals are set differently.

Variations in growth and development because of timing are particularly evident in human adolescence. Some children grow rapidly and mature early, completing their growth quickly and thereby appearing on the high side of developmental charts until their growth ceases and their contemporaries begin to catch up. Others grow and develop slowly and so appear to be behind, even though, given time, they will catch up with and even exceed children who once were larger. All children undergo a spurt of growth at adolescence, but the growth spurt occurs at different times in different individuals.

Growth effects because of timing variation can be seen particularly clearly in girls, in whom the onset of menstruation, often referred to as menarche, gives an excellent indicator of the arrival of sexual maturity. Sexual maturation is accompanied by a spurt in growth. When the growth velocity curves for early-, average-, and late-maturing girls are compared in (Figure 4), the marked differences in size between these girls during growth are apparent. At age 11, the early-maturing girl is already past the peak of her adolescent growth spurt, whereas the late-maturing girl has not even begun to grow rapidly. This sort of timing variation, which occurs in many ways other than that shown here, can be an important contributor to variability (fig 5).

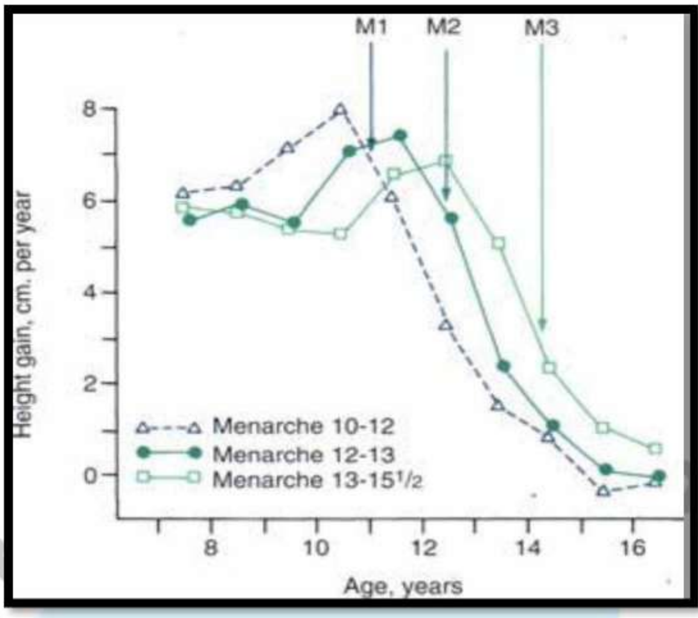


Fig. 4: Growth velocity curves for early-, average-, and late-maturing girls. It is interesting to note that the earlier the adolescent growth spurt occurs, the more intense it appears to be. Obviously, at age 11 or 12, an early maturing girl would be considerably larger than one who matured late. In each case, the onset of menstruation (menarche) (Mi, M2, and M3) came after the peak of growth velocity.

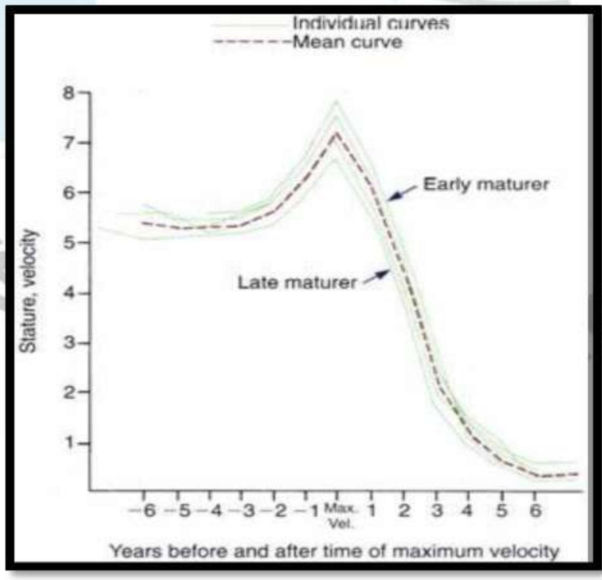


Fig. 5:Velocity curves for four girls with quite different times of menarche, replotted using menarche as a zero time point. It is apparent that the growth pattern in each case is quite similar, with almost all of the variations resulting from timing.

TERMINOLOGY RELATED TO GROWTH GROWTH FIELDS

GROWTH SITES: Are growth fields that have a special significance in the growth of a particular bone, e.g. mandibular condyle in the mandible, maxillary tuberosity in the maxilla. The growth sites may possess some intrinsic potential to grow (debatable).

GROWTH CENTERS: Are special growth sites, which control the overall growth of the bone, e.g. epiphyseal plates of long bones. These are supposed to have an intrinsic growth potential (unlike growth sites).

REMODELING: It is the differential growth activity involving deposition and resorption on the inner and outer surfaces of the bone, e.g. ramus moves posteriorly by a combination of resorption and deposition.

Mechanism of bone growth:

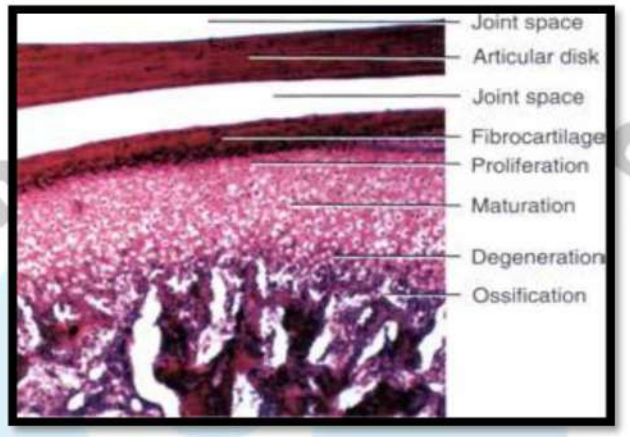
Bone does not grow interstitially (i.e. it does not expand by cell division within its mass) rather, it grows by activity at the margins of the bone tissue.

Bone is laid down in two ways:

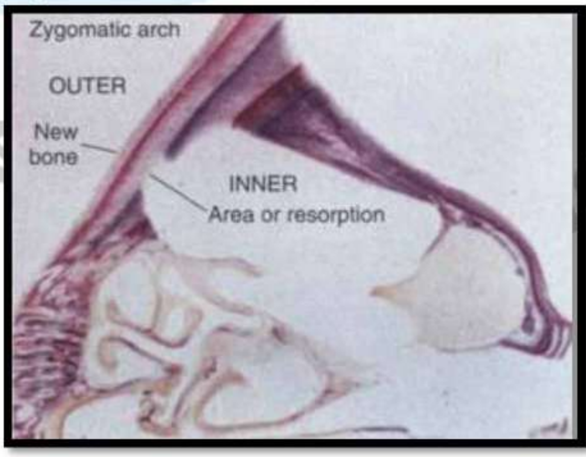
1- Endochondral ossification: At cartilaginous growth center, chondroblasts lay down a matrix of cartilage within which ossification occurs. At primary growth centers there are zones of cell division, cell hypertrophy and calcification aligned in columns along the direction of the growth. This process is seen in both the epiphyseal plate of long bones and the synchondroses of the cranial bone.
Near the outer end of each epiphyseal plate is a zone of actively dividing cartilage cells. Some of these, pushed toward the diaphysis by proliferative activity beneath, undergo hypertrophy, secrete an extracellular matrix, and eventually degenerate as the matrix begins to mineralize and then is rapidly replaced by bone (see Figure below). As long as the rate at which cartilage cells proliferate is equal to or greater than the rate at which they mature, growth will continue. Eventually, however, toward the end of the normal growth period, the rate of maturation exceeds the rate of proliferation, the last of the cartilage is replaced by bone, and the epiphyseal plate disappears. At that point, the growth of the

bone is complete, except for surface changes in thickness, which can be produced by the periosteum.

Condylar cartilage also lays down bone but seems to be in different way, because the articular surface is covered by a dense connective tissue also the growth of the condylar seems to be a reactive process in response to the growth of other structure of the face.



2- Intramembranous ossification: Growth is gained by the process of remodeling (resorption and deposition), usually growth is occur by enlargement of bone by deposition on its periosteal (surface) and by resorption in some parts of its surface to maintain the overall shape of the bone in addition to that, the endosteal remodeling (deposition and resorption) maintains the internal architecture of cortical plate and trabeculae.



Sutural growth: The bone of the face and skull articulate together mostly at sutures, and growth at sutures can be regarded as a special kind of periosteal remodeling –an infilling of bone in response to tensional growth forces separating the bones of either side of the suture.

Displacement: Growth which causes the mass of the bone to be moved relative to its neighbors, usually brought about by forces exerted by the soft tissues and by intrinsic growth of the bones themselves, e.g. epiphyseal plates and synchondroses; an example is forward and downward translation of the maxillary complex (fig.1).

Drift: The change in the position of the bony structure owing to the remodeling of that structure, as seen in (fig.2) in which the palate moves downward during growth as a result of bone being laid down on its inferior surface and resorbed on its superior surface.

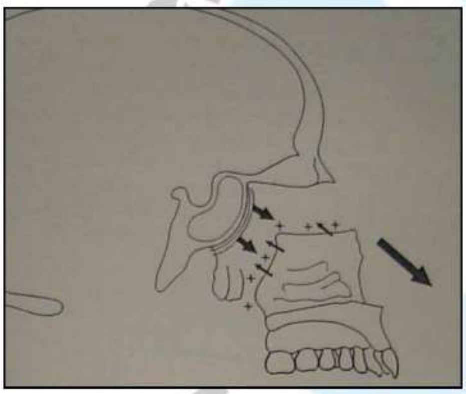


Fig.1: Displacement

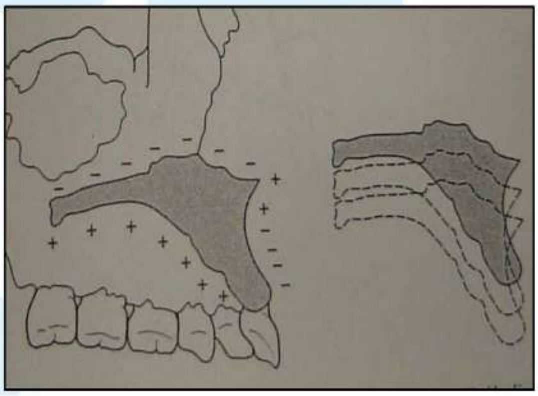


Fig.2 Drift

The post natal growth of the craniofacial complex:

Can be divided into four areas that grow rather differently:

a. *The cranial vault* the bone that covers the upper and outer surface of the brain.

b. *The cranial base* the bony floor under the brain, which is also a dividing line between the cranium and the face.

c. *The nasomaxillary complex* made up of the nose, maxilla, and the associated structures.

d. *The mandible.*

A-THE CRANIAL VAULT

Is the part of the skull which develops from the membranous bones surrounding the brain and the therefore it follows the neural growth pattern (the growth in the cranial vault is because of the enlarging brain.)

. It comprises:

1- Parietal bones (2)
2- Fontal bone
3- Squamous part of temporal bones (2)
4- Occipital bone.

The rate of bone growth is more during infancy and by the fifth year of life more than 90 percent of the growth of cranial vault is achieved.

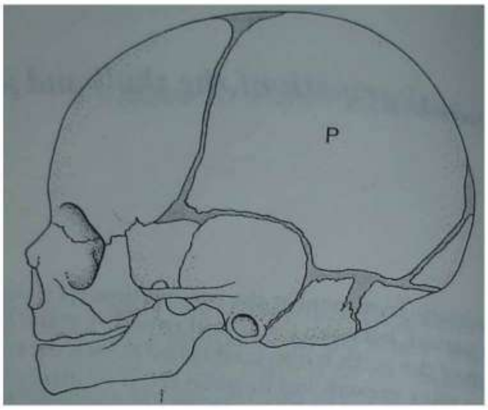
It is made up of a number of flat bones that are formed directly by *intramembranous ossification,* without cartilaginous precursors.

From the time that ossification begins at a number of centers that foreshadow the eventual anatomic bony units, the growth process is entirely the result of periosteal activity at the surfaces of the bones. Some selective resorption occurs early in postnatal life on the inner surfaces of the cranial bones to help flatten them out as they expand. Apposition can be seen on both the internal and external tables of the cranial bones as they become thicker.

Remodeling and growth occur primarily at the periosteum lined contact areas between adjacent skull bone, called the skeletal sutures.

At birth, the flat bones of the skull are rather widely separated by relatively loose connective tissues. These open spaces, the fontanelles (Fig. 3), allow a considerable amount of transient deformation of the skull at birth-a fact which is important in allowing the relatively large head to pass through the birth canal.

After birth, apposition of bone along the edges of the fontanelles eliminates these open spaces fairly quickly, then closes by 18 months.



(Fig. 3) Fontanelles in cranium

Growth of cranial vault consists of:

1- Drift: Internal cranial aspects of the bones are resorbed while bone is laid down on the external surface.
2- Displacement: The bones are separated by growing brain, with fill-in bone growth occurring at the sutures to maintain continuously of the cranial vault.

It should be realized that there is actual translation as well as remodeling of the individual bones, with the structures being moved outward by the growing brain. Despite early accomplishment of the pattern, the parietal bones do not close until the middle of third decade of life.

B-THE CRANIAL BASE:

The cranial base, unlike cranial vault, is not completely dependent on brain growth and may have some intrinsic genetic guidance and a pattern that is, similar in some dimensions, to that of the facial skeleton.

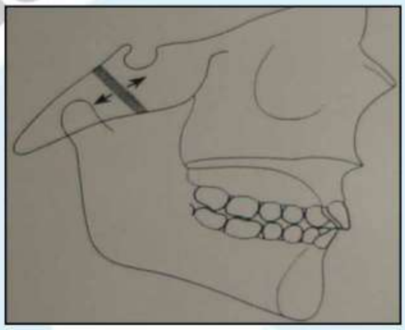
In contrast to the cranial vault, the bones of the cranial base are formed initially in the cartilage and are later transformed by endochondral ossification into bone. This is particularly true of the midline structures.

As one moves laterally, growth at sutures becomes more important, but the cranial base is essentially a midline structure.

Growth of the cranial base is influenced by both neural and somatic growth patterns, with 50 per cent of postnatal growth being complete by the age of 3 years.

As in the calvarium (cranial vault), there is both remodeling and sutural infilling as the brain enlarges, but there are also primary cartilaginous growth sites in this region — the synchondroses. Of these, the spheno-occipital synchondrosis is of special interest as it makes an important contribution to growth of the cranial base during childhood, continuing to grow until 13–15 years in females and 15–17 years of age in males, fusing at approximately 20 years.

The spheno-occipital synchondrosis is anterior to the temporomandibular joints, but posterior to the anterior cranial fossa, and, therefore, its growth is significant clinically as it influences the overall facial skeletal pattern (Fig.4).



(Fig.4)

Growth at the spheno-occipital synchondrosis increases the length of the cranial base.

Thus the middle cranial fossa follows a somatic growth pattern and enlarges both by anteroposterior growth at the spheno-occipital synchondrosis and by remodelling.

The anterior cranial fossa follows a neural growth pattern and enlarges and increases in anteroposterior length by remodelling, with resorption intracranially and corresponding extracranial deposition.

There is no further growth of the anterior cranial fossa between the sella turcica and foramen caecum after the age of 7 years. Therefore, after this age the anterior cranial base may be used as a stable reference structure upon which sequential lateral skull radiographs may be superimposed to analyse changes in facial form due to growth and orthodontic treatment.

The cranial base plays an important part in determining how the mandible and maxilla relate to each other, For example, Class II skeletal facial pattern is often associated with the presence of a long cranial base which causes the mandible to be set back relative to the maxilla.

In the same way, the overall shape of the cranial base affects the jaw relationship, with a smaller cranial base angle tending to cause a Class III skeletal pattern, and a larger cranial base angle being more likely to be associated with a Class II skeletal pattern (Fig. 5).

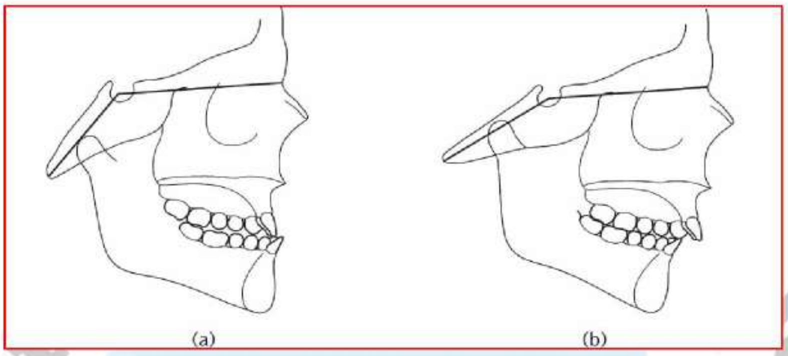
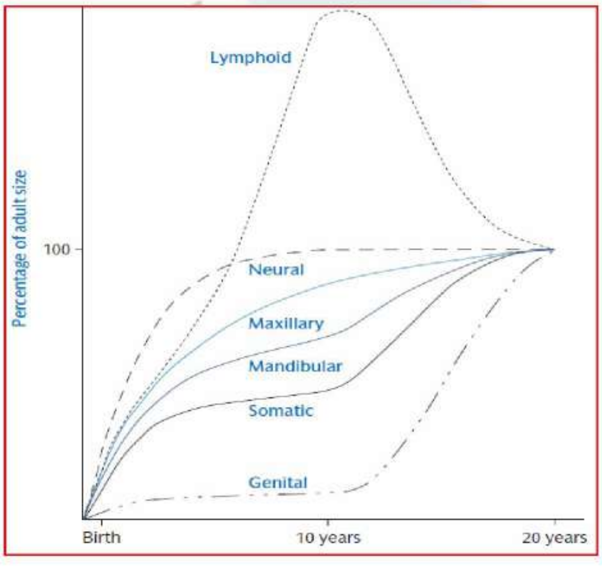


Fig.5 :a:low cranial base angle associated with Class III, b:High cranial base angle associated with Class II

The cranial base angle usually remains constant during the postnatal period, but can increase or decrease due to surface remodelling and differential growth at the spheno-occipital synchondrosis.

C-Naso maxillary complex:

Postnatal growth of the maxilla follows a growth pattern that is thought to be intermediate between a neural and a somatic growth pattern (see Fig. 6).



(Fig. 6):Post natal growth pattern

Clinical orthodontic practice is primarily concerned with the dentition and its supporting alveolar bone which is part of the maxilla and premaxilla. However, the middle third of the facial skeleton is a complex structure and also includes, among others, the palatal, zygomatic, ethmoid, vomer, and nasal bones. These articulate with each other and with the anterior cranial base at sutures.

Growth of the maxillary complex occurs in part by displacement with fill-in growth at sutures and in part by drift and periosteal remodelling. Passive forward displacement is important up to the age of 7 years, due to the effects of growth of the cranial base.

When neural growth is completed, maxillary growth slows and subsequently, approximately one-third of growth is due to displacement (0.2–1 mm per year) with the remainder due to sutural growth (1–2 mm per year). In total, up to 10 mm of bone is added by growth at the sutures.

Much of the antero-posterior growth of the maxilla is in a backward direction at the tuberosities which also lengthens the dental arch, allowing the permanent molar teeth to erupt. A forwards displacement of the maxilla gives room for the deposition of bone at the tuberosities (see Fig.7).

Downward growth of the mid face occurs by:

1-Vertical development of the alveolar process

2-Eruption of the teeth

3-Inferior drift of the hard palate, i.e. the palate remodels downwards by deposition of bone on its inferior surface (the palatal vault) and resorption on its superior surface(the fl oor of the nose and maxillary sinuses) (see Fig. 1).

4-These changes are also associated with some downward displacement of the bones as they enlarge, again necessitating infilling at sutures.

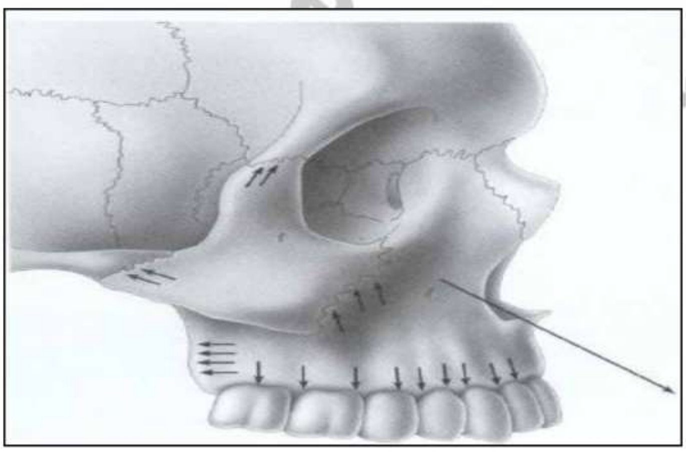


Fig.: 7: Naso maxillary complex growth

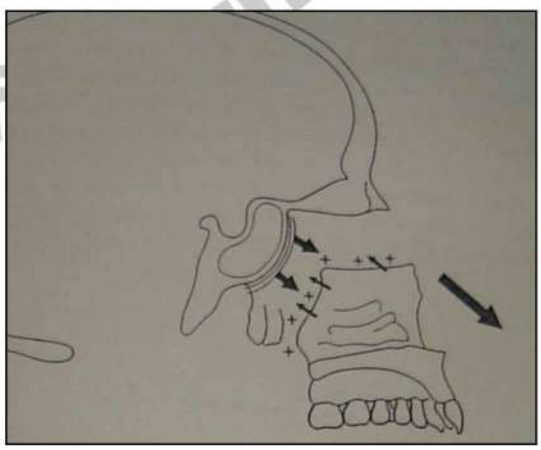


Fig.1: Down ward displacement of Nasomaxillary complex

Lateral growth in the mid-face occurs by displacement of the two halves of the maxilla, with deposition of bone at the midline suture. Internal remodeling leads to enlargement of the air sinuses and nasal cavity as the bones of the mid-face increase in size.

Therefore, growth is accompanied by complex patterns of surface remodeling on the anterior and lateral surfaces of the maxilla which maintain the overall shape of the bone as it enlarges. Despite being translated anteriorly, in fact much of the anterior surface of the maxilla is resorptive in order to maintain the concave contours beneath the pyriform fossa and zygomatic buttresses.

Growth of the nasal structures is variable but occurs at a more rapid rate than the rest of the maxilla. During the pubertal growth spurt, nasal dimensions increase 25 per cent faster than maxillary dimensions.

Maxillary growth ceases on average at about 14 years in girls and rather later at about 16 years in boys.

D-The Mandible:

The mandible is derived from the first pharyngeal arch and it is a membrane bone ossifying laterally to Meckles cartilage.

The role of the condylar cartilage in the growth of the mandible is not yet entirely clear. It is not a primary growth centre in its own right, but rather it grows in response to some other controlling factors. However, normal growth at the condylar cartilage is required for normal mandibular growth to take place.

Postnatal growth of the mandible follows a pattern intermediate between a neural and somatic pattern, although it follows the somatic pattern more closely than does the growth of the maxilla **(Fig 6).**

Most mandibular growth occurs as a result of periosteal activity.

As the mandible is displaced forwards growth at the condylar cartilage fills in posteriorly while at the same time periosteal remodelling maintains its shape.

Bone is laid down on the posterior margin of the vertical ramus and resorbed on the anterior margin, and this posterior drift of the ramus allows lengthening of the dental arch posteriorly. At the same time the vertical ramus becomes taller to accommodate the increase in height of the alveolar processes.

Remodelling also brings about an increase in the width of the mandible, particularly posteriorly. Lengthening of the mandible and anterior remodelling together cause the chin to become more prominent, an obvious feature of facial maturation especially in males. Indeed, just as in the maxilla, the whole surface of the mandible undergoes many complex patterns of remodeling as it grows in order to maintain its proper anatomical form.

Before puberty growth occurs at steady rate with an increase of 1–2 mm per year in ramus height and 2–3 mm per year in body length. However, growth rates can double during puberty and the associated growth spurt.

Mandibular growth slows to adult levels rather later than maxillary growth, on average at about 17 years in girls and 19 years in boys, although it may continue for longer.

Facial soft tissue growth

An important concept is that the growth of the facial soft tissues does not perfectly parallel the growth of the underlying hard tissues.

Growth of the Lips

The lips trail behind the growth of the jaws prior to adolescence, then undergo a growth spurt to catch up. Because lip height is relatively short during the mixed dentition years, lip separation at rest (often termed *lip incompetence)* is maximal during childhood and decreases during adolescence (Figure4). Because the lips move downward relative to the lips and teeth during adolescence (and continue to do so as the face ages), what looks like too much display of gingiva prior to and in adolescence can look perfectly normal in a young adult. Lip thickness reaches its maximum during adolescence, then decreases to the point that in their 20s and 30s, some women consider loss of lip thickness a problem and seek treatment to increase it.

A B

C D

Fig.3: Lip thickness increases during the adolescent growth spurt, then decreases (and therefore is maximal at surprisingly early ages). For some girls, loss of lip thickness is perceived as a problem by their early 20s. A, Age 14-8, at the end of the adolescent growth spurt. B, Age 16-11. C, Age 18-6. D, Age 19-7

Growth of the Nose

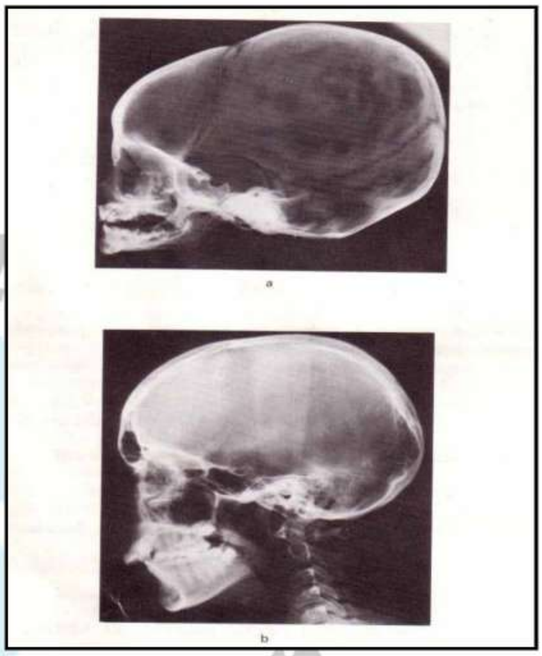
Growth of the nasal bone is complete at about **age of 10 years**. Growth thereafter is only of the nasal cartilage and soft tissues, both of which undergo a considerable adolescent spurt. The result is that the nose becomes much more prominent at adolescence, especially in boys (Fig. 1). The lips are framed by the nose above and chin below, both of which become more prominent with adolescent and post-adolescent growth while the lips do not, so the relative prominence of the lips decreases. This can become an important point in determining how much lip support should be provided by the teeth at the time orthodontic treatment typically ends in late adolescence.

A B

C D

Fig. 1: The nasal bone grows up until about age 10, but after age 10, growth of the nose is largely in the cartilaginous and soft tissue portions. Especially in boys, the nose becomes much more prominent as growth continues after the adolescent growth spurt (and this process continues into the adult years). A, Age 4-9. B, Age 12-4. C, Age 14-8. D, Age 17-8.

Maxillary sinus



As the sinus has the volume of small peas at birth, the eruption of deciduous teeth will modify its volume and it increases in size with the eruption of the 1st molar, about 8 years it has a pyramidal form that will lengthen after the eruption of the canine and the last molar.

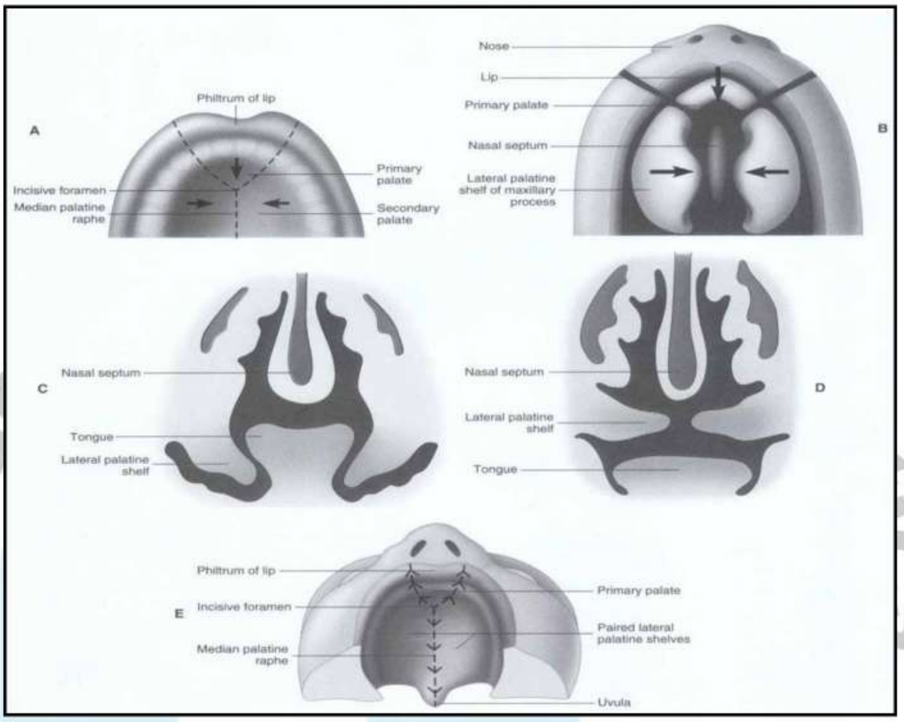
Development of palate

The palate begins to develop early in the 6th week, but the process is not completed until 12th week. The most critical period during palatal development is the end of the 6th week to the beginning of the 9th week.

The entire palate develops from:

1- the primary palate (premaxilla): is the triangular-shaped part of the palate anterior to the incisive foramen. Its origin is the deep portion of the inter-maxillary segment, which arises from the fusion of the two medial nasal prominences.

2- the secondary palate : give rises to the hard and soft palate posterior to the incisive foramen. It arises from paired lateral palatine shelves of the maxilla. These shelves are oriented in a superior-inferior plane with the tongue interposed. Later they become elongated and the tongue becomes smaller and moves inferiorly. This allows the shelves to orient horizontally, to approach one another, and to fuse in to midline. Later on these lateral palatal shelves fuse with the primary palate and nasal septum. Cleft palate results if the lateral palatal shelves failed to fuse with each other, with the nasal septum, or with the primary palate.



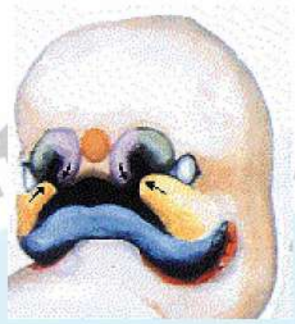
Cleft lip and palate:

The most common craniofacial anomaly, caused by failure of fusion between certain embryological processes during facial morphogenesis . Failure of fusion between the medial and lateral nasal and the maxillary processes results in a **cleft of the lip and/or alveolar process**.

Failure of fusion between the lateral palatine processes results in a **cleft of the palate.**

The etiology of cleft lip and palate is thought to be multifactorial. Genetic is implicated in 20%-30%of the patients. Environmental factors that have been shown in experimental animals to result in clefting include nutritional deficiencies, radiation, several drugs, hypoxia, viruses, and vitamin excesses or deficiencies.

In case of complete or bilateral clefts of the lip, alveolus and palate, the maxillary arch typically is collapsed in the transverse direction, especially in the area of the cleft. The maxillary permanent lateral incisors at the line of cleft may be congenitally missing or malformed, and many atypically shaped supernumerary teeth may be present in the area of the cleft.


Classification:

A cleft can be complete or incomplete, and it can occur unilaterally or bilaterally. A useful classification divides the anatomy into primary and secondary palates. An individual thus may have cleft of the primary palate, the secondary palate, or both.

Cleft lip: is classified either unilateral or bilateral and it could be minor cleft of the lip (small notch in the upper lip) or increase in the severity to complete cleft of the upper lip or continue to reach the nostril or to the internal angle of the eye, mostly unilateral, sometimes cleft lip may include cleft of the alveolar ridge.

Cleft palate: the fusion of the palatal components that form the palate usually start from the anterior aspect and continue posteriorly so that cleft palate could happen at any site through this process of fusion.

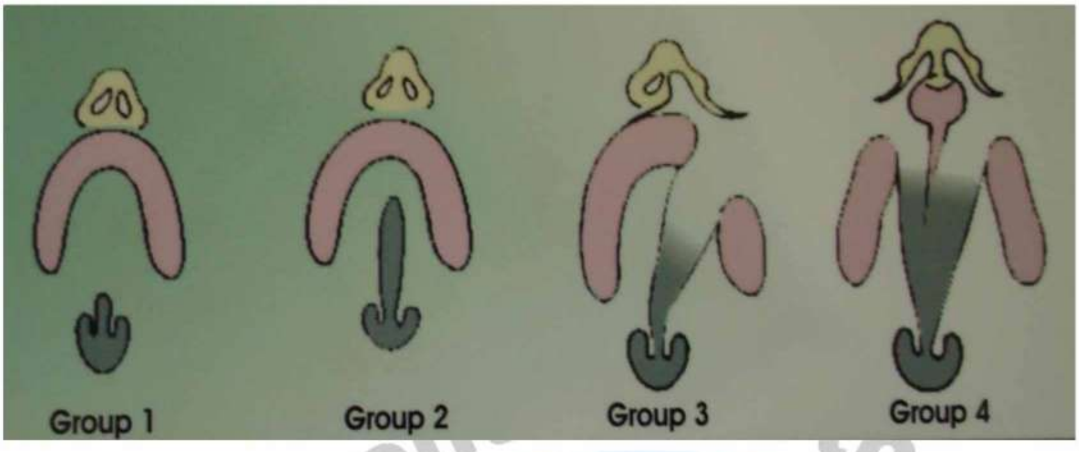
Cleft palate can be classified according to its severity as follows:

Class I : Cleft of soft palate (uvula)

Class II : Cleft of the secondary palate (median palatine cleft)

Class III: Complete unilateral cleft palate

Class IV: Complete bilateral cleft palate



Facial growth and the occlusion

The alveolar bone is highly adaptable, depending for its existence and location on the presence and position of the teeth: remove a tooth and the associated alveolar process resorbs, move a tooth into the same area make the bone remodels.

Dento-alveolar compensation

Because the upper and lower teeth erupt into the 'neutral zone' of muscle balance between lips, cheeks and tongue **they tend to be guided towards one another to establish an occlusion and to compensate for any transverse or antero-posterior mal-relationships of the jaws**. Variations in vertical jaw relationships are compensated, to a greater or lesser degree, on eruption of the teeth and growth of the alveolar processes. Where the skeletal mal-relationships are too severe, the dento-alveolar compensation described above may not be sufficient to establish a normal occlusion and so crossbite, open bite and antero-posterior arch mal-relationships may develop. Therefore, mal-occlusion often will be less severe than might have been expected from the jaw mal-relationship by this compensation(see Figure 2).

(so compensation occurs Dento-alveolarly by the effect of soft tissue in response to jaws mal-relation to decrease its severity)

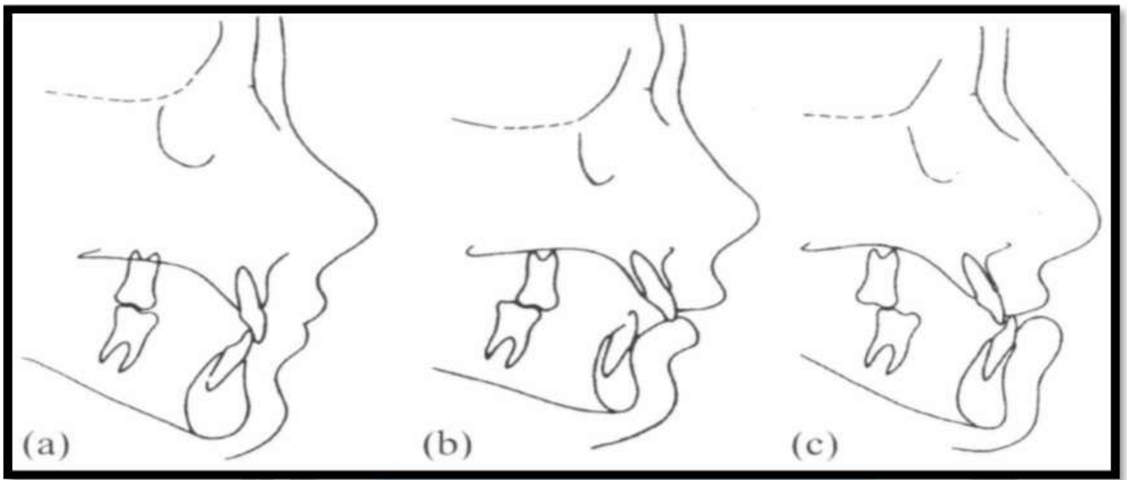
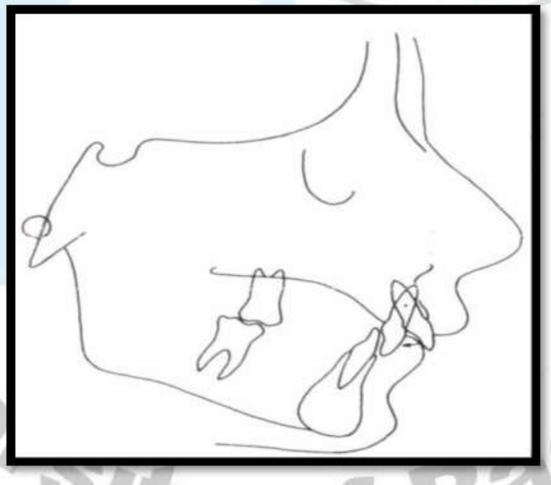


Figure 2 skeletal patterns: (a) Class I; (b) Class II; (c) Class III

Dento-alveolar compensation is not always advantageous: in some cases of mandibular retrusion, for example, compensation occurs by retroclination of the upper incisors (see Figure below).



This type of incisor relationship is usually associated with a deep overbite and may, when associated with poor oral hygiene, be traumatic as well as being unsightly.

Dento-alveolar adaptation

As the face grows, the intermaxillary space increases in height and the anteroposterior jaw relationship may change. As a result of vertical growth of the

teeth and alveolar processes, occlusal contacts, and the soft tissue environment of the teeth, so the existing occlusion tends to be maintained. Dentoalveolar adaptation is a dynamic process (occurs as a result to normal growth in normal jaws relation)..

Dento-alveolar adaptation is greatest vertically, in response to vertical growth

of the intermaxillary space. Little change in transverse jaw relationships occurs with growth. Where changes in antero-posterior jaw relationships occur there will usually be a corresponding dento-alveolar adaptation. Most commonly the mandible grows forwards slightly more than the maxilla, so the upper incisors expected to procline whilst the lower incisors retrocline. The proclination of the upper incisors does not produce spacing in the same upper arch because the upper buccal segments come forwards by a comparable amount. Retroclination of the lower incisors usually results in crowding (late lower incisor crowding in young adults).

Growth rotations:

Growth rotations are most obvious and have their greatest impact on the mandible (particularly in vertical dimension) while their effects on the maxilla are small.

Mandibular growth rotations result from the interplay of growth of a number of structures which determines the ratio of the posterior to anterior facial heights.

The posterior facial height is affected by the followings:

1- The direction of the mandibular growth at the condyles.
2- The vertical growth at the spheno-occipital synchondrosis.

The anterior facial height is affected by

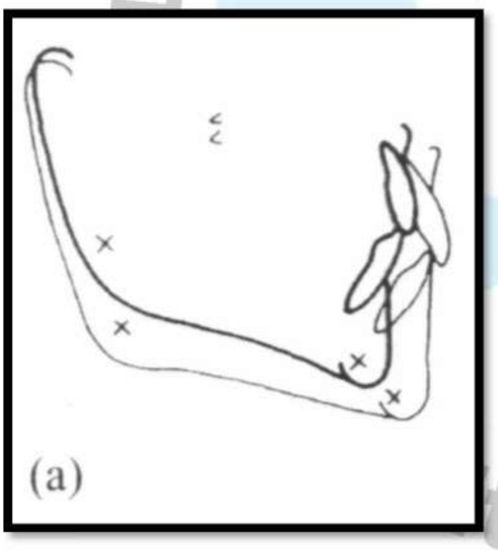
1- The eruption of the teeth.
2- The vertical growth of the soft tissues including the masticatory musculature.

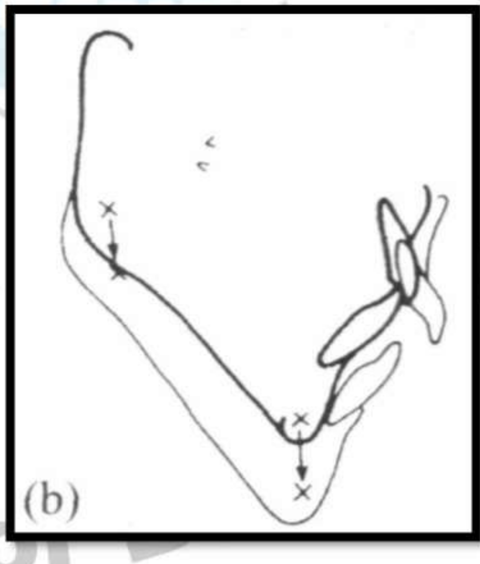
Types of growth rotations:

a-The rotation of either jaw is considered "forward" or “ anterior” and given a negative sign if there is more growth posteriorly than anteriorly (clockwise rotation) bringing the chin forward and upward(tendency to skeletal deepbite).

b-The rotation is "backward" or “ posterior ” and given a positive direction if it lengthens anterior facial dimensions more than posterior ones, bringing the chin downward and backward (counter clockwise rotation).(tendency to skeletal openbite)

c- Average rotation: A mild forward rotation which produces a well balanced facial appearance.





Forward growth rotations are more common than backward rotations with the average being a mild forward rotation which produces a-well balanced facial appearance. A marked forward growth rotation tends to reduce anterior vertical facial proportions and increased overbite (deepbite).while backward rotation will tend to increase anterior vertical facial proportions and reduced overbite (anterior openbite).

Growth rotation not only affect vertical dimension but also affect anterio-posterior relation of the facial skeleton.for example , correction of classII malocclusion will

be helped by a forward rotation as there will be forward growth of the mandible, but made more difficult by a backward rotation as there will be backward growth of the mandible increasing the skeltal class II so myofunctional appliance is contraindicated in case of class II div.1 when the rotation of the mandible is backward. (backward rotation usually is un favourable).

Devlopmental Anomalies:

1-Supernumerary teeth : Extra teeth in the dental arch.

2-Congenitally missing teeth: Reduce no. of teeth in the dental arch.(Lower second premolar; Upper lateral incisor and wisdom teeth).

3-Cleft lip and /or palate .

Principles of Genetics:

Genetic Factors and Inherited Factors, Its Role on Cranio-Facial Abnormalities

Basic Information and Definitions

Before proceeding, a few basic genetic definitions and concept descriptions are required.

Human Genome

- An organism's *genome* is defined as the complete set of genetic instructions for that organism. The human genome is made up of a double helix of deoxyribonucleic acid (DNA) comprised of ~3.2 billion chemical nucleotide base pairs (A, Adenine; G, Guanine; T, Thymine and C, Cytosine), see Figure 7.1.
- This genetic information is normally organized into smaller units (ranging in length from ~50 to 250 million base pairs each) called *chromosomes*. A chromosome is made up of a continuous stretch of the double helical DNA that is wrapped around proteins that are called histones.

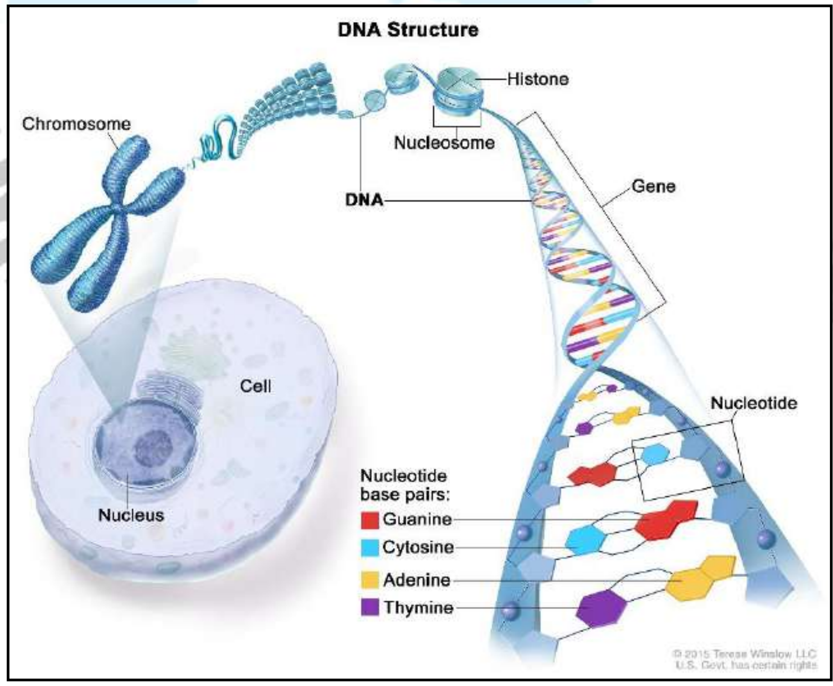


Figure 7. 1: Chromosome and DNA structure.

- Altogether, we each inherit a total of 46 chromosomes; 22 *homologous pairs* of chromosomes called *autosomes* that are numbered by size and other characteristics, along with one pair of *sex chromosomes* that are homologous (X,X) in females and only partly homologous (X,Y) in males, see Figure 7.2.

- *Homologous chromosomes* are units of genetic material that are similar in size and structural features. Upon conception, a person inherits all 46 chromosomes (22 autosomal pairs total and one pair of sex chromosomes) that make them a unique individual; one chromosome for each autosomal pair is contributed by each parent, and one sex chromosome originates from each parent. Chromosomes in all subsequent cells are copies of the original maternal or paternal chromosomes, see Figure 7.2.

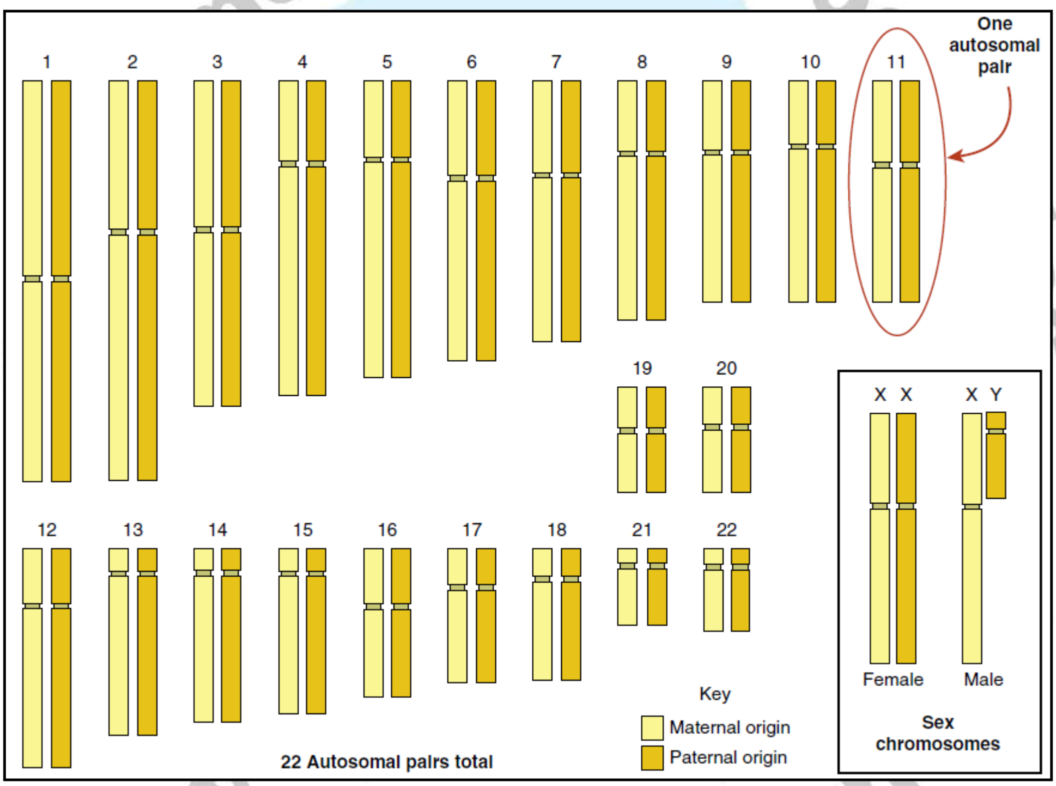


Figure 7.2: Diagram of human chromosomes.

- Looking closer at the chromosomes, they are further organized into smaller units called *genes*, which represent the smallest physical and functional unit of inheritance, see Figure 7.3. A *gene* can be defined as the complete DNA sequence that codes for the synthesis of a specific polypeptide or the synthesis of a specific RNA molecule. Based on the findings of the Human Genome Project (HGP), we have learned that: a) there are an estimated 25,000 genes in the human genome; b) our genes only make up 2% of the whole genome; and c) the average gene is 3000 nucleotide base pairs in length.

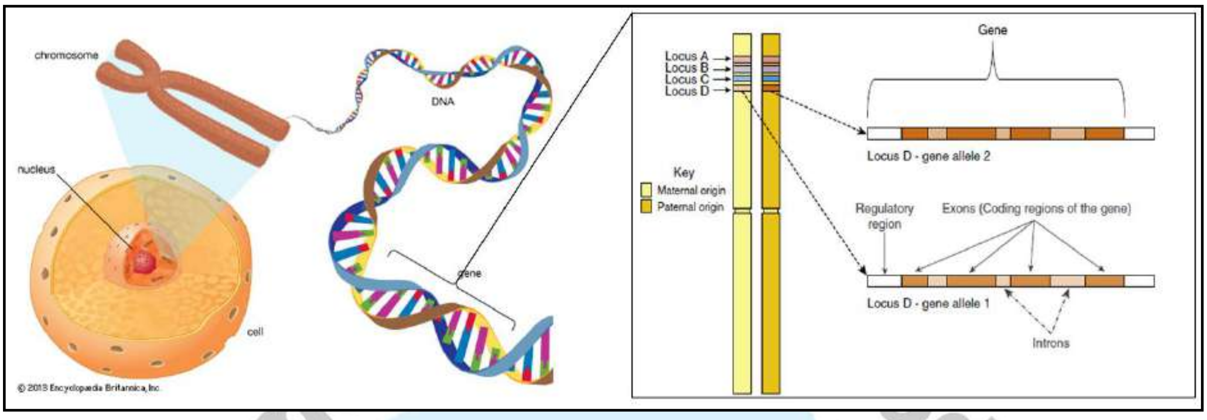


Figure 7. 1: One autosomal pair of chromosomes illustrating the concepts of four unique gene loci contained on the autosomal pair, multiple alleles, and the general structure of a gene.

- **Allele vs Gene**

  Within the human genome, every gene resides in a specific location referred to as a locus. The term locus is used when describing a single genetic region or location, and loci is plural. Genes at the same locus on a pair of homologous chromosomes are called alleles. One allele would be a copy of the maternal allele and the other a copy of the paternal allele. If these alleles are not identical, they can produce different polypeptide sequences and possibly diverse effects. When a pair of alleles are identical in DNA sequence (e.g., allele A and allele A), the individual is said to be homozygous for that locus. However, when the two alleles have one or more differences in the DNA sequence (e.g., allele A and allele a), the individual is said to be heterozygous for that locus.

Genotype vs Phenotype

- *Genotype* is a complete heritable genetic identity; it is a unique genome that would be revealed by personal genome sequencing. A genotype generally refers to the combination of alleles at a given locus within the genome (e.g., *AA, Aa, or aa*). A person's genotype cannot be seen with our eyes but must be determined with the use of a genetic test or analysis. According to the information gained in the HGP, we now know that the human genome is ~99.9% identical from one person to another. Thus, there is only an estimated 0.1% variation within the entire DNA code between two people that makes each individual unique.

- In contrast to genotypes, *phenotypes* are the observable properties, measurable features, and physical characteristics of an individual. A phenotype is generated by the summation of the effects arising from an individual's genotype and the environment in which the individual develops over a period of time, see Figure 7.4.

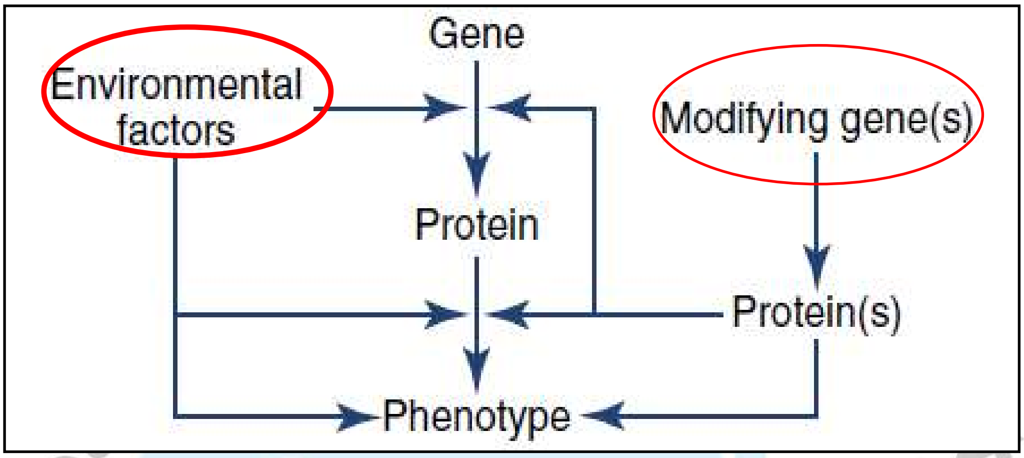


Figure 7. 4: Environmental factors and other genes may modify the clinical expression of the disease or other type of trait but are not of crucial importance for its development.

Heritability of Malocclusion

The trait is a particular aspect or character of phenotype, e.g. number of teeth, arch length and arch width. Syndrome is a combination of traits that occur together in non-random pattern that is different from the usual pattern. Depending on the genetic influence on traits, the traits can be considered to be of three types:

i. Monogenic traits (Mendelian): Traits that develop because of the influence of a single gene locus.

ii. Polygenic traits (complex or common): Traits that are resulted from complex interaction of multiple genes.

iii. Multifactorial traits: When polygenic traits are influenced by environmental factors along with multiple genetic factors, meaning they are influenced by the interaction of multiple genes, as well as environmental factors.

Thus, describes how the genetic information is passed down one generation to the next, as follow:

I. **Autosomal dominant trait or syndrome** – if the gene locus is located on one of 22 autosomal chromosome pairs and the trait or disease manifests itself when the affected person carries only one copy of the gene responsible, along with one normal allele, then the individual is heterozygous for that allele. However, the affected individual could be homozygous for the responsible gene allele. The mode of inheritance of the trait is called autosomal dominant.

II. **Autosomal recessive trait or syndrome** – if the production of the trait or syndrome does not occur when only one copy of a particular allele is present at the locus on a pair of autosomes, but does occur when two copies of that particular allele are present at the locus of a pair set of autosomes. Two copies of the defective gene are required for expression of the trait. The parents are heterozygous.

III. **X-linked (recessive) trait** – recessive genes on X chromosome. Express themselves phenotypically in males as if they were dominant genes because a male usually only has one X chromosome (hemizygous). A male with the genotype is affected in the pedigree.

- ***But why should a student of orthodontics be interested in genetics?***

The reason is very simple, whatever affects the growth, development and function of the oral and facial structures is of interest to the student of orthodontics. We have to know exactly why or how a malocclusion occurs, to what extent does it express in the next generation, what is its prevalence and how will it react to a certain treatment plan. And, most importantly, if it can be prevented.

Mode of Transmission of Malocclusion

Malocclusion may be defined as a significant deviation from what is defined as normal or 'ideal' occlusion. Many components are involved in normal occlusion.

The most important are: (a) the size of the maxilla; (b) the size of the mandible, both ramus and body; (c) the factors which determine the relationship between the two skeletal bases, such as cranial base and environmental factors; (d) the arch form; (e) the size and morphology of the teeth; (f) the number of teeth present; and (g) soft tissue morphology and behavior, lips, tongue, and peri-oral musculature.

⋆**Important Note:**

For an anomaly to be considered of hereditary origin, it should occur and be a well-defined variation in family groups. A diagnosis of genetic malocclusion should not be made on the basis of a single case of recurrence in the family. Longitudinal studies of pedigree same family are a great help in recognizing and quantifying such malocclusions.

Dental and Skeletal Characteristics that are Inherited

Most problems in orthodontics are not strictly the result of only genetic or only environmental factors, unless trauma, but a combination of both. It is important to understand the cause of the problem before attempting treatment.

- **Class II Division 1 Malocclusion**

Class II division 1 malocclusion appears to have a polygenic/multifactorial inheritance, see Figure 7.5.

Environmental factors can also contribute to the aetiology of class II division 1 malocclusions such as digit sucking. Soft tissues can exert an influence on the position and inclination of upper and lower incisors and the need to achieve lip/tongue contact for anterior oral seal during swallowing can encourage the lower lip to retrocline the lower incisors and the protruding tongue to procline the uppers, influencing the severity of the overjet.

Figure 7.5: Class II division 1 malocclusion

- **Class II div 2 (have strong genetic component)**

Class II division 2 malocclusion exhibits high genetic influence and is often considered as a genetic trait. Results of many studies suggest the possibility of autosomal dominant inheritance. Class II div 2 is a multifactorial (polygenic complex) trait; a number of genes (acting additively) rather than being the effect of a single controlling gene for the entire occlusal malformation. High lip line, lip morphology and behaviour are also considered to be causing Class II division 2 malocclusion. Furthermore, the presence of strong masticatory muscle pattern in Class II division 2 cases is explained by the genetically determined muscular and neuromuscular system, see Figure 7.6.

Figure 7.6: Class II division 2 malocclusion.

- **Class III (have strong genetic component)**

Class III malocclusion with mandibular prognathism often runs in families. The most famous example of a genetic trait in humans passing through several generations is probably the pedigree of the so-called "Hapsburg family", see Figure 7.7. This was the famous mandibular prognathism demonstrated by several generations of the Hungarian/Austrian dual monarchy. Many studies had suggested a strong genetic basis for mandibular prognathism (autosomal dominant trait). The genetic factors appear to be heterogeneous with monogenic influence in some families and multifactorial (polygenic complex) influence in others. Although wide range of environmental factors have also been suggested as a contributor to the development of mandibular prognathism. Among these are enlarged tonsils, nasal blockage, posture, hormonal disturbances, endocrine imbalances and trauma/disease. Soft tissues do not play a part in the aetiology of class III.

Figure 7.7: Mandibular prognathism in the Hapsburg family. (A) Phillip II and Prince Ferdinand, 1575 (Titian). (B) Phillip IV, 1638 (Velasquez). (C) Charles IV and family, 1800 (Goya). In C, note the strong lower jaw in baby, father, and grandmother but not in mother.

Malocclusion associated with genetic syndromes

Craniofacial disorders and genetic aetiology with malocclusion include:

1) Facial clefts, cleft lip and cleft palate.
2) Cleidocranial dysplasia.
3) Gardner's syndrome.
4) Down's syndrome.
5) Osteogenesis imperfecta.

Butler's Field Theory

According to this theory, mammalian dentition can be divided into several developmental fields, see Figure 7.8. The developmental fields include molar/premolar field, the canine field and the incisor field. Within each developmental field, there is a key tooth, which is more stable developmentally and on either side of this key tooth, the remaining teeth within the field become progressively less stable.

- Within Molar/Premolar Field: Within molar/ maximum variability will be seen for the third molars. Third molars are the most common teeth to be congenitally absent and to be impacted. When premolars are congenitally absent, the second premolars are more commonly affected than the first premolars.
- Within Incisor Field: Within incisor field, according to Butler's field theory, the maximum variability will be seen for the lateral incisor. Variabilities of lateral incisor include:

a) Peg-shaped lateral incisor.
b) Congenitally missing laterals.

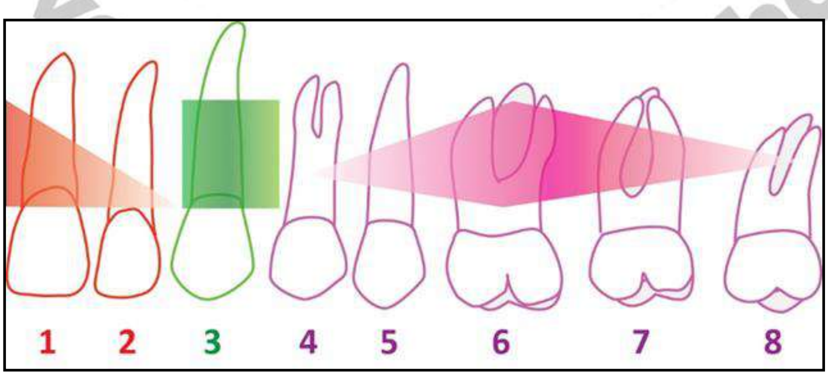


Figure 7.8: Butler's Field Theory

Local occlusal variables

- **Hypodontia**

Hypodontia has a hereditary nature. Maxillary lateral incisor is the most common tooth to be congenitally missing, next to third molars followed by the second premolar, see Figure 7.9. Hypodontia often exhibits familial occurrence and fits polygenic models of inheritance.

Congenital absence of teeth and reduction in tooth size are associated, hypodontia and hypoplasia of maxillary lateral incisors frequently present simultaneously. Hypodontia and the reduction in tooth size are in fact controlled by the same or related gene loci.

Figure 7.9: Familial hypodontia, In the upper panel there is hypodontia with UR2, UL2, LL8, LL5, LR5 and LR8 absent. In the middle panel there is more severe hypodontia, with UR8, UR5, UR4, UL4, UL5, UL8, LR8, LR5, LL5 and LL8 absent. In the lower panel there is oligodontia, with the UR8, UR5, UR4, UR2, UL2, UL5, UL8, LL8, LL5, LL1, LR4, LR5, LR8 absent

- **Supernumerary**

Supernumerary teeth, most frequently seen on premaxillary region, also appears to be genetically determined. Mesiodens are more commonly present in parents and siblings of the patients who exhibit them, see Figure 7.10. The mode of transmission could be explained by a single autosomal dominant gene.

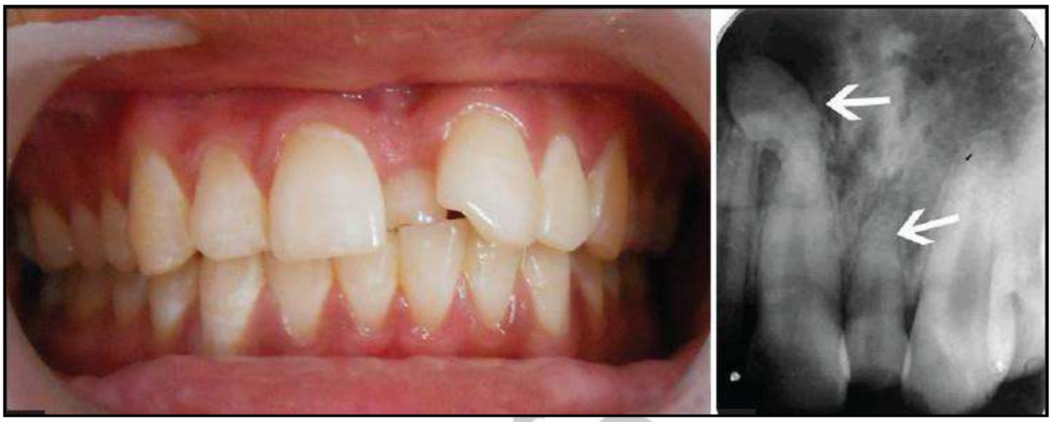


Figure 7.10: Supernumerary teeth (mesiodens).

- **Tooth size and shape**

Studies have shown that tooth crown dimensions are strongly determined by heredity. As dietary habits in humans adapt from a hunter/gatherer to a defined food culture, evolutionary selection pressures are tending to reduce tooth volume, which is manifested in third molar, second premolar and lateral incisor "fields", see Figure 7.11.

Figure 7.11: Peg shaped maxillary lateral incisors (bilateral red cycles).

- **Ectopic maxillary canine**

Various studies have indicated a genetic tendency for ectopic maxillary canine. Palatally ectopic canines have an inherited trait (see Figure 7.12), being one of the anomalies in a complex and genetically related dental disturbances, often occurring in combination with missing teeth, microdontia, supernumerary teeth and other ectopically positioned teeth. Studies have also shown an association between ectopic maxillary canines and class II malocclusion, which has a strong basis. In addition, tooth transposition most commonly affects maxillary canine/first premolar class position and shows a familial occurrence.

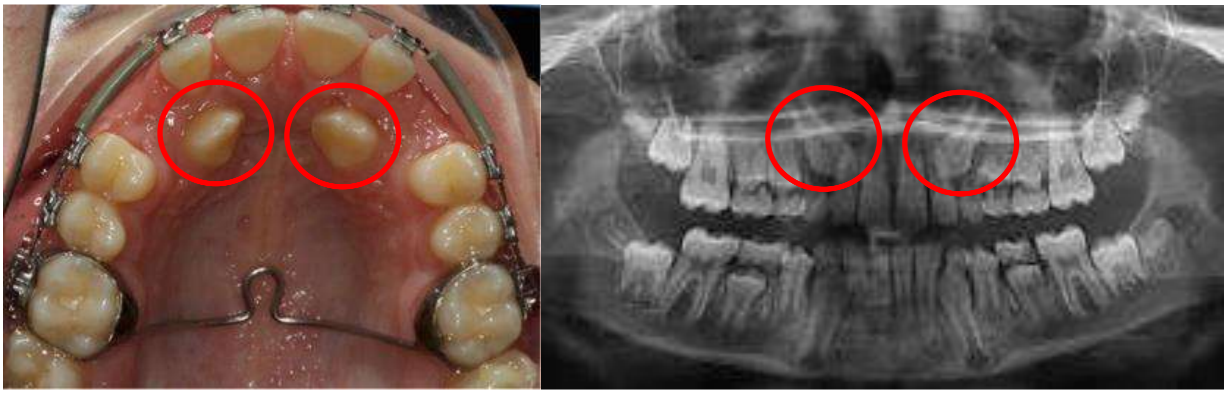
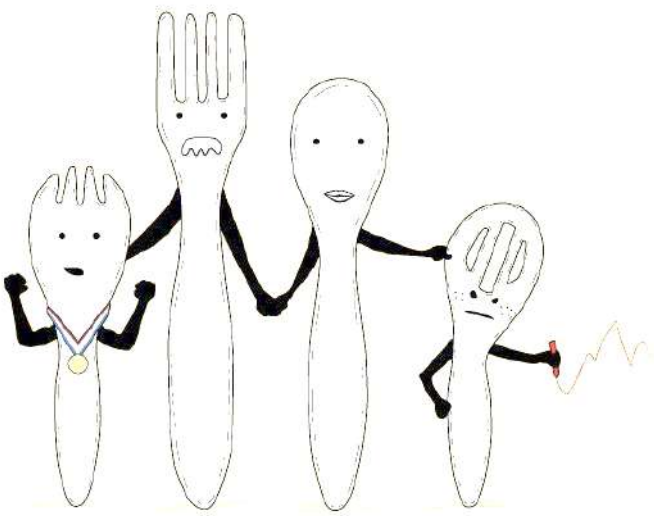


Figure 7.12: Palataly bilateral ectopic maxillary canine, (red cycles).

Clinical Implications of Genetics in Orthodontics

Malocclusion with a "genetic cause" is generally thought to be less responsive to treatment than those with an "environmental cause". The greater the genetic component, the worse the prognosis for a successful outcome by means of orthodontic intervention. However, knowing exactly the relative contribution of genetic and environmental factors is not always possible. Malocclusions of genetic origin (skeletal discrepancies) when detected in growing period, are being successfully treated using orthopaedic and functional appliances, except in extreme cases where surgical intervention is required. When malocclusion is primarily of genetic origin, for example, severe mandibular prognathism then treatment will be palliative or surgical. Examination of parents and older siblings can give information regarding the treatment need for a child and treatment can be begun at an early age.



Genetics in summary….

Development of occlusion

The development of dentition is an important part of craniofacial growth as the formation, eruption, exfoliation and exchange of teeth take place during this period.

According to Angle occlusion is"The normal relation of the occlusal inclined planes of the teeth when the jaws are closed"

According to Ash and Ramfjord occlusion is the " The contact relationship of the teeth in function and parafunction"

Periods of Occlusal development can be divided into the following development periods:

1-Neo-natal period (at birth).

2- Primary dentition period.

3- Mixed dentition period.

4- Permanent dentition period

Neonatal period

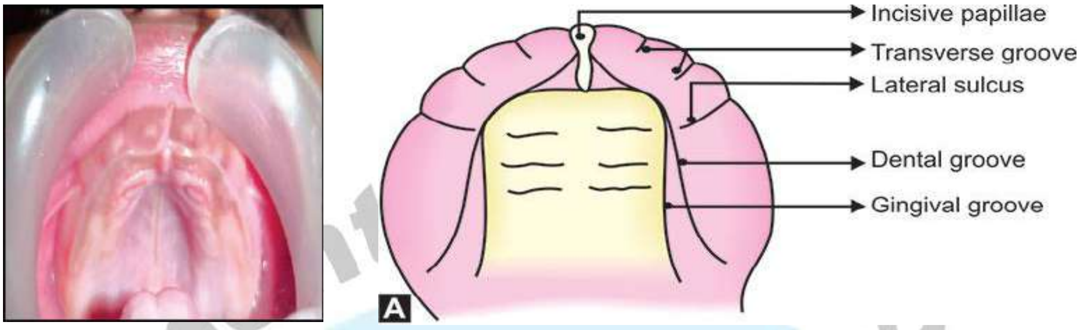
Alveolar processes at the time of birth known as gum pads. Which is Pink in color, firm and are covered by a dense layer of fibrous periosteum , the pads get divided into 'labio- buccal' & 'lingual portion', by a **Dental groove**,and gum pad soon gets segmented into 10 segment by a groove called **Transverse groove**, & each segment is a developing tooth site.The groove between the canine and the 1st molar region is called the **lateral sulcus** which helps to judge the inter-arch relationship.

*** The upper gum pad** is horse shoe shaped, **shows**

-Gingival groove separates gum pad from the palate

- Dental groove starts at the incisive papilla, extends backward to touch the gingival groove in the canine region & then moves laterally to end in the molar region

-Lateral sulcus.

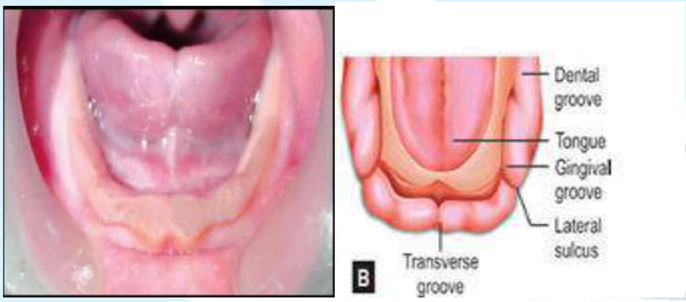


*** The lower gum pad:** U shaped , characterized by

-Gingival groove lingual extension of the gum pads

-dental groove

- Lateral sulcus.



Relationship of Gum Pads

- ❖ Anterior open bite is seen at rest with contact only at the molar region.
- ❖ Upper gum pad being more wider and longer than lower gum pads thus when approximated a complete over jet present all around.
- ❖ Class II pattern with the maxillary gum pad being more prominent Mandible is distal to the maxilla and usually the upper jaw overlap the lower jaw in anterior posterior and transverse direction.
- ❖ Mandibular lateral sulci posterior to maxillary lateral sulci

The anterior opening of the mouth will facilitate the feeding process without discomfort to the mother, at this stage the labial frenum is usually attached to the incisive papillary region and after the eruptin of the deciduous teeth it will migrate in upward direction and gives the insicive papillary attachment is due to alveolaor bone formation in association with the develoment of deciduous teeth ,the upper lip at this stage is usually short,and the anterior oral seal of the mouth occure due to the contact between lower lip and the tongue.

Neonatal Jaw Relationships

Mandibular functional movements are mainly vertical and to a little extent anteroposterior. Lateral movements are absent,precise bite or jaw relationship is not yet seen,therefore neonatal jaw relationship can not be used as a diagnostic criterion for reliable prediction of subsequent occlusion in primary dentition.

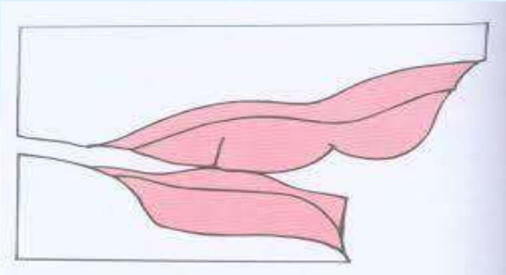


Fig 4 Relation between upper and lower gum pads at birth

The newly born child mouth is usually without teeth,sometimes Natal teeth that are present above the gumline (have already erupted) at birth.

Neonatal teeth or Early Infansive teeth that erupt during the 1st month of life these teeth looklike the deciduous teeth.

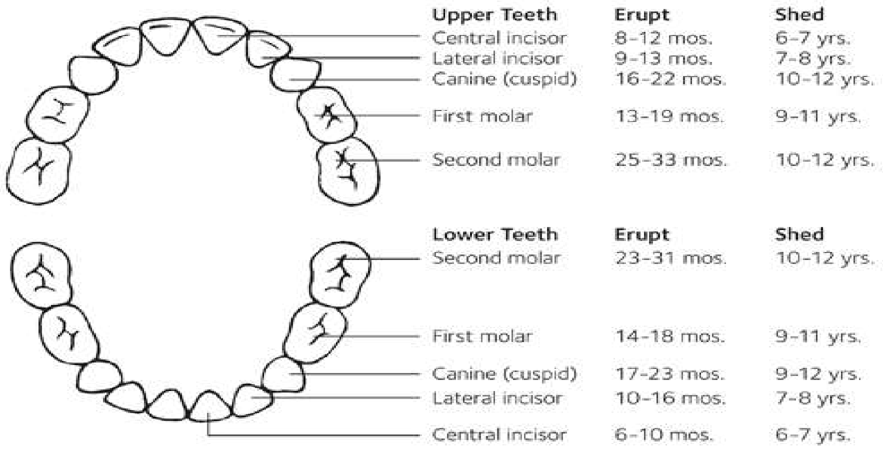
Pre-erupted teeth erupt during the second or third month.

they are contained enamel,dentine and pulpal tissue and usually without roots or there is a very short root with them. No intervention is usually recommended unless they are causing difficulty to the infant or mother . The incidence of natal and neonatal teeth is estimated to be l:1000and 1:30000respectively. These teeth are almost always mandibular incisors, which frequently display enamel hypoplasia. There are familial tendencies for such teeth. They should not be removed if normal but removed if supernumerary or mobile

Deciduous Dentition

Deciduous teeth or **primary teeth**, are the first set of teeth in the growth development of humans . They develop during the embryonic stage of development starts at the sixth week of tooth development as the dental lamina, there are ten buds on the upper and lower arches that will eventually become the primary (deciduous) dentition. These teeth will continue to form until they erupt and become visible in the mouth during infancy, there are a total of twenty teeth that is made up of central incisors, lateral incisors, canines, first molars, and secondary molars; there is one in each quadrant, making a total of four of each tooth: five per quadrant and ten per arch. The eruption of these teeth (teething) starts from the eruption of the first deciduous tooth, usually the deciduous mandibular central incisors. By 2½ years of age, deciduous dentition is usually complete and in full function.

The sequence of eruption and sheddind of deciduous teeth



Normal Signs of Primary Dentition

1-Ovoid arch form

2- Striaght or vertical inclinion of the incisors

3- Deep bite are present this could be duo to vertical inclination of primary incisors over aperiod of time these deep bite reduced duo to eruption of primary molars ,rapid attrition of incisors and forward movement of the mandible due to growth , and which change to edge to edge relationship

4-Minimal overjet and absence of crowding.

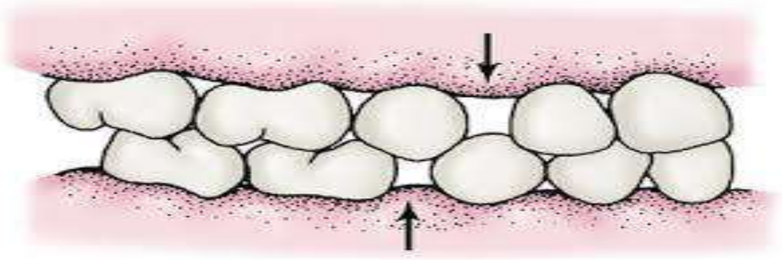
Two types of primary dentitions seen

A- **Closed primary dentition**: absence of spaces is an indication that crowding of teeth may occur when the larger permanent teeth erupt.

B- **Spaced or opened primary dentition**: in which interdental spaces are present called spaced dentition there are 2 types of spacing.

1- **Physiologic or generalized spaces** :usually seen in the deciduous dentition to accommodate the larger permanent teeth in the jaws, more prominent in the anterior region.

2- **Primate spaces or anthropoid spaces**: naturally occurring spacing between the teeth of the primary dentition. In the maxillary arch, it is located between the lateral incisors and canines, where as in the mandibular arch the space is between the canines and first molars, This space is used for early mesial shift.

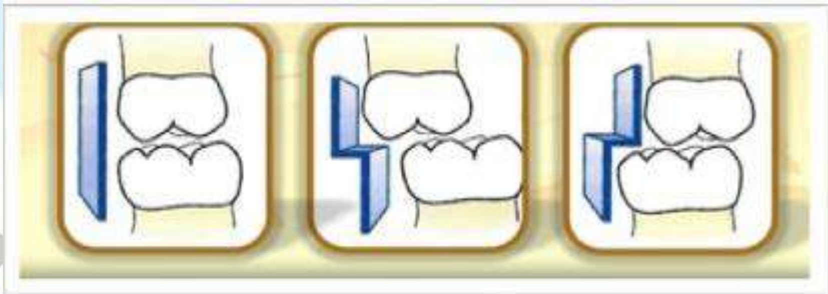


molar relation in primary dentition described in terms of terminal plans,terminal planes are the distal surfaces of the 2nd primary molars,these two planes can be related in **3** ways:

1-**Flush terminal plane**:both maxillary and mandibular planes are at the same level anteroposteriorly, normal molar relationship in the primary dentition, because the mesiodistal width of the mandibular molar is greater than the mesiodistal width of the maxillary molar.

2-Mesial teminal plane:maxillary terminal plane is relatively more posterior than the mandibular terminal plane forming a mesial step.

3-Distal terminal plane: the maxillary terminal plane is relatively more anterior to the mandibular.



All of primary teeth are gradually replaced with a permanent, but in the absence of permanent replacements, they can remain functional for many years. The replacement of primary teeth begins around age six, when the permanent teeth start to appear in the mouth, resulting in mixed dentition. The erupting permanent teeth cause root resorption, where the permanent teeth push on the roots of the primary teeth, causing the roots to be dissolved by odontoclasts (as well as surrounding alveolar bone by osteoclasts) and become absorbed by the forming permanent teeth. The process of shedding primary teeth and their replacement by permanent teeth is called **exfoliation**. This may last from age six to age thirteen. By age twelve there usually are only permanent teeth remaining. However, it is not extremely rare for one or more primary teeth to be retained beyond this age, sometimes well into adulthood, often because the permanent tooth fails to develop.

The spaces of the deciduous teeth try to increase with age due to growth of the jaws in anteroposterior,vertical,and transverse direction,and due to attrition, and these teeth subjected to large amount of attrition due to wear at the incisal age, and proximal surfaces since the deciduous teeth mostly converted to edge to edge relationship at late stages, the occlusal forces with root resorption will increase the mobility of the deciduous teeth and if the closed case (no spacing)this will produce attrtion at the proximal surfaces due to friction produced by movement during mastiction,so the mobilty progress the spaces to increased and this will facilitated the normal shedding of the incisors.

Mixed Dentition period

(Around 6 years- 13 years) Most malocclusions make their appearance during this stage The mixed dentition period can be divided into:

1.First transitional period.

2- Inter-transitional period.

3-Second transitional period.

First Transitional Period

Emergence of the first permanent molars and transition of incisors
The following events take place during this period.

Eruption of Permanent First Molars

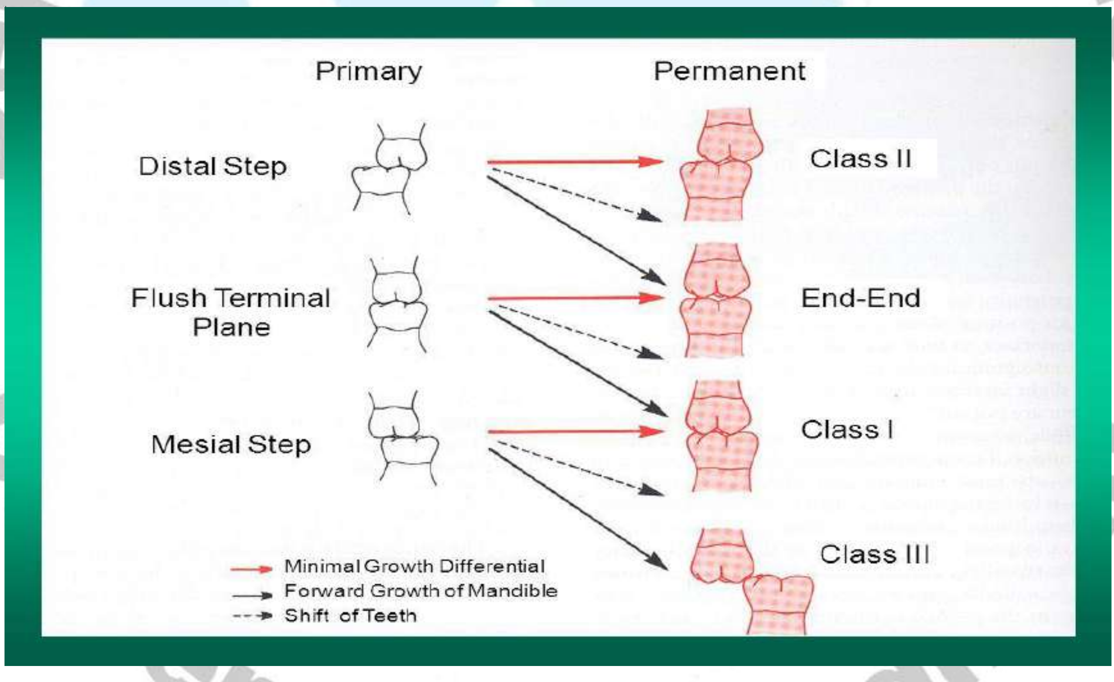
The first permanent molars erupt at 6 years. They play an important role in the establishing and in the functioning of occlusion, in the permanent dentition.

Anteroposterior positioning of the permanent molars is influenced by:

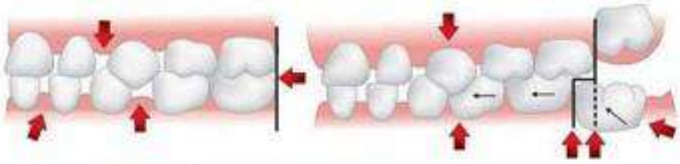
Terminal plane relationship the distal surface of the upper & lower2nd deciduous molar• When the deciduous second molars are in a flush terminal plane, the permanent first molar erupts initially into a cusp-to-cusp relationship, which later transforms into a Class I molar relation using the primate spaces .Later, cusp-to-cusp relationship of the permanent first molar can be converted to a Class I relationship by the mesial shift of the permanent first molar following exfoliation of the primary molar and thus making use of the Leeway space (late mesial shift)

Distal Step: When the deciduous second molars are in a distal step, the permanent first molar will erupt into a class II relation. This molar configuration is not self correcting and will cause a class II malocclusion despite Leeway space and differential growth.

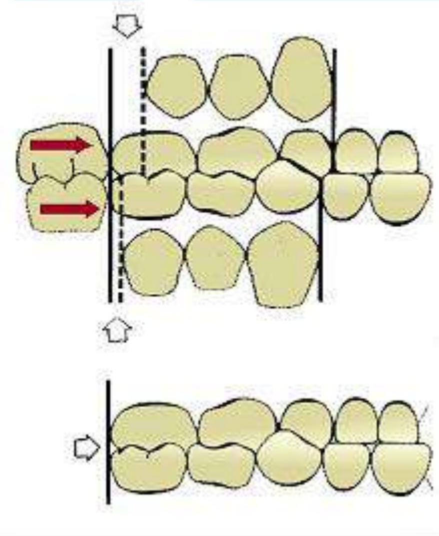
Mesial Step: Primary second molars in mesial step relationship lead to a class I molar relation in mixed dentition. This may remain or progress to a half or full cusp class III with continued mandibular growth



.**Early mesial Shift**: Early shift occurs during the early mixed dentition period. Since this occurs early in the mixed dentition, it is called early shift , the eruptive force of first permanent molar push the deciduous 1st & 2nd deciduous molar to close the primate space. In a spaced arch, eruptive force of the permanent molars causes closing of any spaces between the primary molars or primate spaces, thus allowing molars to shift mesially



Late mesial Shift: This occurs in the late mixed dentition period when the second deciduous molar exfoliate the first permanent molar drift mesialy & use leeway space and is thus called late shift. When the primary second molar are lost there is an adjustment in the occlusion of the first molar teeth,There is adecrease in arch length in both maxillary and mandibular arches as the first molar shift mesialy this shift is more in mandible which accounts for the establishment of full cusp molar class I relation from flash terminal plane relation ship in deciduous dentition this shift is called late mesial shift of molars.

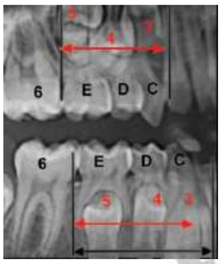


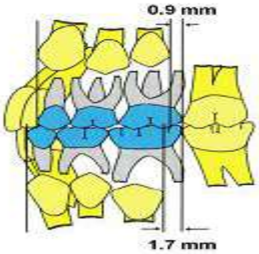
Leeway Space of Nance

Described by Nance in 1947 (the combined mesiodistal width of the permenant canines and premolars 3,4 and 5 is usually less than of the deciduous canines and molars CD&E).

Maxilla: 0.9 mm/segment = 1.8 mm arch .

Mandible: 1.7 mm/segment = 3.4mm arch





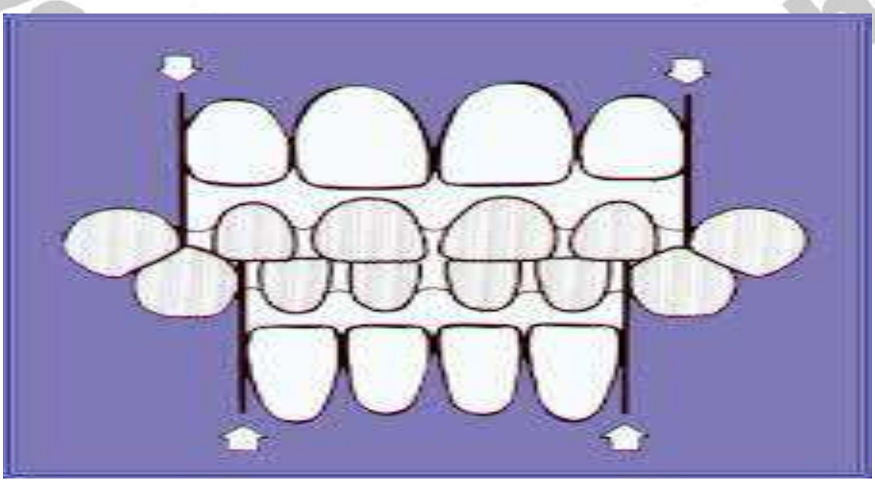
Exchange of Incisors:

Transition of IncisorsPermanent incisors develop lingual to the primary incisors. For incisors to erupt in normal alignment,there is an obligate space requirement in the anterior part of both the arches which is termed as the incisal liability(permenant incisors is larger than deciduous incisors the difference between the amount of space needed for the incisors and the amount avialable for them) is over come by the following factors:

1- Interdental physiological spacing in the primary incisor region. (4 mm in maxillary arch & 3 mm in mandibular arch)

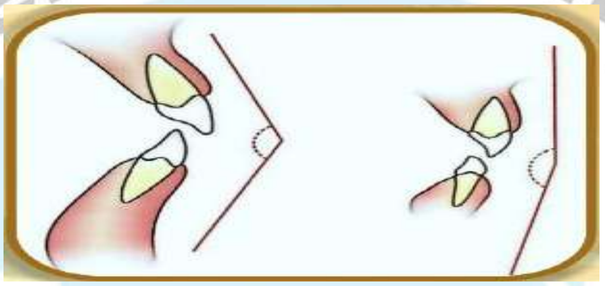
2-Increase in inter-canine arch width: Significant amount of growth occurs with the eruption of incisors and canines

3-Increase in anterior length of the dental arches: Permanent incisors erupt labial to the primary incisors to obtain an added space of around 2-3 mm,change in inclination of permanent incisors, Primary teeth are upright but permanent teeth incline to the labial surfaceThis increases the arch parameter .



Change in inclination of permanent incisors:

Primary teeth are upright but permanent teeth incline to the labial surface thus decreasing the inter-incisal angle from about 150° in the deciduous dentition to 123° in the permanent dentition This increases the arch perimeter



Mixed Dentition period

(Around 6 years- 13 years) The mixed dentition period can be divided into:

1.First transitional period.

2- Inter-transitional period.

3-Second transitional period.

Inter-Transitional Period

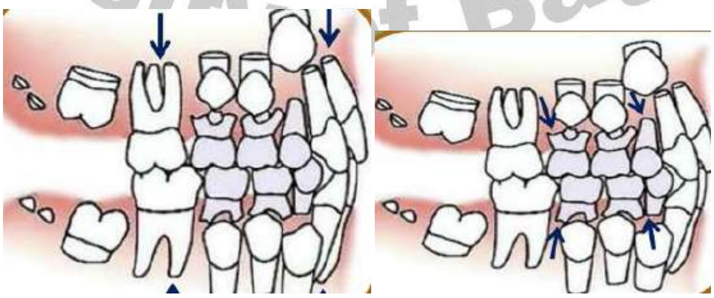
This is a stable phase where little changes take place in the dentition. The teeth present are the permanent incisors and first molar along with the deciduous canines and molars. Some of the features of this stage are:

1. Any asymmetry in emergence and corresponding differences in height levels or crown lengths between the right and left side teeth are made up.
2. Occlusal and interproximal wear of deciduous teeth causes occlusal morphology to approach that of a plane.
3. Ugly duckling stage.
4. Root formation of emerged incisors, canines and molars continues, along with concomitant increase in alveolar process height.
5. Resorption of roots of deciduous molars.

it is a silent period extend from 8.5 years of age to I0 years of age ,this period is called (Lull period) In this period ,the teeth present are

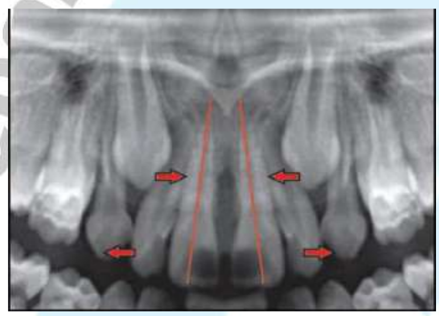
6EDC21 12CDE6

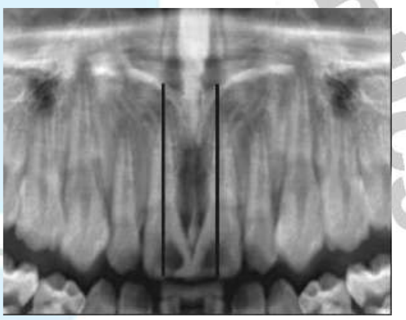
This phase prepares for the second transitional phase



Ugly Duckling Stage (Broadbent's phenomenon):

Around the age of 8 - 9 years, a midline diastema is commonly seen in the upper arch, which is usually misinterpreted by the parents as a malocclusion. Its typical features are: Flaring of the lateral incisors. Maxillary midline diastema, crowns of canines on 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 maxillary midline diastema , With the eruption of the canines, the impingement from the roots shift incisally thus driving the incisor crowns medially, resulting in closure of the diastema as well as the correction of the flared lateral incisors





Second Transitional Period

This period is marked by the eruption of the four permanent second molar,establishment of proper occlusion,replacement of deciduous canines and molars by permolars and permenant cuspid respectively

The following events take place:

1. *Exfoliation of primary molars and canines* At around 10 years of age, the first deciduous tooth in the posterior region, usually the mandibular canine sheds and marks the beginning of the second transitional period.

Usually no crowding is seen before emergence except maybe between the maxillary first premolar and canine.

2. *Eruption of permanent canines and premolars* These teeth erupt 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. Favorable occlusion in this region is largely dependent on:

- Favorable eruption sequence.
- Satisfactory tooth size- available space ratio.
- Attainment of normal molar relation with minimum diminution of space available for bicuspids.

3. *Eruption of permanent second molars*: the eruption of second permenant molars(upper&lower) at the age of 12 years old, it takes along path of eruption, but less than the path of eruption of canine,so ,they subjected to less amount of crowding, the malocclusion of second molars is very rare,and their impaction very rare,but sometimes the lower second molars may be impacted, Before emergence second molars are oriented in a mesial and lingual direction. These teeth are formed palatally and are guided into occlusion by the Cone Funnel mechanism (the upper palatal cusp/cone slides into the lower occlusal fossa/funnel). The arch length is reduced prior to second molar eruption by the mesial eruptive forces. Therefore, crowding if present is accentuated

Mixed dentition problems

1-*Premature loss of deciduous teeth*

The major effect of early loss of a primary tooth, whether due to caries, premature exfoliation, or planned extraction, is localization of preexisting crowding. In an uncrowded mouth this will not occur. However, where some crowding exists and a primary tooth is extracted, the adjacent teeth will drift or tilt around into the space provided. The extent to which this occurs depends upon the degree of crowding, the patient'sage, and the site.

2-*Retained deciduous teeth*

A difference of more than 6 months between the shedding of contralateral teeth should be regarded with suspicion. Provided that the permanent successor is present, retained primary teeth should be extracted, particularly if they are causing deflection of the permanent

tooth.
3 Infra-occluded (submerged) primary molars
term for describing the process where a tooth fails to achieve or maintain its occlusal relationship with adjacent or opposing teeth.
4 Impacted first permanent molars
5 Dilaceration
Dilaceration is a distortion or bend in the root of a tooth. It usually affects the upper central and/or lateral incisor
6 Supernumerary teeth
7 Habits
8 First permanent molars of poor long-term prognosis
9 Median diastema

The Permanent Dentition

Permanent teeth or adult teeth are the second set of teeth formed in mammals. In humans, there are thirty-two permanent teeth, consisting of six maxillary and six mandibular molars, four maxillary and four mandibular premolars, two maxillary and two mandibular canines, four maxillary and four mandibular incisors.

The first permanent tooth usually appears in the mouth at around six years of age, and the mouth will then be in a transition time with both primary (or deciduous dentition) teeth and permanent teeth during the mixed dentition period until the last primary tooth is lost or shed.

The first of the permanent teeth to erupt are the permanent first molars, right behind the last 'milk' molars of the primary dentition. These first permanent molars are important for the correct development of a permanent dentition. Up to the age of thirteen years, twenty-eight of the thirty-two permanent teeth will appear.

The full permanent dentition is completed much later during the permanent dentition period. The four last permanent teeth, the third molars, usually appear between the ages of 17 and 25 years; they are considered wisdom teeth.

Cacification of permenant begins at birth with the calcification of the cusps of the first permanent molar and extends as late as the 25th year of life. Complete calcification of incisor crowns take place by 4 – 5 years and of the other permanent teeth by 6 – 8 years except for third molars, at approximately 13 years of age all permanent teeth except third molars are fully erupted,

The permanent incisors develop lingual to the deciduous incisors and move labially as they erupt. The premolars develop below the diverging roots of the deciduous molars.
The third molars erupt at 18-25 years of age, Their path of eruption is nearly similar to the path of eruption of the second molars.the upper molars developed at the posteroinferior position of the maxillary tuberosity ,so , these teeth are subjected to a high amount of crowding in comparison with the first or second molars due to the lack of space available for them.the lower third molars may be subjected to impaction due to lack of space,these teeth may be absent or congenitally missing.

Features of the permanent dentition:
- Coinciding midline.
- Class I molar relationship of the permanent first molar.
- Vertical overbite of about one-third the clinical crown height of the mandibular central incisors

The sequence of Permenant teeth emergence:

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 Change in eruption sequence is a reliable sign of disturbance in normal development of the dentition

.

	Calsification(months)	Eruption(years)
Maxillary teeth		
Central incisor	3-4	7-8
Lateral incisor	10-12	8-9
canine	4-5	11-12
First premolar	18-21	10-11
Second premolar	24-27	10-12
First molar	Around birth	5-6
Second molar	30-36	12-13
Third molar	84-108	17-25
Mandibularteeth		
Central incisor	3-4	6-7
Lateral incisor	3-4	7-8
canine	4-5	9-10
First premolar	21-24	10-12
Secondpremolar	27-30	11-12
First molar	Around birth	5-6
Second molar	30-36	12-13
Third molar	96-120	17-25

Root development complete 2–3 years after eruption

Abnormalities of eruption and exfolation

1-Eruption cyst

An eruption cyst is caused by an accumulation of fluid or blood in the follicular space overlying the crown of an erupting tooth. They usually rupture spontaneously, but very occasionally marsupialization may be necessary.

2-Failure of/delayed eruption

There is a wide individual variation in eruption times, Where there is a generalized tardiness in tooth eruption in an otherwise fi t child, a period of observation is indicated. However, the following may be indicators of some abnormality and therefore warrant further investigation:

1-A disruption in the normal sequence of eruption.

2-An asymmetry in eruption pattern between contralateral teeth. If a tooth on one side of the arch has erupted and 6 months later there is still no sign of its equivalent on the other side, radiographic examination is indicated. Localized failure of eruption is usually due to mechanical obstruction – this is advantageous as if the obstruction is removed then the affected tooth/teeth has the potential to erupt. More rarely, there is an abnor-mality of the eruption mechanism, which results in primary failure of eruption (the tooth does not erupt into the mouth) or arrest of eruption(the tooth erupts, but then fails to keep up with eruption/ development).

This problem usually affects molar teeth and unfortunately for the individuals concerned, commonly affects more than one molar tooth in a quadrant. Extraction of the affected teeth is often necessary.

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

DISTURBANCES DURING ERUPTION OF TEETH

1. Concrescence Cemental union of two teeth.
2. Retarded eruption Due to endocrine disturbances, vitamin deficiencies, local causes
3. Ankylosed teeth Teeth fail to erupt to the occlusal level as they are fused to the bone.

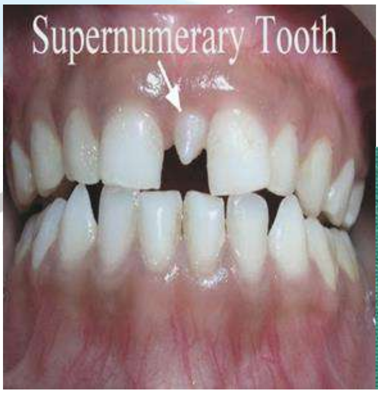
Causes of delayed eruption

Generalized causes

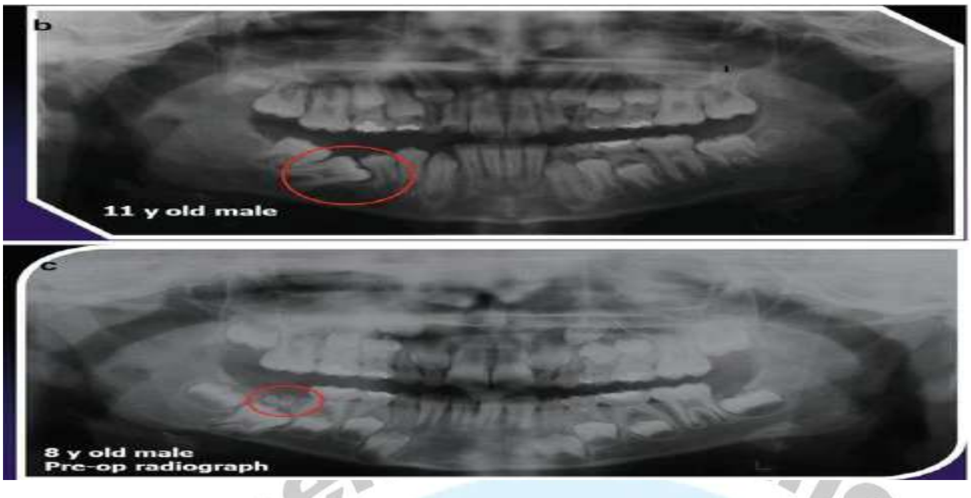
- Hereditary gingival fibromatosis
- Down syndrome
- Cleidocranial dysostosis
- Cleft lip and palate
- Rickets

Localized causes

- Congenital absence
- Crowding
- Delayed exfoliation of primary predecessor
- Supernumerary tooth
- Dilaceration
- Abnormal position of crypt
- Primary failure of eruption



Supernumerary tooth dialaceration



Primary failure of eruption

What to refer and when

***Deciduous dentition*
• Cleft lip and/or palate (if patient not under the care of a cleft team)
• Other craniofacial anomalies
***Mixed dentition*
• Severe Class III skeletal problems which would benefit from orthopaedic treatment
• Delayed eruption of the permanent incisors
• Impaction or failure of eruption First permanent molars of poor long-term prognosis where forced extraction is being considered
• Marked mandibular displacement on closure and/or anterior crossbites
• Ectopic maxillary canines
• Patients with medical problems where monitoring of the occlusion would be beneficial
• Pathology e.g. cysts on of the first permanent molars

Development of Dentition

Prenatal Development of Dentition

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

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

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

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

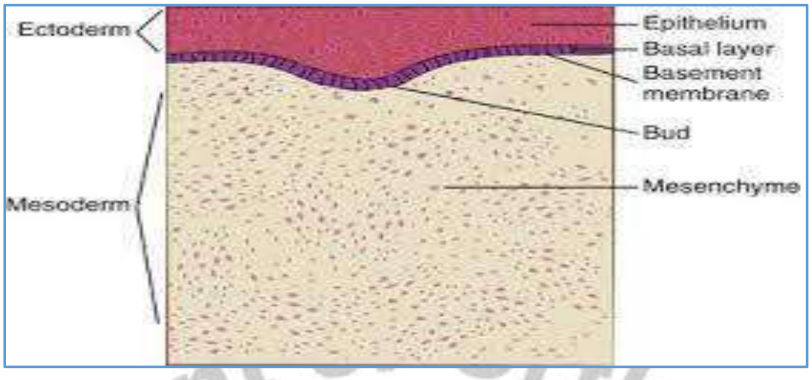


Figure no.1 tooth bud

Stages of Tooth Bud Development

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

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

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

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

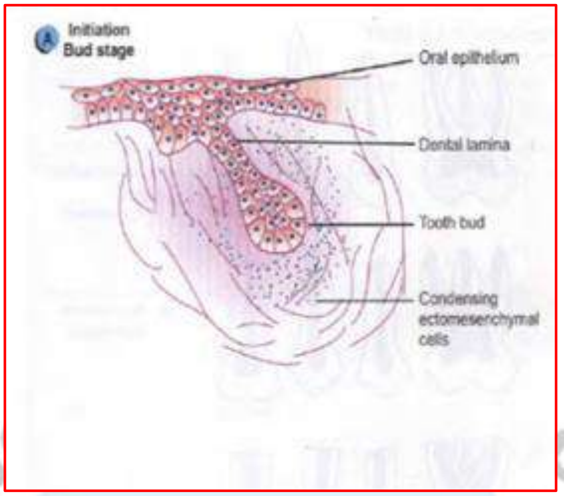


Figure no.2 Initiation stage

2. ***Proliferation***: Unequal growth in different parts of the bud produces a shallow invagination on the deep surface of the bud to produce a cap shaped structure. Histologically it is made up of the outer enamel epithelium (cuboidal cells) at the convexity of the cap and the inner enamel epithelium (tall, columnar cells) at the concavity of the cap. Between the above 2 layers polygonal cells are located which is known as the stellate reticulum. These cells assume a branched reticular network as more intercellular fluid is produced.

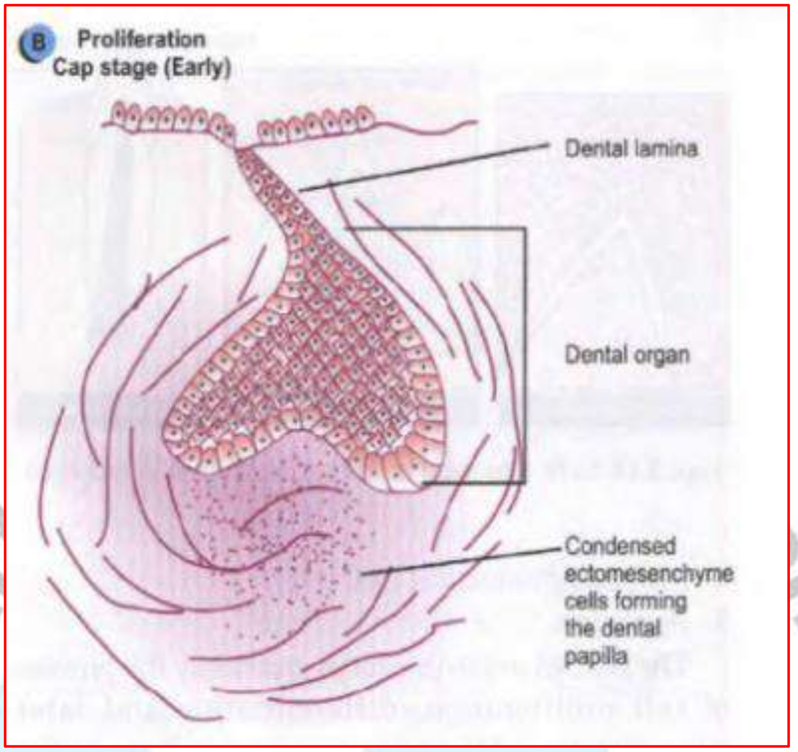


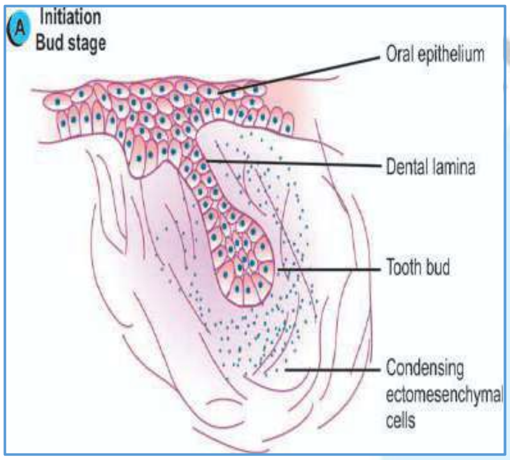
Figure 3: Proliferation stage

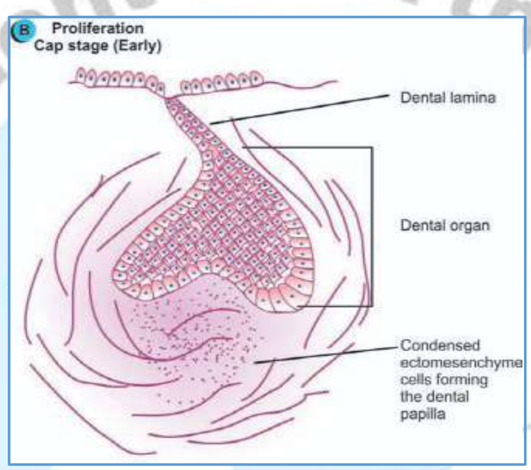
3. ***Histo-differentiation***: The enamel organ now assumes a bell shape as the invagination of the cap continues and the margins grow longer. Four different layers are seen. The inner enamel epithelium (IEE) cells remain tall columnar cells. The outer enamel epithelium flatten to low cuboidal cells.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

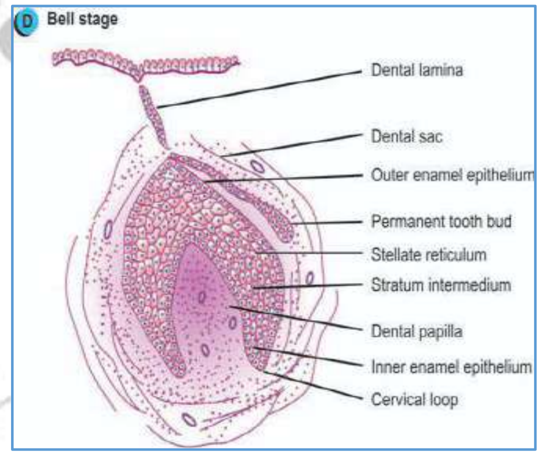
4. ***Morpho-differentiation (bell stage)***

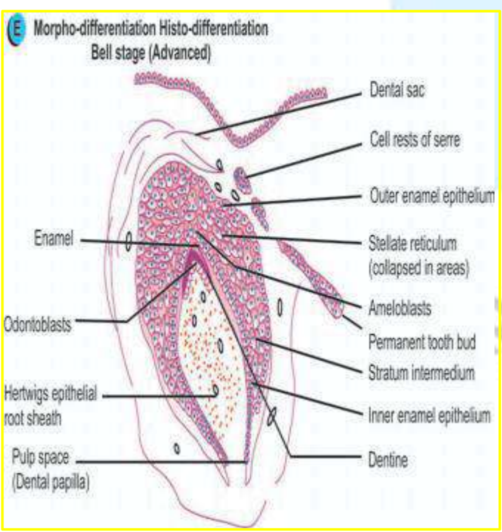
5. ***Apposition***

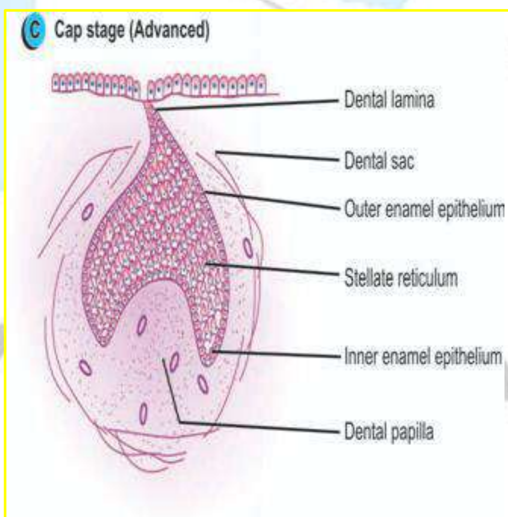
The enamel organ produces enamel by the process of cell proliferation, differentiation and later mineralization. Mineralization commences in the deciduous dentition around the 14th week of intrauterine life and occurs first in the central incisors. The permanent tooth buds appear around the fourth to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











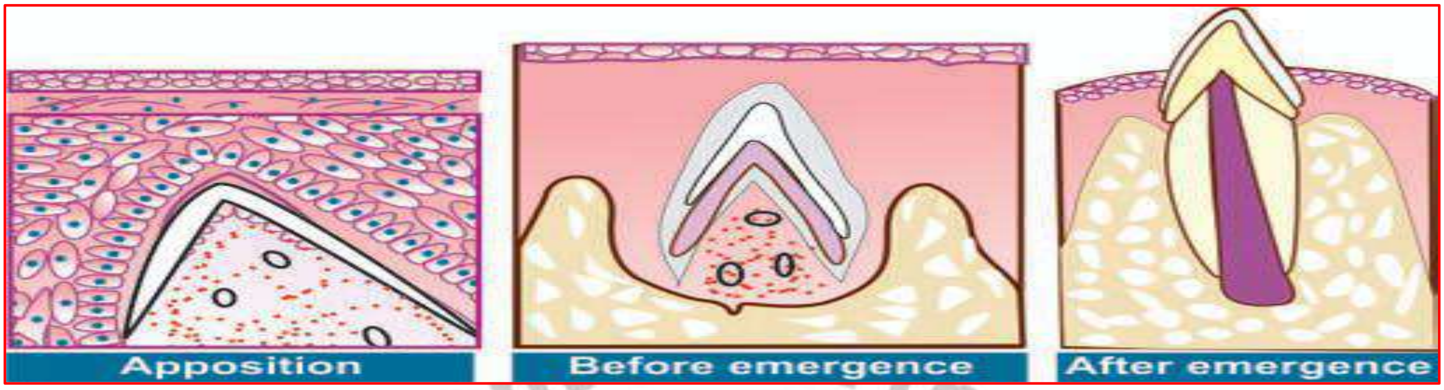


Figure no.4 A to H: Life cycle of tooth

Eruption

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

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

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

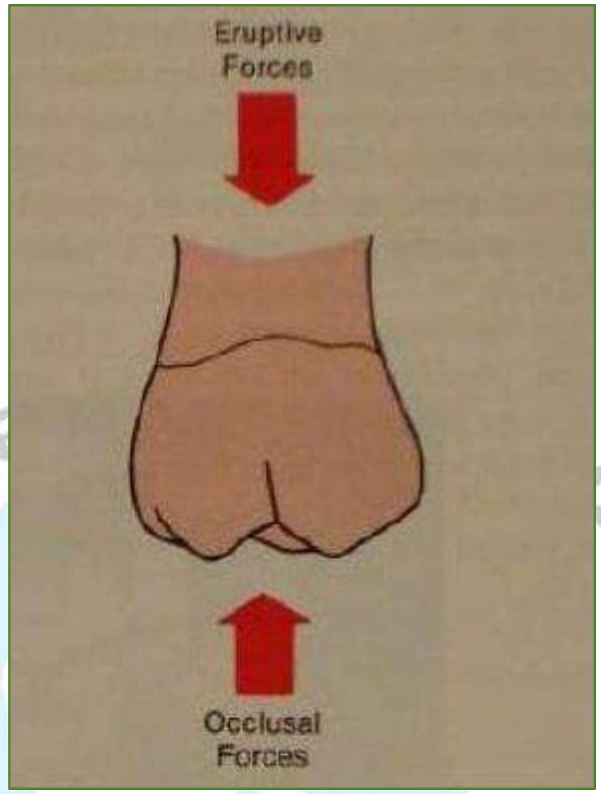


Figure 5: Eruption

Factors Determining Tooth Position During Eruption

Tooth passes through four distinct stages of development:

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

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

• Presence or absence of adjacent teeth

• Rate of resorption of primary teeth

• Early loss of primary teeth

• Localized pathologic conditions.

3. *Intraoral stage* Tooth can be moved by lip, cheek, tongue muscles or 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.

Developmental Disturbances Affecting The Teeth

Disturbances During Initiation Of Tooth Germs

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

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

Figure no,6 Anodontia

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

• *Mesiodens :* between maxillary central incisors.

Figure no.7 Supernumerary teeth Mesiodens

• *Peridens :* located buccal to the arch

• *Distomolar :* distal to the third molar.

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

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

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

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

Disturbances During Morpho differentiation of Tooth Germs

1. Hutchinson's incisors: Screwdriver shaped notched incisors, e.g. in congenital syphilis.

Figure no.8 Hutchinson's incisors

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

Figure no.9 Mulberry molars.

3. Peg shaped laterals: Proximal surfaces of the crown converge giving the tooth a conical shape.

Figure no.10 Peg shaped laterals

4.MacrodontiaTeeth: larger than normal. It may be true or relative generalized.

Figure no.11 MacrodontiaTeeth

5. MicrodontiaTeeth: smaller than normal. It may be true or relative generalized; most commonly the lateral incisor and third molars.

Figure no.12 ***Microdontia*** **Teeth**

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

Figure no. 13 Dens in dente.

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

Figure no. 14 Dens evaginatus

8. *Gemination :* Single tooth germ splits into partially or fully separated crowns but with a common root and root canal.

9. *Fusion* Two tooth germs unite to form a single large crown with two root canals; seen in incisors.

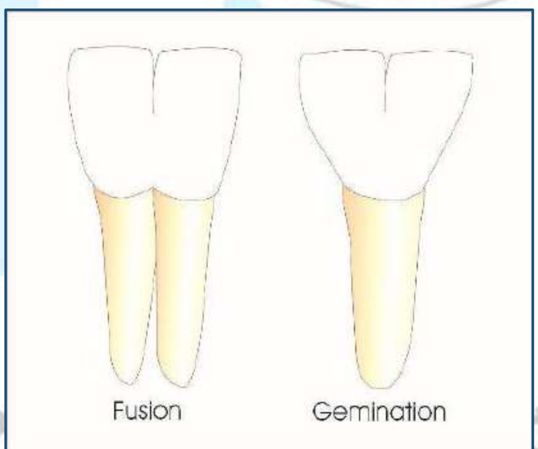


Figure no.15 Gemination and Fusion

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

Figure 16: Dilaceration

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

Figure 17: Taurodontism.

Disturbances During Apposition of Hard Tissues

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

Figure no.18 Enamel hypoplasia

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

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

• Hereditary enamel hypoplasia Tooth appears yellow due to reduced enamel thickness.

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

Figure no.19 Amelogenesis imperfect

• Hypoplastic Defective matrix formation

• Hypocalcification Defective mineralization of matrix.

• Hypomaturation Immature enamel crystals.

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

Figure 20: Dentinogenesis imperfect

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

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

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

7. *Pigmentation of enamel and dentine*

• Erythroblastosis fetalis: enamel is green/blue.

• Porphyria: red to brownish

• Tetracyclines: brownish

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

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

Disturbances During Calcification Of Hard Tissue

1. *Enamel hypocalcification* Calcification is subnormal. It may be local, systemic or hereditary.

2. *Interglobular dentine* Areas of partially calcified dentine.

Disturbances During Eruption of Teeth

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

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

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

Figure no.21Ankylosed teeth

Dimensional Changes In The Dental Arches

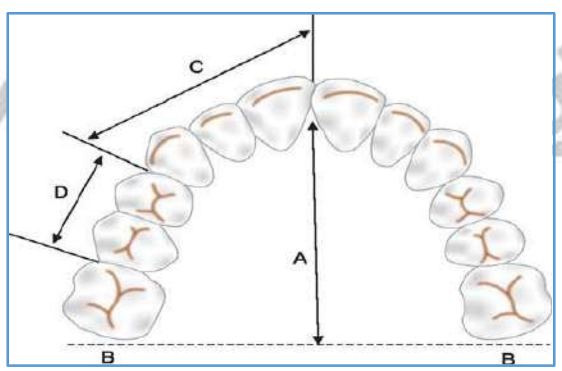


Figure no.22 Dimensional Changes In The Dental Arches

The usual arch dimensions measured are:

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

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

b. Clinically significant differences exist in the manner and magnitude of width changes in the maxilla and mandible. Width increase correlates highly with vertical alveolar process growth. Maxillary alveolar processes diverge while mandibular alveolar processes are more Parallel. Thus, maxillary width increases more and can be easily altered in treatment.

c. The only significant increase in mandibular inter-canine width occurs during eruption of Incisors when primary cuspids are moved distally into primate spaces and does not increase significantly thereafter.

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

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

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

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

a. Late mesial shift of first permanent molar as “Leeway space” (**Fig. 23)** is pre-empted.

b. Mesial drifting tendency of posterior teeth throughout life.

c. Slight interproximal wear of teeth.

d. Lingual positioning of incisors.

e. Original tipped position of incisors and molars.

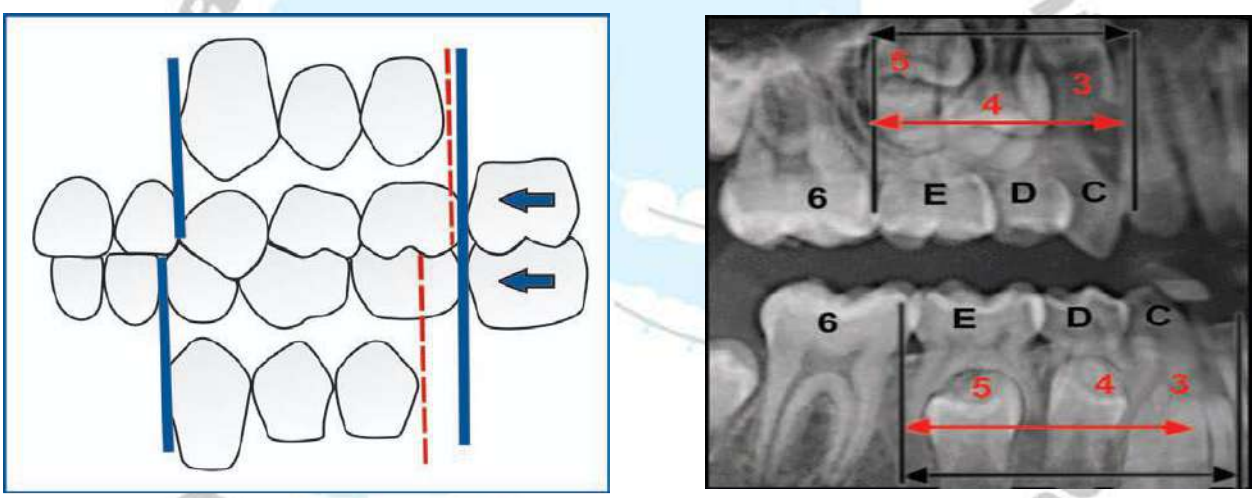


Figure no.23 Leeway space

Conclusion

Development of dentition in humans is complex and depends on many variables. Development of dentition deviates markedly from that of other parts and structures of the body. Crowns of teeth are formed directly to adult size and housed within the jaws years Before theyemerge.To determine an abnormal course of development, it is the responsibility of an orthodontist to have adequate knowledge on the subject to differentiate abnormal from normal before initiating therapy.

Orthodontic Tooth Movement

Orthodontic movement of teeth is based on the observation that if prolonged light pressure is applied to a tooth, tooth movement will occur as the bone around the tooth remodels. Bone is selectively removed in some areas and added in others. In essence, the tooth moves through the bone carrying its attachment apparatus with it, as the socket of the tooth migrates. Because the bony response is mediated by the periodontal ligament (PDL), tooth movement is primarily a PDL phenomenon.

Forces applied to the teeth can also affect the pattern of bone apposition and resorption at sites distant from the teeth, particularly the sutures of the maxilla and bony surfaces on both sides of the temporomandibular joint. In addition, it is possible now to apply force to implants in the maxilla or mandible to influence growth at maxillary sutures and at the mandibular condyle, affecting skeletal growth with minimal or no tooth movement. Thus the biologic response to orthodontic therapy includes not only the response of the PDL but also the response of growing areas distant from the dentition. It is not possible to move bones in the same way teeth are moved, because pressure against sutures, synchondroses or joints does not stimulate similar remodeling of adjacent bone, but it is possible to generate formation of new bone.

1.1. Histology of Periodontium

During tooth movement, changes in the periodontium occur, depending on magnitude, direction, and duration of the force applied, as well as the age of the orthodontically treated patient. Tooth movement is a complicated process, requiring changes in the gingiva, periodontal ligament, root cementum, and alveolar bone with their differences in cell population and remodeling capacity. Therefore, a brief description of the normal periodontium is illustrated below:

1.1.1. Gingiva

The gingiva is differentiated into the free and attached gingiva. In a clinically healthy condition, the free gingiva is in close contact with the enamel surface, and its margin is located 0.5 to 2mm coronal to the cementoenamel junction after completed tooth eruption, see Figure 1.1. The attached gingiva is firmly attached to the underlying alveolar bone and cementum by connective tissue fibers and is therefore comparatively immobile in relation to the underlying tissue.

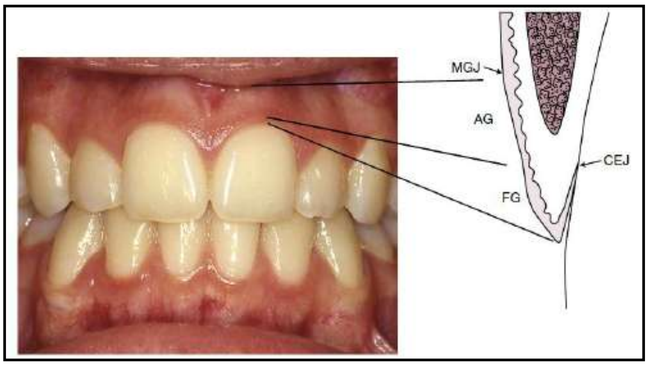


Figure 1.1: Macroscopic anatomy of the gingiva showing free gingiva (FG), attached gingiva (AG), mucogingival junction (MGJ), and cementoenamel junction (CEJ).

The predominant component of the gingiva is the connective tissue, consists of collagen fibers, fibroblasts, vessels, nerves, and matrix. The fibroblast is engaged in the production of various types of fibers but is also instrumental in the synthesis of the connective tissue matrix. The collagen fibers are bundles of collagen fibrils with a distinct orientation. They provide the resilience and tone necessary for maintaining its architectural form and the integrity of the dentogingival attachment. They are usually divided into the following groups, see Figure 1.2:

1. Circular fibers: run in the free gingiva and encircle the tooth.
2. Dentogingival fibers: are embedded in the cementum of the supraalveolar portion of the root and project from the cementum in a fanlike configuration into the free gingival tissue.
3. Dentoperiosteal fibers: are embedded in the same portion of the cementum as the dentogingival fibers but terminate in the tissue of the attached gingiva.
4. Transseptal fibers: run straight across the interdental septum and are embedded in the cementum of adjacent teeth.

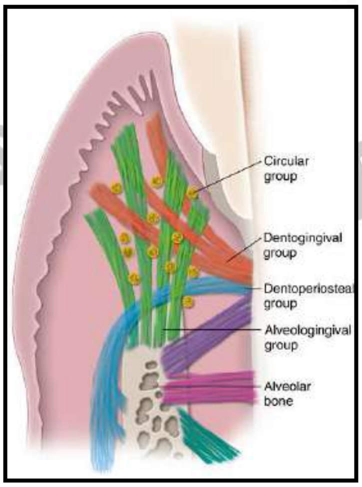


Figure 1.2: The collagen fibers bundles run in the gingiva.

1.1.2. Periodontal Ligament

The periodontal ligament (PDL), about 0.25mm wide, is the soft, richly vascular and cellular connective tissue that surrounds the roots of the teeth and joins the root cementum with the lamina dura or the alveolar bone proper. In the coronal direction, the PDL is continuous with the lamina propria of the gingiva and is separated from the gingiva by the collagen fiber bundles, which connect the alveolar bone crest with the root (the alveolar crest fibers). The PDL and the root cementum develop from the follicle, which surrounds the tooth bud. The true periodontal fibers, the principal fibers, develop along with the eruption of the tooth.

The orientation of the collagen fiber bundles alters continuously during tooth eruption. When the tooth has reached contact in occlusion and is functioning properly, they associate with the following well-oriented groups: alveolar crest fibers and horizontal, oblique, apical, and interradicular fibers, as shown in Figure 1.3.

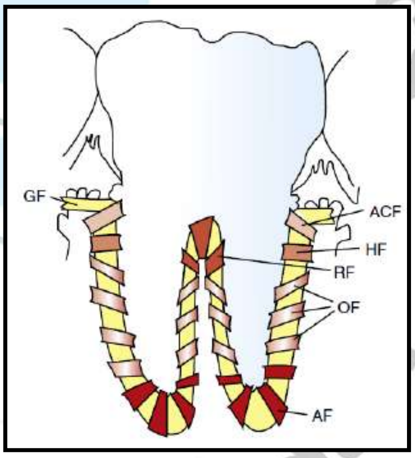


Figure 1.3: The PDL fibers: Alveolar-crest fibers (ACF), Apical fibers (AF), gingival fibers (GF), horizontal fibers (HF), Oblique fibers (OF), and interradicular fibers (RF).

The individual bundles have a slightly wavy course, which allows the tooth to move within its socket (physiologic mobility). The presence of a PDL makes it possible to distribute and resorb the forces elicited during mastication and is essential for movement of the teeth in orthodontic treatment. The fibrils of the PDL are embedded in a ground substance with connective tissue polysaccharides (glycosaminoglycans), which vary with age. The tissue response to orthodontic forces, including cell mobilization and conversion of collagen fibers, is considerably slower in older individuals than in children and adolescents. The ground substance has a more rapid turnover than the collagen fibers. During physiologic conditions, collagen turnover in the PDL is much higher than that in most other tissues (e.g., twice as high as that of the gingiva).

The high turnover has been attributed to the fact that forces on the PDL are multidirectional, having vertical and horizontal components. The lower collagen turnover in the gingiva may result from the lowered functional stress as the transseptal fibers function in a manner similar to tendons, providing firm anchorage of the tooth.

1.1.3. Alveolar Bone

The alveolar bone is covered with the periosteum, which is differentiated from the surrounding connective tissue. The contiguous mesenchymal cells acquire the character of osteoblasts. The matrix-producing and proliferating cells in the cambium layer, as well as osteocytes inside the bone matrix, are subject to mechanical influence. The alveolar process forms and supports the sockets of the teeth. It consists of dense outer cortical bone plates with varying amounts of spongy or cancellous bone between them. The thickness of the cortical laminae varies in different locations, as shown in Figure 1.4.

The cancellous bone contains bone trabeculae architecture of which is partly genetically determined and partly the result of forces to which teeth are exposed during function or orthodontic treatment.

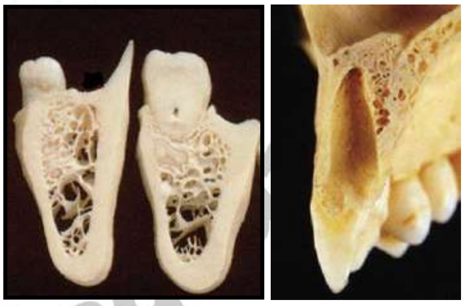


Figure 1.4: Alveolar bone in maxilla and mandible.

1.2. Periodontal and Bone Response to Normal Function

Tooth movements can be broadly divided into three types:

1. Physiologic
2. Pathologic/ (Pathologic migration)
3. Orthodontic.

The term physiologic tooth movement designates, primarily, the slight tipping of the functioning tooth in its socket and secondarily, the changes in tooth position that occur in young persons during and after tooth eruption. These are normal or routine in nature and the tooth and its supporting structures are designed to undertake and withstand such movements. During masticatory function, the teeth and periodontal structures are subjected to intermittent heavy forces. Tooth contacts last for 1 second or less; forces are quite heavy, ranging from 1 or 2kg while soft substances are being chewed to as much as 50kg against a more resistant object. When a tooth is subjected to heavy loads of this type, quick displacement of the tooth within the PDL space is prevented by the incompressible tissue fluid. Instead, the force is transmitted to the alveolar bone, which bends in response.

Very little of the fluid within the PDL space is squeezed out during the first second of pressure application. If pressure against a tooth is maintained, however, the fluid is rapidly expressed, and the tooth displaces within the PDL space, compressing the ligament itself against adjacent bone. Not surprisingly, this hurts. Pain is normally felt after 3 to 5 seconds of heavy force application, indicating that the fluids are expressed and crushing pressure is applied against the PDL in this amount of time. The resistance provided by tissue fluids allows normal mastication, with its force applications of 1second or less, to occur without pain, see Table 1.1.

Table 1.1: Physiologic Response to Heavy Pressure Against a Tooth

Time (seconds)	Event
<1	PDL fluid incompressible, alveolar bone bends, piezoelectric signal generated
1-2	PDL fluid expressed, tooth moves within PDL space
3-5	PDL fluid squeezed out, tissues compressed; immediate pain if pressure is heavy

PDL, Periodontal ligament.

Although the PDL is adapted to resist forces of short duration, it rapidly loses its adaptive capability as the tissue fluids are squeezed out of its confined area.

Prolonged force, even of low magnitude, produces a different physiologic response-remodeling of the adjacent bone. Orthodontic tooth movement is made possible by the application of prolonged forces. In addition, light prolonged forces in the natural environment-forces from the lips, cheeks, or tongue resting against the teeth-have the same potential as orthodontic forces to cause the teeth to move to a different location. Resting pressures from the lips or cheeks and tongue are usually not balanced. In some areas, as in the mandibular anterior, tongue pressure is greater than lip pressure. In other areas, as in the maxillary incisor region, lip pressure is greater. Active stabilization produced by metabolic effects in the PDL probably explains why teeth are stable in the presence of imbalanced pressures that would otherwise cause tooth movement. See Figure 1.5.

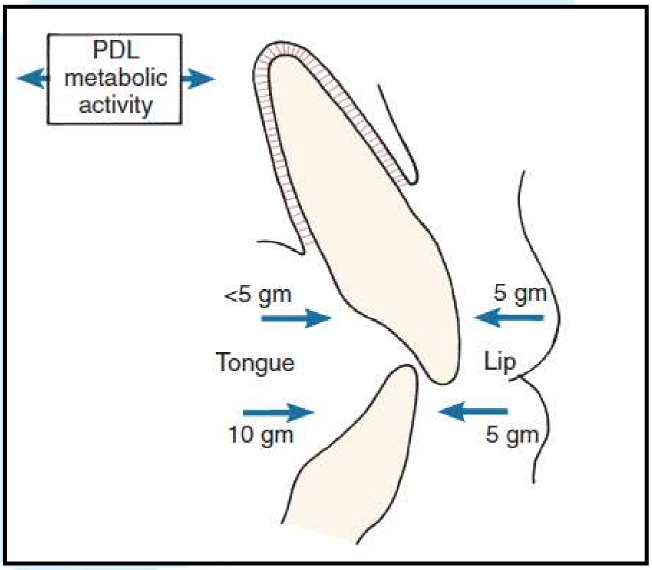


Figure 1.5: Resting pressures from the lips or cheeks and tongue

1.3. Periodontal and Bone Response to Orthodontic Forces

Orthodontic tooth movement is based on the observation that if prolonged light pressure is applied to a tooth, tooth movement will occur as the bone around the tooth remodels. Bone is selectively removed in areas and added in the other area. The response to sustained force against the teeth is a function of force magnitude. Heavy forces lead to rapidly developing pain, necrosis of cellular elements within the PDL, and the phenomenon of “undermining resorption” of alveolar bone near the affected tooth, as shown in Figure 1.6. Lighter forces are compatible with survival of cells within the PDL and a remodeling of the tooth socket by a relatively painless “frontal resorption” of the tooth socket.

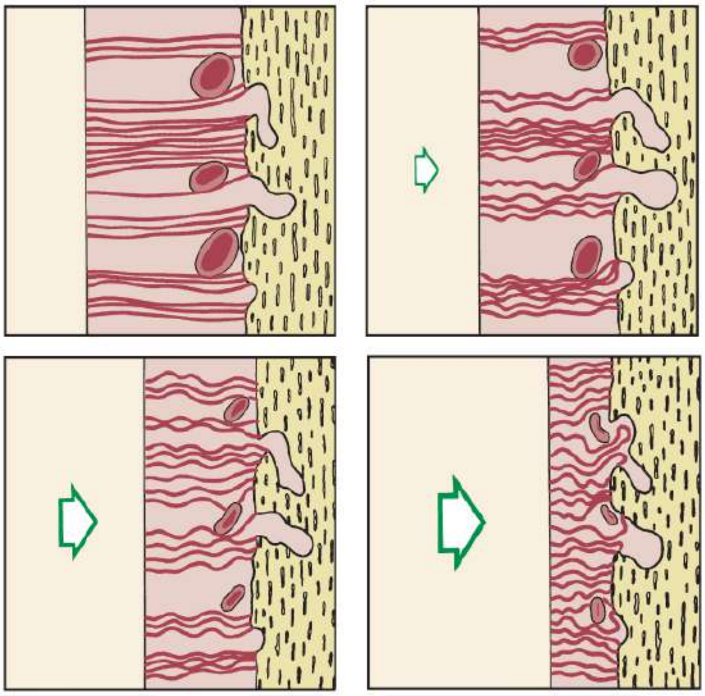


Figure 1.6: Diagrammatic representation of the increasing compression of blood vessels as pressure increases in the periodontal ligament. At a certain magnitude of continuous pressure, blood vessels are totally occluded and a sterile necrosis of periodontal ligament tissue ensues

Table 1.2: Physiologic Response to Sustained Pressure Against a Tooth

TIME		
Light Pressure	Heavy Pressure	Event
<1 second		PDL fluid incompressible, alveolar bone bends, piezoelectric signal generated
1-2 seconds		PDL fluid expressed, tooth moves within PDL space
3-5 seconds		Blood vessels within PDL partially compressed on pressure side, dilated on tension side; PDL fibers and cells mechanically distorted
Minutes		Blood flow altered, oxygen tension begins to change; prostaglandins and cytokines released
Hours		Metabolic changes occurring: chemical messengers affect cellular activity, enzyme levels change
~4 hours		Increased cAMP levels detectable, cellular differentiation begins within PDL
~2 days		Tooth movement beginning as osteoclasts and osteoblasts remodel bony socket
	3-5 seconds	Blood vessels within PDL occluded on pressure side
	Minutes	Blood flow cut off to compressed PDL area
	Hours	Cell death in compressed area
	3-5 days	Cell differentiation in adjacent narrow spaces, undermining resorption begins
	7-14 days	Undermining resorption removes lamina dura adjacent to compressed PDL, tooth movement occurs

cAMP, Cyclic adenosine monophosphate; *PDL,* periodontal ligament.

1.4. Theories of Orthodontic Tooth Movement

Theories of orthodontic Tooth movement are:

1. Pressure tension theory.
2. Blood flow/ Fluid Dynamic theory.
3. Piezoelectric/ Bioelectric theory.

1.4.1. Pressure tension theory

Schwartz proposed the pressure tension theory in 1932. This is the simplest and the most widely accepted theory. According to this theory: 'Whenever a tooth is subjected to an orthodontic force, it results in areas of pressure and tension. The alveolar bone is resorbed whenever the root, for a certain length of time, causes compression of PDL, i.e. the pressure side. New alveolar bone is deposited whenever there is a stretching force acting on PDL fibers, i.e. the tension side'.

1.4.2. Blood flow/ Fluid Dynamic theory

Bien (1966) has been credited for proposing the fluid dynamic or the blood flow theory. According to this theory: 'Tooth movement occurs as a result of alterations in fluid dynamics in the PDL. Periodontal space is a confined space and the passage of fluid in and out of this space is limited. The contents of PDL create a unique hydrodynamic condition resembling a hydraulic mechanism'.

When a force of short duration is applied to a tooth, the fluid in the periodontal space escapes through tiny vascular channels. When the force is removed, the fluid is replenished by diffusion from capillary walls and recirculation of the interstitial fluid. A force of greater magnitude and duration causes the interstitial fluid in PDL space to get squeezed out and move towards the apex and cervical margins. This results in the slowing down of the tooth movement and is called the "squeeze film" effect.

Bien characterized three distinct but interacting fluid systems in PDL:

1. Vascular system
2. Cellular system
3. Interstitial fluid system.

1.4.3. Piezoelectric/ Bioelectric/ Bone Bending theory.

Piezoelectricity is a phenomenon observed in many crystalline materials. The deformation of the crystal structure produces a flow of electric current as electrons are displaced from one part of the crystal lattice to another.

Piezoelectric signals have two unique characteristics, see Figure 1.7:

1. A quick decay rate and

2. The production of an equivalent signal opposite in direction, when the force is released.

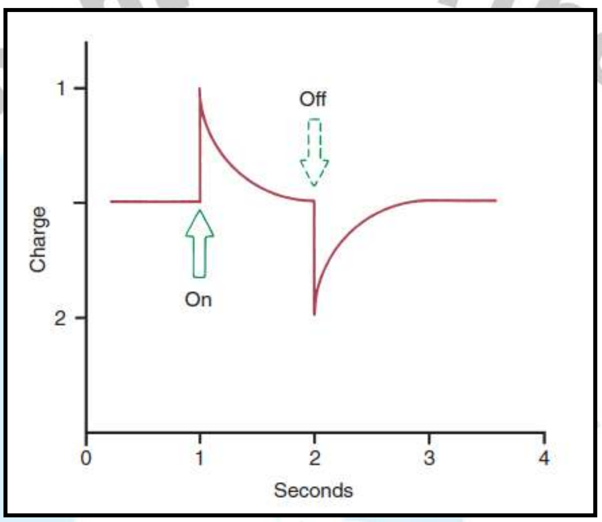


Figure 1.7: Piezoelectricity: When a force is applied to a crystalline structure such as bone or collagen, a flow of current is produced that quickly dies away. When the force is released, an opposite current flow is observed. This piezoelectric effect results from migration of electrons within the crystal lattice as it is distorted by applied force and then returns to its original form when the force is removed.

The piezoelectric signal is created in response to the force, but it quickly reaches zero even though the force is maintained. The piezoelectric signal is again produced, this time in the opposite direction, when the force is removed. Both these characteristics are explained by the migration of electrons within the crystal lattice as it is distorted by pressure. Not only is bone mineral a crystal structure with piezoelectric properties but so is collagen. Hence, the possible sources of electric current are:

1. Collagen
2. Hydroxyapatite
3. Collagen hydroxyapatite interface

4. The mucopolysaccharide fraction of the ground substance.

When the force is applied on a tooth, the adjacent alveolar bone bends. Areas of concavity are associated with negative charge and cause bone deposition. Areas of convexity are associated with positive charge and

cause bone resorption, as shown in Figure 1.8.

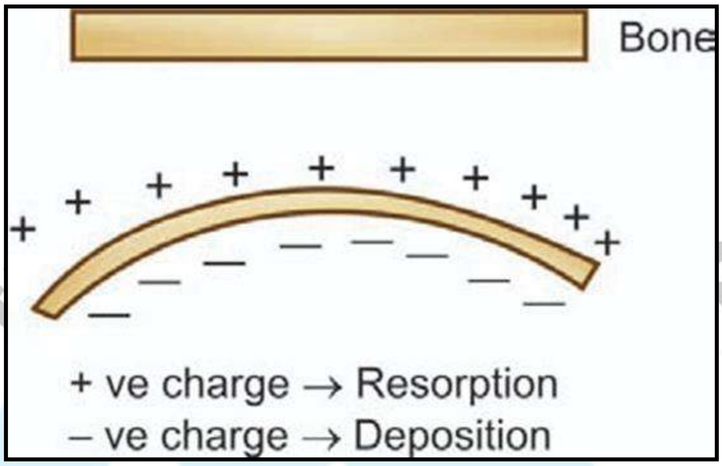


Figure 1.8: Areas of concavity and convexity produced on bone bending

N.B.: For further information, you can read more from:

1. Singh. G. (2007). Textbook of Orthodontics. 2nd ed. Jaypee Brothers Medical Publishers (P) Ltd, New Delhi.
2. Proffit, W. R., Fields, H. W., Larson, B. E., and Sarver, D. M. (2019). Contemporary orthodontics. 6th ed. St Louis: Mosby Elsevier.
3. Graber, L. W., Vanarsdall, R. L., Vig, K. W., and Huang, G. J. (2017). Orthodontics current principles and techniques. 6th ed. Elsevier Health Sciences.

Biomechanics in Orthodontic

1.1. Phases of Tooth Movement

Burstone categorized three distinct yet overlapping stages of tooth movement. They are:

- **Initial phase**
- **Lag phase**
- **Post-lag phase.**

1.1.1. Initial Phase

The initial phase of tooth movement is immediately seen following the application of a force on a tooth. The phase is characterized by a sudden displacement of the tooth within its socket. The movement of the tooth into the periodontal space and the bending of the alveolar bone probably cause it. The extent of movement achieved is nearly same for both light and heavy forces.

1.1.2. Lag Phase

The lag phase is characterized by very little or no tooth movement. It is the phase where the cellular components around the area of interest get activated to cause tooth movement. The lag phase is longer if high forces are applied, as the area of hyalinization created is large and the resorption is rearward. Shorter duration of the lag phase is noticed for lighter forces.

1.1.3. Post-Lag Phase

This phase is characterized by the removal of the hyalinized tissue and tooth movement. The movement is mediated by osteoclasts and there is either direct resorption of the bony surface facing the periodontal ligament or rearward bone resorption.

1.2. Forces, Moments and Couples

- **Force:** can be defined as ‘an act upon a body that changes or tends to change the state of rest or of motion of that body.’
- **Center of Resistance (COR):** Every unrestrained body has a point at which it can (at least in theory) be perfectly balanced. This point is called the center of gravity. When we talk about teeth, we are talking of a body which is restrained by adjacent structures like the periodontal ligament etc. For

such restrained bodies the analogous point to the center of gravity is called the center of resistance. By definition, a force with a line of action passing through the COR produces translation.

The COR of a single-rooted tooth is on the long axis of the tooth, probably between one third and one half of the root length apical to the alveolar crest (see Figure 1A). For a multi-rooted tooth, the COR is probably between the roots, 1 or 2 mm apical to the furcation (see Figure 1B).

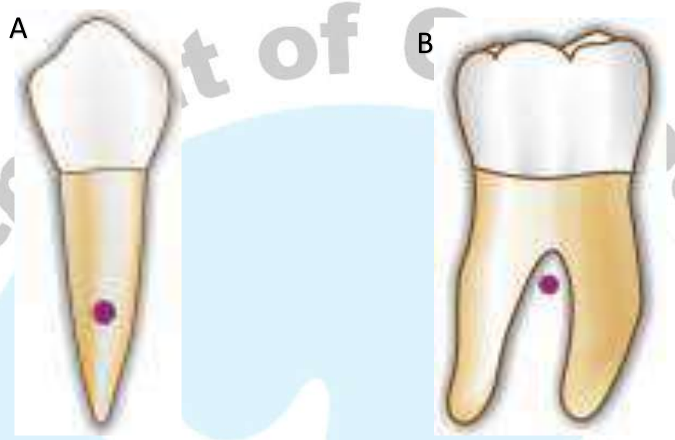


Figure 1: Center of resistance. (A): of single rooted tooth, (B): For a multi-rooted tooth.

The COR varies with:

1) Root length.
2) Alveolar bone height, see Figure 2.
3) The root morphology- single or multi-rooted teeth.

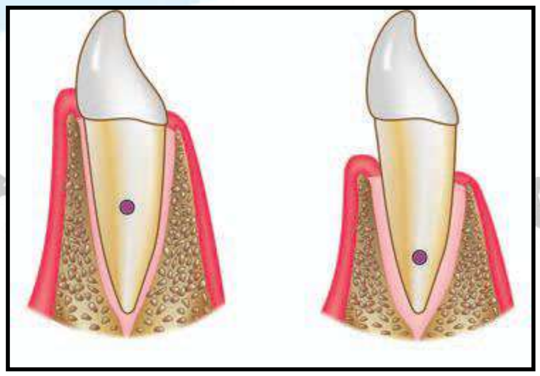


Figure 2: Change in center of resistance of tooth following alveolar bone loss.

- **Moment of force**: When the line of action of an applied force does not pass through the COR, the force will produce some rotation. The potential for rotation is measured as a *moment*.

The magnitude of the moment is equal to the magnitude of the force multiplied by the perpendicular distance of the line of action of the force to the COR (Figure 3A).

- **A couple:** consists of two forces of equal magnitude but opposite in direction, with parallel lines of action. When two forces are applied in this manner the resultant produced is a pure moment (the translatory effect of the individual forces gets cancelled) (Figure 3B).

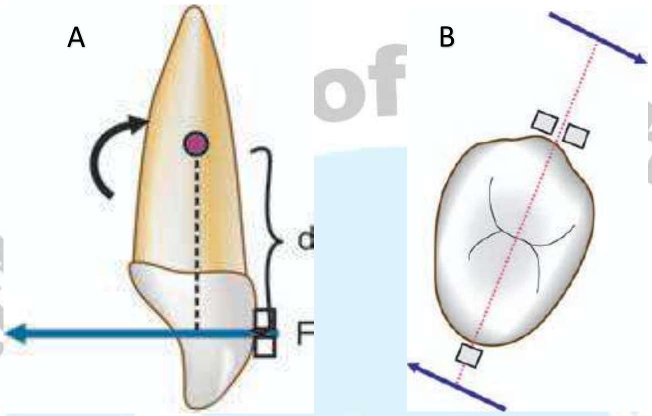


Figure 3: A, Moment-magnitude of force (F) × perpendicular distance of the point of application from the center of resistance (d). **B**, a couple.

- **Center of rotation** (CORo): is the point around which rotation actually occurs when an object is being moved/rotated. The CORo can be at any position on or off a tooth (Figure 4). As the CORo moves towards the apex, the more the displacement of the crown and vice versa.

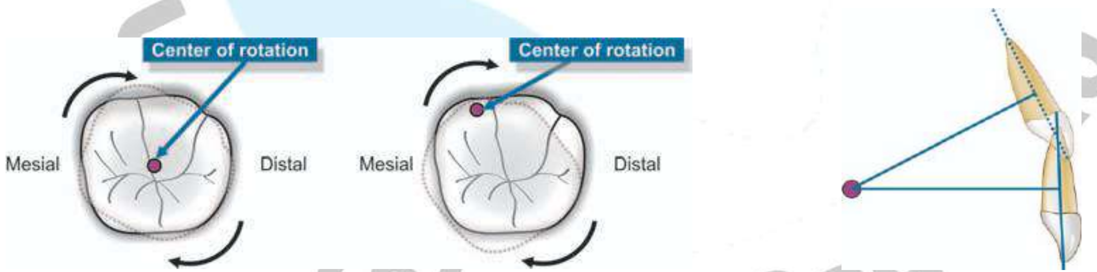


Figure 4: The concept of a center of rotation can be used to define any type of tooth movement in any plane of space.

1.3. Types of Tooth Movements

1) **Tipping or Inclination:** a. Uncontroled. b. Controlled. It is tooth movement with greater movement of the crown of the tooth than of the root. The crown will move to the same direction as the force while the root will move to the opposite direction. The CORo of the motion is apical to the COR, see Figure 5.

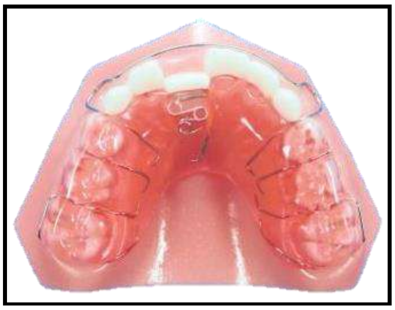


Figure 6: Labial crown tipping of upper right central incisor in a palatal crossbite using upper removable appliance by z-spring.

a. ***Uncontrolled:*** When the CORo is located between the COR and the apex. This is the simplest type of tooth movement, but it is undesirable. Uncontrolled tipping can be useful in some cases, eg: class II div. 2 and class III where the excessively upright incisors often need flaring, (Figure 6A).
b. ***Controlled:*** When the CORo is at root apex. It is a very desirable type of tooth movement; it is obtained with the application of a force to move the crown, and application of a moment to control or maintain the position of the root apex. An example of this inclination is when we want to retract the anterior sector without moving the location of the tooth apex, (Figure 6B).

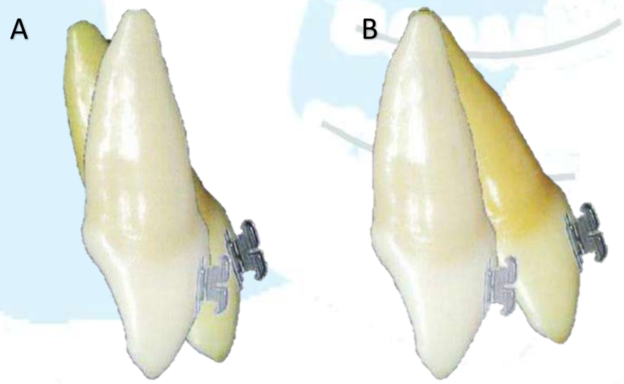


Figure 6: A, Uncontrolled tipping. **B,** Controlled tipping.

2) **Translation:** It is also known as en-mass or bodily movement. Happens when the crown and the root move the same distance and in the same horizontal direction. This is only possible when the line of action of a force passes through the center of resistance of the tooth. The CORo is at infinity.

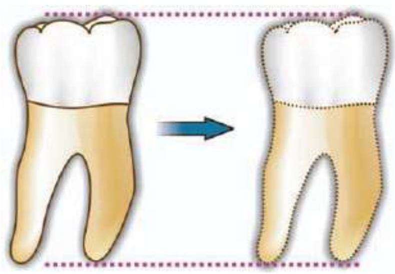


Figure 7: Pure translation.

3) **Vertical Movement:** The movement of the whole tooth (crown and root), could be (see Figure 8):

a. ***Extrusion:*** A translational type of tooth movement parallel to the long axis of the tooth in the direction of the occlusal plane (resembles tooth eruption); e.g. closure of anterior open bites by extrusion of upper and /or lower teeth.

b. ***Intrusion:*** The same definition of extrusion but in an apical direction; e.g. intrusion of upper and / or lower anterior teeth to reduce a deep bite.

4) **Root movement:** It means major movement of the root with minimal crown movement. The CORo of a tooth is at the incisal edge, or bracket, see Figure 8. Root movement includes torque and upright. Torquing means palatal or lingual root movement, while reverse torqueing means buccal or labial root movement. Mesial or distal root movement is called root uprighting. An example for torque movement is the correction of maxillary centrals root inclination in class II div. 2malocclusion.

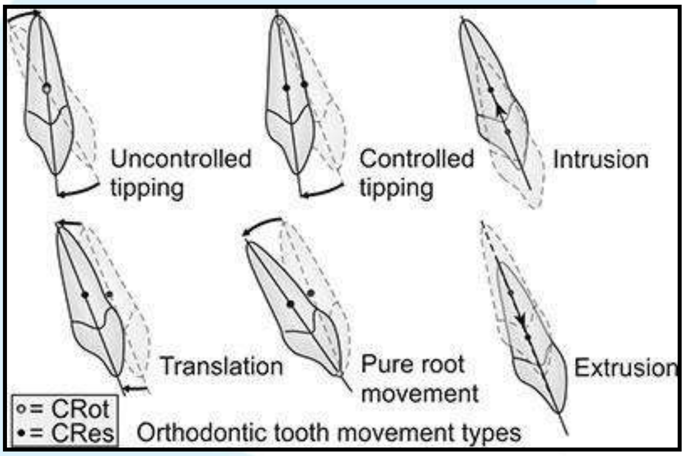


Figure 8: Types of orthodontic tooth movements.

5) **Rotation:** Pure rotation is achieved by the application of what is called couple force system; i.e. applying two equal forces but opposite in direction that result in circular movement of the tooth around its long axis, see Figure 9. The CORo will be situated at the COR of the tooth. Rotational movements have great tendency to relapse after orthodontic treatment due to re-coil action of the PDL fibers.

Figure 9: Rotation.

1.4. Rate of Tooth Movement

It is defined as the displacement of a tooth per unit time, and is usually measured in mm per an hour, a day, a week, or a month. About 1 mm per month may be regarded as an acceptable rate of tooth movement.

The rate of orthodontic movement is affected by many factors:

1.4.1. Nature and duration of force applied

Both light and heavy forces will result in orthodontic movement. If light forces are used; minimizing hyalinization (necrotic area) of periodontal ligament, the rate of tooth movement will be grater. The optimum force for tooth movement is around (20-25g/cm2) of root surface area. The force magnitude applied to an individual tooth will depend upon its root surface area and the type of planned tooth movement.

The manner of orthodontic force application is generally either intermittent (e.g. removable appliances, see Figure 10), interrupted or continuous (e.g. fixed appliances, see Figure 10). The chemical mediators for tooth movement appear in the blood stream within a few hours after force application, and clinical tooth movement occurs with a force duration of as little as six hours per day. However, for optimal tooth movement, application of a light continuous force is preferable to intermittent forces because the cell biology system remains in a constantly responsive state, not a fluctuating state.

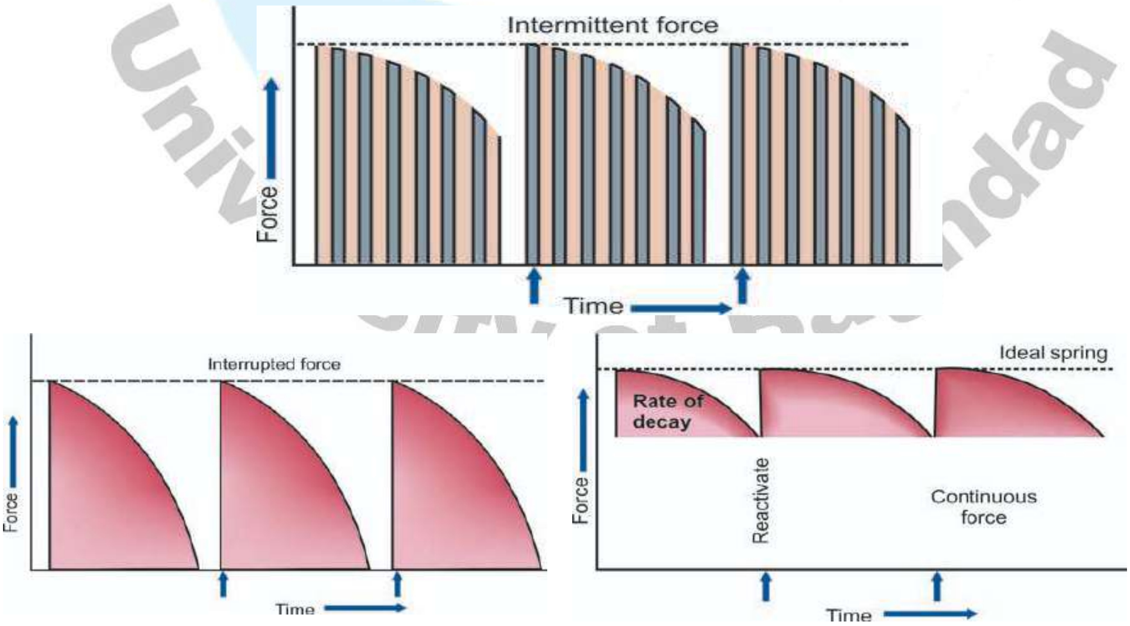


Figure 10: Types of orthodontic forces.

1.4.2. Age

Tooth movement and biologic responses to orthodontic treatment in the adults are slower than in adolescents and children because the PDL is much less cellular in adults. In addition, the alveolar bone in adults is denser.

1.4.3. Individual Variation

Individual differences in rate of growth, bone density and metabolism, and turn over in the PDL may be responsible for the variation in rate of tooth movement. In some individuals, the alveolar bone is loose and cancellouse with large marrow spaces, whereas in other the alveolar bone is dense lamellated bone with few marrow spaces, in this case the tooth movement will be much slower.

1.4.4. Drugs and Chemical Agents

Many studies have been conducted to test the accelerative or preventive effect of many drugs and chemical agents on orthodontic tooth movement, and it has been found that the rate of tooth movement can be altered by applying certain agents locally or systemically. The promoter agents accelerate the required tooth movement by enhancement of bone resorption; e.g. Prostaglandins, Vitamin D3, and Corticosteroids. The suppressor agents reduce tooth movement by reducing bone resorption or enhancing bone formation; e.g. NSAIDs, Calcitonin and Bisphosphonates.

1.5. Accelerated Tooth Movement

Prolonged treatment time in orthodontics is an undesirable side effect for both the patient and the clinician. Usually, between 2 and 3 years of treatment are required for a case to be properly completed.

Because remodeling of alveolar bone is the key component of orthodontic tooth movement and bone remodeling is accelerated during wound healing the idea that teeth could be moved faster after local injury to the alveolar process has been developed. This can be achieved by the following method:

1. Corticotomy
2. Piezocision
3. Microperforation
4. Vibration of the teeth,
5. Application of light to the alveolar process, and
6. Application of therapeutic ultrasound to the teeth and adjacent bone.

N.B.: For further information, you can read more from:

1. Singh. G. (2007). Textbook of Orthodontics. 2nd ed. Jaypee Brothers Medical Publishers (P) Ltd, New Delhi.
2. Proffit, W. R., Fields, H. W., Larson, B. E., and Sarver, D. M. (2019). Contemporary orthodontics. 6th ed. St Louis: Mosby Elsevier.
3. Graber, L. W., Vanarsdall, R. L., Vig, K. W., and Huang, G. J. (2017). Orthodontics current principles and techniques. 6th ed. Elsevier Health Sciences.

Good Luck……

Orthodontics

Iatrogenic effect of tooth movement

Orthodontic treatment have an adverse effects associated with the treatment like other fields in dentistry. These effects can be related to the patient or practitioner.

1) Pain.
2) Periodental disease.
3) Pulp effect.
4) Root resorption.
5) Decalcification and associated caries.
6) Temporal mandibular disorders.

1) Pain associated with orthodontic treatment:

Pain and discomfort is a common adverse effect associated with orthodontic treatment. 70–95% of orthodontic patients experience pain. This pain could be a reason for discontinuing treatment in some cases; the pain and discomfort associated with orthodontic treatment is characterized by pressure, tension, or soreness of the teeth. Pain in the anterior teeth is greater than the posterior teeth. Pain has been reported to begin 4 h after the placement of separators or orthodontic wire, and the worst pain was found to occur on the second day of treatment. Usually, pain lasts for seven days.

Management of pain should include informing the patient of the possibility of experiencing pain to reduce anxiety. Furthermore, the clinician can ask the patient to chew on plastic wafers or chewing gums containing aspirin.

Additionally, clinicians are recommended to prescribe Ibuprofen or acetaminophen analgesics preoperatively and for a short duration after the placement of separators and initial wires.

2) **Periodontal disease and orthodontic treatment:**

Periodontal disease includes gingivitis, alveolar bone loss (periodontitis), and loss of attached gingival support.

The periodontal reaction toward orthodontic appliances depends on multiple factors, such as host resistance, the presence of systemic conditions, the amount and composition of dental plaque, smoking and the negative effects of uncontrolled diabetes.

Bacteria present in dental plaque are the primary causative agent of periodontal disease. Orthodontic treatment with fixed appliances is known to induce an increase in the volume of dental plaque.

Therefore, fixed orthodontic treatment may result in localized gingivitis, which rarely progresses to periodontitis.

Recession of a lower incisor following proclination during orthodontic treatment.

Therefore, oral hygiene instructions should be given before the initiation of orthodontic treatment and reinforced during every visit. Regularly brushing the teeth is the first line of defense in controlling dental plaque in addition to the use of an interproximal brush.

Orthodontic treatment of patients with active periodontal disease is contraindicated as the risk for further periodontal breakdown is markedly increased. And the treatment of uncontrolled diabetic individuals is contraindicated also.

Gingival hyperplasia during orthodontic treatment

3) Pulpal changes during orthodontic treatment:

Although pulpal reactions to orthodontic treatment are minimal, there is probably transient inflammatory response within the pulp, at least at the beginning of treatment. This may contribute to the discomfort that patients often experience for a few days after appliances are placed. The possibility of pulp vitality loss during orthodontic treatment does exist. The risk factors for loss of pulp vitality include a history of trauma associated with the teeth. Pre-treatment periapical radiographs of previously traumatized teeth are essential for comparative purposes. Additionally, the use of heavy uncontrolled, continuous forces by the orthodontist or round tripping of the teeth may lead to loss of pulp vitality since root apex may moved outside the alveolar process. Therefore, orthodontist should use optimal light forces during their treatment.

4) Root resorption:

Limited root resorption involving a number of teeth can be considered as consequence of orthodontic treatment.

The factors which may be contributing in root disease are hormonal disturbance, dietary deficiency, Periodontal disease and orthodontic treatment variables like duration of treatment. The genetic predisposition

makes root resorption associated with orthodontic treatment more predictable.
The risk for root resorption increases with the length of treatment. Treatment of impacted canines can extend treatment time and increase risk for root resorption. Thin, tapered, and dilacerated root morphology, results in roots that are more prone to resorption (ex. maxillary lateral incisor). Additionally, history of trauma associated with the anterior teeth increases the risk for root resorption.
Assessment of the condition through a progress radiograph at 6–12 months after the initiation of orthodontic treatment is recommended. These could be either periapical or panoramic radiographs. The patient must be informed that if root resorption is observed, then active treatment must be stopped for at least 3 months. The reparative process of root resorption begins two weeks after active treatment is stopped. At this stage, an alternative treatment plan should be considered and treatment should be discontinued when severe root resorption is observed.

Severe root resorption during orthodontic treatment

5) **Decalcification and caries associated with orthodontic treatment:**
Decalcification of enamel (*white spots*) is a common adverse effect of orthodontic treatment. Decalcification is considered to be the first step toward cavitation. Decalcification of enamel occurs in 50% of orthodontic patients and the most affected teeth are the maxillary incisors. Additionally, these lesions can develop within four weeks, which is the typical time span for orthodontic follow-up.

Generalized demineralization
following orthodontic treatment with fixed appliances.

The prevention protocol for decalcification includes plaque control through brushing of the teeth with fluoridated tooth paste. Daily rinsing with a 0.02% or 0.05% sodium fluoride solution can also minimize decalcification of enamel. Additionally, fluoridated solutions may delay the progression of lesions. Application of fluoride varnish twice a year or a combination of antibacterial and fluoride varnish may reduce the incidence of decalcification.

6) TMD and orthodontic treatment:

TMD is a condition that can include masticatory muscle pain, internal derangement of the temporomandibular joint (TMJ) disc, and degenerative TMJ disorders as separate problems or can be a combination.

The etiology of TMD is complex and cannot be explained on a cause-and-effect basis. Malocclusion may be considered in some cases as a contributing factor, but it is not the only etiological factor.

Orthodontic treatment during adolescence does not increase the risk for TMD, and it should not be started in patients with acute signs and symptoms of TMD. The orthodontic treatment should be postponed after the attack is controlled.

If the patient develops signs and symptoms during the orthodontic treatment, then all active forces must be discontinued without the need for the removal of the fixed orthodontic appliances. Then, the signs and symptoms of TMD must be controlled using a conservative approach. Once the signs and symptoms are under control, then the practitioner must reevaluate the objectives of treatment. In some cases, the orthodontic treatment must be terminated if the signs and symptoms cannot be controlled.

Accelerated tooth movement:

Methods to accelerate orthodontic tooth movement can be broadly studied under the following categories:

1. Drugs.
2. Surgical Methods.
3. Physical/ Mechanical stimulation methods.

I. Drugs:

Various drugs have been used since long to accelerate orthodontic tooth movement, and have achieved successful results. These include vitamin D, prostaglandin, interleukins, parathyroid hormone, misoprostol etc. But, all of these drugs have some or the other unwanted adverse effect, and as of today, no drug exists that can safely accelerate orthodontic tooth movement.

II. Surgical Methods:

The various surgical methods available are:

1. Corticotomy:

The conventional corticotomy procedure involves elevation of full thickness mucoperiosteal flaps, bucally and/or lingually, followed by placing the corticotomy cuts using either micromotor under irrigation, or piezosurgical instruments. This can be followed by placement of a graft material, wherever required, to augment thickness of bone.

Advantages:

a. It has been proven successfully by many authors, to accelerate tooth movement.

b. Bone can be augmented, thereby preventing periodontal defects, which might arise, as a result of thin alveolar bone.

Disadvantages:

a. High morbidity associated with the procedure.

b. Invasive procedure.

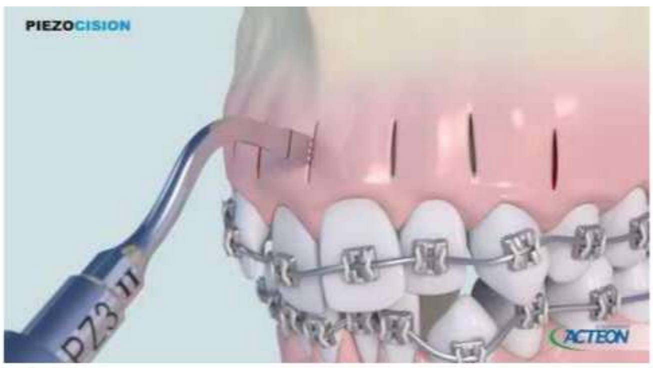
c. Chances of damage to adjacent vital structures.

d. Post-operative pain, swelling, chances of infection, avascular necrosis.

e. Low acceptance by the patient.

2. Piezocision:

The surgery was performed 1 week after placement of orthodontic appliance, under local anaesthesia. Gingival vertical incisions, only bucally, were made below the interdental papilla, as far as possible, in the attached gingival using a No.15 scalpel. These incisions need to be deep enough so as to pass through the periosteum, and contact the cortical bone. No suturing is required, except for the areas, where the graft material needs to be stabilized. Patient is placed on an antibiotic, mouthwash regimen.



Advantages
a. Minimally invasive.
b. Better patient acceptance.
Disadvantages
Risk of root damage, as incisions and corticotomies are "blindly" done.

3. Micro-Osteoperforations (MOP):
This based on microperforation in which screw like those used for skeletal anchorage is placed through the gingiva into interproximal alveolar bone and then removed. It is said that 3 such perforations in each interproximal area are enough to generate a regional acceleration of bone remodeling, and thereby produce faster tooth movement.

III. Physical/Mechanical Stimulation:
Surgical methods, regardless of technique, are still invasive to some degree, and hence have their associated complications. Hence, non-invasive methods have come to the fore. These modalities include lasers, vibration, direct electric current etc.

1. Laser:
In the last decade, many histological studies have attempted to determine the effect of low-intensity laser therapy on the histochemical pathways directly associated with orthodontic tooth movement. Increased osteoblastic and osteoclastic activity after low-level laser therapy was observed. The variations amongst the studies seem to arise from variations in frequency of application of laser, intensity of laser, and method of force application on the tooth.

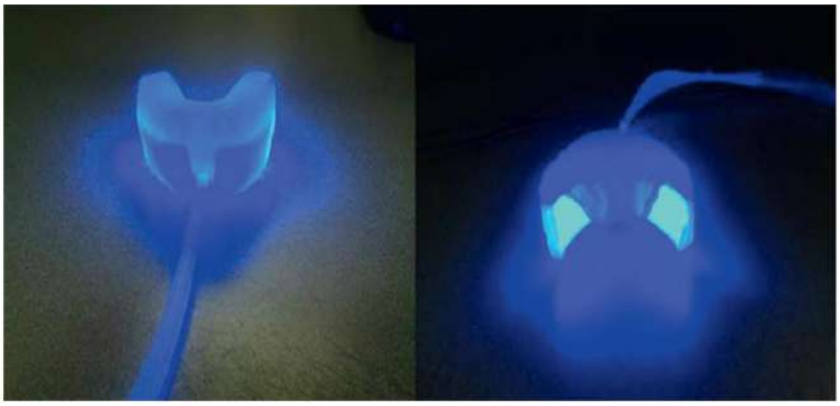
2. Vibration:

This device consists of an activator, which is the active part of the appliance that delivers the vibration impulses with a USB interface through which it can be connected to a computer to review the patient usage of the appliance, a mouthpiece that contacts the teeth.

It is a portable device that can be charged similar to any other electronic device; it is based on delivery of high-frequency vibration (30 Hz) to the teeth for approximately 20 minutes per day. Various case studies using this device have shown the treatment times to be reduced by up to 30-40%.

3. Tissue-Penetrating Light:

It provides light with an 800- to 850-nanometer wave length (just above the visible spectrum) adjacent to the alveolar bone. Light in this spectrum does penetrate soft tissue, and the idea is that it "infuses light energy directly into the bone tissue". This is said to excite intracellular enzymes and increase cellular activity in the PDL and bone, increasing the rate of bone remodeling and tooth movement.



The intraoral device delivers light at an infrared frequency that penetrates the soft tissue over the alveolar bone

4. Therapeutic Ultrasound:

It is known that therapeutic ultrasound (which is different from diagnostic ultrasound) increases blood flow in treated areas. The theory is that increased blood flow in the PDL would increase the rate of bone remodeling and tooth movement and also could decrease root resorption.

Introduction to Orthodontic Appliances

المرحلة الرابعة

Lec. 1 أ.م.د. ليث محمد كريم

Orthodontic Appliances

The appliance that apply mild pressure to a tooth or a group of teeth and their supporting tissue in a predetermined direction to achieve tooth movement within the bone and other tooth supporting tissues.

Classification of Orthodontic Appliances:

The simplest classification is based on the patient's ability to remove the orthodontic appliance. Based on this the appliances can be classified as:

A. Removable appliance:

An appliance which can be removed for cleaning by the patient or for adjustment by the Orthodontist. These appliances can be taken out of the mouth by patient when required.

According to their *mode of action*, removable orthodontic appliances are divided into three main groups:

1-*Active removable appliances:* These appliances are capable of exerting pressure and perform tooth movement.

***2-Passive removable appliances*:**

These appliances remain passive in the mouth and exert no active pressure. Example as space maintainer, retainers, habit breaker.



***3-Functional appliances*: These appliances work by transmitting or modifying muscle forces to the teeth and their supporting tissues.**

Example as: Andersen appliance, Frankel's functional regulators.

B. Removable-Fixed (combination) appliances:

Here some part of appliances can be removed by the patient and other parts remain fixed on the teeth.

C. Fixed appliances:

These cannot be removed by the patient and consists of:

1. **Bands- cemented on teeth (occasionally cast metal caps).**
2. **Attachments or brackets of different types attached on the bands or on teeth directly with bonding materials.**
3. **Labial or lingual archwires – These may themselves be active or passive and may carry auxiliary springs for movement of teeth.**

Removable orthodontic Appliances

The patient can insert and remove these appliances without the intervention of a clinician. They may be active or passive, depending upon their capability to exert / generate forces.

Active removable orthodontic appliances

designed to achieve tooth movement (mainly tipping) by means of active components, e.g. wire springs, screws etc.

- **Advantages of removable appliances**

1. **The patient can continue with routine oral hygiene procedures without any hindrance.**
2. **Most forms of tipping movement can be carried out successfully.**
3. **These appliances are less complicated than fixed appliances and generally more acceptable to the patients.**
4. **Since these are relatively simple appliances they can be delivered and monitored by the general dentist.**
5. **Appliance fabrication is done in specialized labs and hence the chair side time for appliance delivery is considerably less as compared to the fixed appliances.**

6. Since only a few movements are carried out simultaneously with these appliances the time required by the clinician to activate an appliance is less.
7. These appliances are relatively cheap as compared to the fixed appliances.

- **Disadvantages of removable orthodontic appliances**

1. Patient cooperation is the key word in removable appliance therapy.

2. These appliances are capable of only certain types of movements; they do not give three-dimensional control over the teeth to be moved. This limits their utility.

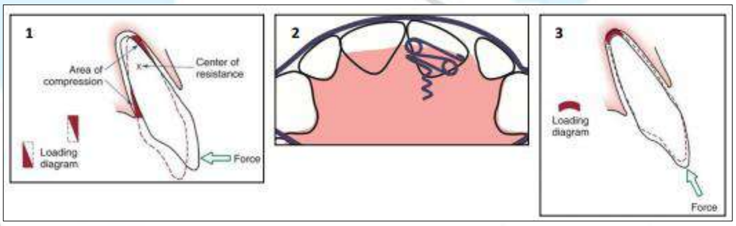
3. Multiple movements are difficult, if not impossible to carryout.

4. The patient has to have a certain amount of dexterity and skill to be able to remove and replace the appliance for successful treatment to be possible.

5. The chance of appliance loss and/or breakage is more.

Types of tooth movement done by removable appliances:

1. **Tipping movement**
   a. **Labio-lingual (bucco-palatal) direction**
   b. **Mesio-distal direction**
2. **Rotation of less than 90° (couple force system)**
3. **Intrusion and extrusion (combination appliance)**



Components of the removable orthodontic appliances:

According to their function:

1-Active components: which produce force for tooth movement, as springs, screw, elastics, active labial bows.

2-Retentive components: responsible for holding the appliance inside the mouth, as clasps.

3-Acrylic base plate: as a major connector connecting the components.

4-Anchorage: which is an imaginary component resisting unwanted tooth movement, while certain teeth are being moved by the active components.

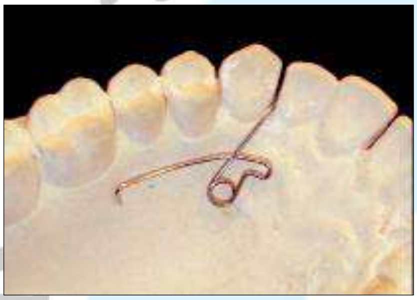
Active components

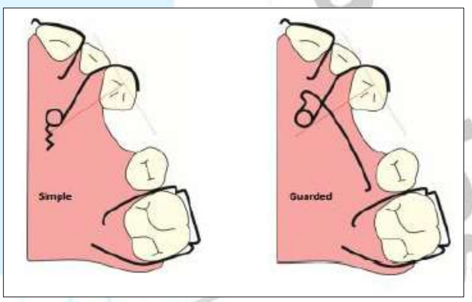
responsible for producing the desired tooth movement. They can be categorized as springs, bows, screws and auxiliary elastics.

<u>Springs</u>:

- Palatal finger springs

Palatal finger springs are constructed in 0.5- or 0.6-mm stainless steel wire and used to move teeth mesially or distally along the dental arch. The incorporation of a helix increases the length of the wire and allows the delivery of lighter forces whilst a guard wire will protect the spring from distortion. By convention, the helix is placed such that activation of the spring is done by opening of the coil as tooth movement occurs; the spring should be positioned at right angles to the planned tooth movement.



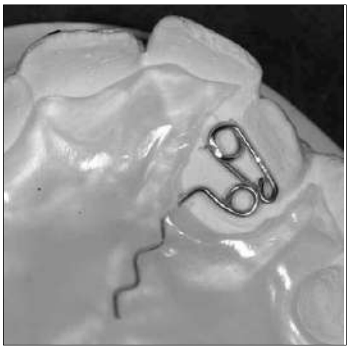


- Buccal canine retractor

Buccal canine retractors are constructed in 0.7-mm stainless steel, reduced to 0.5-mm if sleeved. These springs can be used to retract buccally displaced maxillary canines.

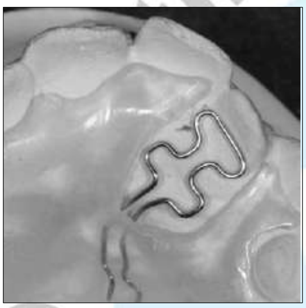
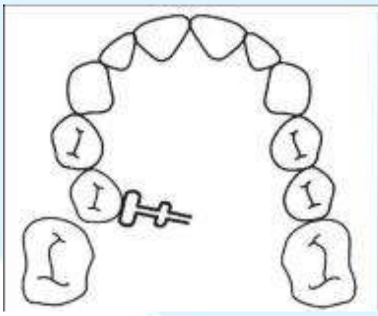
Z-spring

The Z-spring is constructed in 0.5-mm stainless steel wire and generally used to move one or two teeth (recurved or double) labially. Activation is achieved by pulling the spring away from the baseplate (opening the coils) at an angle of approximately 45° to the long axis of the tooth, which will tend to displace the appliance away from the palate; good anterior retention is therefore important.

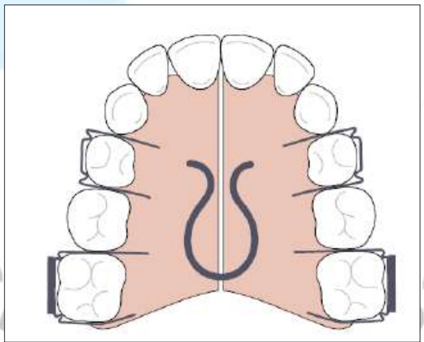
- T-spring

T-springs are constructed in 0.5-mm stainless steel wire and used to move individual teeth either labially or buccally. Activation is again produced by pulling the spring away from the baseplate and therefore retention also needs to be good.

Coffin spring

A coffin spring provides a useful alternative to a screw for expansion. This heavy spring is constructed in 1.25-mm wire and activated by pulling the two halves of the appliance apart manually or flattening the spring with pliers. Coffin springs deliver high forces that will tend to displace the appliance and good retention is important.



<u>Active labial bows</u>

An active labial bow can be used to reduce an increased overjet by tipping the teeth palatally if the upper labial segment is proclined and spaced. However, a normal labial bow will only allow a small range of activation and this can be improved either by increasing the amount of wire in the bow, as in a Mills bow, or by constructing it in a lighter wire, such as a Roberts retractor.

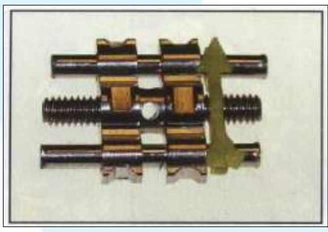
<u>**Screws**</u>

■ **Screws may be designed to move a single tooth or groups of teeth. The direction of tooth movement is determined by the position of the screw in the appliance.**

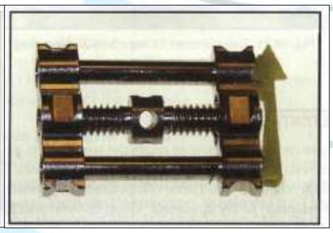
■ **Activation is achieved by turning the screw with a small wire key inserted into one of the holes of screw so that the two sections of the acrylic are moved a part, if the screw is over activated the appliance will not be fully seated.**

■ **There are basically two types of screws**

a- Jack screw: which is the most commonly used it consist of two halves threaded central cylinder, turned by means of a key which separates the two halves by a distance, usually about 0.2 mm each quarter turn.



Screw before opening



Screw after opening

b- Piston-screw (Landen screw) activated by moving the screw assembly forward by screwdriver.

■ **They are bulky, expensive and depends on patient's cooperation.**

■ **It is mainly used for (direction of tooth movement depend on the position of the screw in the appliance):**

a. Arch expansion; screw placed in the center of the arch.

b. Labial/buccal movement of one or a group of teeth.

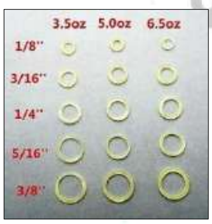
c. Mesial/ distal movement of one or more teeth.



<u>Elastics</u>:

- Although elastic deteriorates rapidly in the mouth it is still used where no suitable spring is available.
- Commonly used for intermaxillary traction with fixed & removable appliances. Adams clasp can be used as attachment site. The hooks for the elastics may be incorporated in the clasps or may be separate.
  - They have the advantage of being almost invisible.

They are not commonly used as the active component of a removable appliance because they tend to ride up the teeth and damage the gingival tissues.

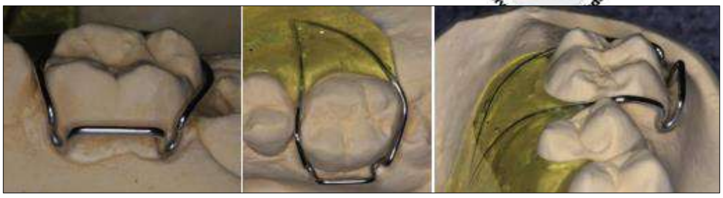



Retentive components

The retentive components are responsible for holding the appliance inside the patient mouth in the correct position and prevent dislodgement, they can also contribute in anchorage.

Adams clasp

Adams clasps are constructed in 0.7-mm stainless steel wire and most commonly used on the first molars, although they can be used on premolars and anterior teeth. The arrowheads of the clasp engage undercuts at the mesial and distal corners of the buccal tooth surface and can easily be adjusted at the chairside to increase retention. The bridge of an Adams clasp can also be used by the patient to remove the appliance from the mouth, whilst the orthodontist can use it to attach auxiliary springs or tubes for headgear.

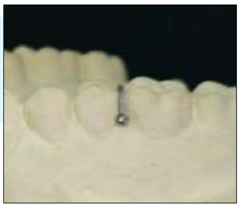


Southend clasp

The Southend clasp is also constructed in 0.7-mm stainless steel wire, but is used for retention on the incisor teeth. This clasp is activated by bending the U-loop towards the baseplate, which carries the clasp back into the labial undercut of the tooth.

Ball-ended clasp

Ball-ended clasps engage into interproximal undercuts between the teeth and are activated by bending the ball towards the contact point.



Labial bow

A labial bow is constructed from 0.7-mm stainless steel wire and can provide retention from the labial surface of the incisor teeth, which can be increased by contouring the wire around these teeth in a fitted labial bow or by placing an acrylic facing on the wire of the bow. The labial bow has some flexibility by incorporating U-loops at each end, which allow activation by compressing the U-loop.

Introduction to Orthodontic Appliances

المرحلة الرابعة

Lec. 2 **أ.م.د. ليث محمد كريم**

Acrylic base plate

The material most often used for base plate is cold cure or heat cure acrylic. It forms a major part of the removable appliance. Base plate acts as a support for pressure sources and distributes the reaction of these forces to the anchorage areas. In the maxillary arch it should extend to the distal of the first molar and slightly cut off in the midline, while in the lower arch does not extend too deep to avoid trauma to the sulcus and any undercut area should be blocked.

Properties of base plate

1. **It incorporates both the retentive and active components into a single functional unit (act as major connector).**
2. **It helps in anchorage and retention of the appliance in the mouth by contact with the palate and with teeth intended not to move and distributes the forces from the active components over a large area.**
3. **It protects the palatal springs against distortion in the mouth.**
4. **Bite planes can be incorporated into the base plate and used to treat specific problems.**
5. **The baseplate should be as thin as possible to reduce bulk yet thick enough for strength. It should be closely adapted to all teeth except those which are to be moved.**

Modifications of acrylic base plate

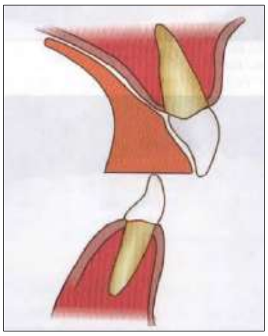
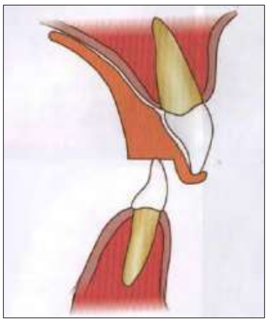
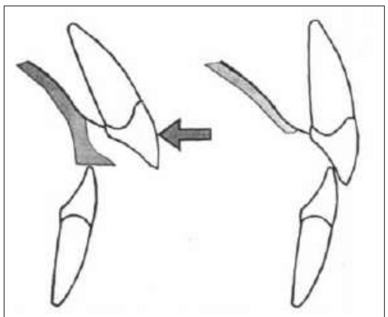
Bite plane **(anterior or posterior) can be added to acrylic base plate**

1. Flat anterior bite plane (FABP):

Action: the anterior bite plane is added to the maxillary plate to prevent the posterior teeth from occluding by contacting with lower incisors opening the bite posteriorly.

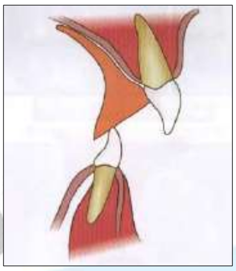
Properties: the bite plane should be wide enough that the patient cannot bite behind it. It should be flat, not inclined posteriorly, to avoid mandibular retrusion effect. This is particularly important in class II malocclusion.

Indication: it *corrects deep bite* by separating the molars allowing them to over-erupt & so decreasing the overbite. After opening the bite, the bite plane is cut lingually but not occlusally to allow for upper incisor retraction.

2. Inclined anterior bite plane:

It also corrects deep bite, added to the maxillary plate, but it corrects increased overjet as well by proclining lower incisors and acting as a myofunctional appliance enhancing mandibular growth & retarding maxillary growth.



3. Posterior bite plane:

Action: the posterior bite plane can be added to the maxillary or mandibular plate. It usually covers the occlusal surfaces of all the posterior teeth, so that when the teeth are brought together the mandibular canines, premolars & molars occlude on the bite plane, thus leaving the incisors out of contact & free to be moved without occlusal interferences.

Indications:

-It opens the bite anteriorly to allow, correction of anterior crossbite.

-Treatment of posterior crossbite by expansion screw. The bite plane is flat on both sides to allow for mandibular repositioning after crossbite correction.

Anchorage components:

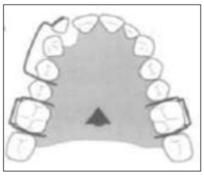
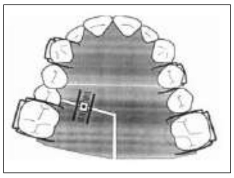
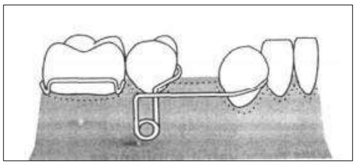
It is an imaginary component of the removable appliance resisting unwanted tooth movement.

In orthodontic treatment we apply force to move the teeth, and according to *Newton's third law* (for every action there is a reaction of equal magnitude and opposite direction), so this means that when we apply a force to move the teeth, the reaction force will be transmitted through the appliance and tends to move the anchor teeth in the opposite direction which is undesirable and should be avoided.

Classification of anchorage: According to the

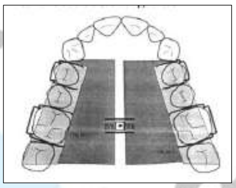
A- Way of applying force:

1- *Simple* anchorage (resistance to tip) the anchor unit's resistance to the tip is used to move other teeth. Simple anchorage is an anchorage that uses teeth that have greater resistance as anchors to move teeth that have smaller resistance. It is used in removable appliance.

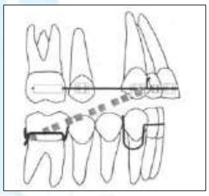
2- ***Stationary*** **anchorage (resistance to bodily movements) means the anchor teeth do not move at all, cannot be used in removable appliance.**

3- ***Reciprocal*** **anchorage involves using two teeth or two groups of teeth that have the same anchor value to each other to produce reciprocal tooth movements for example: diastema closure, transverse expansion.**

B- The jaws involved

1- ***intramaxillary*****: anchorage is established in the same jaw.**
2- ***intermaxillary*****: anchorage is distributed to both jaws.**

C- Anchorage location

1) ***intraoral*****: anchorage is obtained inside the mouth**

2) ***extraoral*****: anchorage is obtained outside the mouth, for example a) cervix: e.g. neck strap, b) occipital: e.g. head, c) cranial: e.g. high pull headgear, and d) facials: e.g. face mask; and 3) muscular: anchorage comes from muscle action.**

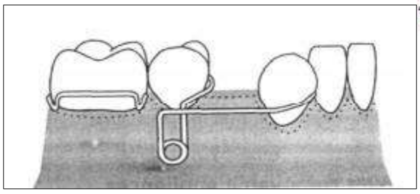
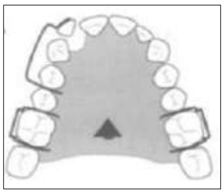

high pull headgear


j- hook


face mask

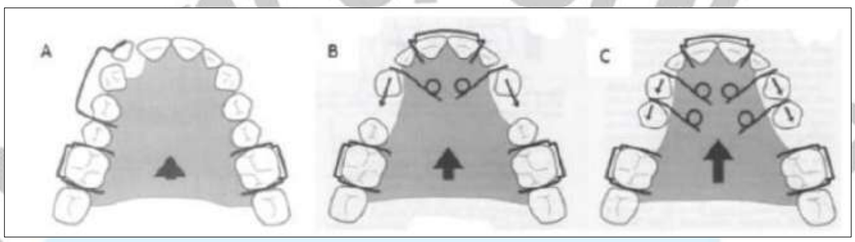
D- Number of anchorage units

1) single or primary anchorage: anchorage only involves one tooth, 2) compound anchorage: anchorage involving two or more teeth, and 3) reinforced anchorage: adding a non-dental anchor location. For example, mucosa, muscles, head, etc.

<u>Factors that affect anchorage</u>

1- <u>The root surface area</u> the tooth root surface area in the anchor group should be larger than the teeth to be moved so that the movement of anchor teeth is as minimal as possible. This can be performed by only moving one tooth each quadrant and involving as many anchor teeth as possible.



2- if the <u>force</u> is too large, the anchor teeth will also move, so keep the force as low as possible.

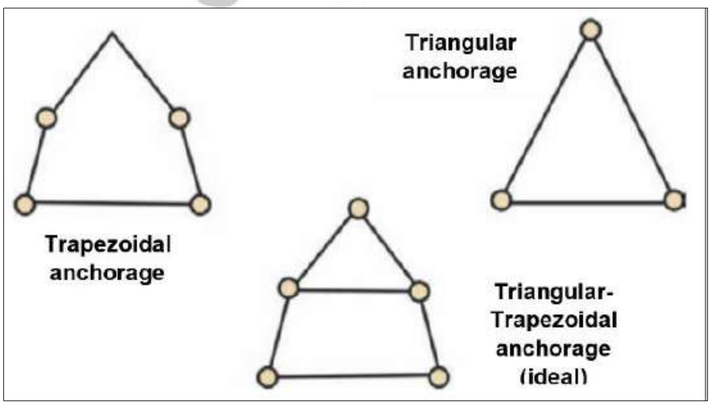
3- <u>Tendency of the teeth to shift to mesial</u>. Therefore, it must be carefully considered if there is a mesial force acting on the anchor teeth. For example, in canine retraction there is an action to move the canine distally and there is a mesial force or retraction acting on the anchor teeth.

<u>Anchorage management</u>:

1- keep the force used light enough to move the wanted teeth without affecting the anchor teeth.

2- increase anchoring resistance:

a- increase the number of teeth in anchor unit (e.g., second molar)
b- reduce the number of teeth to be moved
c- teeth with large root surface area have greater anchorage value than teeth with small root surface area.
d- base plate: covering teeth and mucosa
e cuspal interlock with the teeth of opposing arch example: anterior and posterior bite planes with good occlusal contact with the cusps of the teeth of opposing arch.
f- reinforce the anchorage: Various other ways include, the use of palatal arch, Nance arch, lingual arch, lip bumper, extraoral device.
g- Distribution of the retentive units: Tammoscheit (1969) described three types of anchorage systems based on geometric designs for the placement of the retentive units to obtain the best anchorage value.



Fabrication of a removable orthodontic appliance

The materials used in removable orthodontic appliance are:

a- Stainless steel wires (springs, clasps and labial bow).

b- Acrylic base plate (hot cure acrylic, cold cure acrylic or most commonly orthocryl).

The steps are:

1. Do the necessary wire bending (springs, labial bow and clasps).

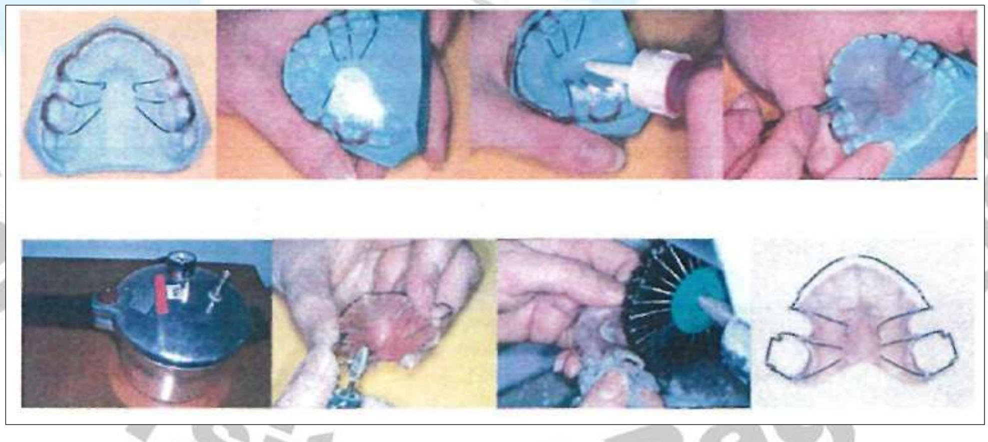
2. Fix the springs and clasps to the cast by wax on the occlusal and labial surfaces of the teeth, so that they do not move during fabrication of the acrylic. Wax is applied on the coils and arms of Z-, recurved, T- and finger springs not to be embedded in the acrylic baseplate.

3. Soak the cast in water for about 5 minutes until no more air bubbles come out of the cast to prevent the monomer from entering inside the cast and fusing the acrylic with the stone of the cast.

4. Materials: either heat cure or cold cure acrylic which is preferred because it is easy to use and faster to fabricate but care must be taken to eliminate residual monomer to reduce the porosity in the appliance, so orthocryl (a type of cold cure acrylic that need to set under pressure in a hydroflask) was introduced and gave better properties, it can be prepared by the dough stage method or by the sprinkle method (salt and pepper) to construct the acrylic base-plate by successively applying polymer and then monomer.

5. Cure in a hydroflask under 2 bar pressure to eliminate porosity. The hydroflask contains water at 40°C to accelerate the curing reaction.

6. The wax is cleaned and the acrylic base plate is finished with a carbide bur and polished with pumice.



Welding:

Welding is the union of two stainless steel wires by melting them onto each other by passing an electrical current through them. This is accomplished by a welder machine.

The two wires are put in firm contact under pressure of the jaws of the welder and then a low voltage high amperage electrical current is passed through the wires to melt the surfaces of the wires and make them fuse.

The resulting welding joints are generally weak and require soldering for reinforcement but can be used for fixation prior to soldering.

Note: the wires should be welded at right angle to each other (not parallel) to have a small contact surface area that concentrates the electrical current and make the wire melt more making a stronger joint.

<u>Soldering:</u>

Soldering is the union of two stainless steel parts by a third material (solder). The requirements are:

1. **A butane gas fine flamed torch.**
2. **Silver solder wires (low melting type, in the shape of wires 0.5-0.6mm in diameter).**
3. **Flux either separately or incorporated in the solder wire.**

Welding and soldering is generally used in orthodontics to:

1. **Repair fractured clasps.**
2. **Solder Hawley arch or buccal canine retractor to the bridge of the Adams clasp.**
3. **Solder a variety of modifications to the bridge of the Adams clasp (e.g. hooks for elastics and face bow tubes).**

Fitting a removable appliance for the first time

An appliance should be ideally fitted as soon as possible after the impression has been taken and any delay in fitting an appliance allows forward movement of posterior teeth following

orthodontic extraction or natural loss of deciduous molars and may interfere with fitting the appliance.

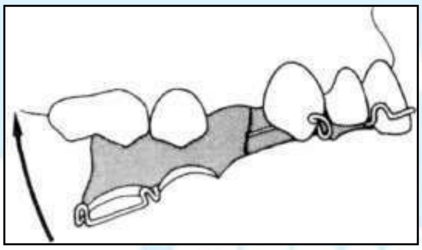
Fitting the appliance

a) Before inserting the appliance

1. Check that you have the correct appliance and design for the patient.
2. Show the appliance to the patient and explain how it works.
3. Check the fitting surface for any roughness

b) Inserting the appliance

1. The appliance should be inserted into the mouth with the anterior part lightly into position and then press the acrylic base upwards until the molar clasps engage. Removal of the appliance: Should be carried out in the reverse order. The finger tips are used to pull down on the bridges of the molar clasps until they disengage readily, make sure the patient can insert and remove the appliance.



2. Adjust the retentive components and check the retention.
3. Activate the springs and check the teeth if they are free to move (adjustment of retention comp., so that the appliance will be retention inside mouth).

c) Instruction to the patient and to the parents:

1- The patient should be shown in a mirror the insertion and removal of the appliance. Insist that the appliance be maneuvered by the bridges of the clasp and not the labial bow or springs. The correct method of insertion is to engage the anterior wire on the incisors and then press the acrylic palate upwards until the molar clasps engage. Removal is accomplished by pulling down on the molar clasps before disengaging the anterior teeth

2- You might face some discomfort during eating and speech in the first few days and in case of appliance damage report immediately to the dentist.

3- You should wear the appliance during day and night (24 hrs).

4- You should clean your teeth and the appliance regularly without distorting any component.

5- Avoid all sticky or hard foods such as; boiled sweets, chewing gum etc. These precautions will minimize the chances of a breakage

Monitoring progress during visits

At each visit:

- **Check for wearing of the appliance: by noticing the following: 1. There is little or no tooth movement. 2. The appliance still looking new. 3. The patient has difficulty in removing and more importantly in inserting the appliance. 4. Springs are still active and patient speech still affected (while wearing the appliance).**
- **Reassess the treatment plan aims.**
- **Record the molar relationship, overjet and overbite.**
- **Check the active and retentive components. Check that the patient is not using them to remove the appliance or putting it in his pocket during meals causing distortion.**
- **Anchorage situation.**
- **Whether the bite-plane or buccal capping need to be increased and/or adjusted.**
- **Record what action needs to be undertaken at the next visit.**

Common problems during treatment

1. Slow rate of tooth movement:

Normally tooth movement should proceed at approximately 1 mm per month in children, and slightly less in adults. If progress is slow, check the following:

- **Is the patient wearing the appliance full-time?**
- **Are the springs correctly positioned?**
- **Are the springs underactive, overactive, or distorted?**
- **Is tooth movement obstructed by the acrylic or wires of the appliance?**
- **Is tooth movement prevented by occlusion with the opposing arch? It may be necessary to increase the bite-plane or buccal capping to free the occlusion.**

2. Frequent breakage of the appliance

- **The appliance is not being worn full time.**
- **The patient has a habit of clicking the appliance in and out.**
- **The patient is eating inappropriate food while wearing the appliance.**

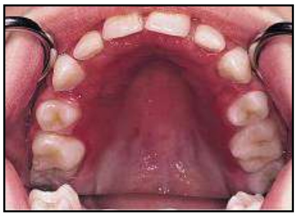
3. Excessive tilting of tooth being moved

- **The further that the spring is from the center of resistance of the tooth the greater is the degree of tilting. Therefore, a spring should be adjusted so that it is as near the gingival margin as possible without causing gingival trauma.**
- **Excessive force is being applied to the tooth.**

4. Lack of overbite reduction

In children, the most common reason for lack of progress with overbite reduction is that the appliance is not being worn during meals. Patients should be advised that their treatment will be quicker and more successful if they wear their appliance for eating, and that adaptation will be enhanced if they start with softer foods.

5. Palatal inflammation



This can occur for two reasons:

- **Poor oral hygiene.**
- **Entrapment of the gingivae between the acrylic and the tooth/teeth being moved.**
- **Trauma from active arm of the spring.**

6. Anchorage loss

This can be increased by the following:

- **Part-time appliance wear, thus allowing the anchor teeth to drift forwards.**
- **Over activation; the forces being applied by the active elements exceed the anchorage resistance of the appliance.**

Appliance repair

Before arranging for a removable appliance to be repaired the following should be considered:

1- How was the appliance broken? If a breakage has been caused by the patient failing to follow instructions, it is important to be sure any co-operation problems have been overcome before proceeding with the repair.

2- Would it be more cost-effective to make a new appliance?

Occasionally it is possible to adapt what remains of the spring or another component of the appliance to continue the desired movement.

3- Is the working model available, or is an up-to-date impression required to facilitate the repair.

4- How will the tooth movements which have been achieved be retained while the repair is being carried out Often there is no alternative but to try and carry out the repair in the shortest possible time information and instruction for the patient after insertion the appliance is meant to be worn at all times - 24 hours a day- the appliance should remain in the mouth throughout usual activities such as; eating, sleeping, playing sports etc. It is only to be removed when cleaning the teeth.

Repairing a fractured <u>Adam's clasp:</u>

The Adam's clasp is commonly fractured from the U-loop because it has an acute bend. The procedure of soldering is as follows:

1. **Flux is added on the wire to prevent its oxidation under the flame.**
2. **Direct flame is used to heat the wires until they become red. Care must be taken not to overheat the neighboring acrylic.**
3. **Silver solder is added to unite the two fractured parts.**
4. **The soldering joint is immediately quenched in water to give the solder hardness.**
5. **Excess solder is removed by a bur and the joint is polished.**




Acrylic repair

1. Make all active comp. passive
2. Reduce retention
3. Put it inside the mouth
4. Take and impression
5. Send to lab
6. Re-inserted again

Etiology of malocclusion

Classification of etiological factors

The final form of the occlusion and position of the teeth exhibits a wide range of variation. The main factors responsible for producing this variation can be divided into two groups:

1- The general factors which have general effect on the occlusion and play a part in the development of every occlusion.
2- The local factors which do not necessarily appear in everyone but they may be the main cause in producing a malocclusion in an individual.

General factors affecting occlusal development:

- Skeletal factors: the size, shape and relative positions of the upper and lower jaws.
- Muscle factors: the form and function of the muscles which surround the teeth, i.e. the muscles of the lips, cheeks and tongue.
- Dental factors: the size of the dentition in relation to the size of the dental arches.

Skeletal factors:

Excluding any pathological condition, the teeth are supported by the alveolar bone, which in turn is based on the basal bone of the jaws, therefore jaw bone can be subdivided into alveolar bone and basal bone, although both of them are belonged to the same bone.

As the teeth are set in the jaws, the relationship of the jaws to each other will influence the relationship of the dental arches. Jaw relationship can be considered as:

a) Jaws in relation to the cranial base:

Jaws are part of the head therefore each jaw may vary in its positional relationship to other structures of the head. Such variation can occur in sagittal, lateral and vertical planes. In orthodontic diagnosis it is usual to relate the position of upper and lower jaws to the anterior cranial base and each jaw can vary independently in its relation to the cranial base.

b) Jaws in relation to each other:

The relationship of the jaws to each other can also vary in sagittal, lateral and vertical planes, and variation in any plane can affect the occlusion of the teeth.

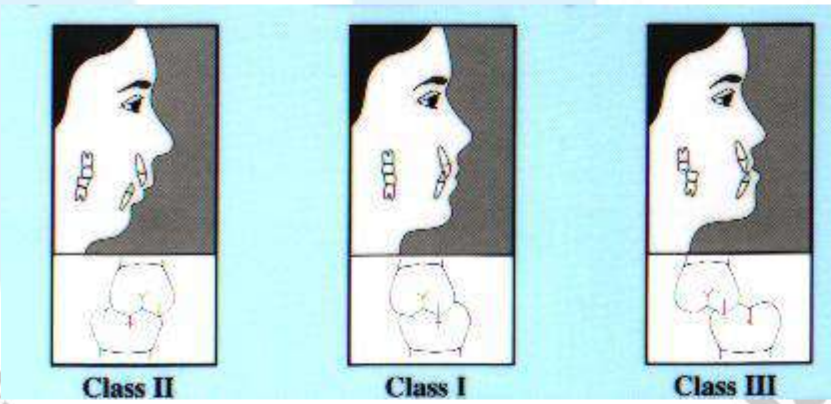
The sagittal or antero-posterior relationship of the upper and lower jaws to each other called the skeletal relationship or skeletal pattern which can be:

Skeletal class I: in which the jaws are in ideal antero-posterior relationship in occlusion.

Skeletal class II: in which the lower jaw in occlusion is positioned further back in relation to the upper jaw.

Skeletal class III: in which the lower jaw in occlusion is positioned further forward in relation to the upper jaw.

Skeletal Patterns



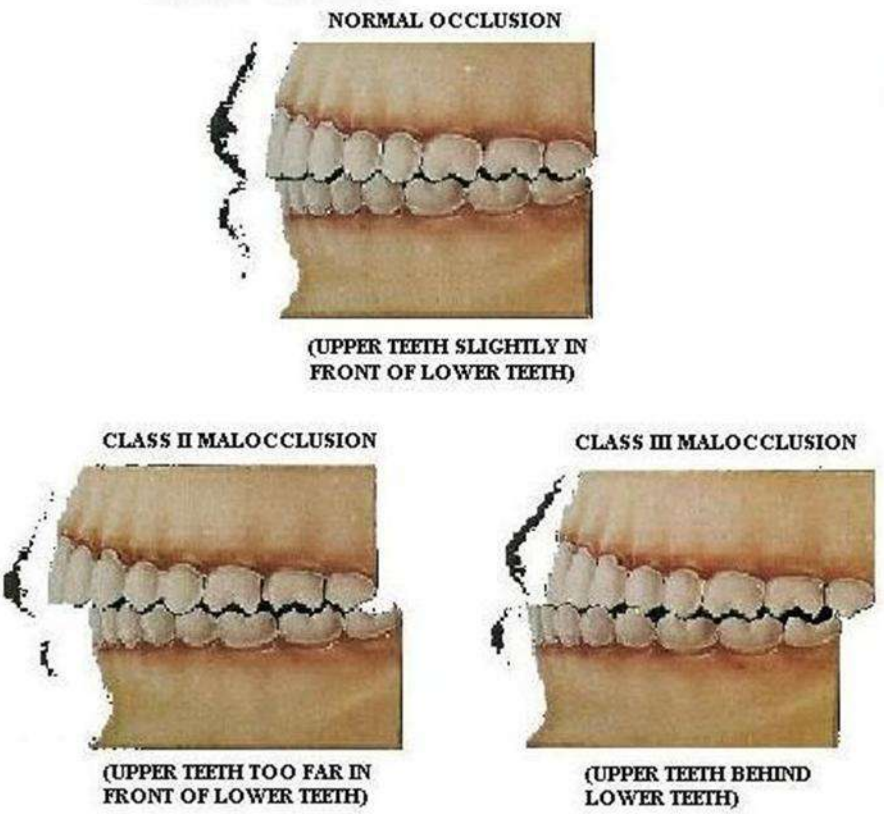
- Variation in the skeletal relationship results from:
    - Variation in the size and position of the jaw: In the sagittal plane if one jaw is excessively small or large in relation to the other in antero-posterior dimension the development of skeletal class II or class III relationship may result.

Also if one jaw is set further back or further forward than the other in relation to the cranial base, again skeletal class II or class III relationship may result.

In lateral plane, if the jaws match in size then the occlusion of buccal teeth in transverse relation is correct. However, if one jaw is wider than the other it may result in buccal cross bite, when lower jaw wider, or scissor bite, when the upper jaw is wider.

In the vertical plane, the effect is mostly seen with the variation in the shape of the lower jaw at the gonial angle. When this angle increased the vertical dimension of the face increased and vice versa.

c) Alveolar bone in relation to basal bone: although the alveolar bone is supported by the basal bone, the relationship between the upper and lower bones is not necessarily the same as that between the upper and lower basal bones. The alveolar bone supports the teeth and will therefore match tooth position rather than basal bone position.



Antero-posterior skeletal relationship

Soft tissue factors:

The teeth erupt into an environment of functional activity governed by the muscles of face, mastication and tongue. The muscles of tongue, lips and cheeks are of particular importance in guiding the teeth into their final position and variation in muscle form and function can affect the position and occlusion of the teeth. All muscles exert their influence by their sites of origin and insertion. Since the origins of these muscles are mainly on the basal bone therefore the position of the jaws must affect the position and action of the muscles which function on the teeth.

- The lips: the several muscles of the lip work as one functional unit; their effect on occlusion development depends on their form, size and function.

  Vertical relationship: In the ideal lip form the lips meet together at rest position this condition called lip competence, if the lips do not meet in rest position a condition due to short upper lip and lips seal achieved only by active contraction of the orbicularis oris and mentalis muscles called lip incompetence sometimes lip seal is prevented due to malocclusion for example the protruding maxillary incisors despite normally developed lips called potentially competent lips.


Competent lips


Potentially competent lips

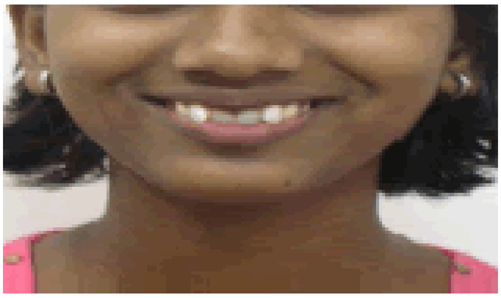

Incompetent lips

Lips are usually brought together during swallowing and speech movements. If they are of sufficient size to be together at rest then lip closure will not place extra force on the teeth. If the lips at rest are apart, then muscular contraction will be required to bring them together during swallowing and speech, which in turn will impose extra forces on the erupting teeth. The effect of these forces on the erupting teeth depends on the sagittal relationship of the lips.

The sagittal relationship: it is determined by the relationship of the basal bone of the jaw to which they are attached. For example the lower lip tends to be further back in class II and further forward in class III, which increase the difficulty to put the lips together and may cause the lower lip to modify the eruptive path of the incisors.

- In skeletal class II the lower lip may function completely or partially behind the upper incisors. For example
  - In not severe case the lower lip may procline the upper incisors resulting in more severe class II than skeletal relationship.
  - In more sever skeletal discrepancy the lower lip may function behind the upper incisors without causing them to be proclined.

- In other skeletal class II the lower lip function entirely in front of upper incisors causing them to be retroclined into the class II division 2 incisor relationship.



- The lower lip may cause retroclination of the lower incisors during swallowing, speech or smiling activities.

Lip line:

The level at which the lips meet together in normal function. The ideal lip line is approximately at the center of the crowns of the upper incisors with the lower lip in front of the upper incisors. If it is low part of the lower lip may function behind the upper incisors causing proclination, if it is completely behind upper incisors there will be no lip line as in class II. It is high in class II division 2 causing retroclination of upper incisors.

Tongue:

The tongue functioning, in conjunction with the lips and cheeks, in guiding the erupting teeth, and this affected by its size, its resting posture and its function.

The size of the tongue is mainly related to the size of the lower jaw. If the lower jaw is larger than the upper jaw, the tongue is too large to fit within the upper arch, therefore tongue finds space between upper and lower arches and prevents full vertical development of the dentoalveolar structures resulting in open bite.

The resting position of the tongue is ideally within the dental arches, filling the space enclosed by the teeth. Sometimes the tongue takes up an adaptive postural position, slightly protruded between teeth to touch the lower lip which will prevent the full vertical development of the incisal segment resulting in incomplete over bite. This is produced to seal the front of the mouth to allow nasal breathing (tongue lower lip anterior oral seal instead of lips oral seal) when there is difficulty to hold the lips together due to vertical or sagittal lip discrepancy.

The function of the tongue is concerned with mastication, swallowing and speech. Its effect on the dentition is mostly related to swallowing. After the food mastication is completed, the swallowing of food and saliva take place in sequence as: a) closure of the lips; b) teeth in light occlusal contact; c) tongue elevated to the palate, and d) momentary clenching of the teeth as food pass into the pharynx.

Variation of normal swallowing are also seen which may be described as:

1- Adaptive swallowing: involves positioning of the tongue between teeth during swallowing and may be carried out with the buccal teeth apart (tongue positioned between teeth, reduce the muscle and air pressures within the upper arch lead to narrow arch and buccal cross bite also prevents the full vertical development of the anterior dento-alveolar segment result in incomplete over bite), or buccal teeth together (lead to incomplete overbite or anterior open bite due to forward position of tongue)
2- Swallowing with endogenous tongue thrust: swallowing activity is accomplished by an anterior thrust of the tongue which is a basic neuromuscular mechanism. It sometimes associated with anterior lisp

during speech. It prevents the full vertical development of the anterior dento-alveolar segments resulting in an incomplete over bite or anterior open bite.

These two variations have somewhat similar effects on developing occlusion however, they respond differently to orthodontic treatment designed to reposition the teeth. The adaptive tongue will be changed if the teeth are moved but the endogenous tongue not and will reproduce the original tooth position if these are altered.

Neutral zone

The fact that the lips and cheeks function outside and the tongue within the dental arches has led to the concept of a neutral zone existing between the inner and outer perimeters of the dental arches, where the forces of lips and cheeks on one hand and of the tongue on the other are balanced and within which the teeth are positioned.

This zone should be considered not only in relation to muscle forces but also in relation to intra oral air pressures which are induced by mandibular positions and movements, and to occlusal contacts and the periodontal ligament.

It is important to keep the teeth in the neutral zone at the end of the orthodontic treatment otherwise they will move to take up other positions.

Dental factors:

The third general factor affecting the occlusion of the teeth is the relationship between the size of the dentition and the size of the jaws. Ideally, there should be adequate space for the teeth to erupt into the mouth without crowding or spacing. In primary dentition the ideal situation exists when there is spacing between the anterior teeth that will give better chance for permanent incisors to erupt without overlapping. The disproportion between teeth size and arch size can be:

- ❖ Excessive dentition size in relation to dental arch size which can have:
  - Overlapping and displacement: when the dental arch is too small for the dentition or teeth too large for the dental arch or both, the teeth will be displaced. The most affected teeth are the last teeth in each group i.e. lateral incisors, second premolars, canines and third molars.
  - Impaction of the teeth: occurs when eruption of teeth is completely blocked by other teeth due to crowding, also it affects the last tooth in each segment.
  - Mesial movement of the teeth: either associated with alveolar growth as part of dentoalveolar forward development also called mesial migration, or movement of individual tooth into space

created by interproximal attrition or loss of the teeth, this can occur any time during or after growth period.

❖ Excessive dental arch size in relation to dentition size: it is less common, occur when there is too small teeth in relation to the size of the dental arch or too large dental arch in relation to the size of the dentition or both which will result in spacing.
The size of the dental arch may not be the same as the size of the basal bone because skeletal relationship and muscular factors can produce a dental arch which is larger or smaller than the basal bone; therefore dentition size should be considered in relation to dental arch rather than jaw size.

Local factors:

Local factors can be classified as follow:

1- *Anomalies of number*

Each jaw is designed to hold only a specific number of teeth at a particular age. The anomalies in the number of teeth can be of two types:

(i) Increased number of teeth or supernumerary teeth:

Supernumerary teeth can vary remarkably in size, shape and location. They may be:

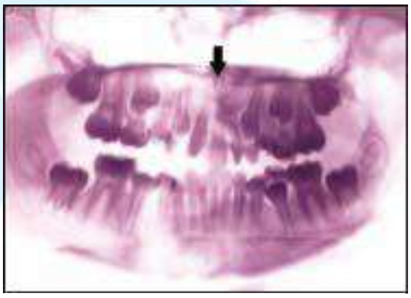
- Supplemental teeth: which bear a close resemblance to a particular group of teeth and erupt close to the original sight of these teeth, i.e. incisors, premolars or molars, etc.

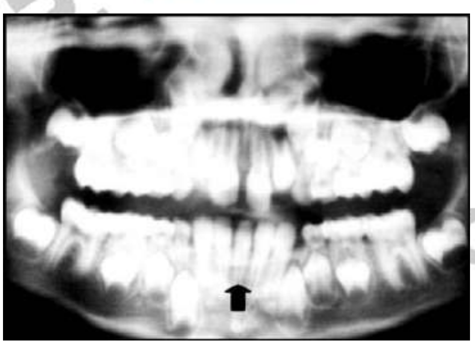

Supplemental tooth in the maxillary lateral incisor region


Supplemental teeth in the mandibular pre-molar region

- Mesiodens: it is the most commonly seen supernumerary tooth. It is usually conical in shape with a short root and crown, situated between the maxillary central incisors and can vary considerably in shape. It can be seen erupted or impacted, singular or in parts. It can occur in the maxilla or in mandible.


Erupted mesiodens


An impacted inverted maxillary


A mandibular mesiodense


An inverted mesiodens preventing the eruption of the left maxillary central incisor

Supernumerary teeth can cause

a. Non-eruption of adjacent teeth.

b. Delay the eruption of adjacent teeth.

c. Deflect the erupting adjacent teeth into abnormal locations.

Supernumerary tooth on the maxillary molar region has deflected the second permanent molar

d. Increase the arch perimeter (increasing the over jet if in the maxillary arch or decreasing the over jet if seen in the mandibular arch.

e. Crowding in the dental arch.

(ii) Less number of teeth or missing teeth

Congenitally missing teeth are more commonly seen in comparison to supernumerary teeth. It can be anodontia or hypodontia or oligodontia.

Anadontia: characterized by the congenital absence of all primary or permanent teeth. It is divided into 2 subsections, complete absence of teeth or partial absence of teeth

Hypodontia, usually missing 1 or 2 permanent teeth,

Oligodontia is the congenital absence of 6 or more teeth.

The most commonly congenitally missing teeth are the third molars, followed by the maxillary lateral incisors.

- Anadontia

- Oligodontia

- Hypodontia

Congenitally missing teeth can lead to:

a. Gaps between teeth.

b. Aberrant swallowing patterns.

c. Abnormal tilting/axial inclination or location of adjacent teeth.

d. Multiple missing teeth can cause a multitude of problems.

Spacing between teeth due to missing maxillary lateral incisors

Tongue thrust habit developing due to the congenital absence of the maxillary lateral incisors

Abnormal position of the maxillary right central incisor in contact with the right canine due to the absence of the right lateral incisor

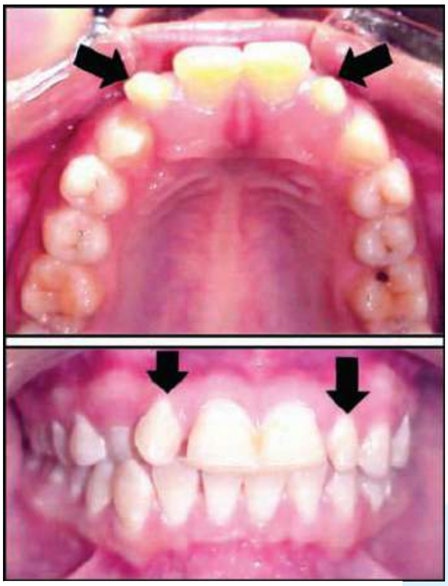
Multitude of problems caused due to missing mandibular central incisors. Retrognathic mandible, convex profile, anterior deep bite, maxillary anterior crowding and end-on molar relationship

2- *Anomalies of tooth size*

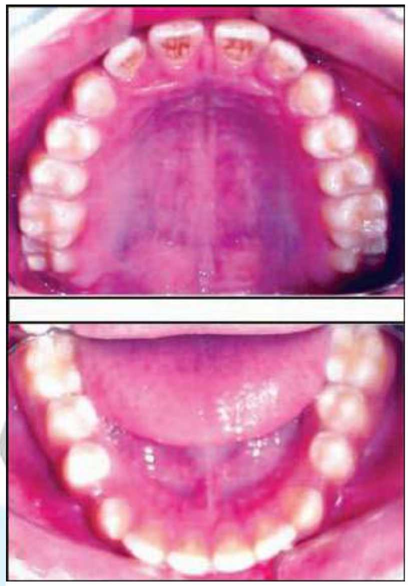
It includes macrodontia and microdontia, which can be localized or generalized.

- The true generalized macrodontia, where all the teeth are larger than normal is seen in cases of pituitary gigantism.
- The true generalized form of microdontia, where all the teeth are small is rarely seen. It is usually associated with cases of pituitary dwarfism.

  The most commonly seen *localized microdontia* involves the maxillary lateral incisors. The tooth is called a 'peg lateral" and exhibits a peg shaped crown with the mesial and distal sides converging incisally. The root may be shorter and more cylindrical than normally seen. *Relative generalized microdontia* may also be seen, but should be considered as an illusion of the true condition.



Peg-shaped maxillary lateral incisors

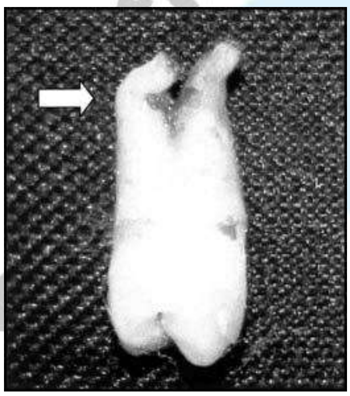


Relative generalized microdontia. Here the jaws are too big for normal sized teeth

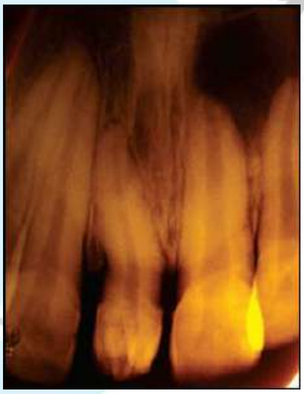
3- *Anomalies of tooth shape*

Anomalies of tooth shape include dilacerations, true fusion, gemination, concrescence, talon cusp, and 'dens in dente'.

- Dilaceration is an anomaly of the tooth shape in which there is a sharp bend or curve in the root or crown. It generally does not affect orthodontic treatment planning but may complicate the extraction of the affected tooth.

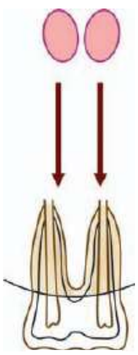


Dilacerated roots of a maxillary first pre-molar



Dilacerated roots might also create problems when they have to be aligned

- True fusion is seen when the tooth arises through the union of two normally separated tooth germs. It might lead to spacing or sometimes it might complicate its movement by orthodontic means.



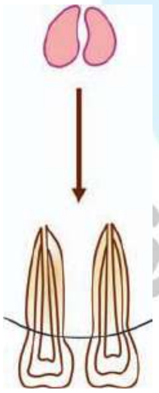
Fusion

True fusion

A larger bracket is required to attain proper rotational control of the tooth

- Geminated teeth are anomalies, which arise from division of a single germ by an invagination, leading to the formation of two incomplete teeth.

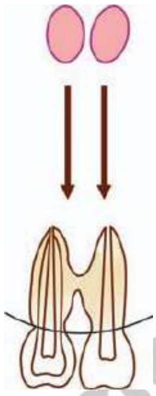
- The term ‘twinning’ has been used to designate the production of equivalent structures.



Twinning

Two near equal sized teeth in place of the maxillary left lateral incisor

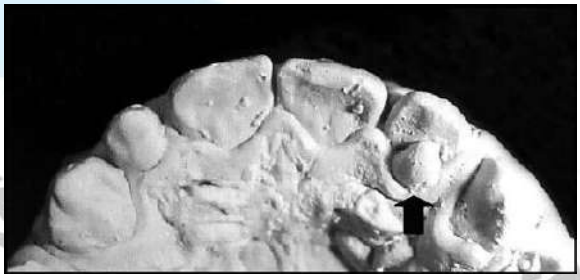
- Concrescence refers to fusion of cementum of teeth which occurs after root formation has been completed.



Concrescence

Concresence following root completion

- The talon cusp is an anomalous structure projecting lingually from the cingulum area of a maxillary or mandibular permanent incisor. It might interfere in proper occlusion. It's grinding invariably leads to pulpal exposure necessitating root canal treatment.
  The term 'Dens in Dente' is used to denote a developmental variation which radiographically may resemble a tooth within a tooth.



Talon's cusp as seen on the maxillary lateral incisor

Talon's cusp on the right lateral incisor preventing its ideal alignment in the arch, it appears to be rotates mesiopalatally.

4- *Abnormal labial frenum*

At birth the labial frenum is attached to the alveolar ridge with some fibers crossing over and attaching with the lingual dental papilla. As the teeth erupt, bone is deposited and the frenal attachment migrates superiorly with respect to the alveolar ridge. Some fibers may persist between the maxillary central incisors. These fibers which persist between these teeth are capable of preventing the two contralateral central incisors from coming into close approximation. This space called a midline diastema which may occur due to various causes:

1. Deciduous dentition
2. Ugly duckling stage
3. Racial predisposition, Negroids
4. Microdontia
5. Congenital absence of lateral incisors
6. Supernumerary tooth in the midline
7. Abnormal frenal attachment
8. Abnormal pressure habits (digit sucking and tongue thrust habit)
9. Trauma
10. Impacted tooth in the midline

A specific test used to determine the role of frenum as a causative factor called the 'blanch test' which can be done as follow:

Step 1: The lip is pulled superiorly and anteriorly

Step 2: Any blanching in the interdental region is indicative of the fibers of the frenum crossing the alveolar ridge

<u>Step 3</u>: The blanch test can be collaborated with an IOPA of the region which shows a slight radiolucent wedging/notching in the interdental alveolar ridge region

Labial frenum, blanch test, intraoral periapical radiograph

5- *<u>Premature loss of deciduous teeth</u>*

The premature loss of a deciduous tooth can lead to malocclusion only if the succedaneous tooth is not close enough to the point of eruption.

When the permanent tooth does not erupt following the loss of the deciduous tooth, the adjacent teeth get time to migrate in its space. This can lead to the mesial migration of the posterior teeth result in a decrease in the overall arch length. This might cause the permanent successor to erupt malpositioned or get impacted or cause a shift in the midline (in case of anterior teeth).

In case an anterior deciduous is lost prematurely; there is a tendency for spacing to occur between the erupted anterior teeth. It might also lead to a shift in the midline, towards the side where the deciduous tooth has been lost.

If one of the posterior deciduous teeth is lost, especially the deciduous second molars, the first permanent molars erupt mesially. This might lead to a loss in the arch length. This is seemed most commonly in the maxillary arch where there is lesser space for the canine to erupt; therefore it may erupt labially.

Mesially tilting of the erupted mandibular first molars may cause the second premolars to remain impacted

Mesial tilting of the mandibular 1st permanent molars leading to a decreased space for the eruption of the 2nd premolars

6- *Prolonged retention of deciduous teeth*

Any deciduous tooth may be retained beyond the usual eruption age of their permanent successor, this may cause:

i. Buccal/labial or palatal/lingual deflection in its path of eruption;

ii. Impaction of the permanent tooth.

Lingually erupting mandibular lateral incisors, due to over retained deciduous teeth

Left maxillary central incisor deflected palatally into cross-bite

Most commonly impacted tooth is the maxillary canine (third molars not taken into account). The reasons for this include:

i. It is the last anterior tooth to erupt
ii. Space occupied by the deciduous canine is less than the mesiodistal width of the permanent canines
iii. The premolars might migrate mesially leaving limited space for the canines to erupt
iv. It has the longest path of eruption
v. Controversially, as it may seem, it is the only tooth to erupt after root completion.

7- *Delayed eruption of permanent teeth*

The sequence of eruption has a certain amount of flexibility; but if one of the teeth does not occupy its designated place in this sequence there is a likelihood of migration of other teeth into the available space. As a result the tooth whose eruption has been delayed might get displaced or impacted.

Various reasons have been attributed for the delay eruption of the permanent teeth:

1. Early loss adjacent primary teeth with a consequential flaring or spacing between erupted permanent teeth. This may lead to decreased space availability for eruption of the succedaneous teeth.

2. Early loss of primary tooth leading to mucosal thickening over the succedaneous tooth. The mucosa might have to be incised to accelerate eruption.

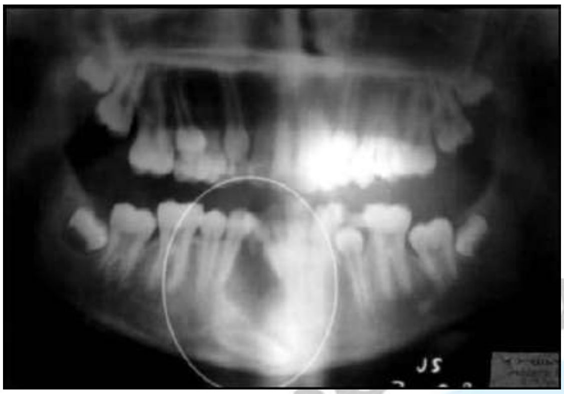
Mucosal thickening over the lateral incisors preventing their eruption

3. Early loss of the primary tooth might cause excessive bone deposition over the succedaneous tooth

4. Hereditary, in certain children teeth erupt much later than established norms

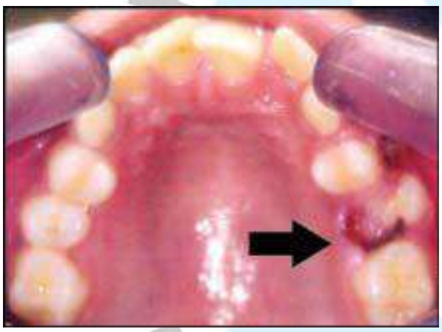
5. Presence of supernumerary tooth can block the erupting permanent tooth.

6. Presence of odontomas or other cysts and tumors (in the path of eruption) might prevent the permanent tooth from erupting



Impacted canine and destruction associated with a cystic growth in the mandible

7. Presence of deciduous root fragment that are not absorbed can block the erupting tooth or may deflect it preventing its eruption in an ideal location.



Retained roots of the deciduous 2nd molar deflected the erupting 2nd pre-molar buccally

8. Presence of ankylosed deciduous teeth. These might not get absorbed causing a delay in the eruption of the permanent tooth.

Ankylosed deciduous canines, which did not expoliate on time, resulted in labially erupting permanent canines

9. The succedaneous tooth might be congenitally missing, delaying the loss of the primary tooth

10. In certain endocrine disorders the eruption of permanent teeth might be delayed, e.g. hypothyroidism.

Whatever the reasons for the delay in eruption, it is important to maintain and if required to create space for its eruption.

Proper knowledge of preventive and interceptive orthodontics can definitely reduce the occurrence of malocclusions, if not prevent them from occurring; this can significantly reduce the severity of the malocclusion.

8- *Abnormal eruptive path*

Each tooth travels on a distinct path from its inception to the location at which it erupts. It can deviate from this eruption path because of many reasons:

1. Tooth bud facing and/or placed or displaced from its ideal location

2. Presence of a supernumerary tooth may divert a tooth from its eruptive path

3. Presence of odontomas or a cyst may divert it if not altogether prevent its eruption.

4. Unresorbed or retained deciduous teeth might force a tooth to erupt along a path of least resistance rather than in place of the deciduous tooth

5. Retained root fragments (especially of deciduous molars) may deflect an erupting permanent tooth

6. A true arch length deficiencies or excess of tooth material may cause one or more teeth to deviate from their eruptive path

A true arch length deficiency

The tooth that most frequently erupts in an abnormal location is the maximally canine. Various reasons have been attributed for this behavior. These include:

a. It travels the longest distance, from near the floor of the orbit to the cover of the arch.
b. It is the last anterior tooth to erupt and loss in arch length—anterior or posterior may impinge on the space required for its eruption.
c. Abnormal position of the tooth bud. Ideally it should slide along the distal aspect of the root of the lateral incisor. Any problem in the position of the lateral incisor may divert the erupting canine.

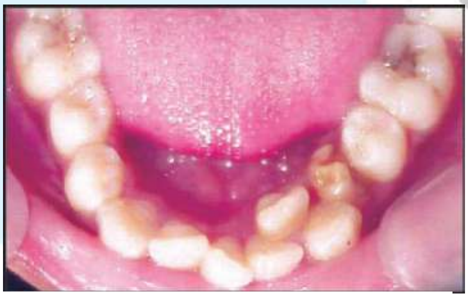
9- <u>Ankylosis</u>

Ankylosis is a condition which involves the union of the root or part of a root directly to the bone, i.e. without the intervening periodontal membrane. Ankylosis of teeth is seen more commonly associated with certain infection, endocrine disorders and congenital disorders, e.g. Cleidocranial dysostosis, but these are rare occurrences. It should be suspected in cases where there is a past history of trauma, or a mobile tooth has regained stability.

10- *Dental caries*

Proximal caries are especially to blame for the reduction in arch length. This might be brought about by migration of adjacent teeth and/or tilting of adjacent teeth into the space available and/or supra-eruption of the teeth in the opposing arch. A clear reduction in arch length can be expected if several adjacent teeth involved by proximal caries are left unrestored. This is especially true for deciduous molars.

Proximal decay in the 1st molar leading to decreased arch length



Mesial migration of the left posterior segment due to the presence of a grossly decayed deciduous 1st molar

Also caries can lead to the premature loss of deciduous or permanent teeth which can by themselves cause malocclusion.

11- *Improper dental restorations*

Improper dental restorations can cause malocclusion. How?

- Under contoured proximal restoration can lead to a significant decrease in the arch length especially in the deciduous molars.
- Over contoured proximal restorations might bulge into the space to be occupied by a succedaneous tooth and result in a reduction of this space.

- Overhang or poor proximal contacts may predispose to periodontal breakdown around these teeth.
- Premature contacts on over contoured occlusal restoration can cause a functional shift of the mandible during jaw closure,
- Under-contoured occlusal restorations can lead to the supra-eruption of the opposing dentition.

Abnormal pressure habits and functional aberrations

These are possibly the most frequently encountered causes of malocclusion. These include:

a. Abnormal sucking

b. Thumb and finger sucking.

Patient with a thumb sucking habit

c. Tongue thrust and tongue sucking.

Tongue thrust habit because of an abnormally large tongue

d. Lip and nail biting.

Lip biting

e. Abnormal swallowing habits (improper deglutition)

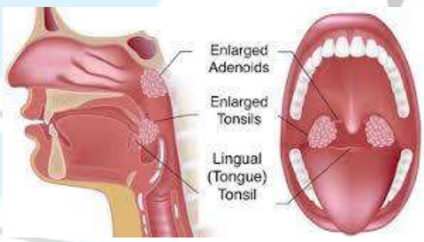
f. Speech defects

g. Respiratory abnormalities (mouth breathing, etc.).

Typical features of a mouth breather. Note the gingival inflammation in the maxillary anterior region

h. Tonsils and adenoids

Patient suffering from enlarged adenoids



i. Psychogenic habits and bruxism.

All of these habits are functional abrasions which produce forces that are abnormal. Since these forces are produced repeatedly over time they are capable of bringing about a permanent deformity in the developing musculoskeletal unit.

The deformity produced depends upon the intensity, duration and frequency of the habit. The effect of habits basically follows the functional matrix theory of growth as proposed by Moss—in its simplest form it says that—"function creates form and normal function creates normal form".

Fixed orthodontic Appliances

They are devices which have attachments that are fixed onto the tooth surface, and forces are exerted via these attachments using archwires and /or other auxiliaries. The appliances cannot and should not be adjusted or removed by the patient.

ADVANTAGES OF FIXED ORTHODONTIC APPLIANCES

1. Precise tooth control is possible.
2. Multiple tooth movements are possible.
3. Patient cooperation is reduced in comparison to removable appliance
4. All types of tooth movements are possible.

DISADVANTAGES OF FIXED ORTHODONTIC APPLIANCES

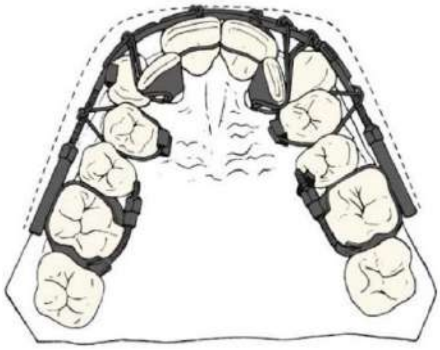
1. Oral hygiene requirement.
2. Esthetics.
3. Special training for operator.
4. Increased cost of treatment.
5. Increased chair side time.
6. Anchorage control is more difficult.
7. The possibility of producing adverse tooth movement.

INDICATIONS FOR THE USE OF FIXED APPLIANCES

1. Correction of mild to moderate skeletal discrepancies. As fixed appliances can be used to achieve bodily movement it is possible, within limits, to compensate for skeletal discrepancies and treat a greater range of malocclusions.
2. Intrusion/extrusion of teeth.
3. Correction of rotations.
4. Overbite reduction by intrusion of incisors.
5. Multiple tooth movements required in one arch.
6. Active closure of extraction spaces, or spaces due to hypodontia.

The development of contemporary Fixed Appliances

Edward Angle's position as the “father of modern orthodontics” is based not only on his contributions to classification and diagnosis but also on his creativity in developing new orthodontic appliances.

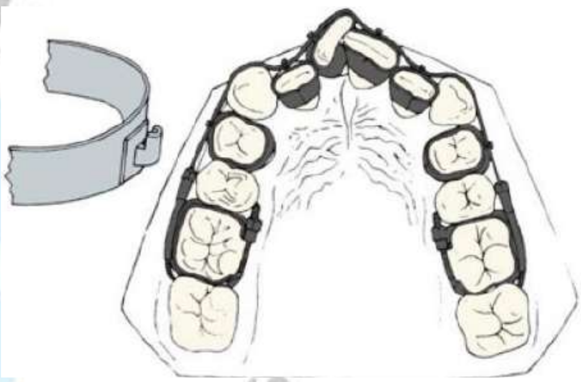


E-Arch:

Edward Angle's E-arch from the early 1900s. Ligatures from a heavy labial arch were used to bring malposed teeth to the line of occlusion.

Ribbon Arch

Angle's ribbon arch appliance, introduced about 1910, was well-adapted to bring teeth into alignment but was too flexible to allow precise positioning of roots. It was the first introduction of brackets. Used a gold wire of 10x20.



Edgewise

To overcome the deficiencies of the ribbon arch, Angle reoriented the slot from vertical to horizontal and inserted a rectangular wire rotated at 90 degrees to the orientation it had with the ribbon arch, thus the name “edgewise”

Begg Appliance

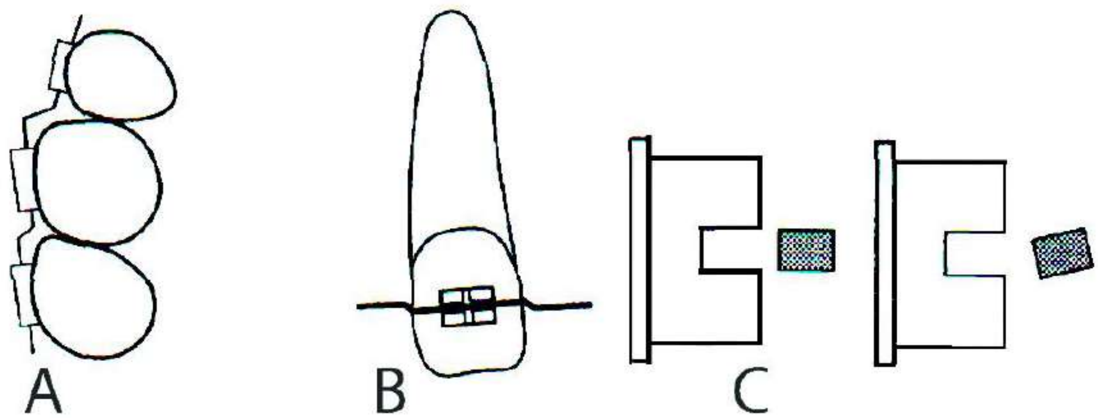
The Begg appliance used a modification of the ribbon arch attachment, into which round archwires were pinned. A variety of auxiliary archwires were used in this system to obtain control of root position.

Contemporary Edgewise

The Begg appliance became widely popular in the 1960s because it was more efficient than the edgewise appliance of that era, in the sense that equivalent results could be produced with less investment of the clinician's time. Developments since then have reversed the balance; the contemporary edgewise appliance has evolved far beyond the original design while retaining the basic principle of a rectangular wire in a rectangular slot, and now is more efficient than the Begg appliance, which is the reason for its almost universal use now, known as:

Straight-Wire Appliance

Angle used the same bracket on all teeth, as did the other appliance systems. In the 1980s, Andrews developed bracket modifications for specific teeth to eliminate the many repetitive bends (first, second and third order bends) in archwires that were necessary to compensate for differences in tooth anatomy, and bonding made it much easier to have different brackets for each tooth. The result was the "straight-wire" appliance. This was the key step in improving the efficiency of the edgewise appliance.

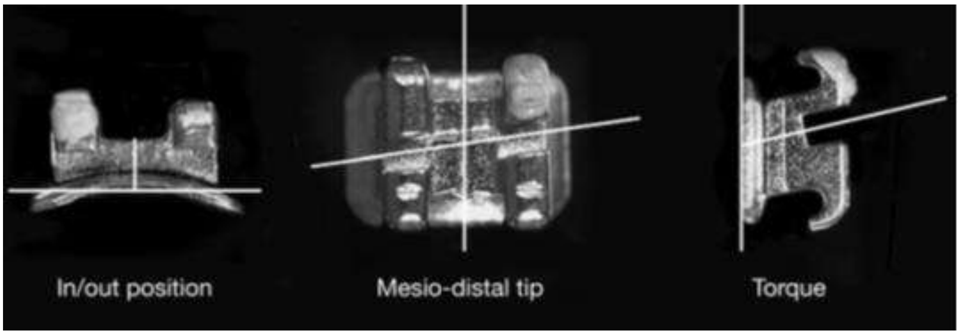


Basic bends with standard edgewise appliance

A: First order bends: made in the horizontal direction, and are required to make the wire conform anatomically to the labial & buccal contours of teeth.

B: Second order bends: made in the vertical plane, used for uprighting teeth and paralleling of the roots.

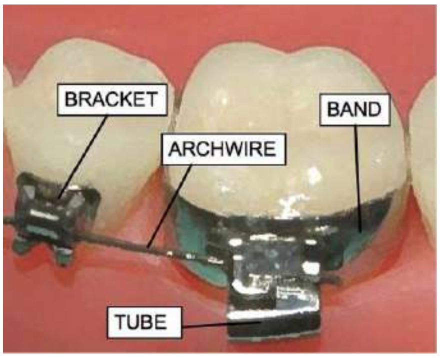
C: Third order bends: made for torque.



Features of the brackets of straight wire appliance:

- Variable distance from base of slot to base of bracket for correct in/out position.
- Pre-angulated slots for correct mesiodistal tooth angulation or tip;
- Bracket bases inclined for correct inclination or torque.

Components of Fixed orthodontic Appliance: they can be broadly classified into:



I. **Attachments**
II. **Archwire.**
III. **Auxiliaries.**

I- Attachments:

These include:

A. Bands
B. Brackets.
C. Other attachments: Buccal tubes, Buttons, eyelet, sheath, cleat, ….etc.

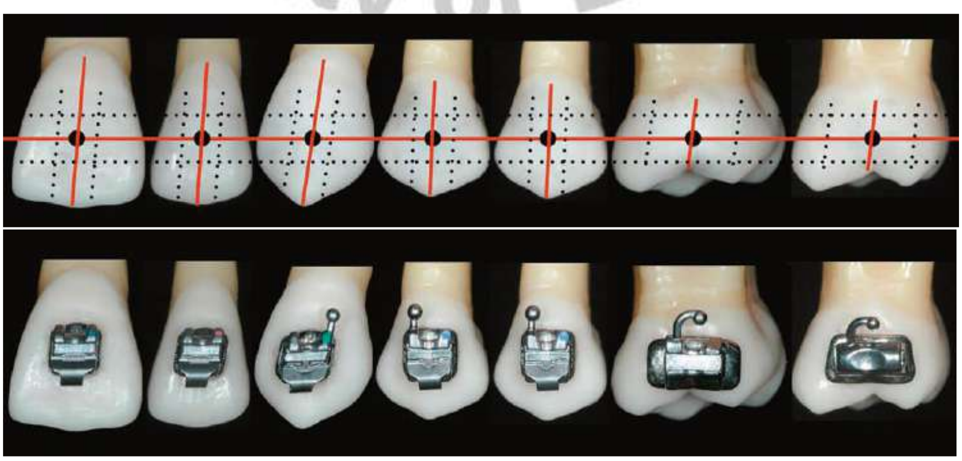
The attachments may be welded to bands, or directly placed on the tooth surface.

A. Bands:

These are rings encircling the tooth to which buccal, and as required, lingual attachments are soldered or welded. Until the 1980s, the only practical way to place a fixed attachment was to put it on a band that could be cemented to a tooth.

B. Brackets:

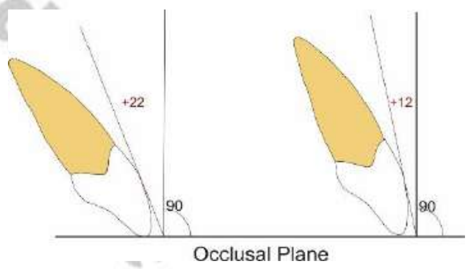
Each bracket is made up of a bracket base, stem with bracket slot, tie-wings to retain the ligature as it secures the arch wire into the slot, and some form of hook used for intramaxillary or intermaxillary attachment of elastics or coils.



There are many bracket types, the basic ways to classify brackets are:

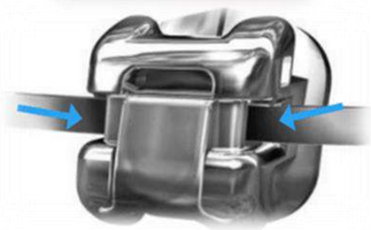
1- According to material:
   a. Metallic: e.g. Stainless-steel.
   b. Non-Metallic (Esthetic): Composite, Ceramic, Sapphire.

2- According to prescription (the amount of built-in tip and torque):
   a. Standard edgewise (zero tip and torque).
   b. Roth prescription
   c. McLaughlin, Bennett, & Trevisi (MBT) prescription, ….etc.



3- According to slot size:
   a. 18 mil (milli-inch) slot. (0.018 x 0.025 inch, where 0.018 is the width, and 0.025 is the slot depth)
   b. *22 mil slot (0.022 x 0.028 inch, where 0.022 is the width, and 0.028 is the slot depth)*

4- According to ligation method
   a) Conventional ligating.
   b) Self-ligating brackets (which utilize a permanently installed, moveable component to entrap the arch wire).



C. Other attachments: including but not limited to:

- Buccal Tubes: Used on molars.
- Buttons: Small, mushroom-shaped orthodontic attachments that can be bonded directly onto a tooth or welded on a band. They are usually used on the palatal surface of the teeth (to provide a couple force), or on a partially erupted tooth.

- Eyelets: mostly on partially erupted teeth.

II- <u>Archwires:</u>

The amount and type of force applied to an individual tooth can be controlled by varying the cross-sectional dimension and form of the archwire, and/ or the material of its construction.

In the initial stages of treatment, a wire which is flexible with good resistance to permanent deformation is desirable (e.g. Nickel-titanium archwires), so that displaced teeth can be aligned without the application of excessive forces.

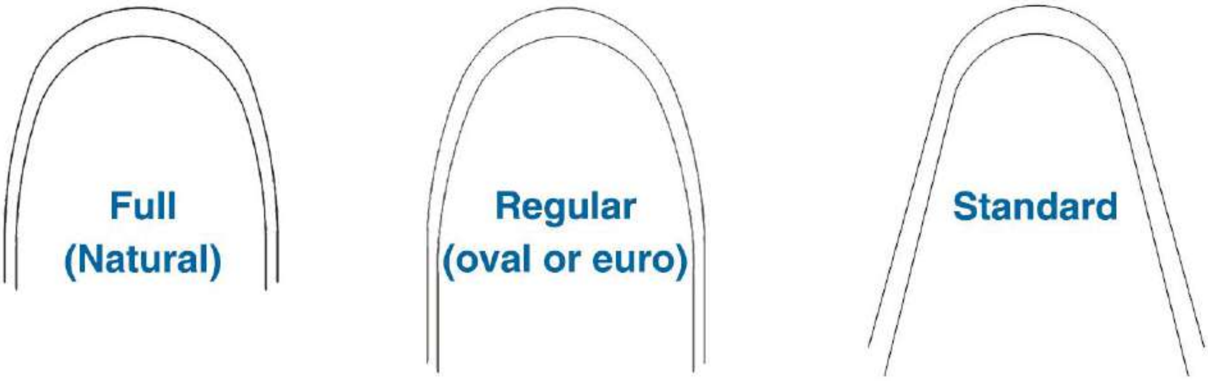
In contrast, in the later stages of treatment rigid arch wires are required to engage the archwire slot fully and to provide fine control over tooth position while resisting the unwanted effects of other forces, such as elastic traction (e.g. stainless-steel).

Archwires can be described according to their material, dimensions, and form.

Material: e.g. stainless-steel, Nickel titanium, Beta Titanium, Etc.

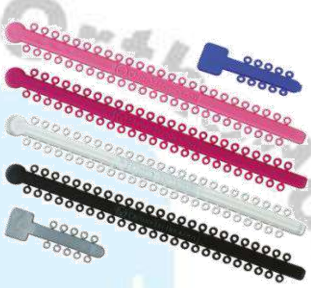
Dimensions: Usually archwire dimension is expressed in milli-inches (= 0.025 mm). A 16 milli-inch (0.016") is a round 0.4 mm wire, and a 16x22 is a rectangular 0.4x0.55 mm wire.

Form: It may be a full form, regular (or oval) form, or standard form.



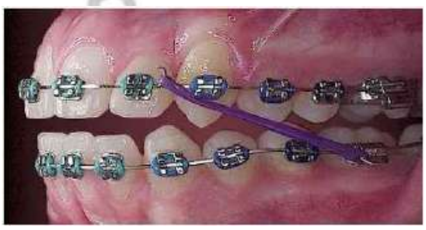
III- Auxiliaries

There are many auxiliaries used with fixed orthodontic appliance, among them are:



Ligatures: these are used to secure the archwire into the bracket. They include elastomeric modules and ligature wires.

Intra-oral elastics: available in different sizes and strength to provide intra and interarch traction. For most purposes they must be changed daily. Class II and Class III elastics are ways to describe these elastics according to their use.



Elastomeric modules (Elastomeric chain, or Power chain)

A chain of connected elastomeric rings used as a force-producing mechanism for orthodontic tooth movement. Elastomeric chains can be long, short, or closed, depending on whether or not there is a distance between the rings at its passive state.

Separators (Elastic separator)

Elastomeric rings of varying thickness that are placed around the interproximal contact point to create the necessary separation over time.

Lingual Appliances:

These are secured to the lingual surfaces of the teeth. There are some problems associated with them including some pronunciations difficulties that occur after insertion, the technique is difficult and time consuming, and the working position is awkward.

Fixing attachments

Attachments can be fixed to the teeth surfaces by either banding or bonding. The procedure of cementing a band to the tooth is called “banding”. The method of fixing attachment directly to enamel using resins is called bonding. It greatly enhances esthetics, and maintenance of oral hygiene as compared to banding.

Banding involves:

a. Separation of teeth.
b. Selection of proper band size with close fit.
c. Cementation of the band preferably using glass ionomer cement.

A number of indications still exist for use of a band rather than a bonded attachment, including:

a. Teeth that will receive heavy intermittent forces against the attachments, e.g., an upper first molar against which extraoral force is placed via a headgear.
b. Teeth that will need both buccal and lingual attachments such as a molar with both headgear tube and transpalatal bar.
c. Teeth with short clinical crowns, so that bonded brackets are difficult to place correctly.
d. Teeth with extensive restorations.

Bonding may be made directly in the office, or indirectly through a lab.

Direct bonding involves:

- Cleaning the tooth surface, to remove any pellicle using a slow hand piece and prophy brush or cup;
- Acid-etching the enamel surface using 35-37% phosphoric acid for 15–30 seconds;
- Washing and drying the tooth surface;
- Placing unfilled primer on the etched area of the tooth;

Direct Bonding

- Placing composite resin on the bracket base;
- Positioning the bracket on the tooth crown;
- Cleaning up excess composite from around the bracket base; and
- Curing the composite, either chemically or with a blue light source.

It is very important to clean up excess composite or 'flash' as this can create problems in maintaining high levels of oral hygiene and result in demineralization around the bracket, a major risk of fixed appliance therapy.

In indirect bonding, the brackets are glued with a temporary material to the teeth on the patient's models, transferred to the mouth with some sort of tray into which the brackets become incorporated, and then bonded simultaneously with adhesives.

The main **advantages** of indirect compared to direct bonding are:

a. The brackets can be positioned more accurately in the laboratory.
b. The clinical chair time is decreased.

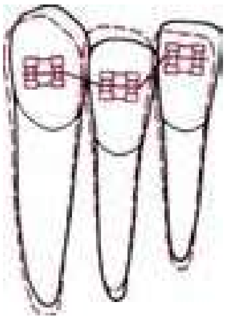
However, the method is:

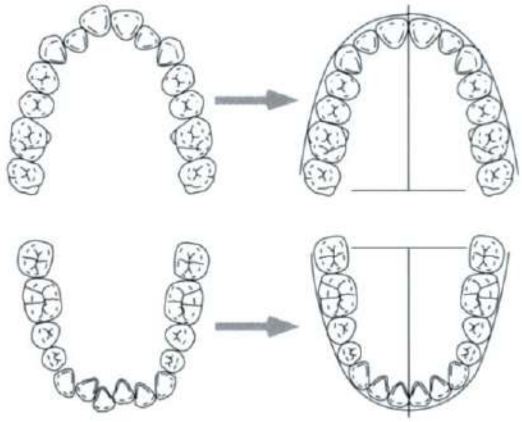
1. Technique-sensitive.
2. The procedure requires greater experience.
3. Removal of excess adhesive can be more difficult and more time consuming with some techniques.
4. The risk for adhesive deficiencies under the brackets is greater.
5. The risk for adhesive leakage to interproximal gingival areas can disturb oral hygiene procedures.
6. The failure rates with some methods seem to be slightly higher.

Indirect Bonding

The comprehensive orthodontic treatment with fixed appliance

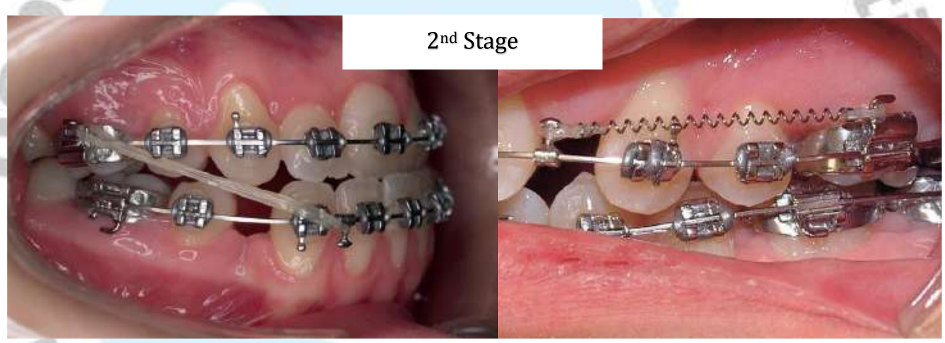
1st stage: Alignment and leveling: Eliminating rotations, bringing the teeth to one line buccolingually and one level occlusogingivally following the archwire shape.
It facilitates future treatment stages.





2nd stage: Correction of molar relationship and space closure (e.g. extraction space).

3rd stage: Finishing (settling): optimizing occlusal relationship between upper and lower dental arches.



Visit frequency

Following insertion, the patient must be seen regularly to evaluate the progress of treatment and make the necessary adjustments. There is no agreement or evidence to support a specific timeframe. Most orthodontists see their patients every 4 weeks, others see them every 6, 8, or 10 weeks intervals.

These visits are also necessary to avoid or prevent problems during orthodontic treatment. The problems encountered are caries and decalcification, debonded brackets, loose bands and soft tissue problems.

Treatment duration

There is no specific way to estimate duration of treatment. It usually takes 12-30 months, depending on the complexity of the case. Missing appointments will lengthen treatment duration.

Pain with fixed orthodontic appliances

Some pain may be felt in the teeth for a period of 3-5 days following each adjustment visit, especially during eating. The pain level is usually mild to moderate. Analgesics like ibuprofen or paracetamol may be used to decrease pain.

Some pain may be felt with salty or sour food because of ulcers. Ulcers often develop as a result of rubbing the cheeks and lips with the appliance during normal function. This usually lasts for few days after insertion, and can be reduced by using orthodontic wax.

Trauma to the cheek may happen because of a protruding wire; it is better to go to the orthodontist to fix it, meanwhile orthodontic wax can be used to reduce irritation.



Instructions for patients wearing a fixed appliance:

1- <u>Teeth cleaning:</u>

A. It is necessary to clean the teeth with a toothbrush using fluoridated toothpaste for three minutes immediately after each time you eat, and before going to bed. It is preferable to have a traveler brush with you all the time to ensure cleaning the teeth after each time you eat.

B. You should clean all the surfaces of the teeth thoroughly including the area between the teeth and brackets.

C. Cleaning the teeth with a fixed orthodontic appliance in place is more difficult and takes more time than without an appliance.

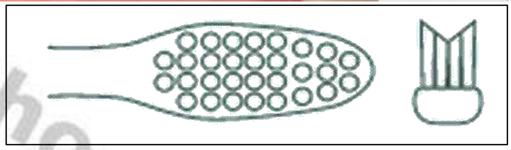
D. Fluoridated alcohol-free mouthwash should be used at least once daily after toothbrushing. You should avoid eating or rinsing your mouth for at least 20 minutes after using the mouthwash.
E. Having snacks and drinks with a high sugar content without proper cleaning of your teeth will result in permanent damage to the teeth.

2- Food:
A. Avoid snacks and drinks with a high sugar content between meals and at bedtime.
B. Avoid sticky food, especially sweets and chewing gum, as they will stick to the teeth and the appliance, this will increase the accumulation of bacterial plaque around orthodontic brackets, leading to decay
C. Avoid hard food like nuts as it can damage the appliance, and requiring repair. Fruits and vegetables that are relatively hard, like apples or carrots should be cut into small pieces.
D. Avoid frizzy drinks and consuming large quantities of fruit juice.
E. Since it will be necessary to use a tooth brush after eating, most patients find it best to avoid snacks between main meals.

3- Appliance breakage:
A. In case of appliance breakage, you should contact your orthodontist immediately to schedule an emergency appointment. You should not wait for your regular appointment, as this may result in unfavorable tooth movement, or further damage to the appliance which will eventually increase treatment duration.
B. Repeated breakages of an appliance because of poor care may result in stopping treatment.
C. You should wear a protective shield while practicing contact sports, according to your orthodontist's instruction.

4- Maintain regular visits and follow your orthodontist's instructions.

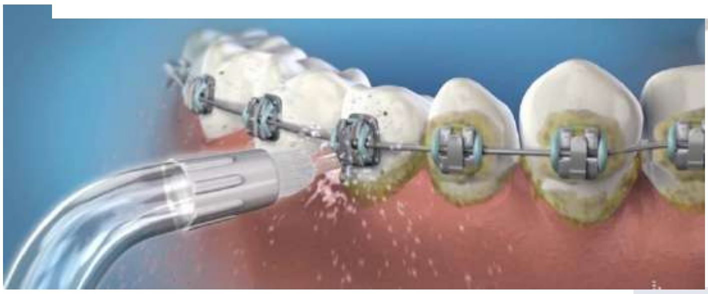
Oral Hygiene measures for patients with fixed orthodontic appliance:



- Tooth brushing: preferably using a V trim tooth brush to clean the appliance, and a regular brush to clean the occlusal and lingual/palatal surfaces of the teeth.
- Using interdental brush for interproximal and detailed cleaning.
- Flossing: The floss is passed between the archwire and the teeth using a floss threader. A superfloss may also be used without the need for a floss threader. Alternatively, a water flosser may be used.
- Mouth rinses: Fluoridated mouth rinses are usually used.

Interdental brush

Using a floss and a floss threader to clean between the teeth.



Water jet may also be used to clean the teeth

Superfloss parts: 1) plastic threader, 2) spongy part, 3) soft nylon floss.

Risks of orthodontic treatment

Orthodontic treatment is not without risk. These include:

1- Enamel demineralization

The incidence of demineralization during fixed appliance therapy is high and can result in the development of enamel opacities on the labial surfaces of the teeth. The main etiological factors are poor oral hygiene and a diet high in refined sugars. In combination and over the long-term, these factors will inevitably result in demineralization and permanent marking of the teeth.

2- Enamel fracture and abrasion

The removal of a fixed appliance bonded to enamel carries a small risk of fracture at the enamel–dentinal junction if the bracket bond strengths are too high. In reality, bond strengths used are considerably lower than this, and at debond failure usually occurs at the bracket base–adhesive junction. An exception to this proved to be some early ceramic bracket systems; manufacturers were concerned with failure of the bracket bond during treatment and enhanced the mechanical bonding chemically. This resulted in excessive bond strengths and a significant risk of enamel fracture on debonding. Modern ceramic bracket bases are designed with features that facilitate easier debonding, which reduces the risk of enamel fracture. Attrition of teeth occluding against ceramic brackets is the most important disadvantage of the ceramic brackets. The clinician must avoid bracket contact with opposing teeth.

3- Root resorption

External apical root resorption (EARR) is an almost universal finding following orthodontic treatment, but this is usually not clinically significant and has no influence on long-term health of the teeth. Severe root resorption, when more than one-third of the root length is lost, has been reported to occur in between 1% and 5% of orthodontically treated teeth.

4- **Damage to the pulp**

The use of excessive force or pushing the apex of teeth through the cortical plate can result in a loss of vitality. Teeth with a history of trauma are more susceptible to vitality loss during treatment, but in most cases, there is no obvious cause. Fortunately, loss of vitality is a rare complication of orthodontics.

5- **Gingivitis**

Gingival irritation is inevitable with the use of fixed appliances, especially when bands are used, and this is exacerbated by poor oral hygiene that can result in gingival hyperplasia.

Gingival health improves significantly following the removal of appliances, with a reduction in probing depths mainly due to shrinkage of hyperplastic tissues.

6- **Alveolar bone loss**

A small loss of alveolar bone height following orthodontic treatment has been reported in relation to teeth adjacent to extraction sites, but there appears to be no long-term effect on periodontal health from orthodontic treatment.

An exception to this is orthodontic treatment in patients with active periodontal disease because this can rapidly increase bone loss. Periodontal disease should be treated, stable and well maintained in these patients prior to commencing orthodontic treatment. Orthodontic treatment can also result in recession when teeth are moved excessively in a labial or buccal direction during treatment, resulting in a bony dehiscence and gingival recession.

7- **Oral ulceration**

Traumatic ulceration in susceptible individuals is common particularly during the early stages of treatment.

8- Allergic reaction

Orthodontic wires and brackets contain nickel and patients allergic to nickel could have non-specific intraoral signs including erythematous areas and severe gingivitis despite good oral hygiene.

Instruments commonly used with fixed orthodontic appliance

Separating plier s: used for the placement of elastic separators.

Bracket holding tweezer or bracket positioning tweezer is used in orthodontics, for holding and positioning the brackets.

Mathieu Hemostat a multipurpose instrument used to place elastic and steel ligatures on orthodontic brackets.

Howe pliers is a utility pliers which has serrated tips for gripping wires. It is useful for placement and removal of archwires as well as placement of pins and other auxiliaries

Cutters: there are hard and ligature wire cutters

Distal end cutter: it cuts and holds the wire distally to the buccal tube or bracket

Height gauge it is used to check the height of bracket placement from the incisal edge.

Band seater is used to place and adjust orthodontic band

Band removing pliers: As the name implies, it helps removing bands

Bracket debonding pliers: may be straight or angulated, used to remove bonded brackets.

Lecture: 3 **Orthodontics** د. عمارسالم

Anchorage

The movement of teeth occurs through the application of forces. In order to make a change in tooth position, adequate support (“anchorage”) must be available from which to apply these forces. This support can be derived from multiple structures including teeth.

These forces act reciprocally on the teeth that are intended for movement and upon those structures used for support. According to Newton’s third law, which states that for every action there is an equal and opposite reaction, remains the basis of all orthodontic tooth movement.

If the supporting structures were teeth, then there may be unintentional or adverse changes in anchorage support.

Definition: It is the site of delivery from which a force is exerted.

Others defined it as the resistance to reaction forces that is provided usually by other teeth, occasionally by the palate, sometimes by the head or neck, and by anchors screwed to the jaws.

Classification of anchorage

For understanding anchorage, it is convenient to divide anchorage into intraoral and extraoral anchorage. Further, intraoral anchorage can be subdivided into intramaxillary and intermaxillary anchorage. Both can be of three types-simple, stationary or reciprocal.

1. Anchorage classified according to the site where the anchorage units as:
   a. Intraoral
   b. Extraoral
2. Anchorage classified according to the jaws involved as:
   a. Intramaxillary
   b. Intermaxillary.
3. Anchorage classified according to the manner of force application as:
   a. Simple
   b. Stationary
   c. Reciprocal.
4. Anchorage classified according to space requirements:
   a. Maximum (Type A).
   b. Moderate (Type B).
   c. Minimum (Type C).

Intraoral anchorage

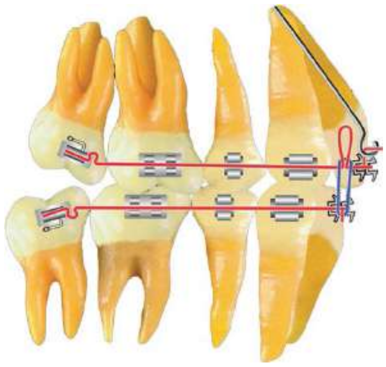
This type of anchorage is said to exist when and only when all the anchorage units are present within the oral cavity. Anchorage from all the intraoral sources of anchorage including the teeth, palate, etc. can form part of this type of anchorage. Mucosa and bone—the palatal vault can be used as a source of anchorage via the acrylic base plate of removable appliance or acrylic button attached to palatal arches.

Intraoral anchorage can be further divided into intramaxillary or intermaxillary anchorage depending upon the location of anchorage-providing elements between the two jaws.

Simple anchorage

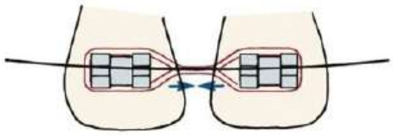
It is said to exist when the manner and application of force is such that it tends to change the axial inclination of the tooth or teeth that form the anchorage unit in the plane of space in which the force is being applied. Thus, resistance to tipping of the anchorage units might be utilized to retract certain other teeth, which is better obtained by engaging a greater number of teeth than are to be moved. The root surface area of the anchorage units should be at least double that of the units to be moved. e.g., the movement of a single tooth using a screw appliance.

STATIONARY ANCHORAGE

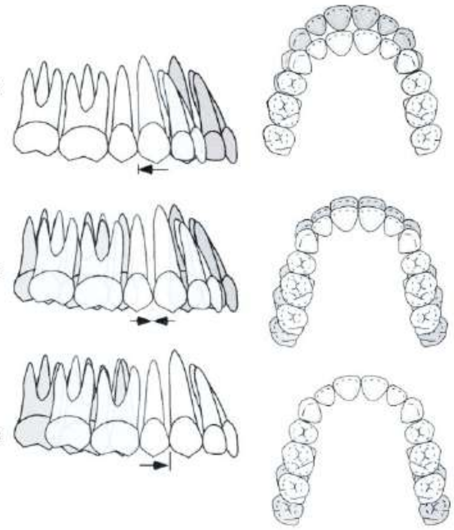


Stationary anchorage is said to exist when the application of force tends to displace the anchorage units bodily in the plane of space in which the force is being applied. The anchorage potential of teeth being moved bodily is considerably greater as compared to teeth being tipped.

RECIPROCAL ANCHORAGE



Reciprocal anchorage is said to exist when two teeth or two sets of teeth move to an equal extent in an opposite direction. Here the root surface area of the so-called anchorage units is equal to that of the teeth to be moved. The effect of the forces exerted is equal, i.e. the two sets of teeth are displaced in the opposing direction but by the same amount. e.g., arch expansion using a midline screw, closure of median diastema.



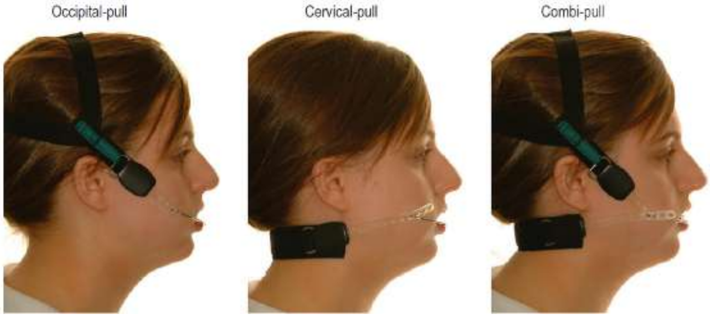
Maximum anchorage (type A):
Anchor unit should not move, or at least must not move more than ⅓ of the available space.

Moderate anchorage (type B):
About ½ of the space available is utilized by movement of the anchor unit.

Minimum anchorage (type C):
The anchor unit should consume more than the majority or at least ⅔ of the space available.

Extraoral anchorage (EOA)

As the name implies, here the anchorage units are situated outside the oral *cavity* or extraorally. The extraoral structures most frequently used at the cervical region (as with the use of the cervical pull headgear, the occiput (as with the occipital pull headgear, the forehead and the chin (e.g. the face mask).



With the use of extraoral anchorage there is hardly any chance of any changes taking place in the anchorage units.

The biggest disadvantage of extraoral anchorage is the apparent lack of patient cooperation.

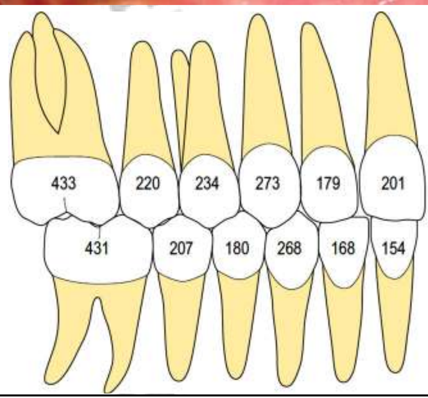
ANCHORAGE PLANNING

It is very essential to carefully assess the anchorage demands of the individual case and select the most appropriate treatment plan. The anchorage requirement depends on:

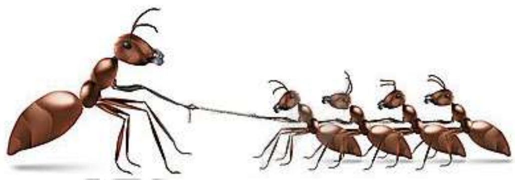
a. *The number of teeth to be moved* the greater the number of teeth being moved the greater is the anchorage demand.

Moving teeth in segments as in retracting the canine separately rather than retracting the complete anterior segment together will decrease the load on the anchor teeth.

b. *The type of teeth to be moved*: teeth with large flat roots and/or more than one root exert more load on the anchor teeth. Hence, it is more difficult to move a canine as compared to an incisor or a molar as compared to a premolar.



Root surface area (mm^2) of the permanent dentition, giving an indication of the relative anchorage value of each tooth



c. Type of tooth movement-moving teeth bodily requires more force as compared to tipping the same teeth.

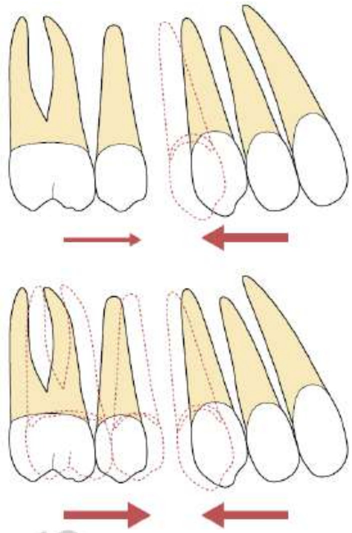
d. Periodontal condition-teeth with decreased bone support or periodontally compromised teeth are easier to move as compared to healthy teeth attached to a strong periodontium.

e. Duration of tooth movement-prolonged treatment time places more strain on the anchor teeth. Short-term treatment might bring about a negligible amount of change in the anchor teeth whereas the same teeth might not be able to withstand the same forces adequately if the treatment becomes prolonged.

Anchorage loss

Tooth movement of the anchoring unit during orthodontic treatment is termed anchorage loss. It is undesirable in most instances.

A common example is during overjet reduction, where teeth in the buccal segments move forward rather than those in the labial segments being retracted. If severe, too much space is lost and a residual overjet results, this is called *Mesial anchorage loss*. There is *vertical and transverse anchorage loss* as well, depending on the direction of unwanted tooth movement. A number of factors can contribute to anchorage loss including:



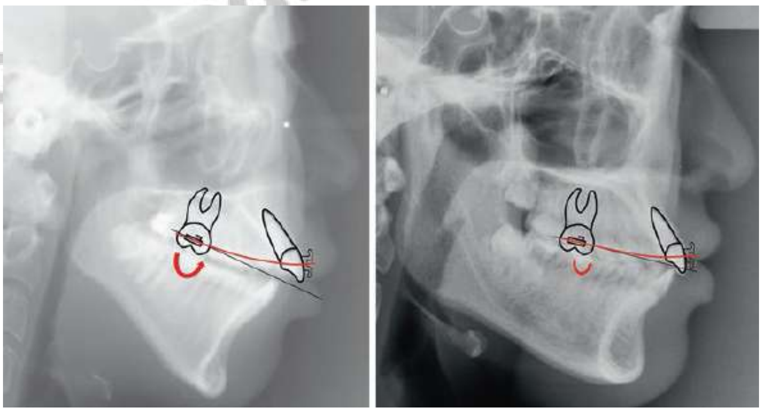
i. *Heavy forces*

Forces should be kept light to reduce anchorage loss. All orthodontic forces will produce some reciprocal force on the anchorage unit. If this is small, there will be minimal movement of these teeth. Forces should be light enough to exceed the threshold for tooth movement where planned but below the threshold for movement of the anchorage unit. With greater force, there is no increase in tooth movement. By increasing forces, there is no greater amount of tooth movement where it is wanted, greater force is applied to the teeth in the anchorage unit and they are more likely to move.

ii. *Maxillary arch*

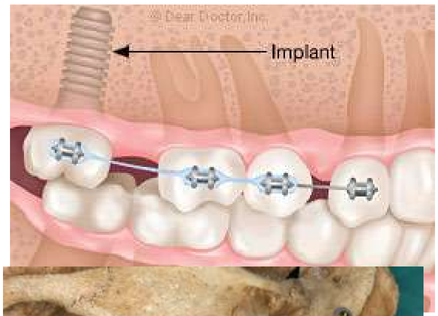
The maxillary arch is particularly susceptible to anchorage loss. This is probably due to a combination of factors, particularly the density of bone.

iii. *Vertical growth pattern*



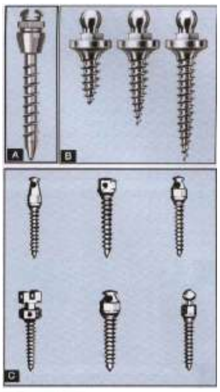
Anchorage loss and space closure occur more readily in patients with an increased vertical proportion. This is possibly due to lower bite forces and less occlusal interference that occurs in cases with a reduced overbite. In addition, more distally tipped molars would tip forward with the insertion of the straight wire appliance more likely than other skeletal patterns with a relatively upright molar.

Skeletal/ Absolute anchorage



Skeletal anchorage may be considered as an entity of its own or may be considered as a part of intraoral anchorage. It is described as absolute anchorage as there is no tooth movement except what was desired i.e., no unwanted tooth movement.

Although endosseous implants and miniplates have been used successfully for orthodontic anchorage and reinforcing anchorage in comparison with extraoral anchorage, their clinical applications are limited because of the comprehensive surgical procedures required and difficult removal after treatment which may make the patient uncooperative during treatment.



On the other hand, temporary anchorage devices (TADs) are simpler alternatives to endosseous implants. Their advantages include smaller size, simpler surgical placement, immediate loading without the need for lab work, easier removal after treatment, and lower cost.

Components of miniscrew

The commonly used screw has three parts: head, core, and thread (helix). Some manufacturers supply miniscrews with a longer neck for use in sites such as the palate or retromolar areas where the overlying gingiva is thicker. Most manufacturers give the outer diameter, which includes the width of the screw threads in the measurement. The diameter and thread length of the miniscrew are the main features to consider when selecting a miniscrew. Some miniscrews require drilling and they are referred to as predrilling miniscrews (cylindrical). Most of the current orthodontic miniscrews are drill-free or self-drilling type (tapered).

Selection of miniscrews

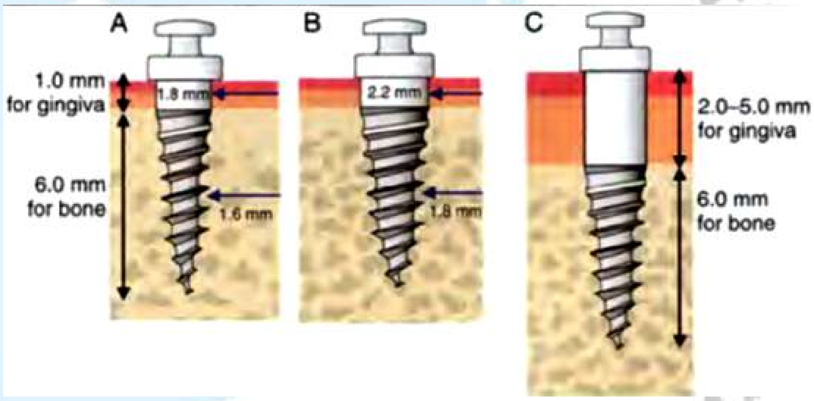
1) Depending on the length;

The length of the screw portion is ranging from 5 mm to 12 mm. Longer miniscrews lead to better mechanical stability like dental prosthetic implants, but more possibilities of invading adjacent anatomical structures, such as roots, maxillary sinus, and nerve, etc. Usually, **6mm** of screw depth is enough for the maxilla, and **5mm** is enough for the mandible. However, always we should consider the depth of soft tissue when choosing the proper length of miniscrews.

2) Depending on the diameter;

There are various diameters of miniscrews which range from 1.2 mm to 2.7 mm, so they can be placed anywhere in the mouth. The choice depends on the inter-radicular distance, quality of bone (the mandible is of better quality) and site of placement.

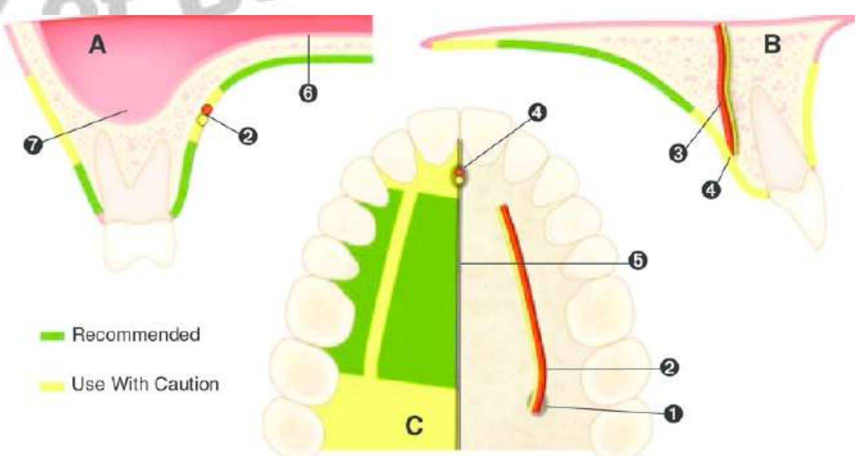
Thicker the miniscrew, the greater becomes mechanical retention, but also the greater possibility for root contact.



Anatomic structures that need to be considered at the site of placement

1. The roots of the teeth.
2. Nerves and blood vessels (ex. greater palatine neurovascular bundle)
3. The bone and sinuses in the vicinity of the intended site of placement are all vulnerable to perforation.

Particular care needs to be taken when considering placing implants in the buccal and lingual alveolar bone and the paramedian areas of the palate.



In contrast, there are no critical anatomic structures in the midpalatal region, the maxillary tuberosity and the retromolar pad area, except for the incisive canal in the palate.

General guidelines for placement

1) Horizontal position:

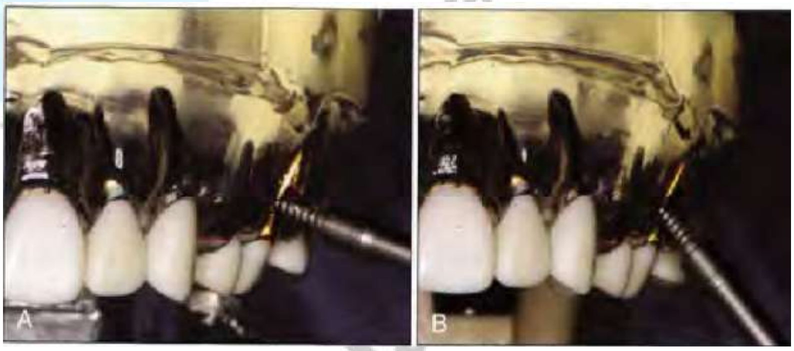
Proper assessment of the interdental distance must be done both clinically and radiographically to avoid root damage.

2) Vertical position:

A coronally placed miniscrew is likely to be on the firm attached gingiva, but the risk of root damage increases because of the conical shape of the roots. A compromised insertion point is therefore the mucogingival junction, where the clinician can minimize possible root damage while preventing soft tissue irritation

3) Insertion Angle (Occlusogingival)

It is generally recommended to apically incline the insertion path to avoid possible root injuries and increase cortical bone support. A 45-degree angulation relative to the occlusal plane is considered acceptable.



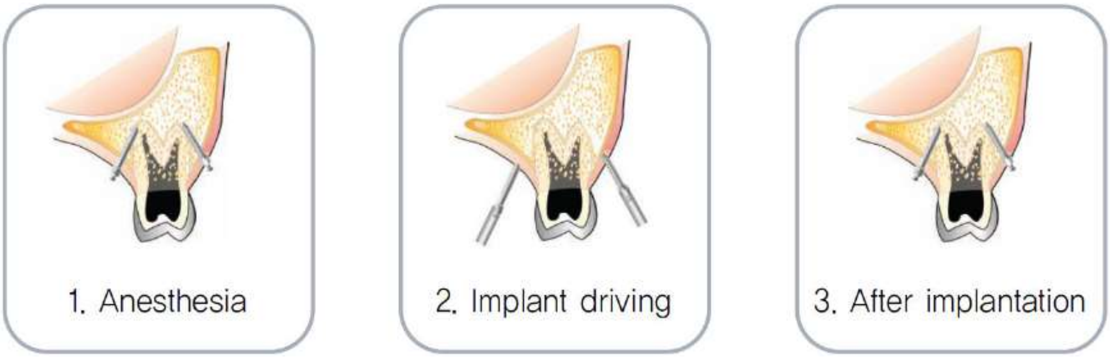
Surgical procedures:

A. Self-drilling:

a. One step:

i. Anesthesia.

ii. Driving of implant.

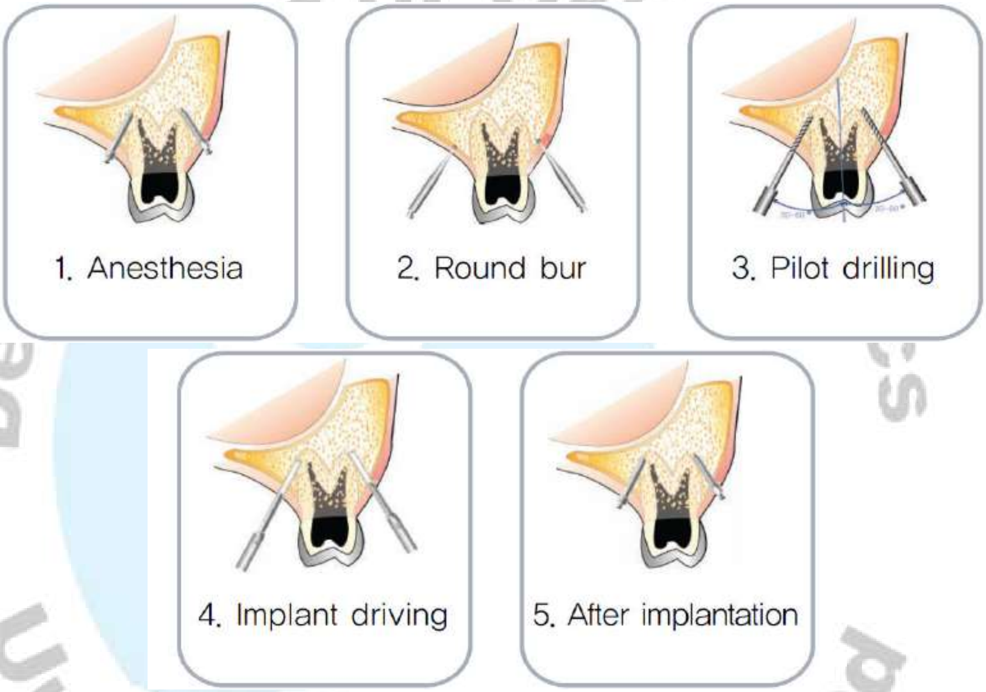


b. Two steps:

i. Anesthesia.
ii. Penetration with a round bur.
iii. Driving of implant.

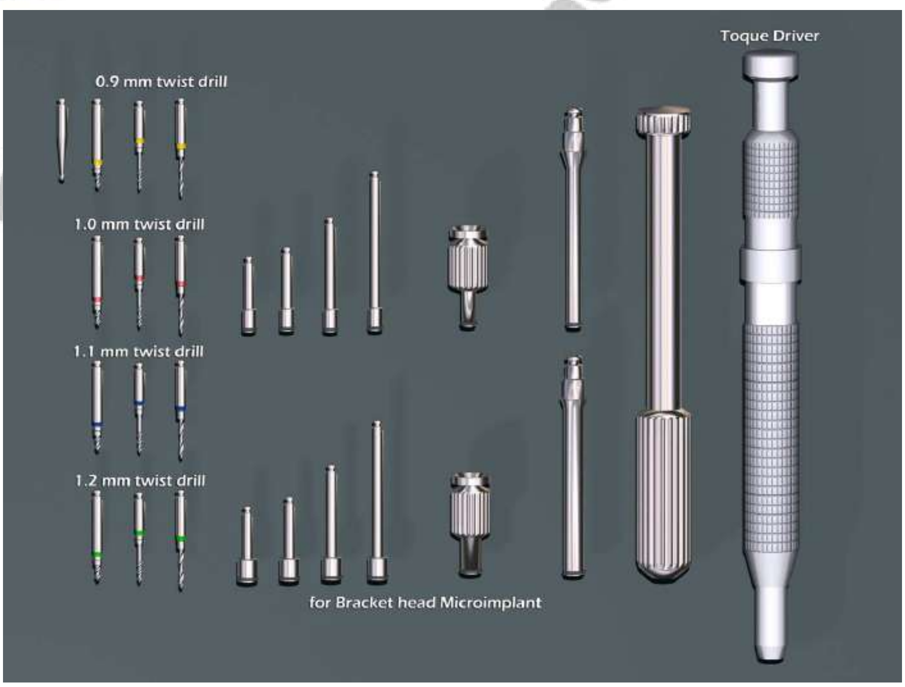
B. Predrilling method:

i. Anesthesia.
ii. Penetration with a round bur.
iii. Pilot drilling.
iv. Driving of implant.



Miniscrew driving

This is done either by engine driver or a hand driver. it is safer to use hand driver to feel resistance of miniscrew driving torque. We should never give excessive force, because if miniscrew is broken during driving, it may be a little troublesome to remove.



Explanation for the possibility of failure

Miniscrews have a failure rate of up to 40% due to miniscrew-related factors, patient-related factors, and management-related factors. The patients should be fully noticed of the possibility of failure before starting miniscrew treatment.

Possible Complications:

1) Soft tissue inflammation, ulceration, abscess, and coverage

Inflammation or an abscess is relatively rare if the miniscrew is placed on the firm attached gingiva. Ulceration or soft tissue coverage is associated with miniscrews placed on or near the buccal frenum.

2) Root damage

Usually with the predrilling method. Root damage can be managed depending on the severity of the injury. Serious injury, including root perforation or fracture, is extremely rare in the drill-free system. Minor injuries on the cementum area can undergo spontaneous healing after the removal of the miniscrew.

3) Root contact during tooth movement

Adjacent tooth movement toward the miniscrew can result in miniscrew-root contact. Root contact by the orthodontic tooth movement remains largely asymptomatic, thus, probable root contact should be diagnosed clinically with no movement of the tooth, excessive crown tipping toward the miniscrew, and (rarely) miniscrew loosening.

4) Miniscrew fracture

Fracture of a miniscrew is rare if the diameter is greater than 1.5 mm and especially if the miniscrew is tapered. With miniscrew fracture, removal of the bone around the miniscrew thread is indicated.

5) Pain

Pain is a relatively common sequela but usually it is not serious. The pain related to miniscrew operation comes from the nerve endings in the soft tissue and periosteum, not necessarily from the bone proper. Non-steroidal anti-inflammatory drug (NSAID) for 2 days following the procedure is sufficient to manage the postoperative pain in most patients.

6) Bleeding and numbness

Excessive bleeding or numbness is not associated with miniscrew implantation on the tooth -bearing area or midpalate region. However, care should be taken not to injure the palatine neurovascular bundle.

Functional appliances

- Classification
- Mode of action
- indications
- Types
- Advantages
- Limitations

Other orthopaedic appliances (EOT)

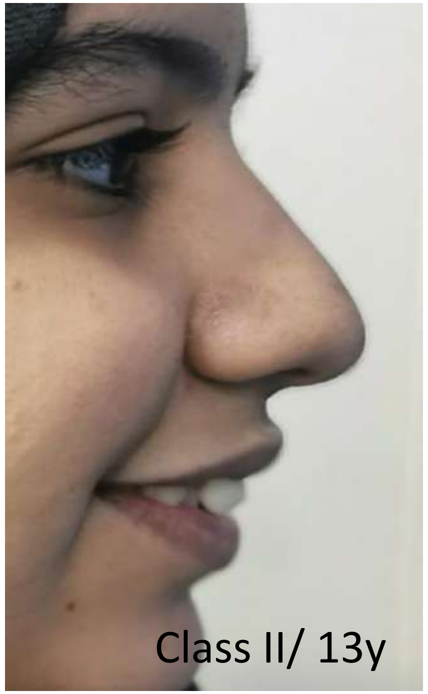
Space regainer

Invisalign®/Clear Aligners

The following question must be asked at diagnostic first visit of a growing patient (<18) to the orthodontic clinic:

"Does this patient require orthodontic, orthopaedic treatment or a combination of both?"

Following are examples of growing patients with various malocclusions:

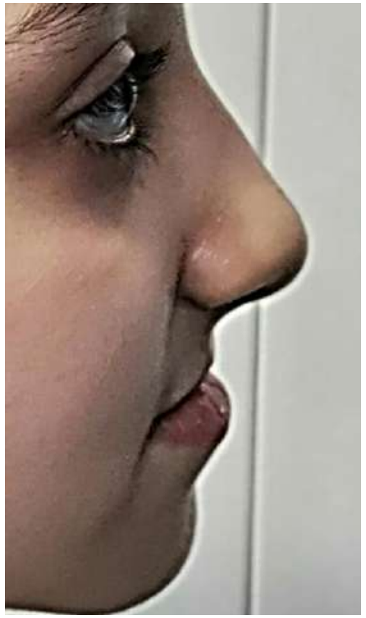


Class II/ 13y

Tongue thrusting/ 6y

Open bite/ 6y

Increased overjet/ 12y



Retrognathic maxilla/ 9y

Orthodontics and Orthopaedics

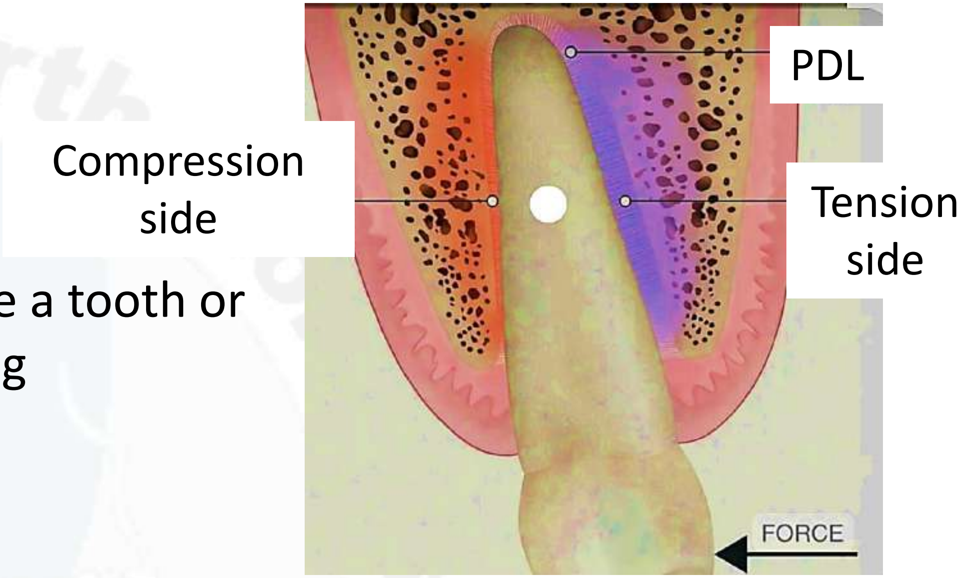
Orthodontic treatment is the correction of dental irregularities but inappropriate for treatment of skeletal discrepancy.

orthopaedic treatment is correction of malocclusion primarily related to skeletal disproportion

Dentofacial orthopaedic treatment

is a wider definition than "orthodontics", aims to treat malocclusion primarily related to musculoskeletal discrepancy. This is by combination of orthodontic treatment of dental irregularities and jaw to jaw relationships by correcting the muscle function and restore facial balance.

Orthodontic force vs orthopaedic force



Orthodontic appliances are designed to apply light force to move a tooth or group of teeth without stimulating the mandibular growth during treatment. The force is about 28 g/ cm^2 of root surface.

Unlikely, orthopaedic force is related to the tolerance of orofacial musculature rather than periodontal ligament (PDL). It is directed to change the position of mandible and correct the relationship of mandible to maxilla.

Definition of Functional appliances/myofunctional appliances

These are removable or fixed appliances that either utilise, eliminate or guide the forces arising from muscle function and altering the position of mandible, causing stretching of the facial soft tissue, to produce a combination of dental and skeletal changes. They are most frequently used for correction of anteroposterior jaw relationship in class II malocclusion, however, class III malocclusion can be treated occasionally.

Classification

They are classified as:

1. **tooth borne** (like Herbst appliance) or **tissue born** (like Fränkel functional regulators)

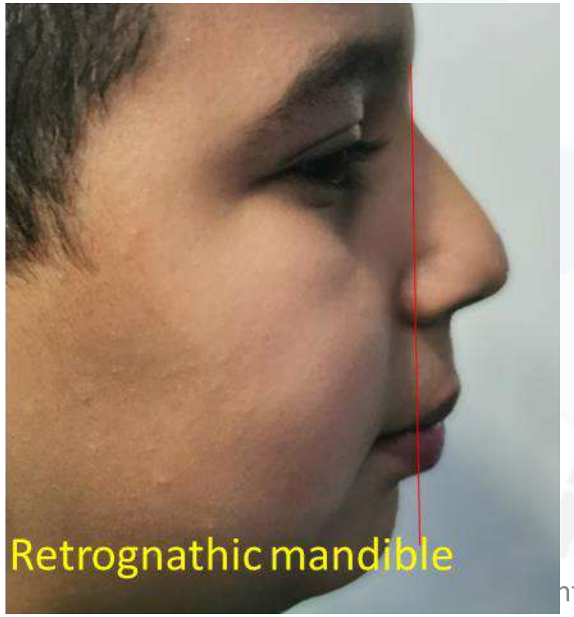
Fränkel appliance

Herbst appliance

2. **passive** carries no active component (such as bionator) or **active** occasionally carries expansion screw and/or springs (such as twin-block).

Indications for functional appliances

1. Mild to moderate class II skeletal discrepancy with mandibular retrognathism
2. Growing patients during pubertal growth spurt (males 14+/-2), females (10+/-2) for ideal response.
3. Compliant patient able to tolerate wearing the appliance and attend the regular visits.



Mode of action of functional appliances

These appliances correct or at least reduce the anteroposterior skeletal discrepancy in a process known as growth modification or dentofacial orthopaedics by:

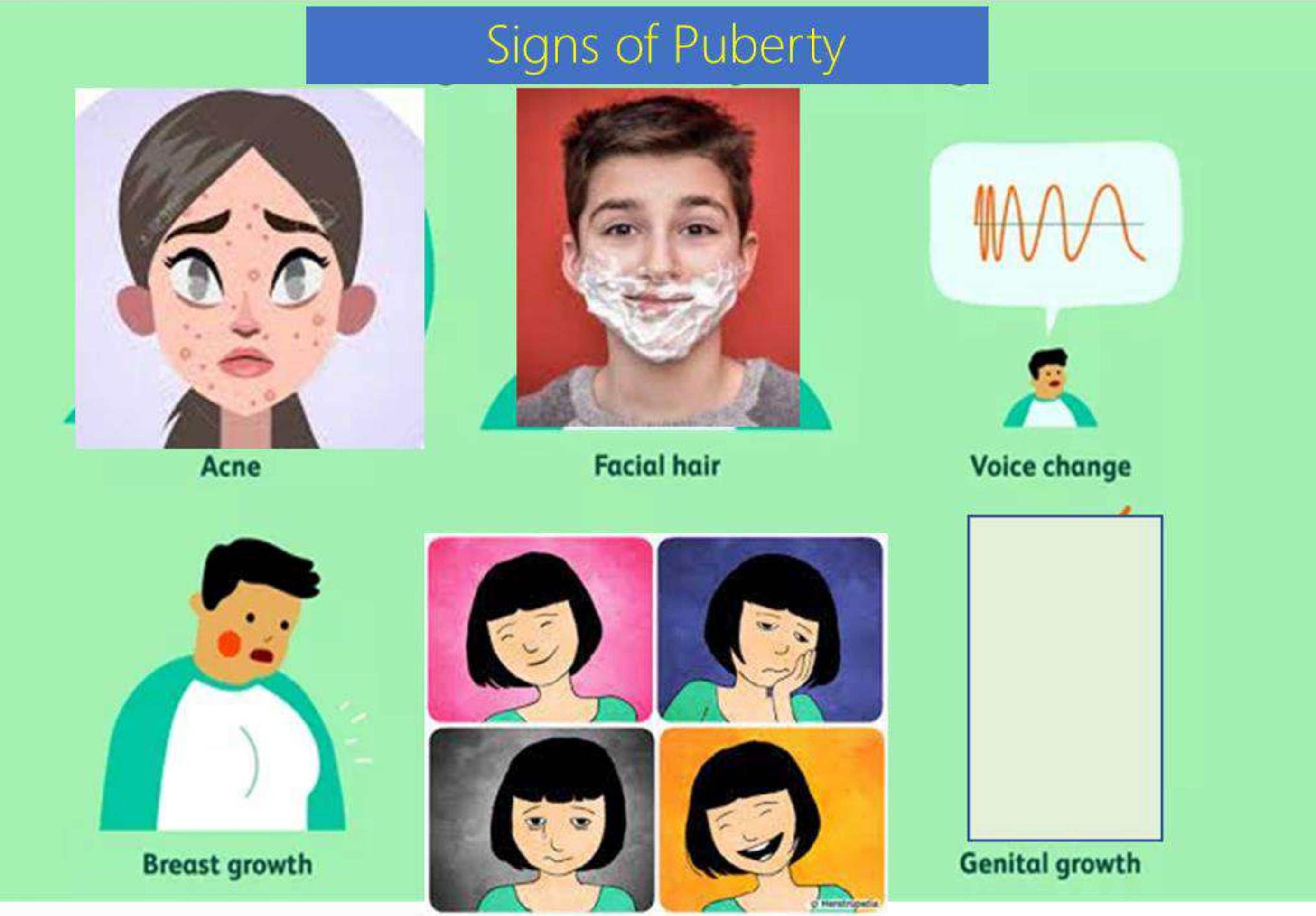
1. forcing the mandible to posture forward to reduce overjet
2. stretching the soft tissues (muscles of mastication)
3. force transmission from the muscle to the appliance to the teeth
4. encourage the back compensatory growth of mandible
5. increasing lower anterior facial height (LAFH)
6. restraining the maxillary growth
7. the resultant correction in overjet is attributed to 70% tooth movement and 30% skeletal changes

g of treatment by functional nces

nal appliances are most effective e patient is growing. It has been ed that treatment should, if possible, with the **pubertal growth spurt**.

the growth spurt?

ned as a period of sudden accelerated rate scattered within periods of rest. The pubertal growth spurt is the ticeable and more dramatic, thought used by hormonal secretions.



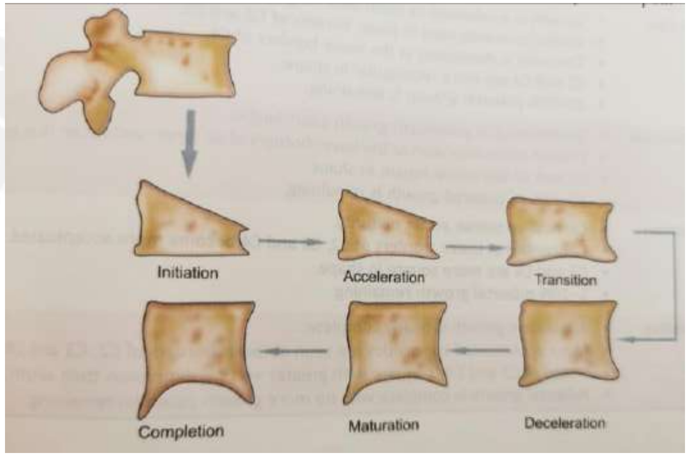
How growth spurt can be predicted?

1. Taking multiple body height measurements

2. Hand-wrist x-ray to estimate development of the phalanges and radius

3. Cervical vertebrae visible on lateral skull radiographs.

During the period of maximum mandibular growth cervical vertebrae C2, C3 and C4 changing the shape from wedge to column to square



Can functional appliance be used in childhood, earlier than pubertal growth spurt?

They can be used especially if there is a psychosocial concerns relating to the aesthetic impact of maxillary incisor prominence or there is a significant increased risk of trauma due to the increased overjet (see the .

However, they appear to have a greater effect on skeletal growth if treatment takes place during the optimum period for the following reasons:

- Skeletal growth will be optimized
- Treatment will coincide with the late mixed or early permanent dentition
- It will allow immediate placement of fixed appliances following functional appliance treatment
- It will reduce overall treatment and retention time

Prominent incisors are more vulnerable to teasing/bullying and trauma

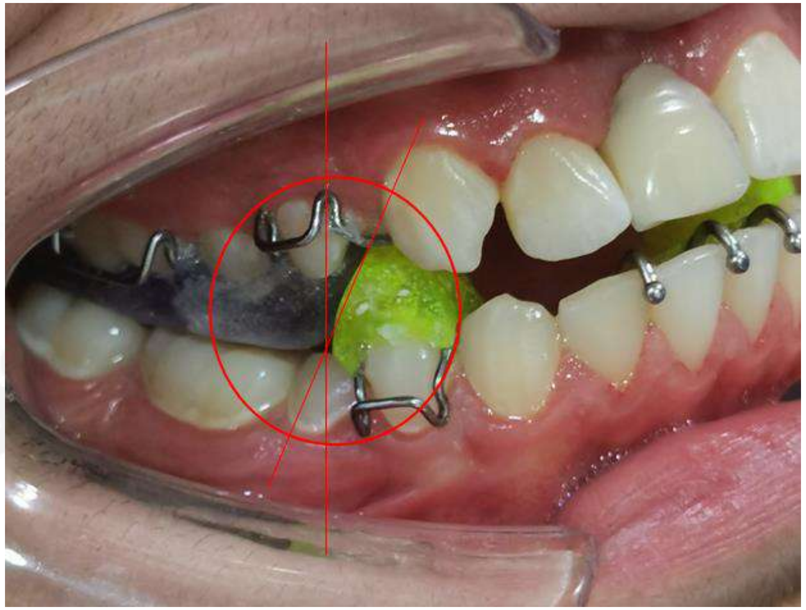
Types of functional appliances

There are many types but most share the common feature of holding the mandible in a postured position. The widely used ones are the following:

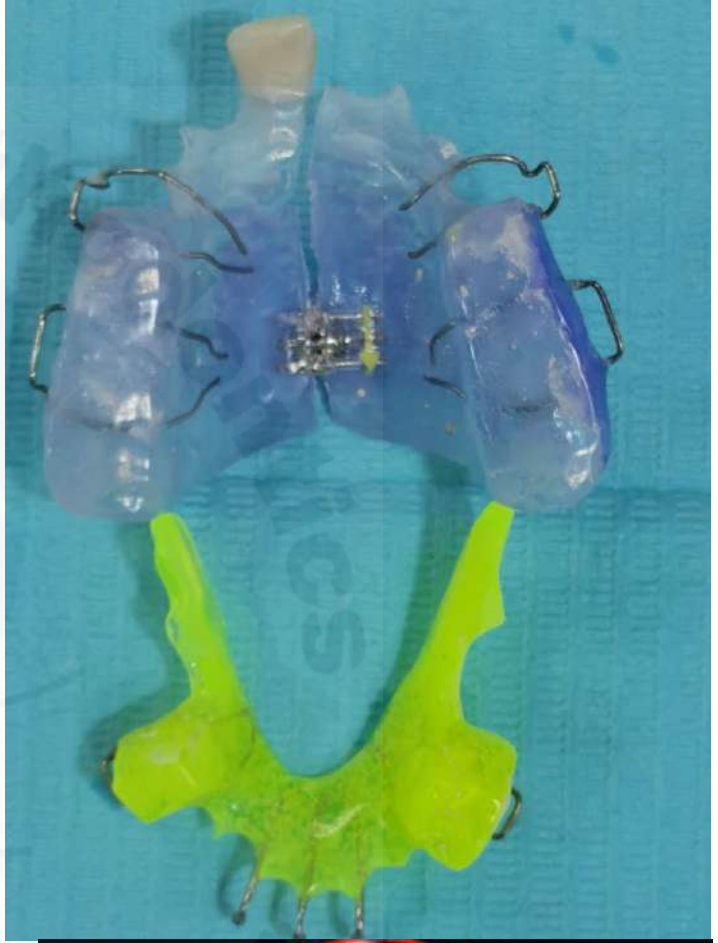
1- Twin-block appliance

The Twin-block appliance was invented in 1977 by William Clark and is the most commonly used functional appliance in the UK. This is because:

1. it is well tolerated by patients, as it is constructed in two parts. The upper and lower parts fit together using posterior bite blocks with interlocking inclined bite-planes, which posture the mandible forwards. The blocks need to be at least 5 mm high, which prevents the patient from biting one block on top of the other. Instead the patient is encouraged to posture the mandible forwards, so that the lower block occludes in front of the upper block in an angle between 45-70^{0}.
2. The appliance can be worn full time, including during eating in some cases, which means that rapid correction is possible.

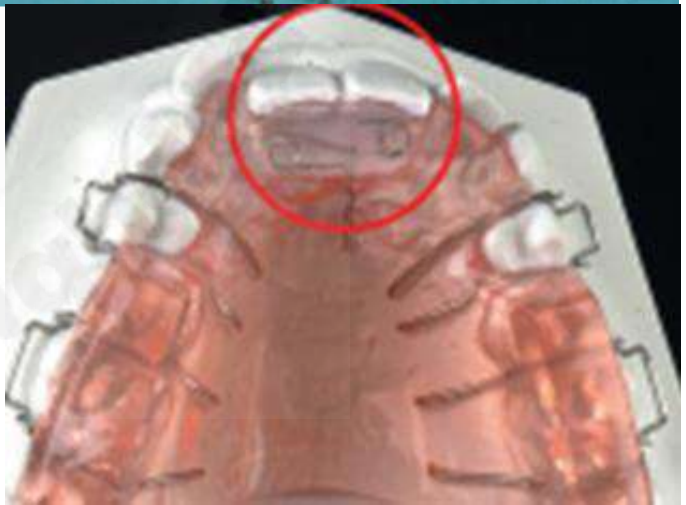


3. It is also possible to modify the appliance to allow expansion of the upper arch by incorporating expansion screw



4. It is also possible to modify the appliance by adding artificial tooth replacement.

5. An alternative modification to allow correction of Class II division 2 malocclusions is by incorporating z-spring in the upper part to procline the incisors and convert the case into class II div1.



5. It is also easy to reactivate the twin-block appliance. This means that during treatment if further advancement of the mandible is required, it is possible to modify the existing appliance rather than having to construct a new appliance.

Disadvantage of Twin-block

One of the side effects of the twin-block appliance is the **residual posterior open bites** at the end of the functional phase. This is seen particularly in cases initially presenting with a deep overbite. The posterior teeth are prevented from erupting by the occlusal coverage of the bite blocks.

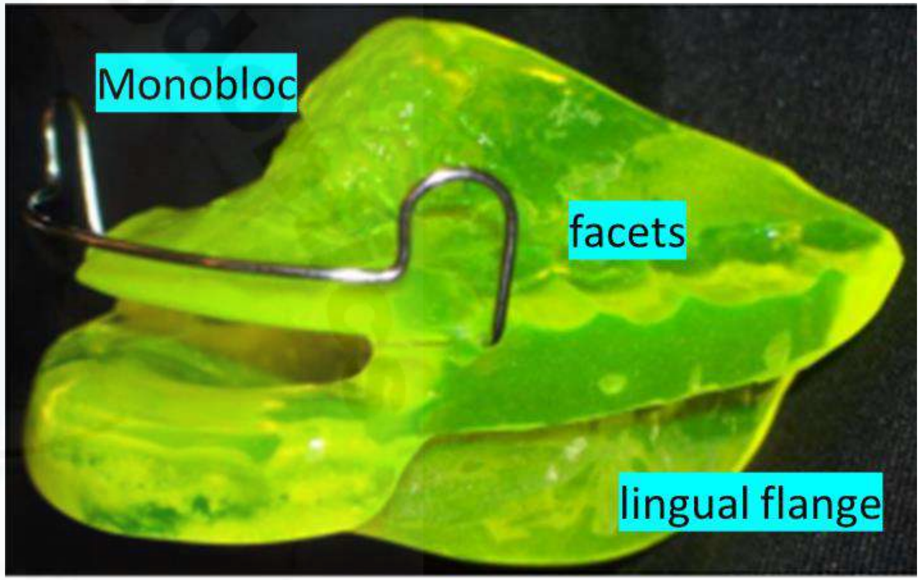
2- Andresen activator

The activator was originally described by Andresen and Häupl the early 1900s.

It was based upon the hypothesis of stimulating increased muscle activity in the mandibular elevator and retractor muscles to act directly on the dentition through the appliance and stimulate the mandibular condyle to allow remodelling and growth.

It is a loose-fitting monobloc appliance that advances the mandible with lingual flanges.

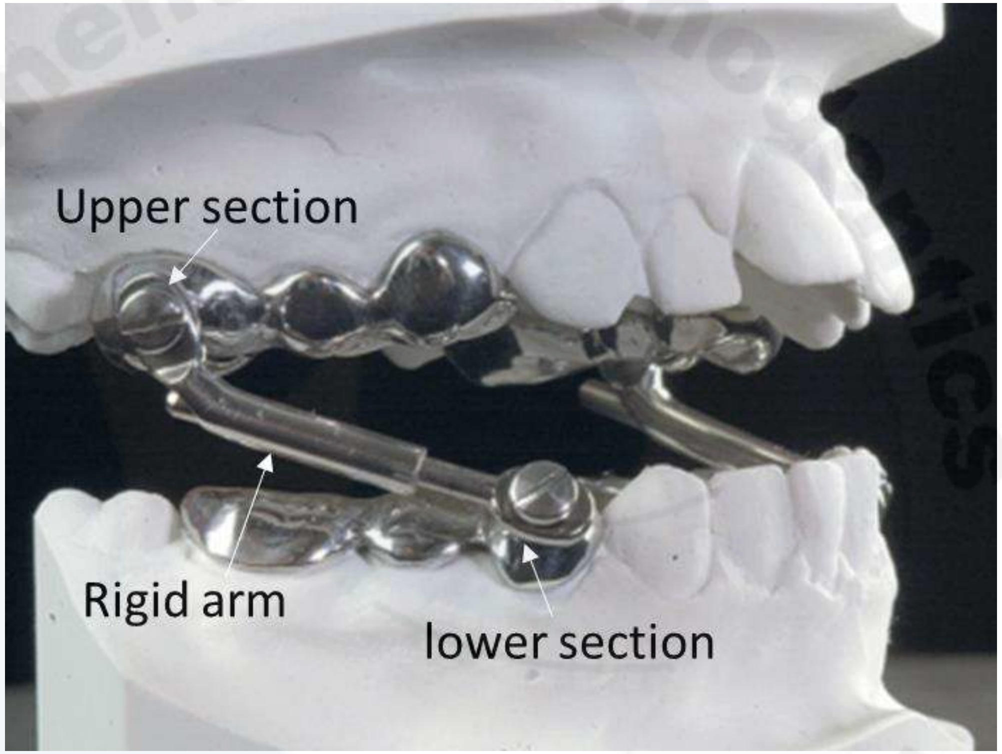
Occlusally, facets were cut in the acrylic to guide eruption of the mandibular posterior teeth mesially and the maxillary posterior teeth distally and buccally.



3- Herbst appliance

The Herbst appliance is a fixed functional appliance.

Components:
There is a section attached (banded or bonded) to the upper buccal molar teeth and another section attached to the lower premolar teeth. These sections are joined by a rigid arm that postures the mandible forwards.



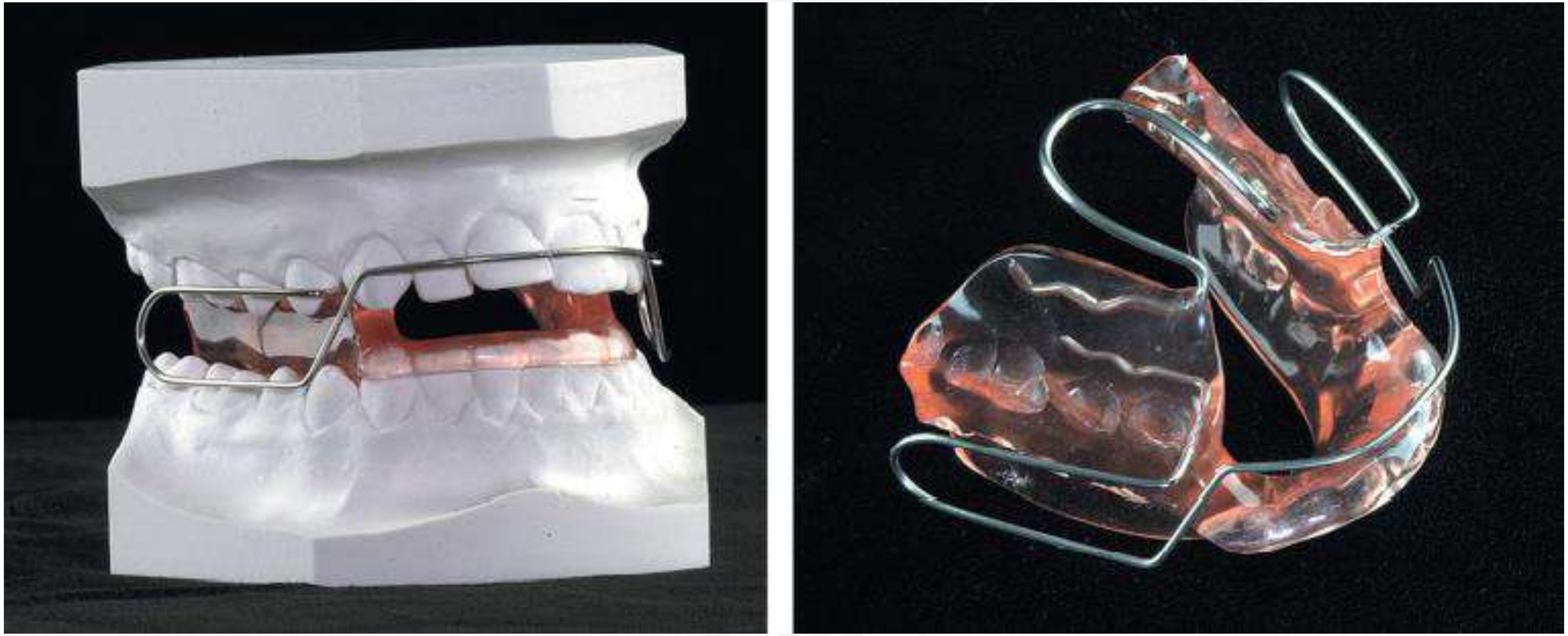
Advantage
As it is a fixed appliance, it removes some (but not all) patient`s compliance factors and better tolerated than the other bulkier functional appliances

Disadvantage

- increased breakages
- higher cost
- Not easy repairable

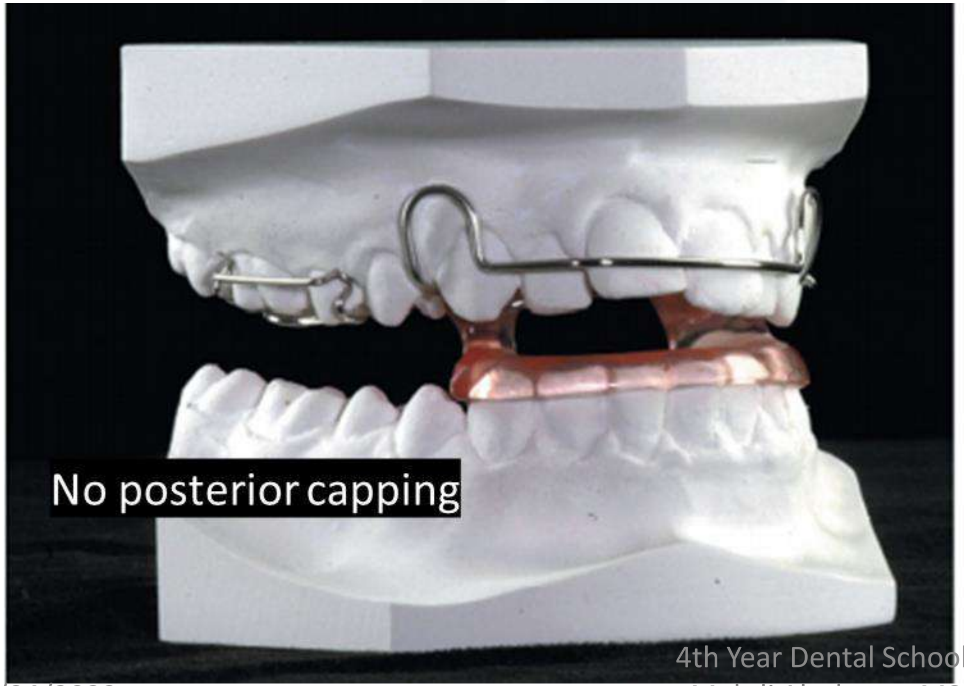
4- Bionator

The bionator was originally designed to modify tongue behaviour, using a heavy wire loop in the palate. The lack of acrylic in the palate makes it easy to wear. A buccal extension of the labial bow holds the cheeks out of contact with the buccal segment teeth, allowing some arch expansion.



5- Medium opening activator (MOA)

This is a one-piece functional appliance, with minimal acrylic to improve patient comfort.



6- Fränkel appliance

This appliance is also called Functional Regulator (FR), it is completely tissue-borne appliance. Four types of Fränkel appliances:

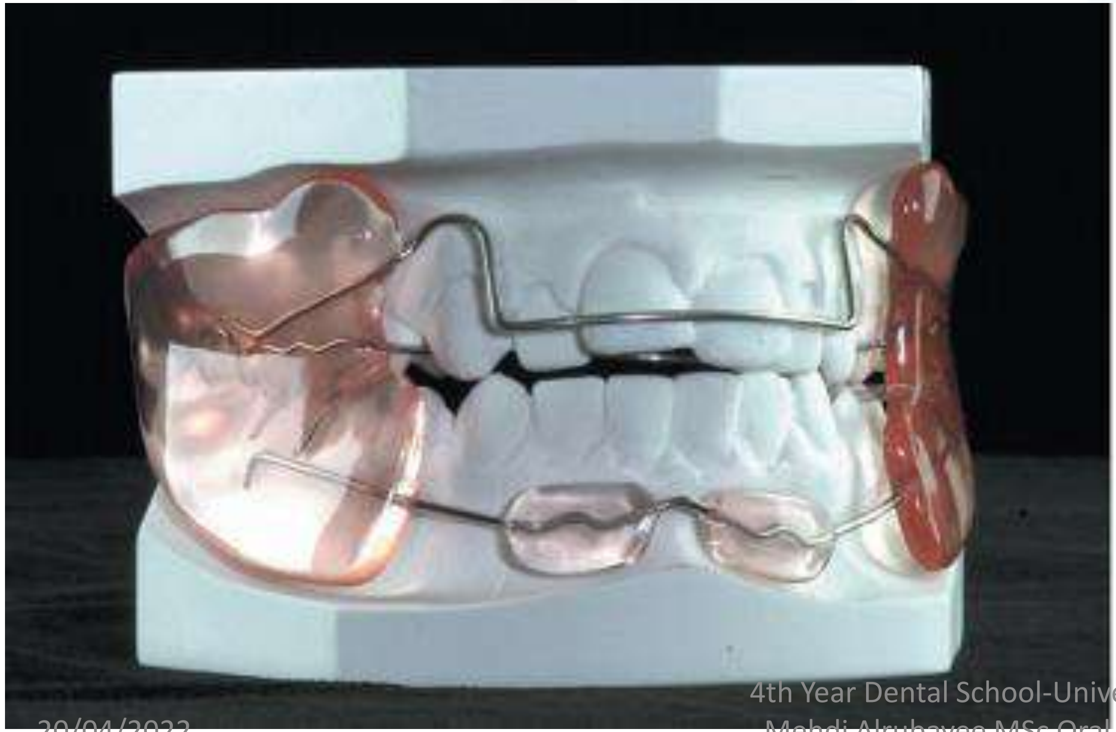
Class II division 1(FR1),

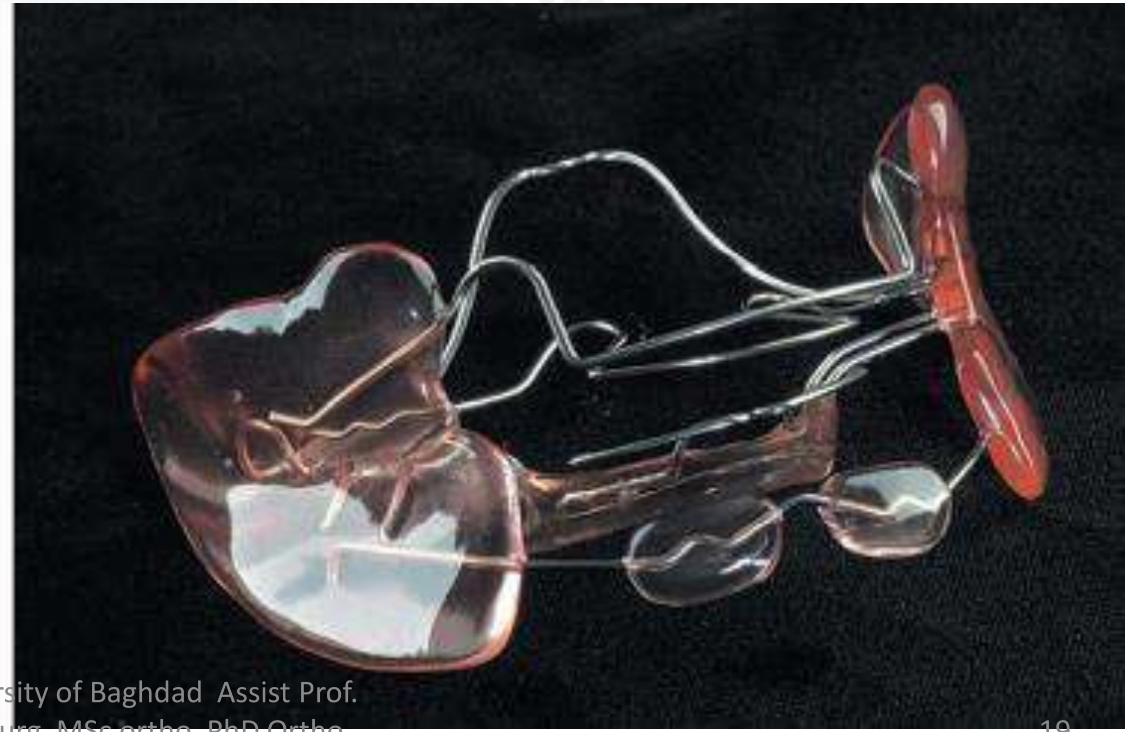
Class II division 2(FR2),

Class III (FR3)

Anterior open bite malocclusions (FR4).

This appliance is rarely used in contemporary orthodontic treatment because of several disadvantages such as difficulty in wearing and fabrication, and is troublesome to repair.



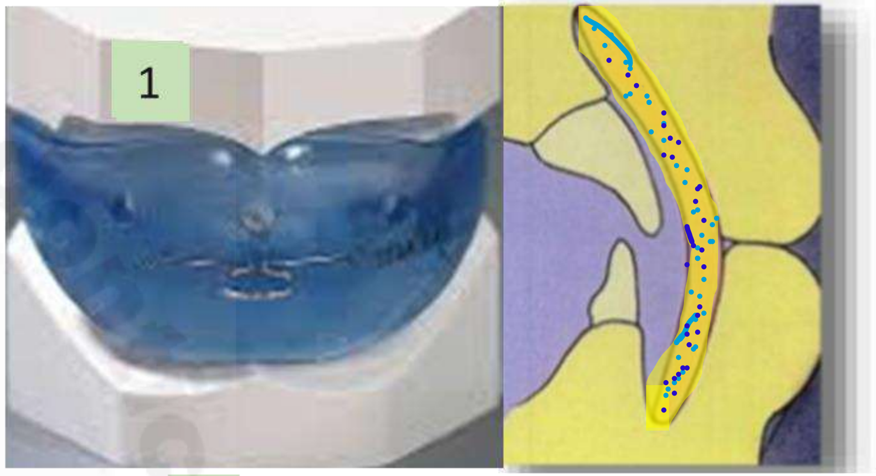


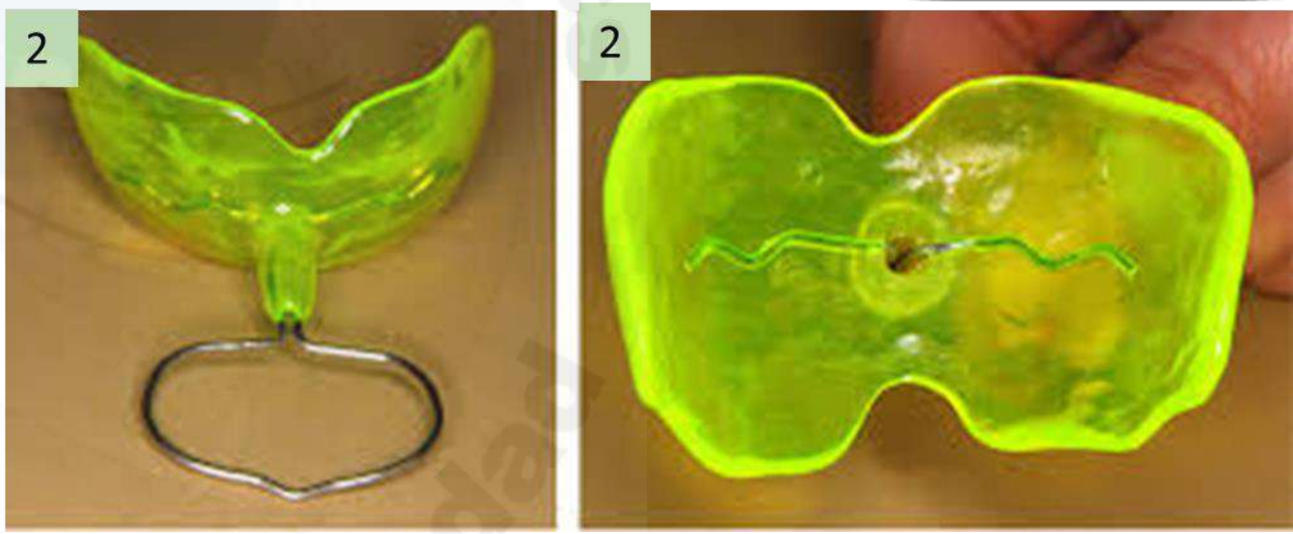
7- Oral screen

It is a curved shield of acrylic centred in the vestibule between the labial/buccal aspects of the teeth from behind and lips and cheeks from the front

Types

- Active: It transfers the force of circumoral musculature to the most proclined teeth
- Passive: eliminate the force exerted by circumoral musculature allowing the teeth to move labially by action of tongue





Advantages

1. Act as habit breaker in patients suffering from mouth breathing, tongue thrusting, lip and cheeks biting
2. Muscle trainer for hypotonic lip and cheek muscles
3. To retrocline mild proclined anterior teeth

8- Lip bumper

lip bumper is a combined removable-fixed functional appliance. Used in both maxilla and mandible to hold the lips away from the teeth. Also used to hold the lower molars back while allowing the lower front teeth to move forward. This provides space for over crowded anterior teeth.

Uses:

- in patients exhibit lower lip sucking
- in patients with hyperactive mentalis
- to support anchorage
- distalization of molars
- as a space regainer

9- Jasper jumper

introduced by J. J. Jasper ,1980.
It is a fixed tooth born functional appliance characterised by more flexibility and less rigidity in comparison to Herbst appliance.

Advantages

1) It produces continuous force
2) Does not require patient compliance
3) Allows greater degree of mandibular freedom than Herbst appliance
4) Oral hygiene is easier to manage.

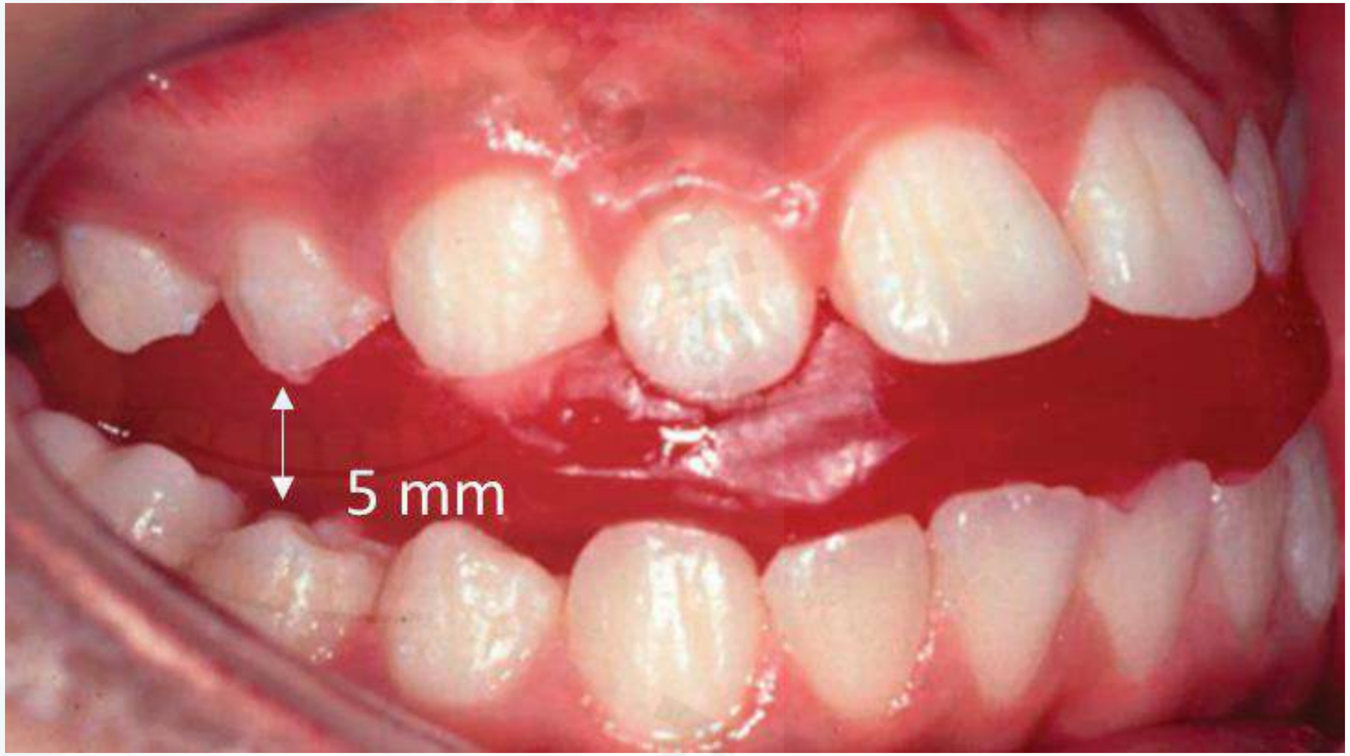
Preparing of the functional appliance

1- *Detailed impressions* with well-extended upper and lower alginate impressions into the lingual and labial vestibules are required.

2- *bite registration* with the mandible postured forward, as all functional appliances work by posturing the mandible forward.

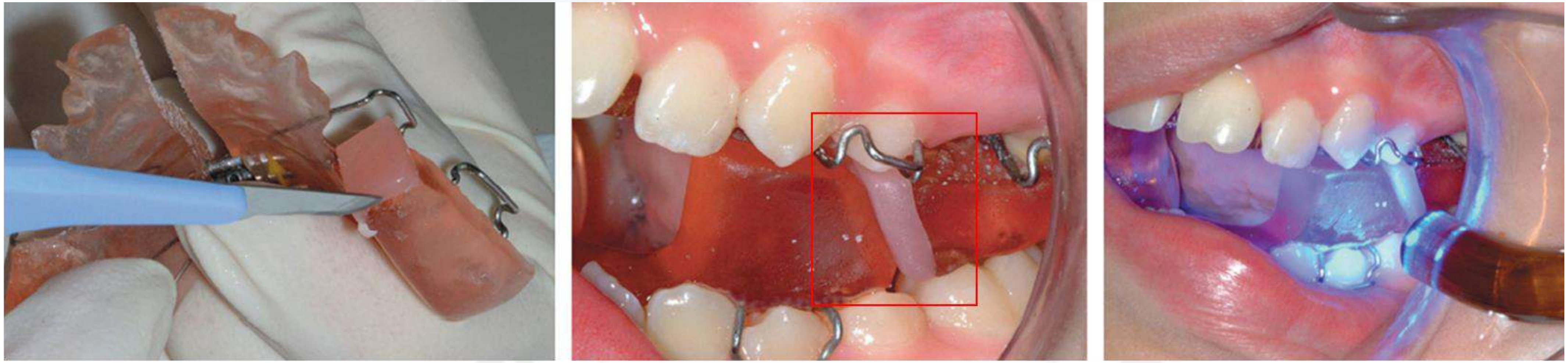
Bite registration with mandible postured forward

3- *Vertically, T*win blocks and activator require at least 5 mm of vertical separation in the buccal segments to allow for the inclined occlusal planes.



Activation of the functional appliance

Activation of the functional appliance is achieved either by incremental advancement of the mandible during treatment which may make it easier to tolerate and improving patient`s compliance or by fabricating a second appliance once the overjet has been partially reduced.



Adding light cure acrylic on upper inclined block for reactivation of twin block

Light curing of the acrylic

Insertion and reviewing the appliance

1- Appliances should be inserted within two weeks after impressions taking to ensure a good fit.

2- The review appointments can be made at 6–10-week intervals. At every review appointment, motivation of the patient is vital, as well as checking the fit of the appliance and treatment progress.

3- No wear or poor wear of appliance can be identified by some signs such as:

- continued speech problems
- a fresh and clean appliance with no signs of wear
- numerous breakages due to repeated removal by the patient.

Duration of treatment and retention of functional appliances

It has been suggested that the treatment time should not be less than 12 months, followed by a retention period of the same length, before the commencement of the second - phase treatment with a fixed appliance to close the posterior open bite created due to moving the mandible forward in the new position.

To sum up

Functional appliances are

1-posturing mandible forward in growing patients

2-used for correction of class II skeletal problems

3- can be followed by fixed appliance

4- they can be used earlier for psychological reasons and to reduce risk of trauma

5- the produce 70% dental effect and 30% skeletal

6- they need patient compliance

7- they are successful in 70-80% of patients

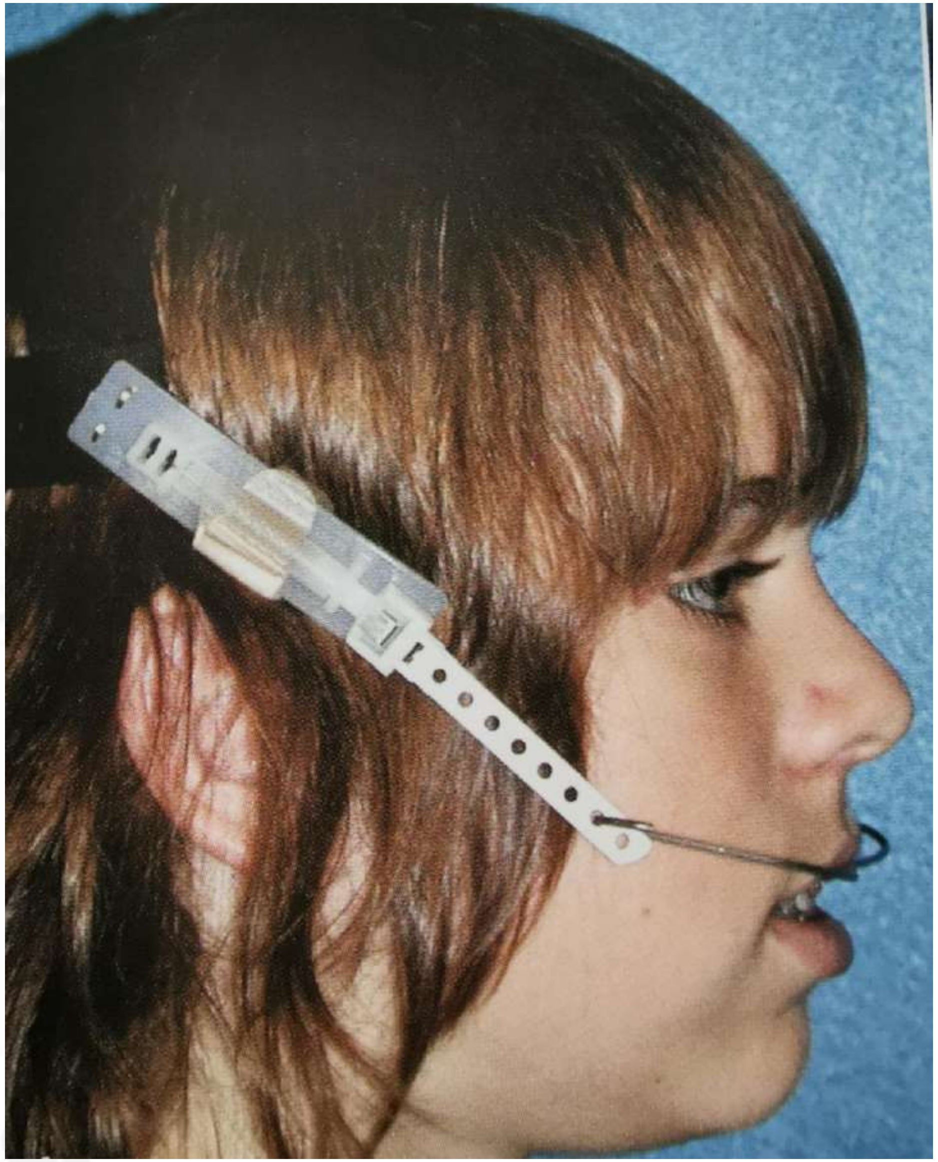
Other orthopaedic appliances

Extra Oral Traction (EOT) Appliances

Extra-oral traction (EOT)

1- Headgear

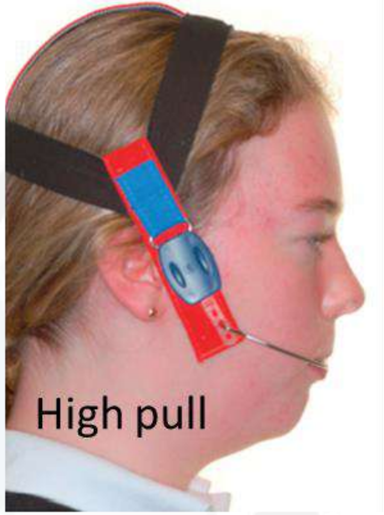
can be added to a fixed appliance, removable appliance or a functional appliance, such as a Twin-block appliance, usually with the aim of achieving orthopaedic changes.



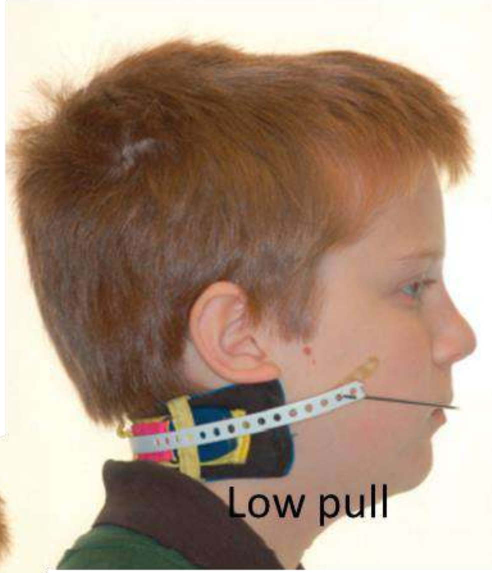
Directions of pull

at the time of treatment planning, the direction of pull should be considered which is one of the following three directions:

1-High-pull headgear (occipital) which helps to restrict the vertical growth of maxilla and reduce overbite, so typically used in cases with increased vertical proportions



2- Low-pull headgear (cervical) which is used to increase the vertical dimension by having an extrusive effect on the molars in cases of reduced vertical proportions



3- Straight-pull headgear which controls the anteroposterior and is typically used in cases with average vertical proportions

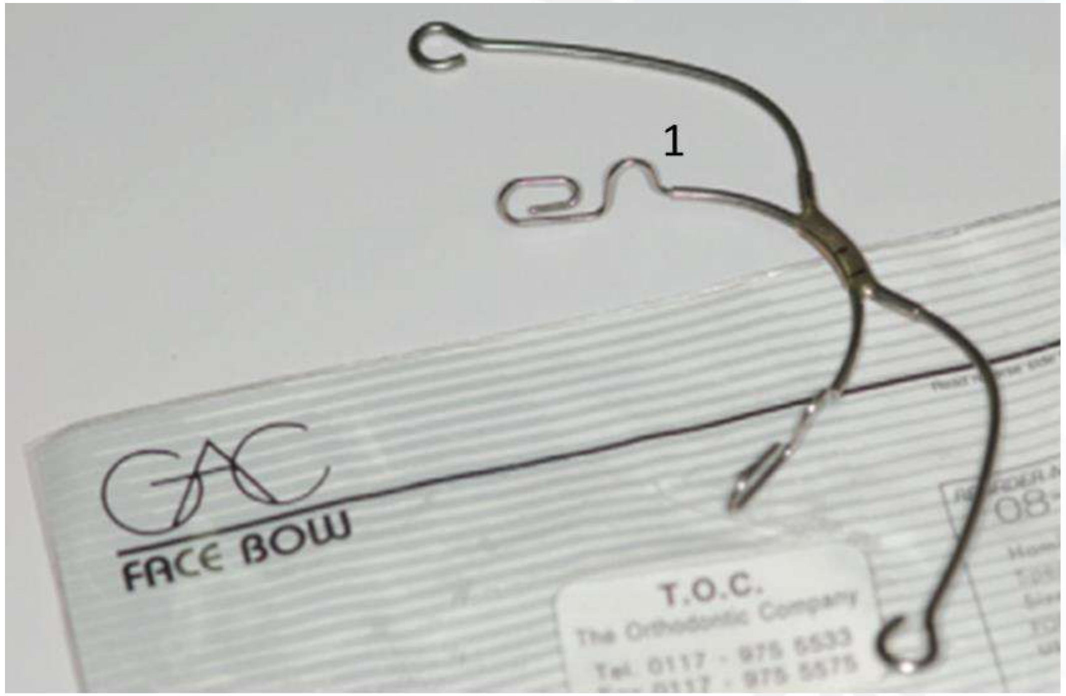
Force magnitude and wearing time

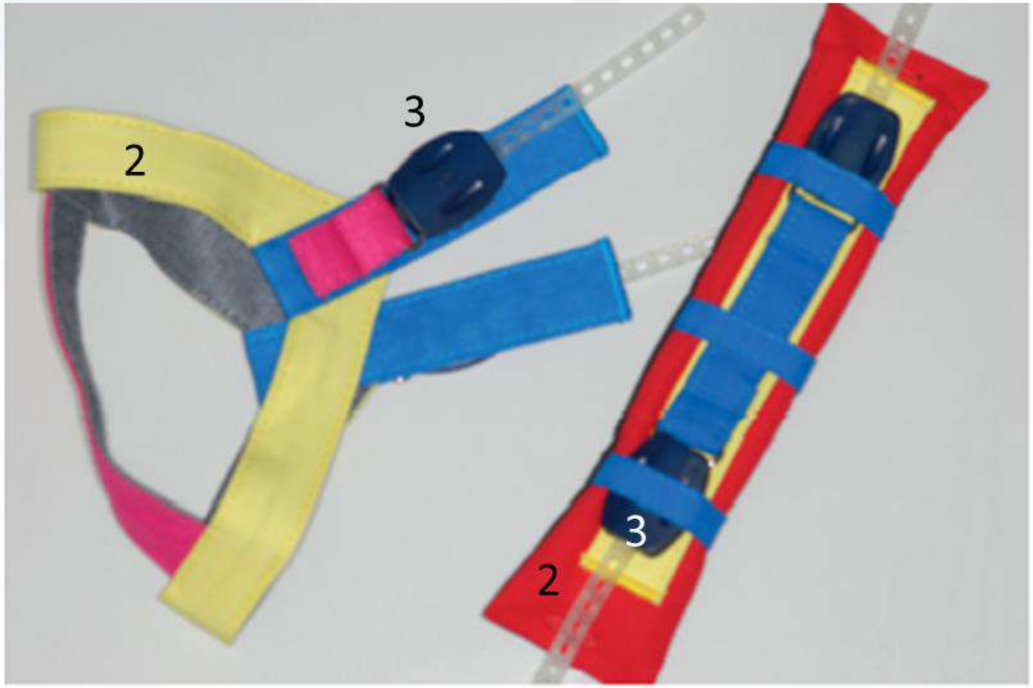
The magnitude and duration of force vary according to the purpose. These appliances usually best achieve by wearing at bedtime. The minimum duration of wearing is shown in the table below:

Purpose	Force (g)	Daily wearing time (hours)
Orthodontic	400-450	12
Orthopaedic (restraining the maxilla)	500	14
Anchorage	250-350	10

Headgear Components

1. Face-bow (inner and outer bows)
2. Headcap or neck strap
3. Spring mechanism or strap: this element connects the face-bow to the headcap or neck strap. It is supplied with safety release mechanism to protect the patient from injuries due to excessive force or accidental pulling out and recoil by other children





Face bow and safety release headgear with snap-away spring mechanism which breaks apart when excessive force is applied

Disadvantages of EOT

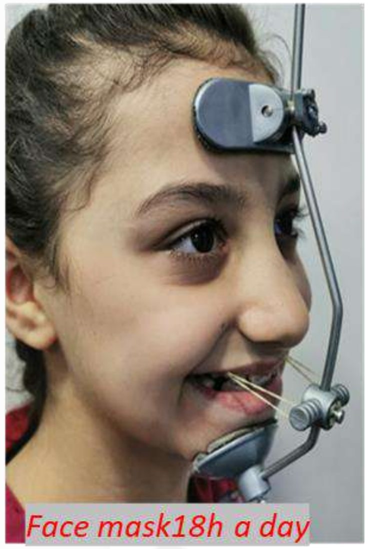
Success with extra-oral traction is dependent on good patient cooperation. Patients may often not wear the headgear for the prescribed duration. This has led nowadays to a reduction in the popularity and the use of headgear within clinical orthodontic practice

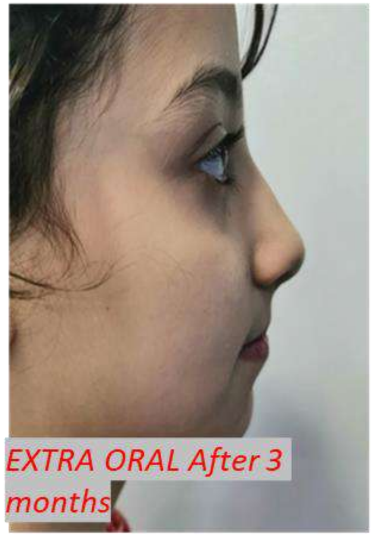
2- Reverse/protraction headgear (Delaire face mask)

This appliance can achieve skeletal changes by advancement of the maxilla and/or restrain or redirect mandibular growth.

This can be achieved in patients, where a face-mask is fitted and worn a minimum of 14 hours per day prior to pubertal growth spurt (before maxilla stops growing).

A forward maxillary pull is applied
with the help of heavy elastics that are attached to hooks on the rigid framework.





3- Chin cap

an extraoral appliance that fitted by mean of a head cap to occipital region and has attachments for the placement and activation of the chin cap.

Used to restrain and redirect the growth of the mandible as early as possible, even in 4-5 years old.

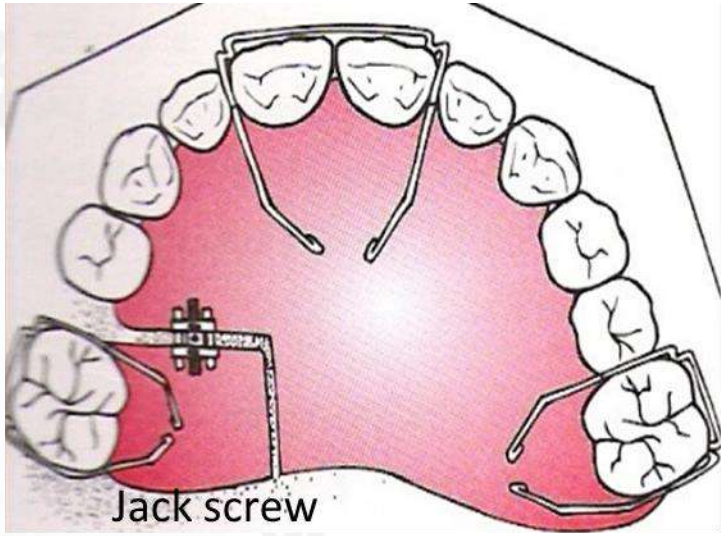
Space regainer

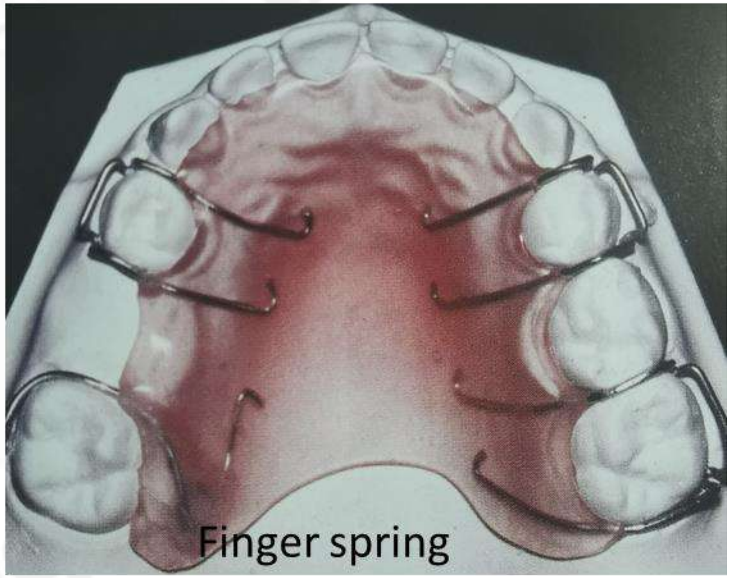
Up to 3 mm localized space deficiency can be reestablished using simple appliance called space regainer.

During mixed dentition, a localized space deficiency may arise due to early loss of the deciduous teeth and drifting of the adjacent teeth towards the space of extracted tooth. It is necessary, if space maintainer was not adequate, to regain the space and return the space discrepancy to zero in order the permanent teeth to erupt in normal positions.

1- Maxillary space regainer

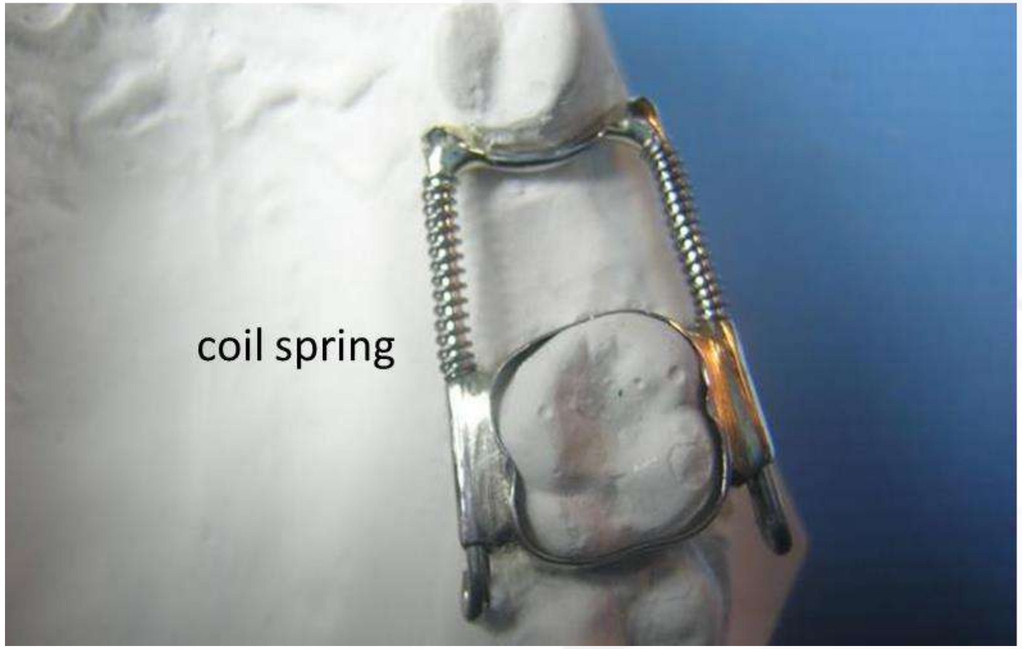
a. Removable maxillary space regainer: a simple removable appliance with multiple Adam`s clasps and finger spring or jack screw can be used to distally tip the permanent molar that shifted due to early extraction of deciduous molar.

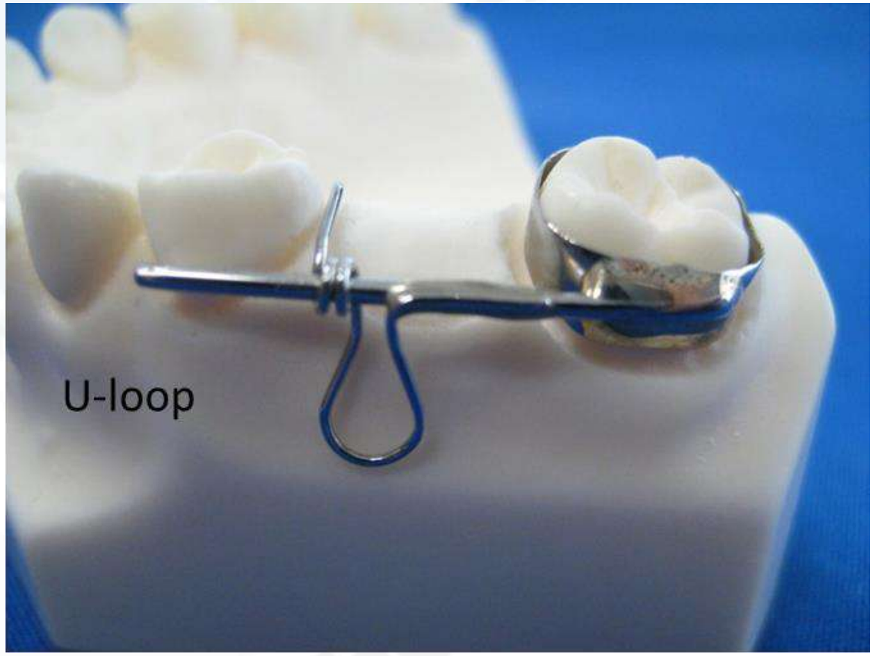




b. Fixed maxillary space regainer

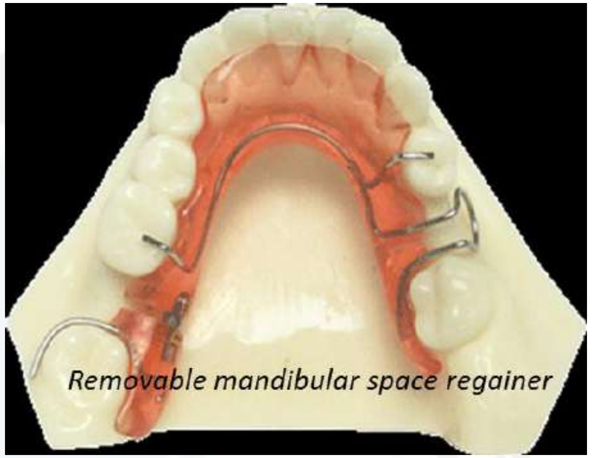
Bodily movement of first permanent molar can be performed using fixed space regainer formed from coil spring or U-loop on segmented archwire.





2. Mandibular space regainer

a. **Removable mandibular space regainer** is less satisfactory than maxillary because it is fragile and prone to breakage due to loss of palatal anchorage.



b. Fixed mandibular space regainer is formed from either adjustable **lingual arch** banded to permanent molars bilaterally against the anchorage offered from incisors.

Or **lip bumper** fitted to tubes on molars. The idea is that lip bumper press against lower lip which creates distal force to tip molars posteriorly

Invisalign®

is a proprietary orthodontic technique that uses a series of sequential computer-generated plastic **aligners** to deliver a course of orthodontic treatment. The concept was around 1945, however, first Align Technology product of clear aligner was computerized in the late 1990s.

Why aligners became popular ?

1- increased treatment demands by adults
2- increased demands for aesthetic treatment
3- developments in 3D printing technology and direct manufacturing from computer software.
4- extensive marketing by manufacturers to clinicians and patients leading to increased awareness

Advantages of aligners

1- more aesthetic appliances
2- improved dental and periodontal health
3- reduced risk of decalcification
4- a reduction in chair-side time, overall treatment time, pain experience, and root resorption.

Process

1- impressions must be taken with poly - vinyl siloxane (PVS) due to its superior accuracy

2- submission of patient`s intraoral and extraoral photographs and radiographs to Align Technology in addition to the completed treatment form

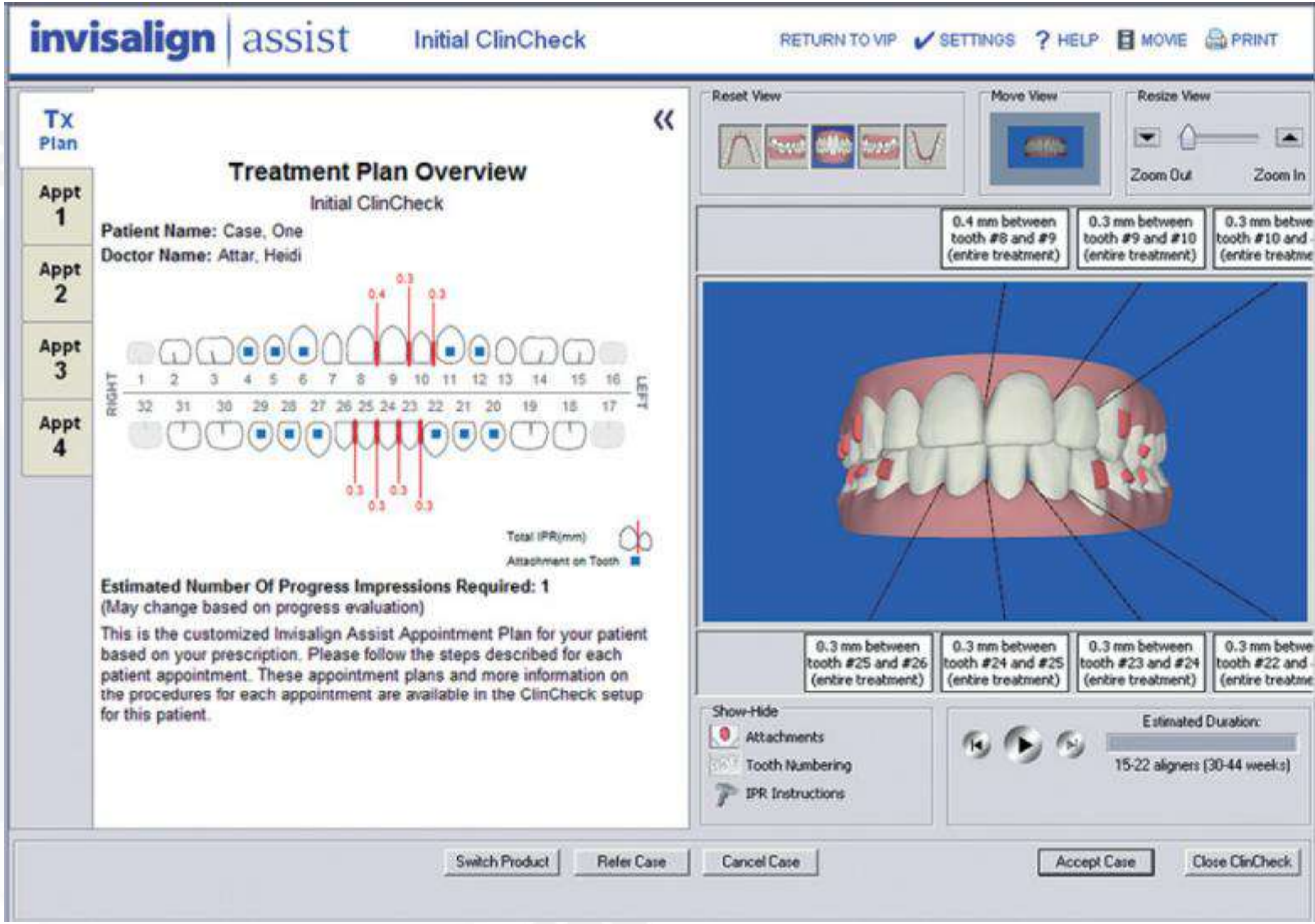
3-PVS impressions and bite registration are scanned to create accurate 3D digital models

4-trained Invisalign computer technician makes a design of series of clear aligners to move the teeth to their final positions

5-This preliminary plan is submitted to the doctor for approval in the form of a computerised movie viewed by using Invisalign ' s ClinCheck software.

6- once the plan is approved by the doctor, a payment is completed and a series of casts are created using stereolithography and a complete set of clear plastic aligners are sent directly to the doctor.

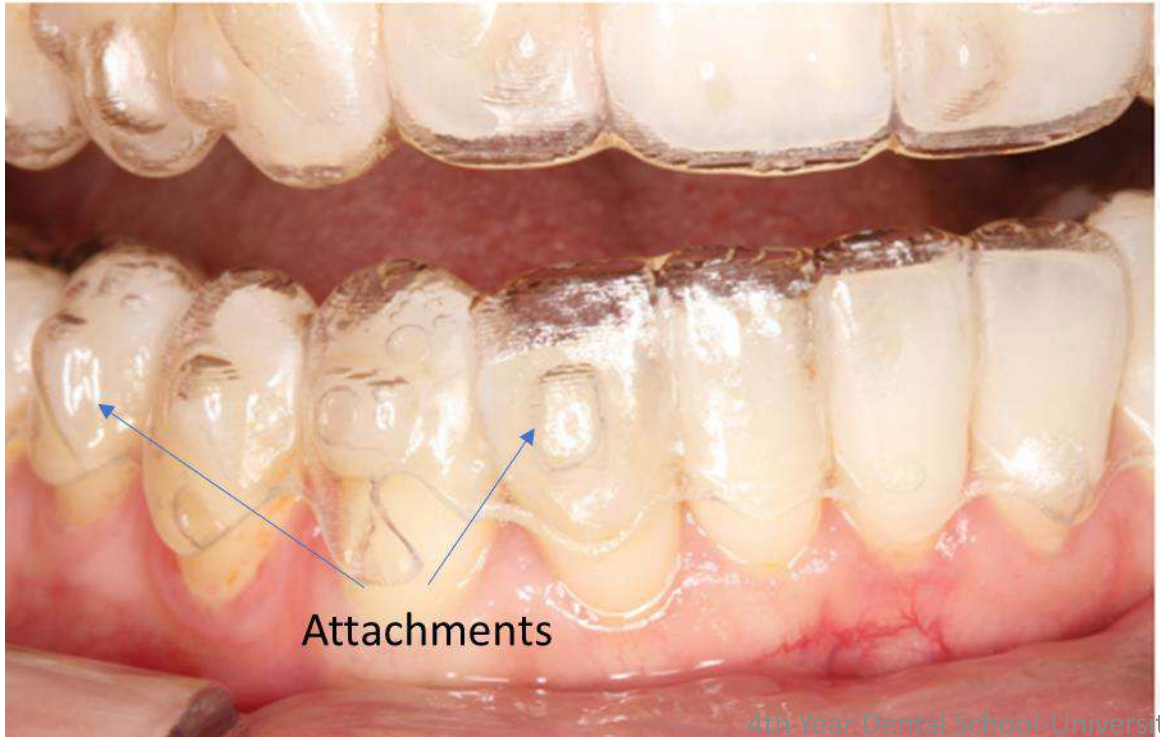
7- Each aligner is prescribed to be worn for 2 weeks and is only removed for eating, drinking, brushing and flossing.



Types of tooth movement achieved by aligners

At the beginning, aligners were designed to manage rotated, proclined, or retroclined anterior teeth; however, there was little scope for mesiodistal or vertical tooth movement, or root torque.

Then after, use of preplanned plastic attachments, in conjunction with advanced plastic aligner materials, enabled more difficult tooth movements (comparable to that of fixed appliance) to be achieved, such as derotation of round teeth (canines and premolars), relative intrusion/extrusion of one or multiple teeth, and root torque.



Simple	Alignment of anterior teeth by tipping Alignment of rotated incisors Mild–moderate anterior crowding (may require interproximal reduction or expansion) Posterior expansion Distal molar tip
Moderate	Closure of mild–moderate spacing Intrusion or extrusion of teeth Severe rotations on round teeth
Complex	Expansion to allow alignment of a totally blocked out tooth Severely ectopic teeth Molar uprighting or any teeth with significant undercuts Closure of extraction spaces Bodily distalization of molars Management of anterior open bite

Thank you

RETENTION AND RELAPSE IN ORTHODONTICS

RELAPSE: It has been defined as the return of the features of the original malocclusion following correction by orthodontic treatment.

CAUSES OF RELAPSE:

1. Persistent etiology: failure to remove Cause of malocclusion → RELAPSE. (Bad habit cases unless stop the bad habit).

2. Incorrect diagnosis and failure to properly plan treatment.

3. Gingival and Periodontal factor:

Teeth moved orthodontically → stretching of periodontal principal fibers and the gingival fibers encircling the teeth → Fibers contract → RELAPSE.

4. Due to growth related changes:

Patient with skeletal problems associated with class II and class III → continued abnormal growth pattern after orthodontic therapy → RELAPSE

5. Bone adaptation: Teeth moved recently are surrounded by lightly calcified osteoid bone → No adequate stabilization of teeth → RELAPSE.

6. Muscular forces: Teeth are encapsulated in all directions by muscles → If muscular imbalance at the end of orthodontic therapy → RELAPSE.

7. Failure to manage rotations: The transseptal fibers of the periodontal ligament take the longest to reorient following correction of derotations and are the main cause of RELAPSE following rotational correction of teeth

8. Role of third molars: If third molar erupt after the orthodontic treatment → Exert pressure on the teeth → Late anterior crowding → RELAPSE.

RETENTION: Is the phase following active orthodontic treatment aimed to stabilization of achieved orthodontic correction **or** holding of the teeth in ideal functional esthetic occlusion, by wearing fixed or removable retainers.

NEED OF RETENTION:

Retention is planned to antagonize the movement of the teeth in the direction of their tendency, and to allow the teeth freedom of movement in every direction except that toward which they tend to return

1. Gingival and periodontal tissue require time post-treatment to reorganize.
2. Soft tissue pressures are likely to cause relapse if teeth are placed in an unstable position.
3. Growth post-treatment may cause relapse.

PRINCIPLES OF RETENTION:

- Relapse potential may be predicted by evaluation of initial occlusion; teeth usually want to return to their original position; this is due to gingival fibers and unbalanced lip-tongue forces.

- Full-time retention is required for 3-4 months to allow for reorganization of PDL
- Retention should continue for at least 12 months in non-growing patients or until growth has ceased in growing patients.

THEOREMS OF RETENTION:

Theorem 1

"Teeth that have been moved tend to return to their former position".

Theorem 2

"Elimination of the cause of malocclusion will prevent relapse".

Theorem 3

"Malocclusion should be over corrected as a safety factor".

Theorem 4

"Proper occlusion is a potent factor in holding teeth in their corrected positions".

Theorem 5

"Bone adjacent the tissue must be allowed time to reorganize around newly positioned teeth".

Theorem 6

"If the lower incisors are based upright over basal bone they are more likely to remain in good alignment"

Theorem 7

"Corrections carried out during periods of growth are less likely to relapse".

Theorem 8

"The farther the teeth have been moved, the lesser is the risk of relapse".

Theorem 9

"Arch form, particularly in the mandibular arch, cannot be permanently altered by appliance therapy".

Theorem 10

"Many treated malocclusions require permanent retaining devices.

RETENTION PLANNING:

Riedal has grouped retention planning into three groups:

1. No retention required.
2. limitted retention.
3. permanent or semipermanent retention

1. No retention required

A. Cross bites

- *Anterior:* When adequate overbite has been achieved
- *Posterior:* When axial inclination of teeth remain reasonable after correction

B. Dentitions treated with serial extractions

C. Corrections achieved by retardation of maxillary growth once the patient has completed growth

D. Dentitions in which teeth have been separated to allow for eruption of previously blocked out teeth

2. Limited retention

A. Class I non-extraction cases with spacing and protrusion of maxillary incisors (until normal lip and tongue function has been achieved)

B. Class I and II extraction cases

C. Early correction of rotated teeth to their normal position before root completion

D. Cases involving ectopic eruption or the presence of supernumerary teeth

E. Corrected deep bites

F. Class Il division II cases: Extended retention to allow for muscle adaptation

*3. **Permanent or semipermanent retention***

A. In many cases, to maintain existing esthetics extraction may not be done. The only way to create space in such cases is through expansion. These cases, especially in mandibular arch require permanent or semipermanent retention.

B. Cases of considerable generalized spacing

C. Severe rotation or severe labiolingual malposition

D. Spacing between maxillary central incisors with an otherwise normal occlusion

Retainers:

-Retainers are passive orthodontic appliances that help in maintaining and stabilizing the position of teeth long enough to permit reorganization of supporting structures after the active phase of orthodontic therapy

- types: -

1. Removable Retainers
2. Fixed Retainers

IDEAL REQUIREMENTS OF RETAINING APPLIANCES

Graber put forward certain criteria that any retaining appliance should possess. These include;

1. It should restrain each tooth in its direction of relapse.
2. It should permit the forces associated with functional activity to act freely on the teeth, permitting them to respond in as nearly a physiologic manner as possible.
3. It should be as self-cleansing as possible and should be reasonably easy to maintain optimal hygiene.

4. Should be as inconspicuous as possible, esthetically good.
5. Strong enough to bear the rigors of day-to-day usage.

REMOVABLE RETAINERS

1. Hawley's appliance

- Most frequently used retainer
- Consists of clasps on molars and a short labial bow extending from canine to canine having adjustment loops. Disadvantages:

1. Need co-operation.
2. Need frequent adjustment.

2. Vacuumed formed retainer (Essix)

- This is a polypropylene or polyvinylchloride (PVC), material typically .020" or .030" thick.
- Plastic removable appliance.

Vacuum-formed retainers offer a number of potential advantages over Hawley retainers:

- Superior aesthetics
- Less interference with speech or function
- More economical , easier and quicker in fabrication
- Less likely to break
- No adjustments
- Superior retention of the lower incisors
- Patient is more likely to wear
- Minimum bulk and high strength

- Studies have determined that Essix retainers are as efficient as Hawley-type or bonded wire retainer.

FIXED RETAINERS

-Utilized in cases where stability is questionable and prolonged retention is planned

-Four main indications:

1. Maintaining lower incisor position during late mandibular growth
:

A. Even mild mandibular growth between the ages of 16-20 can cause lower incisor relapse.

B. A fixed lingual bar bonded only to canines can prevent distal tipping of lower incisors

C. A heavy wire, 28 or 30 mil, should be used due to long span, usually from canine to canine, it is more successful in the lower arch than the upper because of the

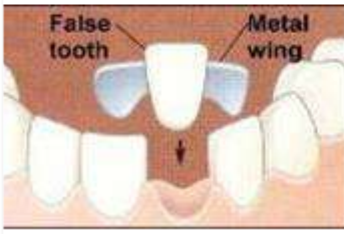
possibility of fracture in the upper arch because of occlusion.

2. Holding diastema closed:

- Utilize lighter wire (17.5 or 19.5 mil twist)
- Bond above cingulum – out of occlusion
- Can prevent bite deepening if lower incisors erupt.

3. Implant or pontic space maintance:

- Reduces mobility of teeth making it easier to place a bridge
- Holds space if prolonged periodontal treatment is required post-ortho, prior to placement of restoration
- Implants should be placed as soon as ortho is completed so it can be included in initial stages of retention.



4. Retaining closed extractions spaces:

- Placed on facial surfaces of posterior teeth
- Mainly used in adults, as they tolerate this better than removable retainers
- More reliable than removable retainer.

A

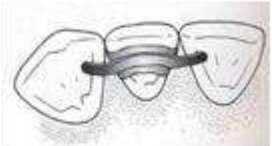
B

Types of fixed retainers :

A. Banded Canine to Canine Retainer.

B. Bonded Lingual Retainers.

C. Band and Spur Retainers.



C

Advantages of fixed retainer:

- Reduced need for patient cooperation.
- Can be used when conventional retainers cannot provide same degree of stability.
- Bonded retainers are more esthetic
- No tissue irritation unlike what may been seen in tissue bearing areas of Hawley's retainer
- Can be used for permanent and semi-permanent retention.
- Do not affect speech.

Disadvantages of fixed retainer:

- Difficult to fabricate and insert.
- Increased chair side time
- More expensive
- Interfere with oral hygiene maintenance
- More prone to breakages

- Loss of healthy tooth material (may cause decalcification).
- Tend to discolor.

ADJUNCTIVE TECHNIQUES USED TO REDUCE RELAPSE

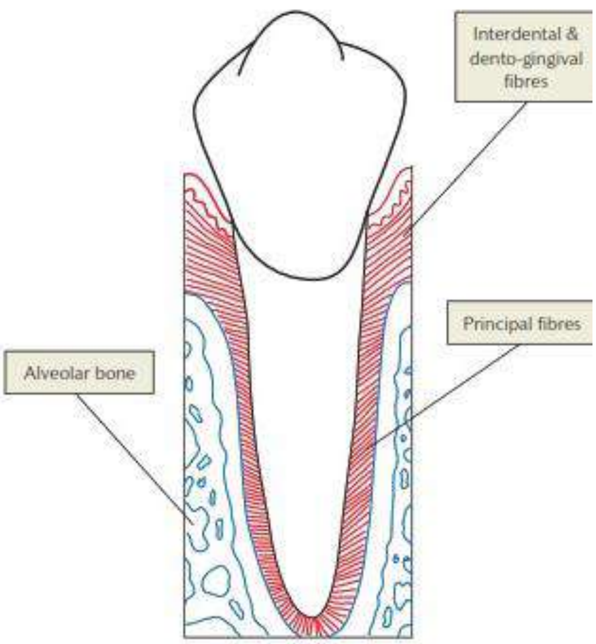
Adjunctive techniques are additional soft and hard tissue procedures, usually used in addition to retainers, to help enhance stability:

- Pericision
- Interdental stripping

1.Pericision

This is also known as circumferential supracrestal fiberotomy. The principle is to cut the interdental and dento-gingival fibres above the level of the alveolar bone. The elastic fibres within the interdental and dento-gingival fibres have a tendency to pull the teeth back towards their original position. This is particularly true with teeth that have been derotated.

Pericision is a simple procedure undertaken under local anesthetic and requires no periodontal dressing after the cuts are made. The cuts are made vertically into the periodontal pocket, severing the supra- alveolar fibres around the neck of the teeth, but taking care not to touch the alveolar bone. The technique has been shown to reduce rotational relapse by up to 30 per cent and is most effective in the maxilla. There are no adverse effects on the periodontal health, provided there is no evidence of inflammation or periodontal disease before the pericision.



2. Enamel interproximal stripping

This is also known as reproximation . The removal of small amounts of enamel mesio-distally has been used to reshape teeth and to create small amounts of space. It is not clear why this process can reduce relapse. It has been suggested that by flattening the interdental contacts, this will increase the stability between adjacent teeth. It may also be the case that by removing small amounts of tooth tissue any minor crowding is relieved, avoiding possible proclination of the lower labial segment and increase in the intercanine width, both of which are potentially unstable movements.

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2.Mitchell L. an introduction to orthodontics. 4th Ed. 2013