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Lec. 12

DEVELOPMENT OF DENTAL ARCH AND OCCLUSION

The stage sequence of dental arch development is the same for everyone. At birth, the alveolar ridges are plain firm tissue with no teeth on them. As the child grows steady changes are seen both on and within the ridge. The alveolar ridge grows and enlarges while the teeth develop to attain their final shape and size within the jaws.

The first primary tooth to erupt is the central incisor at about 7 1/2 months, and the last to erupt is the second primary molar at about 2 1/2 years. Closure of the root apex occurs at 3 years for the second primary molar. The usual sequence of primary dentition eruption is the central incisor (in Palmer notation, designated by the letter A), the lateral incisor (B), the first primary molar (D), and the canine (C), followed by the second primary molar (E). Hence, the typical eruption sequence is A-B-D-C-E.

Development of occlusion can be divided into the following developmental periods:

1.Pre-dental/dentate period: This is the period after birth during which the neonate does not have any teeth. It usually lasts for 6 months after birth. The characteristic feature is the alveolar ridge that are called gum pads. The upper anterior gum pad (intercuspid width) is typically wider than the lower anterior pad, and the upper anterior gum pad protrudes (overjet) about 5 mm relative to the lower anterior gum pad. The upper anterior gum pad usually overlaps (overbite) the lower anterior pad by about 0.5 mm. In the first 6 months of postnatal life, there is marked palatal width increase, and the overjet decreases rapidly. Gum pad relationships at birth cannot be used as reliable diagnostic criteria for predicting subsequent arch relationship. The primacy of life-supporting functions (i.e., respiration and swallowing) is so great at birth that major unpredictable adjustments in maxillary and mandibular positions take place in the first few years of life.

2. The deciduous dentition period: The initiation of primary tooth buds occurs during the first six weeks of intrauterine life. The primary teeth begin to erupt at the age of about 6 months. The eruption of all primary teeth is completed around 3 years of age when the second deciduous molars come into occlusion and their roots complete development. By 3 years of age, however, the relationship of maxilla to mandible is well established, and the overall maxillomandibular pattern does not change significantly thereafter.

3.The mixed dentition period: The mixed dentition period begins at approximately 6 years of age with the eruption of the first permanent molars. During the mixed dentition period, the deciduous teeth along with some permanent teeth are present in the oral cavity.

4. The permanent dentition period: This period is characterized by the presence of all permanent teeth.

Ideal occlusion at a young age predisposes to an ideal adult occlusion. The most desirable occlusion in the permanent dentition is a Class I interdigitation, and certain features in the primary and mixed dentitions, if observed accurately, can provide clinical clues as to whether a Class I relationship of the dentition will eventually develop. The major difference between ideal adult and child occlusions is the teeth present. By 7 years of age, the primary central and lateral incisors have been or are in the process of being replaced by their permanent successors, and the permanent first molars are already erupted. The primary dentition remaining usually includes the canine and first and second molars of both arches.

Criteria for ideal dental occlusion for a 7-year-old child might include the following:

- Class I molar and canine interdigitation
- 2-mm anterior and posterior overjet
- 2-mm anterior overbite
- Coincident dental midlines

Deciduous Dentition Period

The characteristic features of deciduous dentition period are as follows:

I. Spacing in deciduous dentition

It is very common to find physiological spaces in the primary dentition, with the most prevalent spaces mesial to the primary canine in maxilla and distal to the primary canine in mandible. These spaces are called the "primate spaces" or "anthropoid spaces" which are helpful in canine positioning and relationship with opposing arches. Two consistent morphologic arch forms of the primary dentition:

- (Type I): generalized spaces between the teeth were present
- (Type Il): teeth were in proximal contact without spacing

The arch form in both types appears congenital rather than developmental because the original pattern exhibited upon eruption was maintained from ages 3 to 6 years. Until the eruption of the permanent first molars, the sagittal dimension of the primary dental arches remained essentially unchanged, with the possible exception of a slight decrease as a result of the development of dental caries on the proximal surfaces of the molar teeth. Only minor changes in the transverse dimension of the primary dental arches occurred during 3- 6 years of age unless negatively influenced by deleterious functional patterns.

The other spaces in primary dentition are called the **developmental spaces** which play an important role in the development of permanent dentition. Some children do not have such physiological spaces thereby referred to as **closed space or non-spaced dentition**. Such dentition is highly prone to malocclusion during the development of permanent dentition.

2. Shape of dental arch

In deciduous dentition, the dental arch is wider and almost in wide 'U' shape with spaces visible between teeth.

3. Terminal plane relation of the deciduous molars.

The relationship of the distal terminal planes of opposing second primary molar teeth can be classified into one of three categories:

- A flush terminal plane (flush terminus) means that the anterior-posterior positions of the distal surfaces of opposing primary second molars are in the same vertical plane.
- A mesial-step terminus is defined as a lower second primary molar terminal plane that is mesial to the maxillary primary terminus.
- The distal-step terminal plane is a situation in which the mandibular second primary molar terminus is distal to the upper second primary molar terminus.

4. Deep bite

5. Flat curve of Spee

6. Shallow cuspal interdigitation

7. Incisors are more vertically placed

Mixed Dentition Period

The mixed dentition period can be divided into three phases:

l. First transitional period

2. Inter transitional period

3. Second transitional period

1. First transitional period

The first transitional period is characterized by the emergence of the first permanent molars and the exchange of the deciduous incisors with the permanent incisors.

a) Eruption and occlusion of first permanent molar

The mandibular first molar is the first permanent tooth to erupt at around 6 years of age. *The location and relationship of the first permanent molar depends much upon the distal surface relationship between the upper and lower second deciduous molars.* The first permanent molars are guided into the dental arch by the distal surface of the second deciduous molars.

The deciduous molar relation determines the permanent molar relation as the later erupts into occlusion. ***Three distinct kinds of molar adjustment can occur:***

- ♦ Mesial shift during first permanent molar eruption occurs at the expense of any posterior spacing that might have been present Including breakdown spaces resulting from interproximal canes, proximal breakdown of the tooth crown and/or premature loss of the primary teeth. The occlusion forming a mesial step (distal surface of the lower second primary molar is mesial to the same surface of the maxillary molar) is most ideal for Class I development.

- A distal step (distal surface of the lower second primary molar is distal to the same surface of the maxillary molar) indicates a developing Class II malocclusion.
- Proper permanent molar occlusion was achieved from a straight terminal plane by a second mesial shift of the molars as second primary molars are exfoliated. This "late" shift of the mandibular first molar, often under the additional influence of the emerging second permanent molar, occurs at the expense of the leeway space with a decrease in the attendant arch length of 2—3 mm on average.

b) Exchange of incisors

During the first transitional period the deciduous incisors are replaced by the permanent incisors. The mandibular central Incisors are usually the first to erupt. The permanent incisors are considerably larger than the deciduous teeth they replace. This difference between the amount of space needed for the accommodation of the incisors and the amount of space available for this is *called incisal liability*. The incisal liability is roughly about *7 mm in the maxillary arch and about 5 mm m the mandibular arch.*

The mean increase in the *intercanine width was greater in the maxillary arch (3-4 mm) than in the mandibular arch (2-3 mm)*. In the mandibular arch, the greatest tendency to increased width was during *eruption of the lower lateral incisors*, whereas in the maxillary arch, it occurred primarily during eruption of the *maxillary central incisors.* Although the Increase was slightly greater in non-spaced primary arches than in spaced arches, the arches with spaces generally resulted in a favorable alignment of the permanent incisors. About 40% of the arches without primary dental spacing resulted in crowded anterior segments.

The regulatory factors controlling the arrangement of the four permanent incisors is as follows:

l. Utilization of the physiologic spaces that exists in the primary dentition.

2. Increase in the intercanine width.

3. Increase of anterior length in the dental arch will provide space to accommodate the larger permanent Incisors.

4. Both maxillary and mandibular permanent incisors show labial inclination much more than primary incisors making the permanent dental arch circumference wider for the arrangement of larger permanent Incisor.

Increase in the maxillary and mandibular arch width occurs between 6 weeks and 2 years of age. The mandibular intercanine width is established by 8 years of age (i.e., after eruption of the four incisors) and although the arch width increased between 3 and 13 years of age, there is a slight decrease in width, more in the intercanine than in the intermolar area, after complete eruption of the permanent teeth. Incisor alignment patterns and intercanine arch dimensions are essentially established by 8 years of age.

2. Intertransitional period.

It is a relatively lag phase with no active tooth movements to occur. The dental arches are comprised of both primary and permanent teeth. The maxillary and mandibular arches consist of permanent incisors and permanent molars that sandwich the deciduous canines and molars. This phase lasts for 1.5 years and is relatively stable. Only a few changes in the morphology of deciduous teeth are seen because they undergo attrition

3. Second transitional period

The second transitional period (also known as the late mixed dentition) between 9-12 years of age involves the exfoliation of the primary canines and molars in conjunction with the eruption of the permanent canines, premolars and second permanent molars.

a. Exchange of canines and premolar.

The space available for the canine and premolars is limited as the mesial surface of the first permanent molar forms its distal limit and the distal surface of the permanent lateral Incisor forms its mesial limit. The factors to be considered during this period are:

l) Leeway space of Nance
2) Ugly duckling stage.

1) Leeway space of Nance

The combined mesio-distal width of the permanent canines and premolars is usually less than that of the deciduous canines and molars. The surplus space is called Leeway space of Nance. The amount of leeway space is greater in the mandibular arch than in the maxillary arch. It is about 1.8 mm (0.9 mm on each side of the arch) in the maxillary arch and about 3.4 mm (1.7 mm on each side of the arch) in the mandibular arch. This excess space available after the exchange of the deciduous molars and canines is utilized for mesial drift of the mandibular molars to establish class I molar relation.

The most favorable dental arch pattern is one in which leeway space is excessive (i.e., combined sue of unerupted canine and premolars is smaller than arch space available). If leeway space is deficient, dental arch crowding predictably results. Average growth changes in the dental arch is not great enough to compensate for leeway deficiencies.

2) Ugly duckling stage

Also called Broadbent phenomenon. The term ugly duckling stage indicates the unaesthetic appearance of child during this stage. It is a transient or self-correcting malocclusion seen in the maxillary incisor region between 8-9 years of age, seen during the eruption of the permanent canines. As the developing permanent canines erupt, they displace the roots of the lateral incisors mesially. This results in transmitting of the force onto the roots of the central Incisors which also get displaced mesially. A resultant distal divergence of the crowns of the incisors occurs leading to creation of diastema in the incisor region. Broadbent named this as the ugly duckling stage as children tend to look ugly during this phase of development. Parents are often apprehensive during this stage and consult the dentist. This condition usually corrects by itself when canines erupt as the pressure is transferred from the roots to the crown of the incisors.

b. Eruption of the Second Permanent Molar

After the exchange of lateral teeth is completed and the dental arch up to the first molar is established, the second permanent molars begin to erupt. With the eruption of second permanent molar, the arch circumference may become shorter than that of the primary arch by utilization of the Leeway space.

DEVELOPMENT OF OCCLUSION

Occlusion develops from the primary dentition through the transitional (or mixed) dentition to the permanent dentition, a sequence of events occurs m an orderly and timely fashion. These events result in a functional, esthetic, and stable occlusion. When this sequence is disrupted, however, problems arise that may affect the ultimate occlusal status of the permanent dentition. When such disruptions do occur, appropriate corrective measures are needed to restore the normal process of occlusal development. Such corrective procedures may involve some type of passive space maintenance, active tooth guidance, or a combination of both. Usually, the tooth is maintained in its correct relationship in the dental arch as a result of the action of a series of forces. If one of these forces is altered or removed, changes in the relationship of adjacent teeth will occur.

Early loss of primary teeth may develop problems such as:

I -It may affect the alignment of the permanent dentition.
2-Opposing teeth can supra erupt.
3-More distal teeth can drift and tip mesially.
4- More forward teeth can drift and tip distally.
5-Altered tooth positions may include:

- **a)** "Symptomatic" space deficiency with loss of arch length and circumference.
- **b)** Blocked or deflected eruption of permanent teeth.
- **c)** Unattractive appearance.
- **d)** Food impaction areas.
- **e)** Increased caries and periodontal disease, and other negative aspects of malocclusion.

- ❖ The altered occlusal relationships may evidence traumatic interference and untoward jaw relationships. When early primary tooth loss occurs, corrective measures such as passive space maintenance, active tooth guidance with space regained, or a combination of both may be needed to optimize the normal process of occlusal development.

ARCH LENGTH ANALYSIS

Tooth size and alveolar size are the primary factors that determine the status of the permanent dental arch. If tooth size and arch size are not balanced, the effect on the permanent dental arch is crowding or spacing. Crowding is the most common feature of dental arch malocclusion. Only when the combined size of the permanent teeth is balanced with the size of the alveolar apical area is an ideal dental arch possible. Arch length analysis is done to estimate the space adequacy for the succedaneous tooth and to fairly predict how much space will be required for eruption and proper alignment in the dental arch.

Various analysis used for estimating space adequacy are:

1. Nance Analysis

This analysis compares the space required and space available to arrive at the arch length discrepancy. It is used during the mixed dentition period, as a result of comprehensive studies, Nance concluded:

l. The length of the dental arch from the mesial surface of one mandibular first permanent molar to the mesial surface of the corresponding tooth on the opposite side is always shortened during the transition from the mixed to the permanent dentition.

2. In the average patient's mandibular arch a leeway of 1.7 mm per side exists between the combined mesio-distal widths of the primary mandibular canine and first and second primary molars and the mesio-distal widths of the corresponding permanent teeth, with the primary teeth being larger.

3. This difference in the total mesio-distal width of the corresponding three primary teeth in the maxillary arch compared with the width of the three permanent teeth that succeed them is only 0.9 mm per side.

Method:

l. Measure the mesio-distal width of the erupted permanent teeth

2. Measure the mesio-distal width of each unerupted tooth, cuspids and bicuspids from intraoral periapical radiographs

3. The total mesio-distal width of all the teeth in each quadrant will indicate space required to accommodate the permanent teeth

4. Using brass wire, measure the arch perimeter

5. Compare the space required and space available to determine the arch length discrepancy

Limitations:

The Nance arch-length analysis is seldom used, partly because the involved procedures for this analysis require a complete set of periapical radiographs. The clinical reliability of other analyses that do not use radiographs is sufficient for determining major arch-length inadequacies.

2. Moyer's Mixed Dentition Analysis

There is high co-relation between sizes of different teeth m the same individual, thus making it possible to predict the size of unerupted tooth by looking at the teeth present in oral cavity. It is also used during the mixed dentition period.

Advantages:

- **a)** It has minimal error and the range of possible error is precisely known.
- **b)** It can be done with equal reliability either by a beginner or by an expert.
- **c)** It is not time consuming.
- **d)** It requires no special equipment.
- **e)** It can be completed in the mouth as well as on casts.
- **f)** It may be used for both arches.
- **g)** The analysis is based on a correlation of tooth size; one may measure a tooth or a group of teeth and predict accurately the size of the other teeth in the same mouth.
- **h)** The mandibular incisors, because they erupt early in the mixed dentition and may be measured accurately, have been chosen for measurement to predict the size of the upper, as well as the lower, posterior teeth.
- **i)** If the predicted value is greater than available arch length, crowding of teeth can be expected.

Method:

l. Measure the mesio-distal width of mandibular incisors
2. Measure the space for mandibular cuspids and bicuspids from the distal of aligned lateral incisor to mesial aspect of the first permanent molar
3. Measure the space for the maxillary cuspids and bicuspids from the distal aspect of aligned lateral incisor to mesial aspect of the first permanent molar
4. Using Moyer's probability chart find out sum total mesio-distal width of upper and lower cuspids and bicuspids for the given sum width of the lower central and lateral incisors at 75% probability
5. Compare the space available and space required in all four quadrants to determine arch length discrepancy

3.Tanaka and Johnston Analysis.

The Tanaka and Johnston method of arch-length analysis is a variation of Moyer's analysis except that a prediction table is not needed. It is also used during the mixed dentition period. **The method includes:**

1. The sum of the widths of the mandibular permanent incisors is measured and divided by 2.
2. For the lower arch, 10.5 mm is added to the result.
3. For the upper arch, 11 mm is added to the result to obtain the total estimated widths of the canines and premolars. For example, if the width of the lower incisors is 23 mm, divide by 2 and add 10.5 mm for the lower arch. The result is 22 mm compared with 22.2 mm obtained from Moyer's table.

4. One can then take these tooth mass predictions and compare them with the total measured arch length and obtain any inadequacies in the arch length.
5. If the result is positive, there is more space available in the arch than is needed for the unerupted teeth
6. If the result is negative, the unerupted teeth require more space than is available to erupt into ideal alignment

Advantages

- **a)** The technique involves simple, easily repeated procedures and minimal material needs.
- **b)** It does not use prediction charts.
- **c)** This method does not require additional radiographs, but it tends to over predict slightly the widths of the unerupted premolar.

4.Bolton analysis.

Also called as Bolton's tooth size ratio analysis. This analysis is used during the permanent dentition period. According to Bolton, a ratio exists between the mesio-distal widths of maxillary and mandibular teeth. This analysis addresses tooth mass discrepancies between the maxillary and mandibular arches.

1. It can be used to compare the sum of the mesio-distal widths of the 12 maxillary teeth with that of the 12 mandibular teeth, first molar to first molar, and to compare the 6 maxillary teeth with the 6 mandibular teeth, canine to canine.
2. The Bolton analysis ratio measurement is as follows:
   - **a)** If overall ratio is <91.5%, it indicates maxillary tooth material excess which is determined by:

     Sum of mandibular = sum of maxillary / 100 x 91.3

   - **b)** If overall ratio is >91.5%, it indicates maxillary tooth material lack which is determined by:

     Sum of maxillary = sum of mandibular / 100 x 91.3

   - **c)** If the anterior ratio is <77.2%, it indicates maxillary anterior excess which is determined by:

     Sum of mandibular = sum of maxillary / 100 x 77.2

   - **d)** If the anterior ratio is >77.2%, it indicates mandibular anterior excess which is determined by:

     Sum of maxillary = sum of mandibular / 100 x 77.2

3. When a significant discrepancy with these ratios is noted, the clinician must assess where the tooth mass problem is located and decide on the best method to resolve it.