DEVELOPMENT OF MAXILLA AND MANDIBLE

INTRODUCTION:

- Both the maxilla and mandible form from the tissues of the first branchial arch, the mandible forming within the mandibular process and the maxilla within the maxillary process.

DEVELOPMENT OF MANDIBLE:

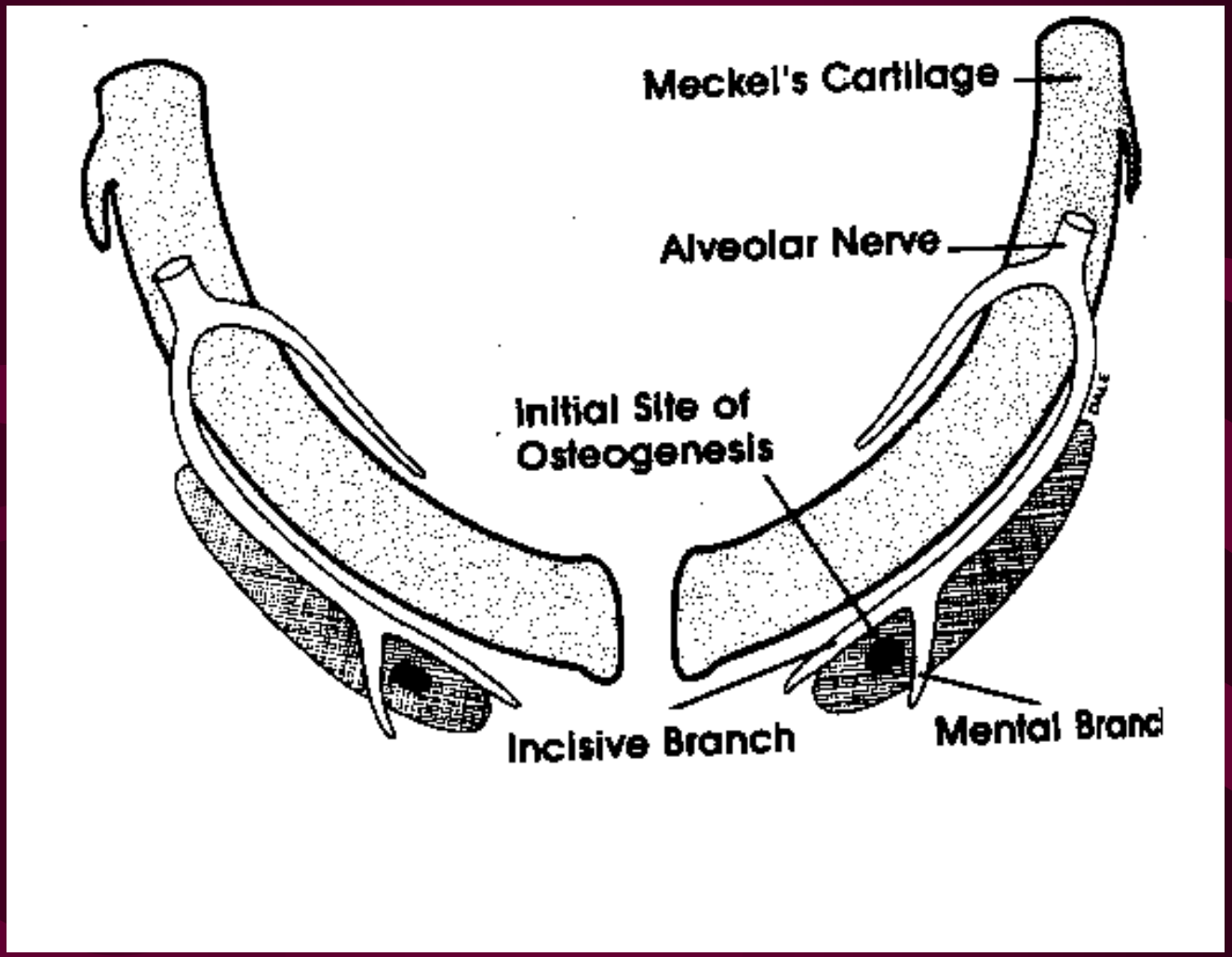
PRENATAL:

- BODY OF MANDIBLE-

- The cartilage of the first arch (Meckel's cartilage) forms the lower jaw in primitive vertebrates. In humans, it has close positional relationship to the developing mandible but makes no contribution to it.
- At six weeks of development this cartilage extends as a solid hyaline cartilagenous rod, surrounded by a fibrocellular capsule from the developing ear region (otic capsule) to the midline of fused mandibular processes.
- The cartilages of each side do not meet in the midline but are separated by a thin band of mesenchyme.

- The mandibular branch of trigeminal nerve (the nerve of the first arch) has a close relationship to Meckel's cartilage, beginning 2/3rds of the way along the length of the cartilage. At this point the mandibular N. divides into lingual and inferior alveolar branches, which run along the medial and lateral aspects of the cartilage respectively. The inferior alveolar N. further divides into incisal and mental branches more anteriorly.
- On the lateral aspect of Meckel's cartilage, during the sixth week of development a condensation of mesenchyme occurs in the angle formed by the division of inferior alveolar N. and its mental and incisor branches.

- Site of initial osteogenesis of mandible



- At 7 weeks, intramembranous ossification begins in this condensation forming the first bone of the mandible.
- From this center of ossification, bone formation spreads rapidly anteriorly to the midline and posteriorly towards the point where the mandibular N. divides into its lingual and inferior alveolar branches.
- This spread of new bone formation occurs anteriorly along the lateral aspect of Meckel's cartilage, forming a trough that consists of lateral and medial plates that unite beneath the incisor N. This trough of bone extends to the midline, where it comes into close approximation with a similar trough formed in the adjoining mandibular process. The two separate centers of ossification remain separated at the mandibular symphysis until shortly after birth.
- The trough is soon converted into a canal as bone forms over the nerve joining the lateral and medial plates.

- Similarly a backward extension of ossification along the lateral aspect of Meckel's cartilage forms a gutter later converted into a canal, that contains the inferior alveolar N. This proceeds in the condensed mesenchyme to the point where the mandibular N. divides into lingual and inf. Alveolar nerves.
- From this bony canal containing inf. Alv. N. medial and lateral alveolar plates of bone develop in relation to the forming tooth germs, so that tooth germs occupy a secondary trough of bone.
- This trough is partitioned and thus the teeth occupy individual compartments, which are finally totally enclosed by bone growth over the tooth germ.
- In this way the body of the mandible is essentially formed.

- **Ramus of the mandible-**

- It develops by a rapid spread of ossification posteriorly into the mesenchyme of the first arch turning away from Meckel's cartilage.
- This point of divergence is marked by the lingula in the adult mandible, the point at which the inf. Alv. N. enters the body of the mandible.
- Thus by 10 weeks the rudimentary mandible is formed almost entirely by membranous ossification with little direct involvement of Meckel's cartilage. Meckel's cartilage has the following fate:

-most posterior extremity forms the malleus of the inner ear.

-its fibrocellular capsule forms sphenomandibular ligament.

The further growth of mandible until birth is strongly influenced by the appearance of three secondary (growth) cartilages and the development of muscular attachments.

1. Condylar cartilage
2. coronoid cartilage
3. symphyseal cartilage

- Secondary cartilages differ from primary cartilage in their cells being larger and there being less intercellular matrix.

1. ***Condylar cartilage***: appears during 12th week of development and rapidly forms a cone or carrot-shaped mass that occupies most of the developing ramus. This mass of cartilage is quickly converted to bone by endochondral ossification so that at 20 weeks only a thin layer of cartilage remains in the condylar head. This remnant of cartilage persists until the end of second decade of life, providing for growth of mandible in the way as epiphyseal cartilage does.

2.***Coronoid cartilage***:

appears at about 4 months of development, surmounting the anterior border and the top of coronoid process. It is relatively transient growth cartilage disappearing long before birth.

3.***Symphyseal cartilages***:

two in number appear in the conn. tissue between the two ends of Meckel's cartilage, but are entirely independent of it. They are obliterated within the 1st year after birth.

Thus mandible is a membrane bone, developed in relation to the nerve of the 1st arch and almost entirely independent of Meckel's cartilage.

- **Development of T.M.J.**

- T.M.J. is an articulation between two bones formed from membranous centers of ossification.
- Before condylar cartilage forms, there is a broad band of undifferentiated mesenchyme between the developing ramus of mandible and the developing squamous tympanic bone.
- With formation of condylar cartilage this band is rapidly reduced in width and converted into a dense strip of mesenchyme.
- The mesenchyme immediately adjacent to the strip breaks down to form the joint cavity, and the strip becomes the articular disc of the joint.

- ***Postnatal:***

➢ Of the facial bones, the mandible undergoes undergoes the largest amount of growth post-natally and also exhibits the largest variability in morphology. Development of different parts of mandible is briefly described as under:

➢ **Ramus**- progressively moves posterior by a combination of deposition and resorption. Resorption occurs on the anterior part of ramus and deposition on the posterior region which leads to a drift in a posterior direction.This is to:

1. accommodate the increasing mass of masticatory muscles inserted into it.
2. accommodate increasing width of pharyngeal space.
3. facilitate lengthening of mandibular body to accommodate the erupting molars.

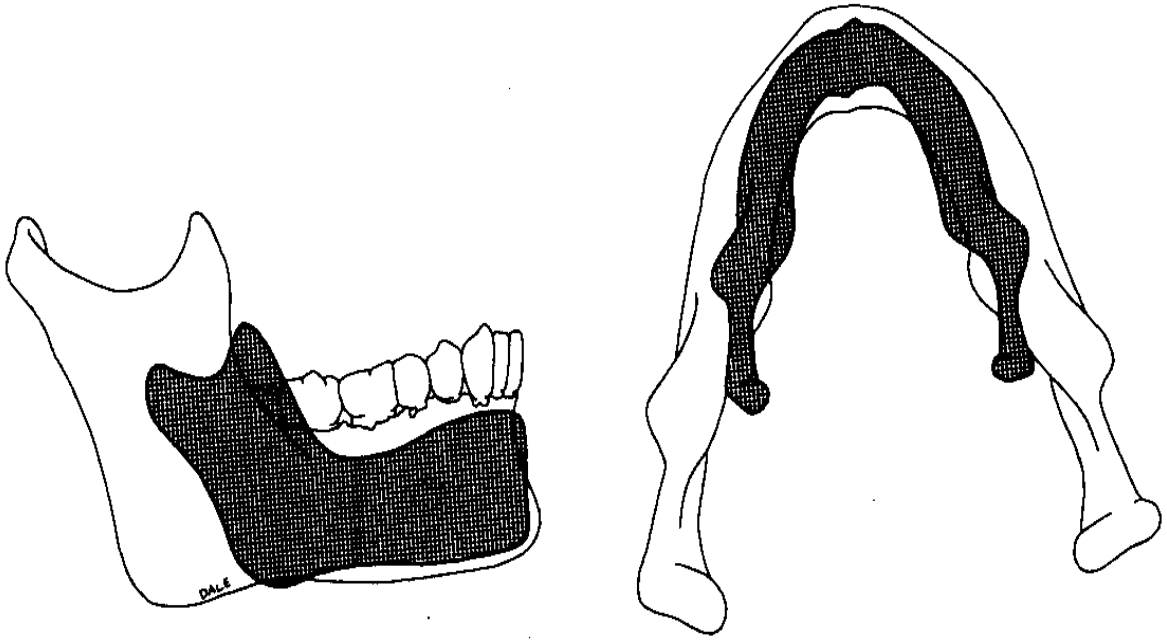


Figure 19-21 Posterior and superior condylar and ramal remodeling produces a backward relocation of the whole ramus. In turn, the mandibular corpus becomes lengthened by remodeling conversions from former parts of the backward-moving ramus.

- **Corpus or body of the mandible-**
- posterior drift of the ramus leads to conversion of former ramal bone into the posterior part of the body of mandible.In this manner the body of mandible lengthens.
- **Angle of the mandible-**
- On the lingual side of the angle of mandible, resorption takes place on the postero-inferior aspect while deposition occurs on antero-superior aspect .
- On the buccal side, resorption occurs on anterior-superior part while deposition takes place on the postero-superior part. This results in flaring of angle of mandible as age advances.

- **The lingual tuberosity-**

- moves posteriorly by deposition on its posterior facing surface.
- It protrudes noticeably in a lingual direction and it lies well towards the midline of the ramus.
- Its prominence is increased by the presence of a large resorption field just below it.

The chin-

- In infancy chin is underdeveloped.As age advances, the growth of chin becomes significant which is influenced by sexual and genetic factors.
- Mental protuberance forms by bone deposition during childhood. Its prominence is increased by bone resorption in the alveolar region above it which creates concavity.

- **The condyle-**

➢ It was earlier believed that as condyle grows towards the cranial base, the entire mandible gets displaces forwards and downwards.

➢ It is now believed that the growth of soft tissues, including muscles and conn. tissues carries the mandible away from the cranial base. Bone growth occurs secondarily at the condyle to maintain constant contact with cranial base.

➢ Condylar growth increases at puberty reaching peak at 12 &1/2 –14 years. The growth ceases around 20 years of age.

The coronoid process-

➢ Its growth follows the enlarging 'V' principle. Viewing the longitudinal section of the coronoid process from the posterior aspect, it can be seen that deposition occurs on the lingual (medial) surfaces of the left and right coronoid process.

- Although additions take place on the lingual side, the vertical dimension of the coronoid process also increases. This follows the ‘V’ principle.
- Briefly the coronoid process has a propeller like twist so that its lingual side faces three general directions all at once, i.e. posteriorly, superiorly and medially.

- **DEVELOPMENT OF MAXILLA:**
- ***Prenatal:***
- By around the 4th week of intrauterine life, five branchial arches form in the region of the head and neck. The first branchial arch is called the mandibular arch.
- The mesoderm covering the developing forebrain proliferates and forms a downward projection that overlaps the upper part of stomodeum called the frontonasal process. The stomodeum is thus overlapped superiorly by the fronto-nasal process. Mandibular arches of both sides form the lateral walls of stomodeum. The mandibular arch gives off a bud from its dorsal end called maxillary process.

- Maxillary process grows ventro-medio-cranial to the main part of mandibular arch which is now called mandibular process. Thus stomodeum is overlapped from above by frontal process, below by the mandibular process, and on either side by the maxillary process. Now the formation of nasal pits divides the fronto-nasal process into:
- a. medial nasal process
- b. lateral nasal process
- Line of fusion of medial nasal process with maxillary process corresponds to the naso-lacrimal duct.
- · The maxilla develops from a center of ossification in the mesenchyme of the maxillary process.
- · No arch cartilage or primary cartilage exists in the maxillary process, but the center of ossification is closely associated with the cartilage of the nasal capsule.
- ·

- The center of ossification appears in the angle between the division of a nerve. (i.e. where the anterosuperior dental N. is given off from the inferior orbital N.)
- From this center, bone formation spreads
- posteriorly below the orbit towards the developing Zygoma and
- anteriorly towards the future incisor region
- superiorly to form the frontal process
- as a result, a bony trough forms for the infraorbital N.
- From this trough, a downward extension of bone forms the lateral alveolar plate of maxillary tooth germs.

- Ossification also spreads into the palatine process to form the hard palate.
- Medial alveolar plate develops from the junction of the palatal process and the main body of the forming maxilla.
- This plate together with the lateral counterpart forms a trough of bone around the maxillary tooth germs.
- A secondary cartilage- Zygomatic or malar cartilage appears in the developing zygomatic process and for a short time adds considerably to the development of the maxilla.
- At birth, the frontal process of maxilla is well marked, but the body consists of the alveolar process containing tooth germs, small though distinguishable zygomatic and palatal process.

- The body of the maxilla is relatively small because the maxillary sinus is not developed. This sinus forms during 16^{th} week as a shallow groove on the nasal aspect of developing maxilla.It develops by expansion of the nasal mucous membrane into the maxillary bone. Later the sinus enlarges by resorption of the internal walls of the maxilla.

- **DEVELOPMENT OF PALATE:**
- The palate is formed by contributions of the:
- a. Maxillary process
- b. Palatal shelves given off by the maxillary process
- c. Frontonasal process
- As the palatal shelves grow medially, their union is prevented by the presence of tongue. Thus initially the developing palatal shelves grow vertically downwards towards the floor of the mouth. Sometime, during the seventh week of intrauterine life, a transformation in the position of the palatal shelves from a vertical to a horizontal position. This transformation is believed to take place within hours.

- Withdrawal of the embryonic face from against the heart prominence results in slight jaw opening. This results in withdrawal of tongue from between the palatal shelves and aids in their elevation.
- By 8 ½ weeks two palatal shelves are in close approximation with each other. As they join the epithelial cells degenerate. The conn. tissue intermingles resulting in their fusion.
- The entire palate does not contact and fuse at the same time. Initially contact occurs in the central region posterior to the premaxilla. From this point, closure occurs both anteriorly and posteriorly. The mesial edges of the palatal processes fuse with the free lower end of nasal septum and thus separates the two nasal cavities from each other and the oral cavity.

Ossification of palate occurs from the 8th week of intra-uterine life. This is an intramembranous type of ossification. The most posterior part of palate does not ossify. This forms the soft palate. The mid palatal suture ossifies by 12-14 years.

Problem of the premaxilla:

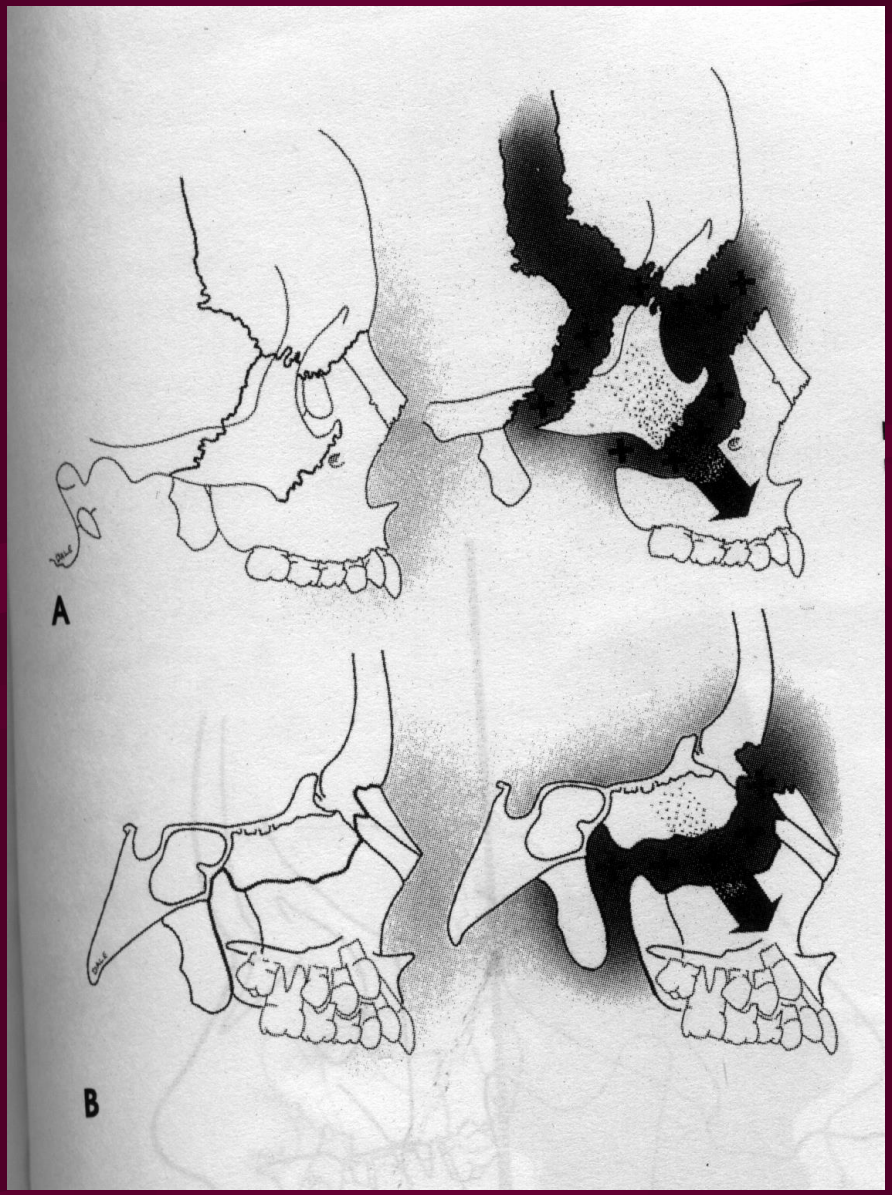
A separate premaxilla is found in most of the mammalian jaws, including those of primates. It however does not occur in humans.

Because it is possible to distinguish an apparent suture line on the palatal surface of the maxilla diverging from the incisive fossa and running to the septa that separate the lateral incisors from the canines, a premaxilla was presumed to have existed sometime in the maxillary development.

However recent study of serial sections through developing human maxilla has established that what seems to be multiple centers is in fact a lamina of bone of complex shape that has developed from one ossification center.

- **Development of alveolar process:**
- Near the end of the second month of fetal life the maxilla as well as the mandible forms a groove that is open towards the surface of the oral cavity.
- Tooth germs are contained in this groove, which also includes the alveolar nerves and vessels.
- Gradually bony septa develop between the adjacent tooth germs and much later the primitive mandibular canal is separated from the dental crypts by a horizontal plate of bone.
- An alveolar process develops only during the eruption of the teeth. During the period of rapid growth a tissue may develop at the alveolar crest that combines characteristics of cartilage and bone. It is called chondroid bone.
- The alveolar process forms with the development and eruption of teeth and conversely it gradually diminishes in height with the loss of teeth.

- ***Post-natal:***
- · The whole of maxilla is continuously displaced anteriorly throughout the growth period. This displacement occurs because expansion of all the facial soft tissues causes a ‘carrying’ effect, moving the bony maxillary complex with them.
- · As maxillary arch moves anteriorly by displacement, a ‘space’ is continuously being created in the region behind the maxilla.


A
B

- The bony maxillary arch grows and elongates posteriorly by bone deposition on the posterior facing surface of maxillary tuberosity. Resorption occurs on the inner surface of the tuberosity which is the posterior wall of the maxillary sinus. The sinus thereby progressively enlarges.
- The displacement of the whole nasomaxillary complex also causes a progressive separation at all the various facial sutures, which triggers the growth of new bone at the sutural edges. This sustains constant articulation at sutural junctions.
- All other inner and outer surfaces of maxillary complex are also involved in regional resorption and deposition and the result is progressive enlargement and reshaping of the entire region.

- In addition to downward displacement and sutural growth, the palate and the maxillary arch grow directly downward by remodeling. In general, upward facing surfaces are resorptive and downward facing surfaces depository, thus producing a downward direction of growth. The nasal side of the hard palate thereby has a resorptive surface and the oral side a depository surface.

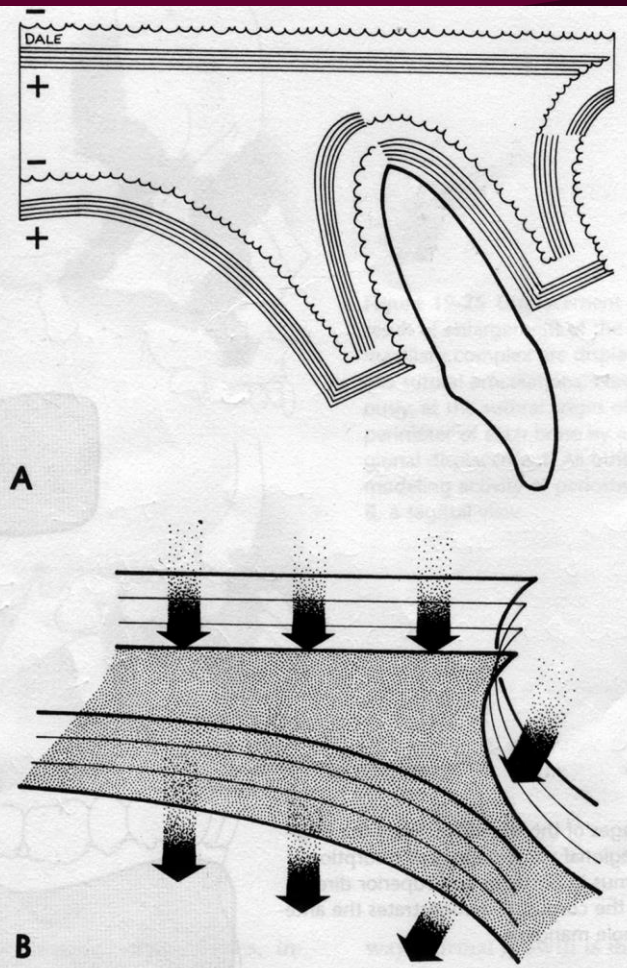


Figure 19-23 Downward remodeling of the palate. This is produced by deposition on the inferior-facing (oral) side and resorption from the superior-facing (nasal) side, thus bringing about a progressive and continuous inferior relocation of the whole palate and maxillary arch, **A.** The maxillary teeth are moved downward at the same time by a process of vertical drift associated with remodeling (resorption and deposition) of alveolar bone, **B.**

- Post-natal development of alveolar process:
- The alveolar bone of the incisor region is remodeling downward alongwith other parts of maxilla.

 Maxillary teeth move downwards by displacement and remodeling. These processes occur simultaneously. The entire dental arch is being displaced as a unit and each tooth is moving downward in conjunction with the remodeling of its bony alveolar socket. The latter process is termed vertical drift and the periodontal ligament produces it,

Eruption is the movement of a tooth out of its socket, whereas vertical drift is a combined movement of the tooth and its socket and constitutes a posteruptive event.

- · Most of the downward displacement of the mandibular dentition is provided by vertical enlargement of the ramus. As maxillary arch descends and nasal region expands, the obliquely upward and backward lengthening of ramus produces an equivalent inferior and anterior placement of lower arch.
- · Much less vertical upward drift occurs for mandibular teeth than vertical downward drift for maxillary teeth. Thus less alveolar remodeling occurs for mandibular teeth than the maxillary teeth.
- · Mandibular incisors as they erupt and drift upward into occlusion come into a normal overjet and overbite relationship with the maxillary incisors.
- · Upper teeth overlap and produce a backward tipping of the mandibular incisors as they drift superiorly. The labial side of alveolar bone is resorptive, together with remodeling of alveolar socket.

- · Bone deposition of the mental protuberance, with retroclination of the incisors, produces a gradually enlarging chin.

- CURVE OF OCCLUSION:
- · Because of long vertical human face, there is a tendency for mandible and occlusal plane to have a downward and backward rotation. This rotational alignment would produce an anterior open bite but for a compensatory action on the part of the dentition, the mandibular incisors and their alveolar sockets undergo additional upward drift, which closes the occlusion in incisor region.
- · The occlusal plane has a characteristic curve that tends to be more or less marked according to the downward rotation of the mandible produced by vertical growth of the nasomaxillary region.
- · As the mandibular anterior teeth undergo this vertical drifting process, their axial inclinations shift to a more upright alignment, till they come into occlusion with the right oriented maxillary teeth.