DEPARTMENT OF ORAL AND MAXILLOFACIAL PATHOLOGY & ORAL MICROBIOLOGY

ALVEOLAR BONE

DEVELOPMENT OF MAXILLA AND MANDIBLE

DEVELOPMENT OF ALVEOLAR PROCESS

STRUCCTURE OF ALVEOLAR PROCESS

PHYSIOLOGIC CHANGES IN ALVEOLAR PROCESS

INTERNAL RECONSTRUCTION OF BONE

CLINICAL CONSIDERATION

- **DEVELOPMENT OF MAXILLA AND MANDIBLE :**
- In the beginning of the second month of fetal life the skull consist of 3 parts.

- 1) The chondrocranium, which is cartilaginous is made up of the base of the skull with the otic and nasal capsules.

- 2) The desmocranium, which is membranous, forms the lateral walls and root of the braincase.

- 3) The appendicular or visceral parts of the skull, which is cartilaginous, consist of the skeletal rods of the branchial arches.

- **MAXILLA :**
- The Human maxilla is homologous to two bones, the maxilla proper and the premaxilla

- - The ossification centers of the premaxilla and maxilla may be separate for a very short time or only one centers of ossification.Therefore humans may not have and independent maxilla.

- - The composition of the human maxilla from premaxilla and maxilla is indicated by incisive fissure, which is clearly visible in palate of young skull, where it extends from the incisive foramen to the alveolus of the canine.

- **MANDIBLE :**
- - It appear as a bilateral structure in the sixth week of fetal life as a thin plate of bone lateral to, and at some distance from Meckel's cartilage.
- - The greater part of Meckel's cartilage disappears without contributing to the formation of the bone of the mandible. Only a small part of the cartilage, some distance from the midline, is the site of endochondral ossification.
- - Here the cartilage calcifies and is destroyed by chrondoclasts, being replaced by connective tissue and then by bone.
- -

Developing tooth

Inf. Alv. nerve

Meckel's cartilage

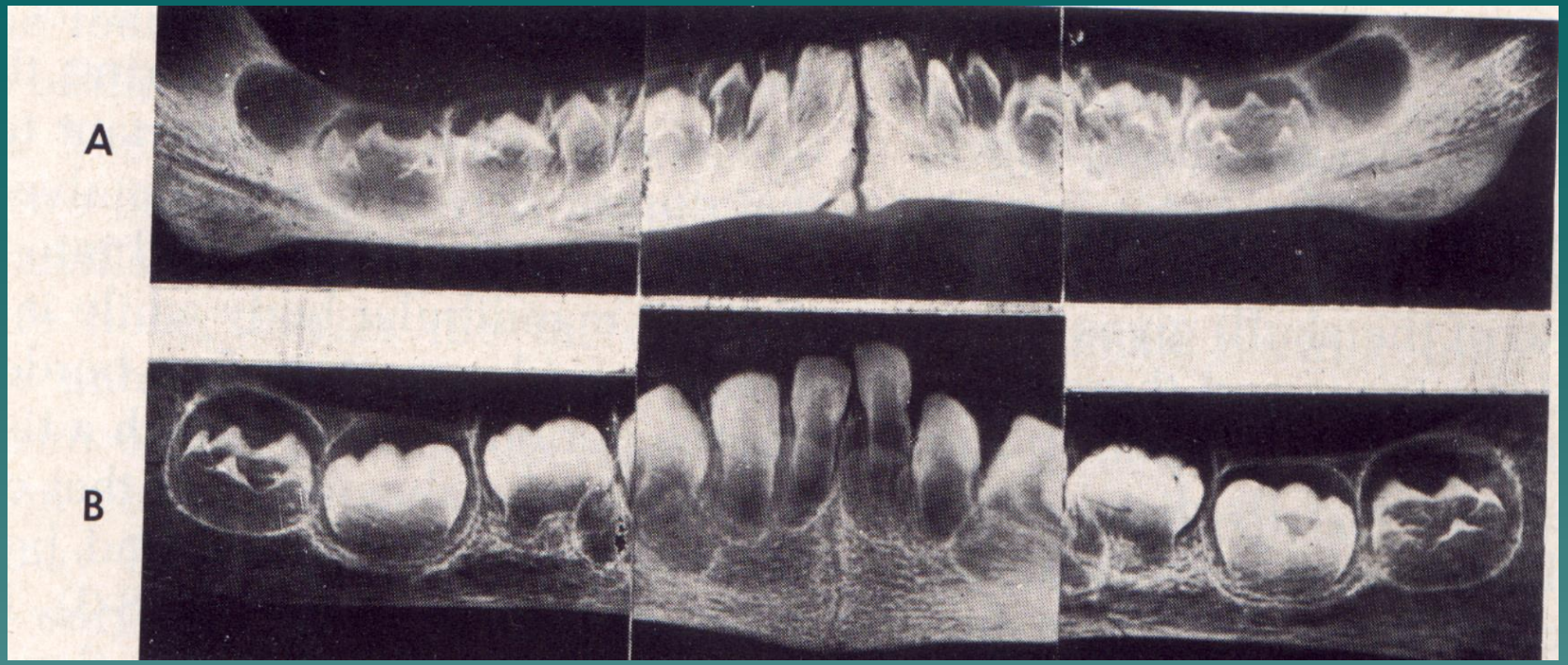
Body of mandible

Development of mandible as intramembranous bone lateral to meckel"s cartilage

Throught fetal life the mandible is a paired bone. Right and left mandibles are joined in the midline by fibro cartilage in the mandibular symphysis.

This cartilage is differentiates from the connective tissue in the midline. In it, small irregular bones, known as the mental ossicles develop and at the end of the first year fuse with the mandibular body.

- At the same time the two halves of the mandible unite by ossification of symphyseal fibro cartilage.



Development of mandibular symphysis

DEVELOPMENT OF ALVEOLAR PROCESS :

- Near the end of the second month of fetal life the maxilla and mandible forms a groove that is opened towards the surface of the oral cavity. This groove, contains tooth germs, alveolar nerves and vessels.
- Gradually bony septa, develop between 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 in the strict sense of the word, develops only during the eruption of the teeth. During growth part of the alveolar process is gradually incorporated into the maxillary and mandibular body while it continues growing at its free borders.

- During the period of rapid growth, a tissue may develop at the alveolar crest that combines characteristics of cartilage and bone and is called *chondroid bone.*
- The alveolar process forms with the development and the eruption of teeth, and conversely, it gradually diminishes in height after the loss of teeth.

STRUCTURE OF ALVEOLAR PROCESS :

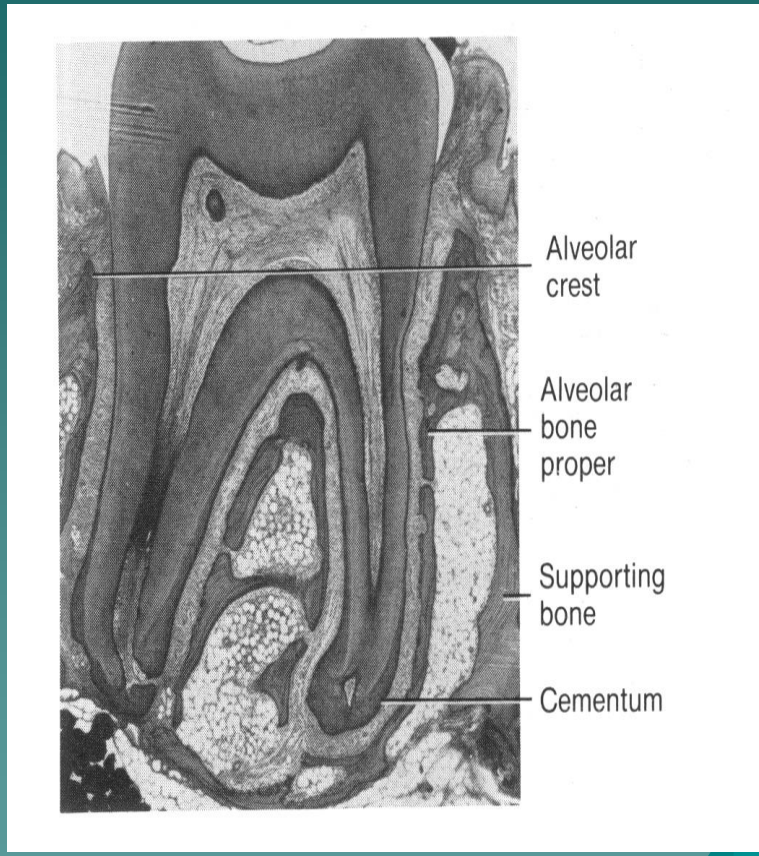
- It may be defined as that part of the maxilla and mandible that forms and supports the sockets of the teeth.

- Anatomically no distinct boundary exists between the body of the maxilla, or the mandible and their respective alveolar processes.

- The alveolar process is composed of two parts. They are

(1)Alveolar bone proper

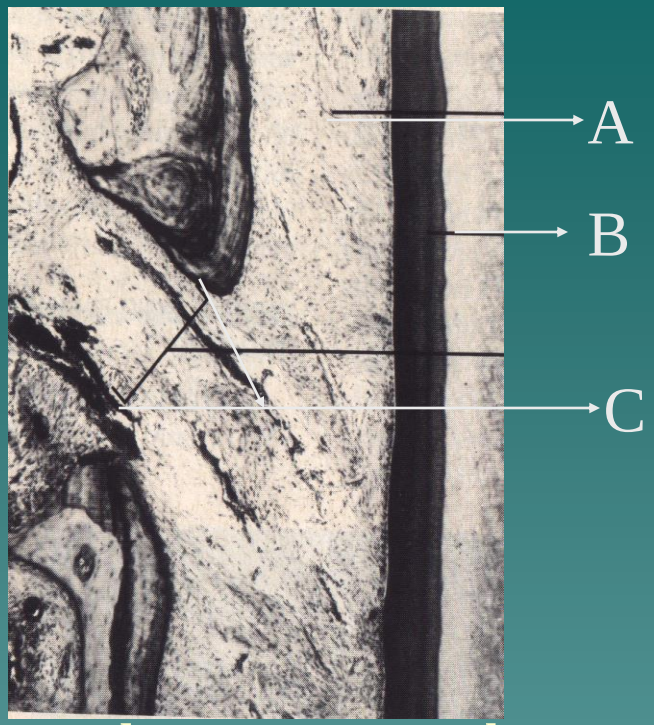
(2)Supporting alveolar bone



1) Alveolar bone proper :

- It consists of a thin lamella of bone that surrounds the root of the tooth and gives attachment to principle fibers of the periodontal ligament.

- It is perforated by many openings that carry nerves and blood vessels into the periodontal ligament, therefore it is called the “cribriform plate”.

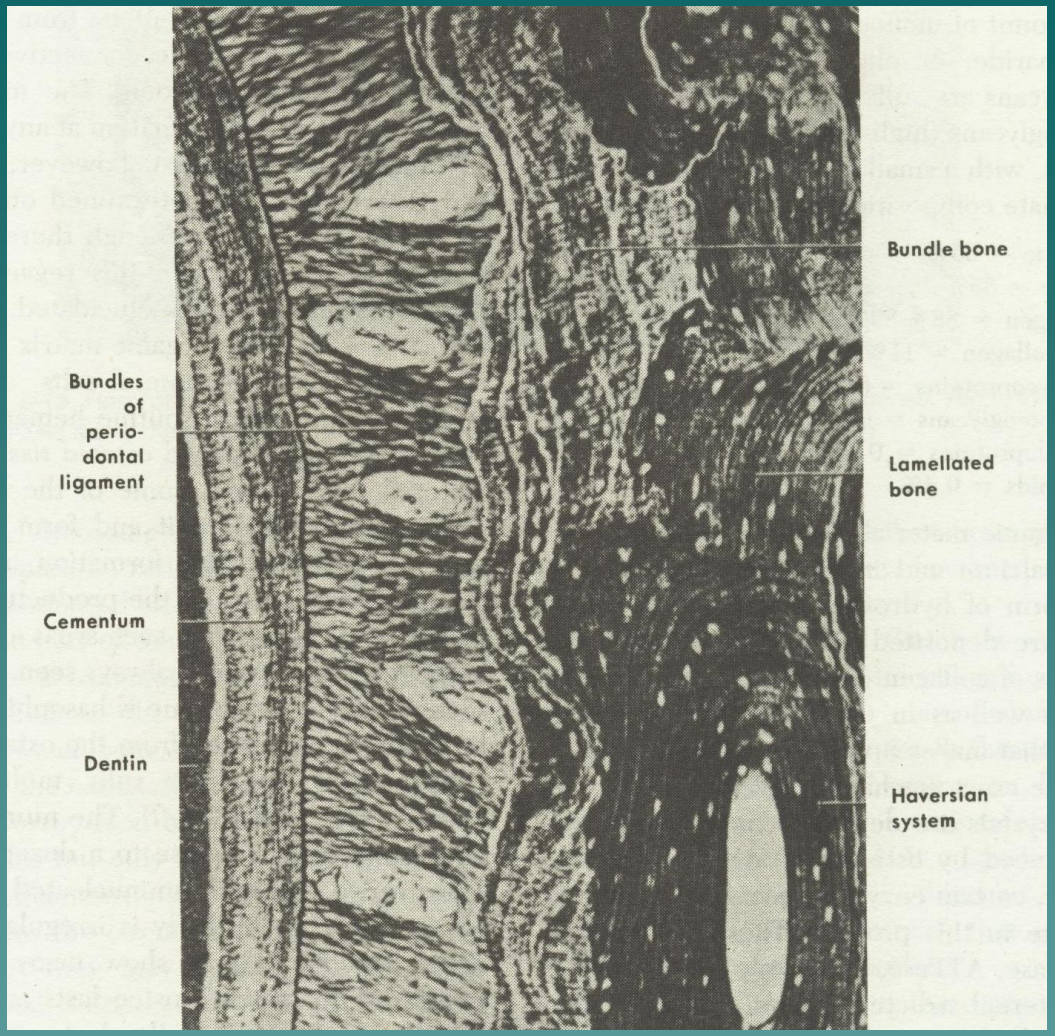


Histologic section showing foramen in alveolar bone proper (cribriform plate)

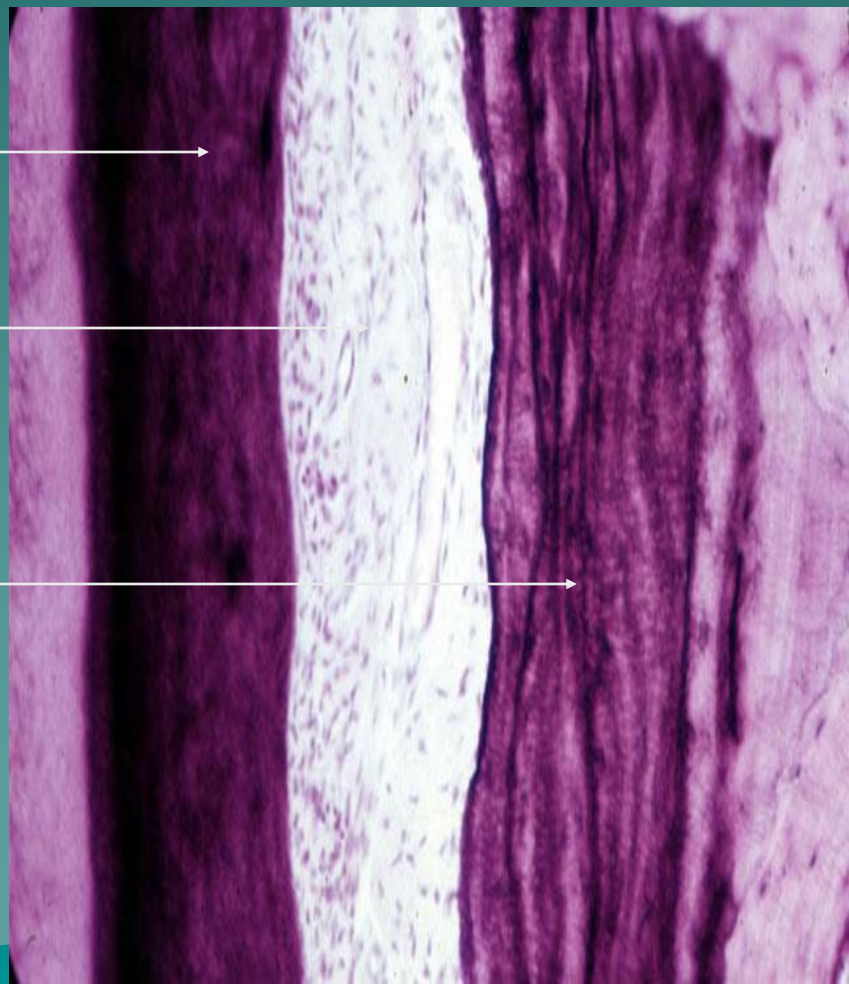
A-Periodontal ligament
B-Cementum
C-Foramen in alv. Bone proper

Consists of

- lamellated bone and
- bundle bone.



- The bundle bone is that bone in which the principal fibers of the periodontal ligament are anchored.
- The term “bundle bone” was chosen because the bundles of the principal fibers continue into bone as sharpey’s fibers.



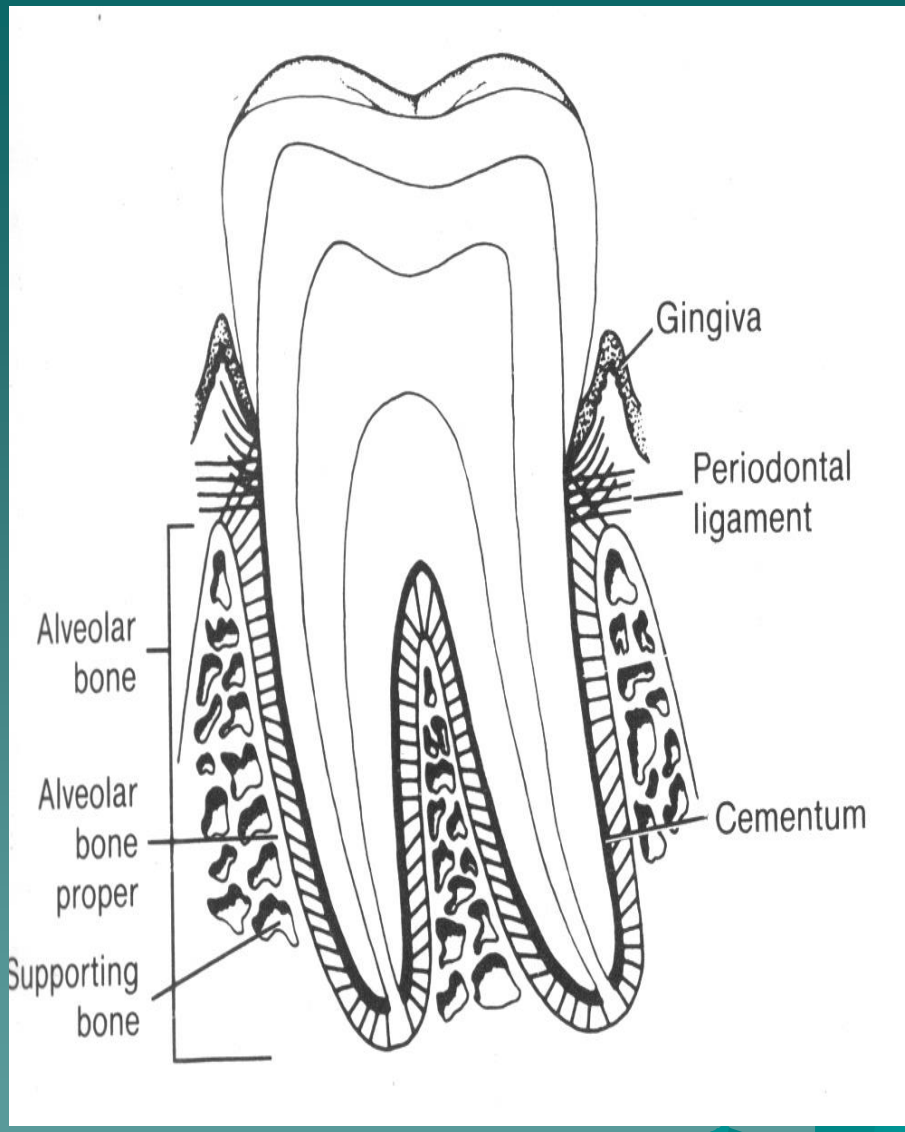
2) Supporting alveolar bone :

- It is that part of the bone which surrounds the alveolar bone proper and gives support to the socket.

- It consists of two parts :

a) Cortical plates

b) Spongy bone :



a) Cortical plates :

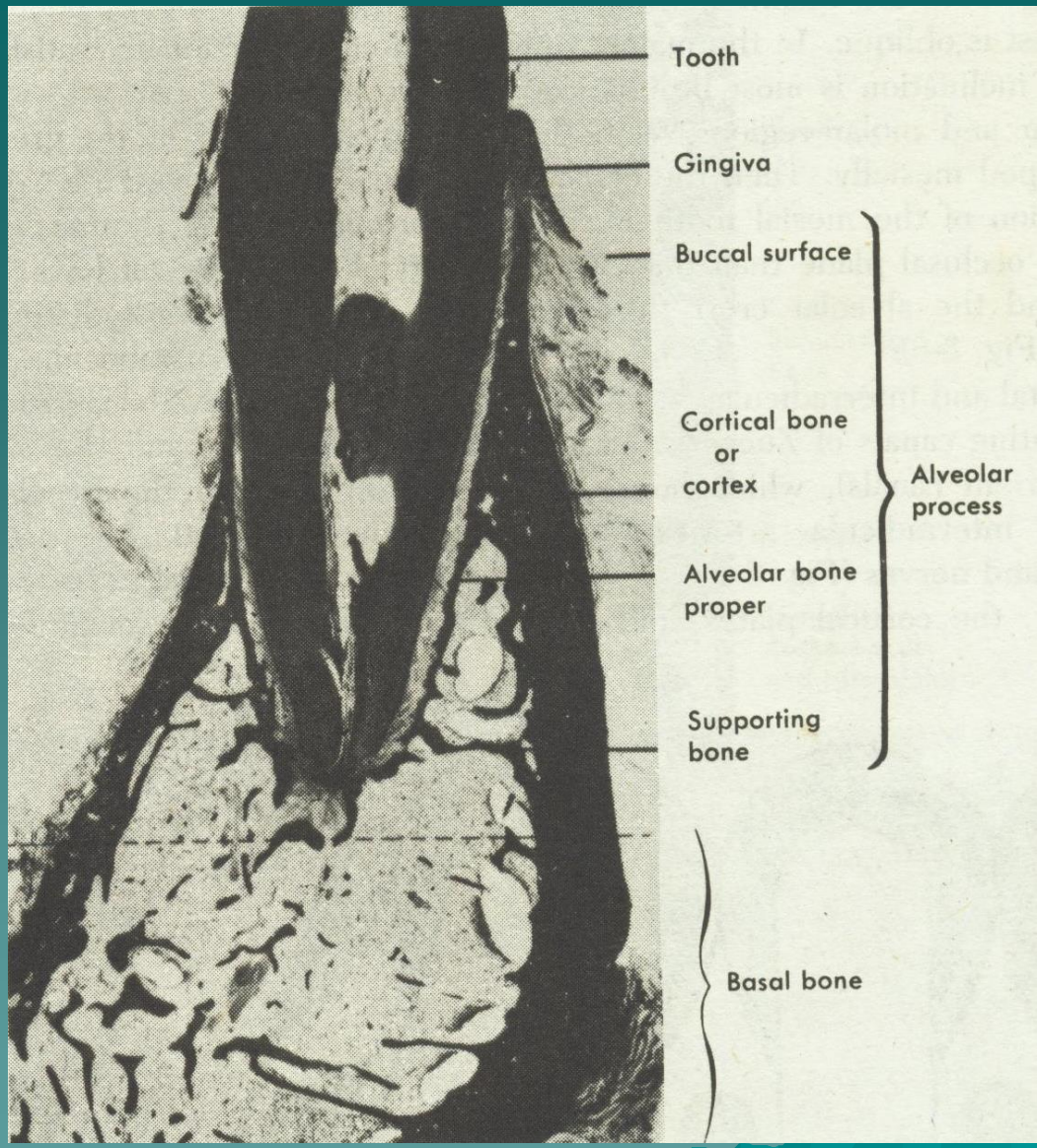
- They consist of compact bone and form the outer and inner plates of the alveolar processes.

- They are continuous with the bony maxilla and mandible and are much thinner in the maxilla than in the mandible. They are thickest in the mandibular premolar and molar regions especially on the buccal side.

- In the maxilla the outer cortical plate is perforated by many small openings through which blood and lymph vessels pass. In the mandible it is dense.

b) Spongy bone :

- It fills the area between cortical plates and the alveolar bone proper.
- In the region of the anterior teeth of both jaws the supporting bone is usually thin, so no spongy bone is found here and the cortical plate is fused with the alveolar bone proper.



- The shape of the outlines of the crest of the alveolar septa in the roentgenogram is dependent on the position of the adjacent teeth. In a healthy mouth the distance between CE junction and the free border of the alveolar bone proper is fairly constant.

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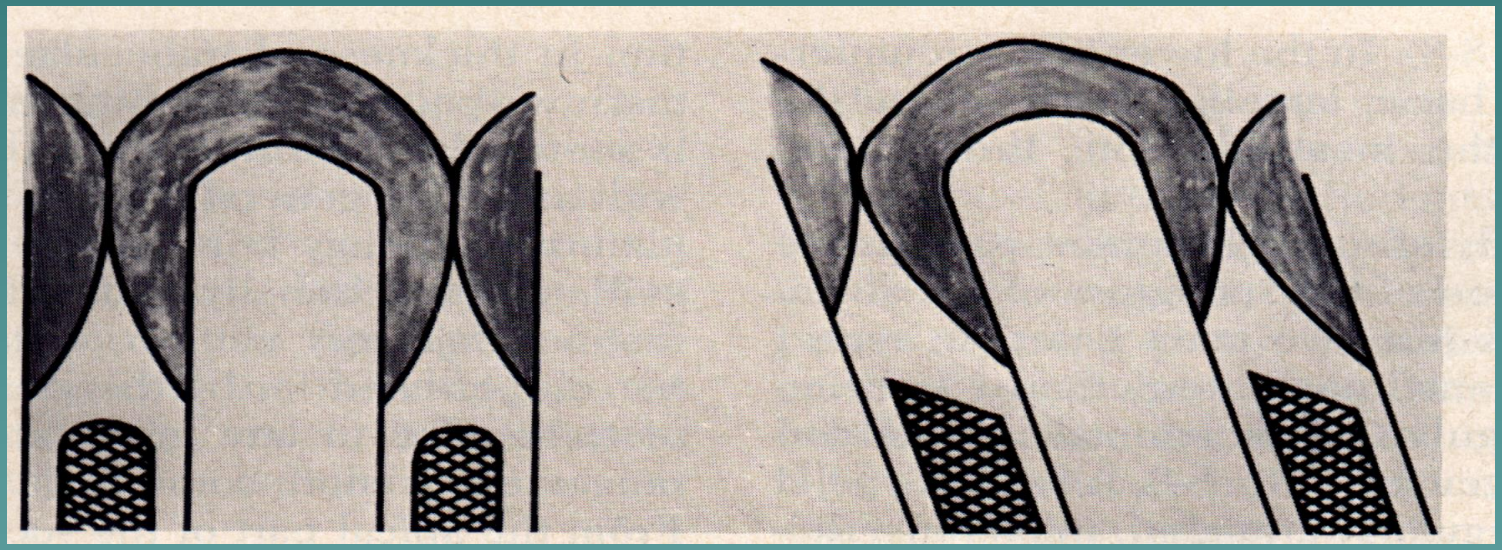
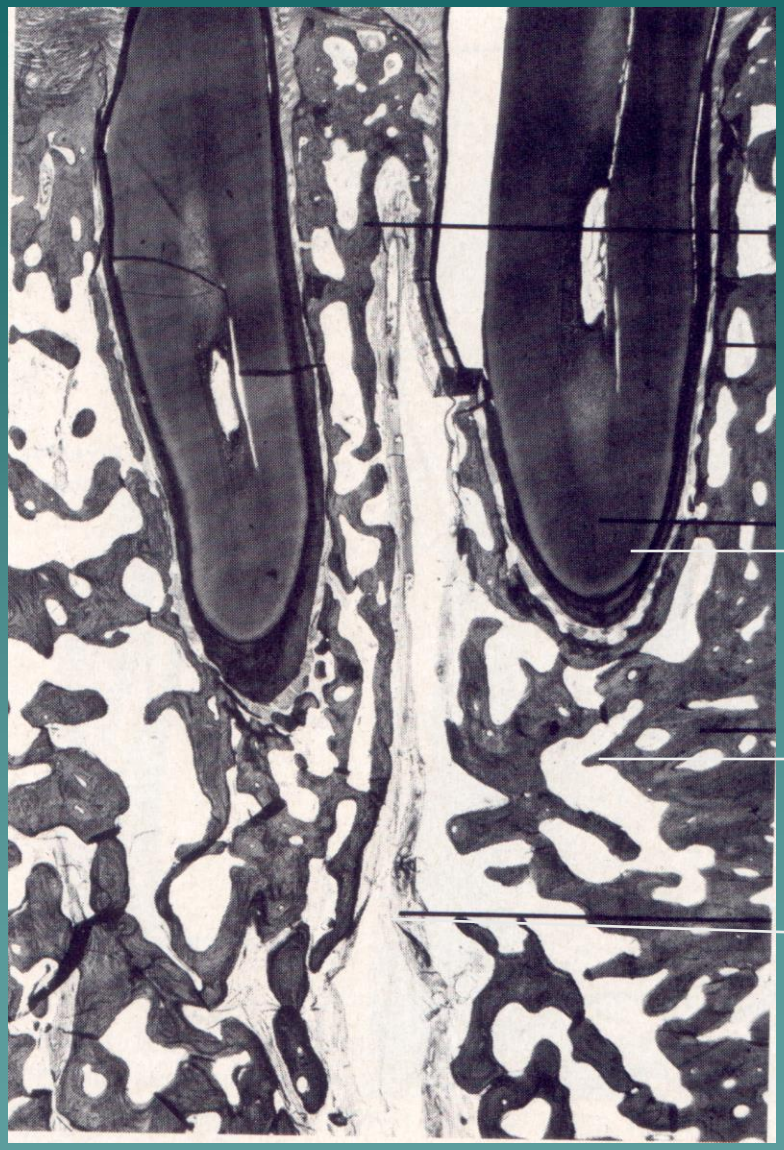
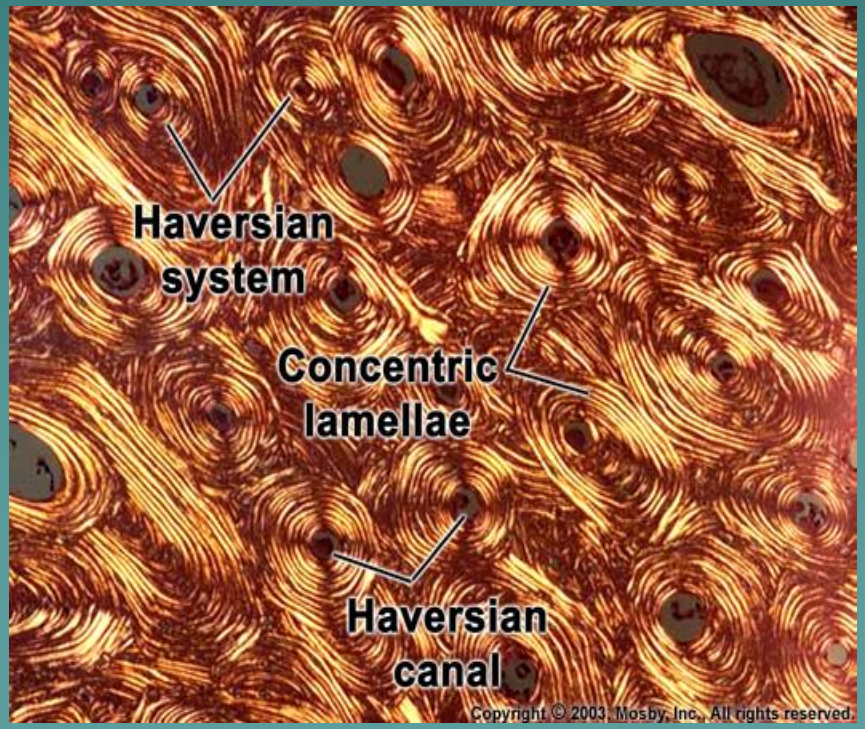


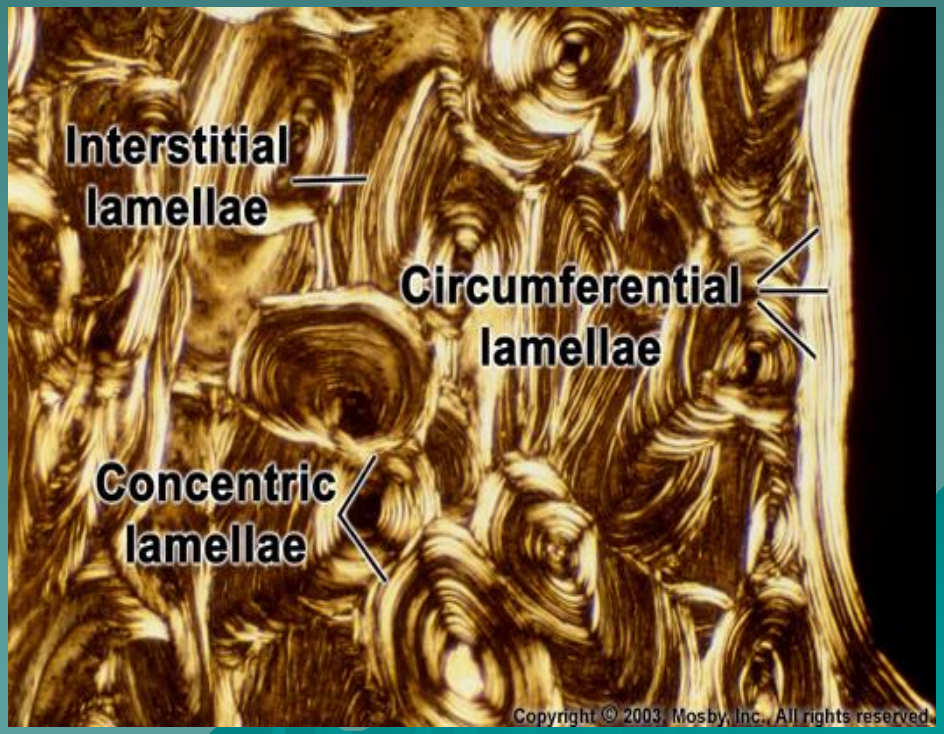
Diagram of relationship between the CE junction of adjacent teeth and the shape of the alveolar crest

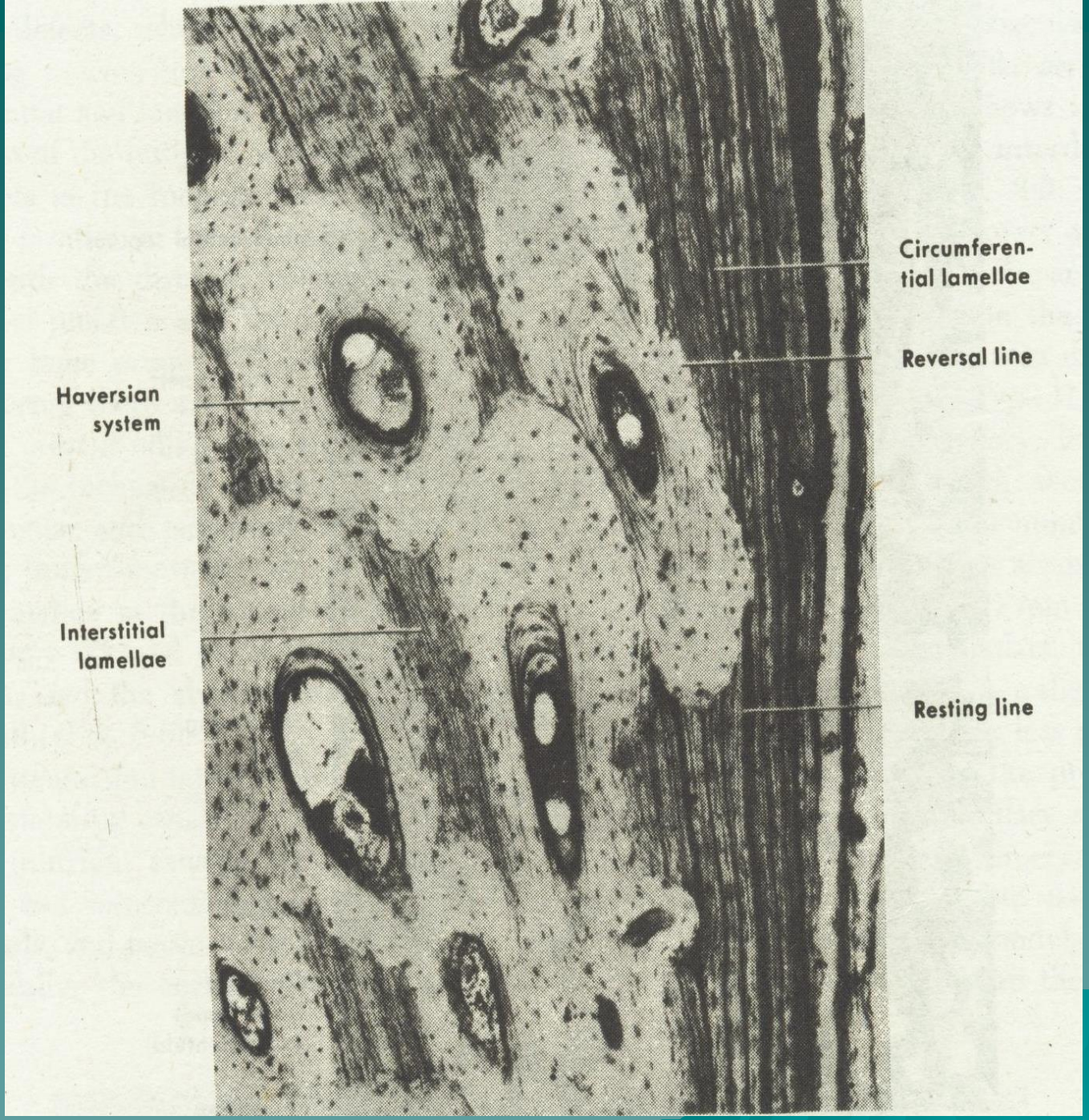
The interdental and interradicular septa contain the perforating canals of Zuckerkandl and Hirschfeld (Nutrient canals),which house the interdental and interradicular arteries ,veins, lymph vessels and nerves.

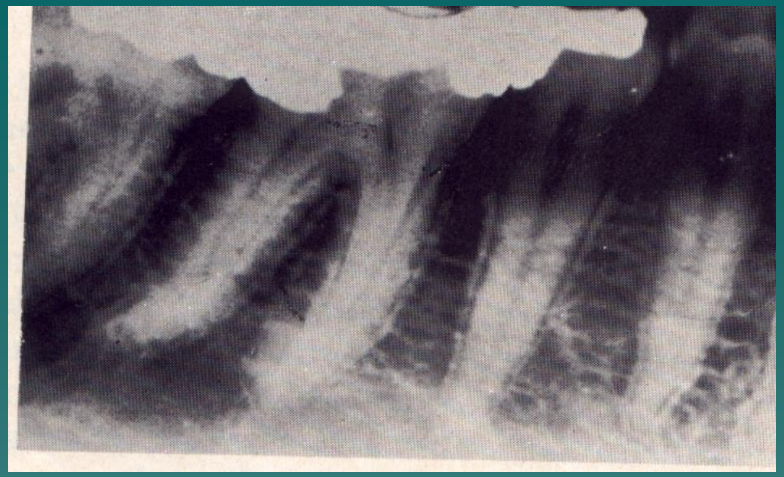


- Histologically, the cortical plates consist of longitudinal lamellae and haversian systems. In the lower jaw, circumferential or basic lamellae reach from the body of the mandible into cortical plates.

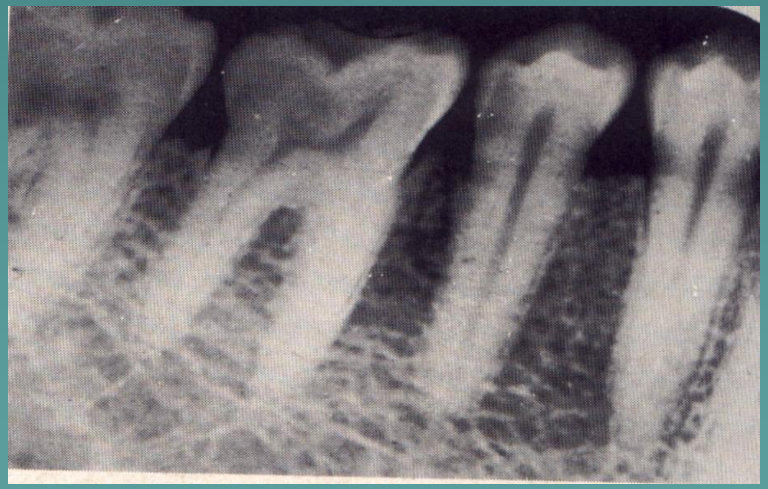





Circumferen-
tial lamellae
Reversal line
Haversian
system
Interstitial
lamellae
Resting line



Type-I



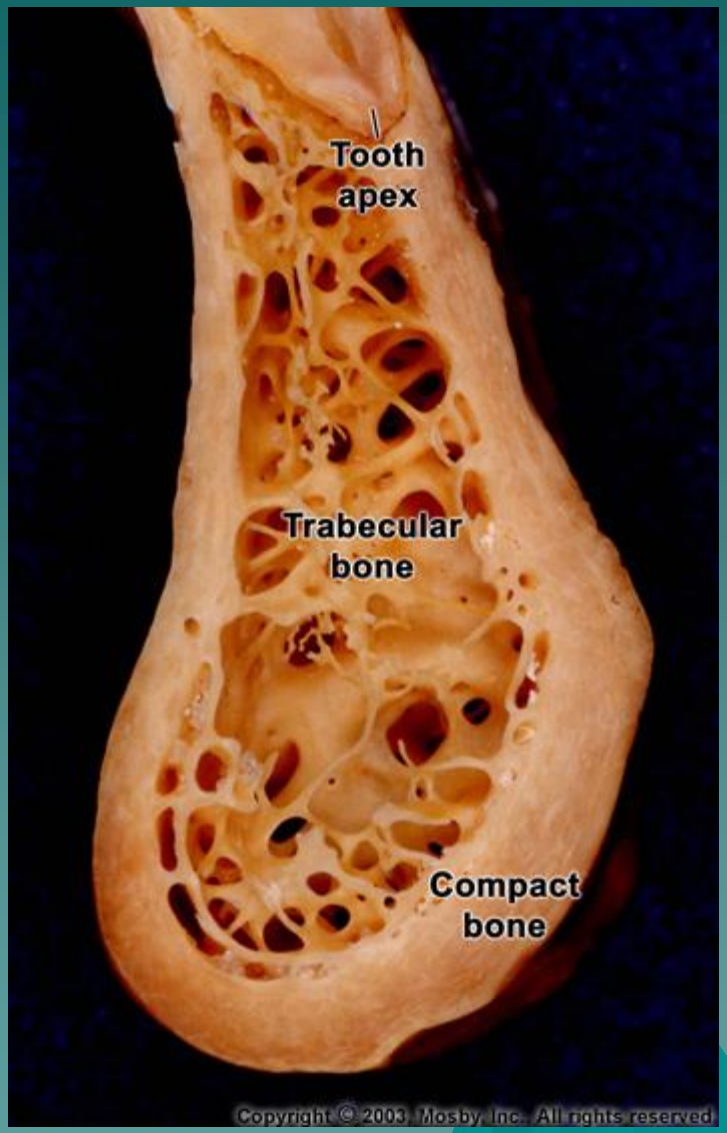
Type-II

Roentgenograms permit the classification of the spongiosa of the alveolar process into two main types.

Type I :- interdental and interradicular trabeculae are regular and horizontal in a ladder like arrangement. This is called the “trajectory pattern”. More common in mandible.

Type II :- shows irregularly arranged, numerous delicate interdental and interradicular trabeculae. It lacks a trajectory pattern. More common in maxilla.

-Marrow spaces in the alveolar process usually contain fatty marrow. They contain hematopoietic marrow in the condylar process, angle of mandible, maxillary tuberosity and in a few other isolated foci.



PHYSIOLOGIC CHANGES IN ALVEOLAR PROCESS

Composition :

Inorganic material – 65%

- Hydroxyapatite

Organic material – 35%

- Collagen (Type – I) 88% - 89%
- Noncollagen 11% - 12%
- Glycoproteins 6.5% - 10%
- Proteoglycans 0.8%
- Sialoproteins - 0.35%
- Lipids - 0.4%

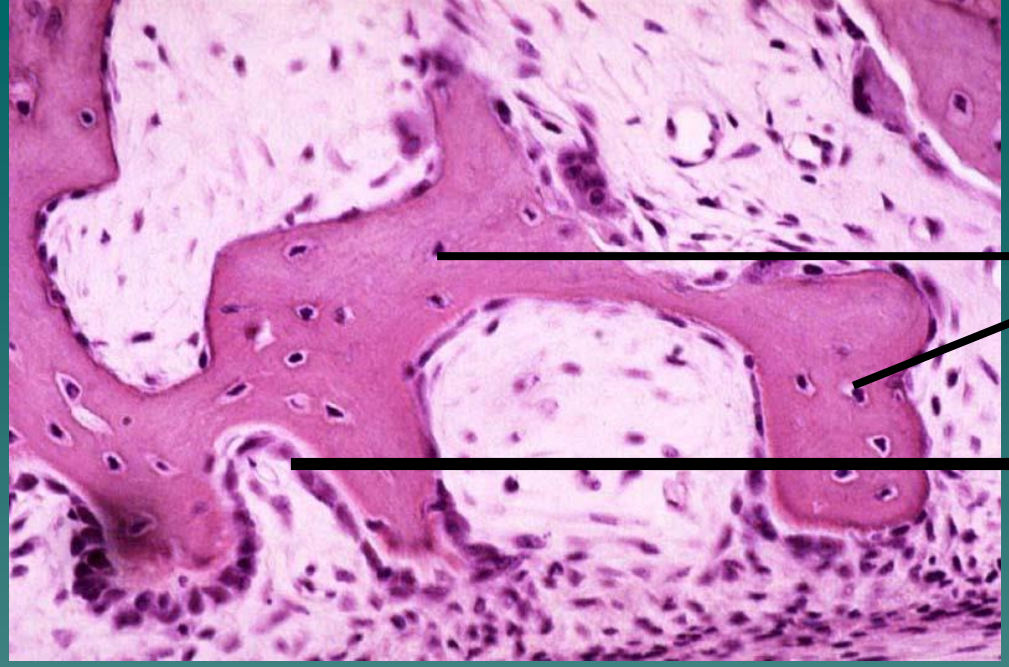
- Hydroxyapatite crystals are deposited on and in between the molecules of collagen as well as in the noncollagen, organic material that makes up the ground substance of bone.

- Internal structure of bone is adapted to mechanical stresses. It changes continuously during growth and alteration of functional stresses. In the jaws structural changes are correlated to the growth, eruption movements, wear and loss of teeth. All these processes are made possible only by a co-ordination of destructive and formative activities.

- Specialized cells, osteoblasts have a formative function, whereas osteoclasts have a destructive function.

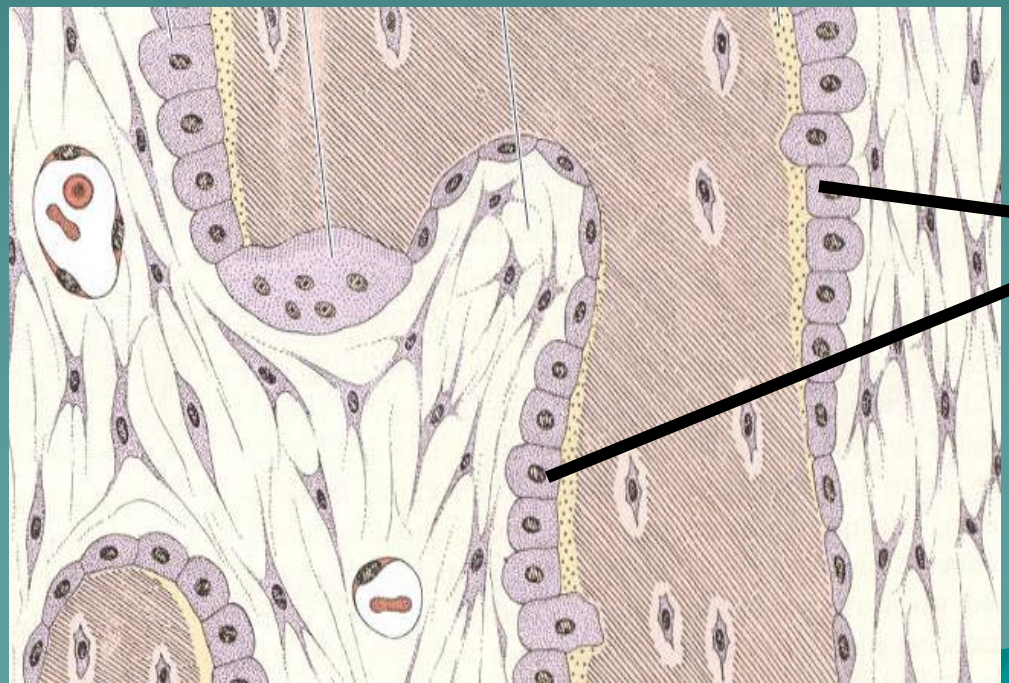
Osteoblasts :

- Their ultrastructure is characteristic of any actively secreting cell, i.e., a prominent golgi body, RER, mitochondria, nucleoli, and many secretory vesicles.
- They differentiate from progenitor cells of the c.t. at the site of bone formation.
- As the osteoblasts secrete the organic matrix of bone, it is at first devoid of mineral salts (stains pink with eosin), and is called *osteoid tissue*, which is later mineralized to form calcified tissue.
- As this material is produced, some of the osteoblasts become embedded in it and form the *osteocytes*.
- In areas of bone formation, mineralization (appears basophilic) always lags behind the production of bone matrix, and therefore in such areas, a superficial layer of osteoid tissue is always seen.



osteocytes

osteoblasts

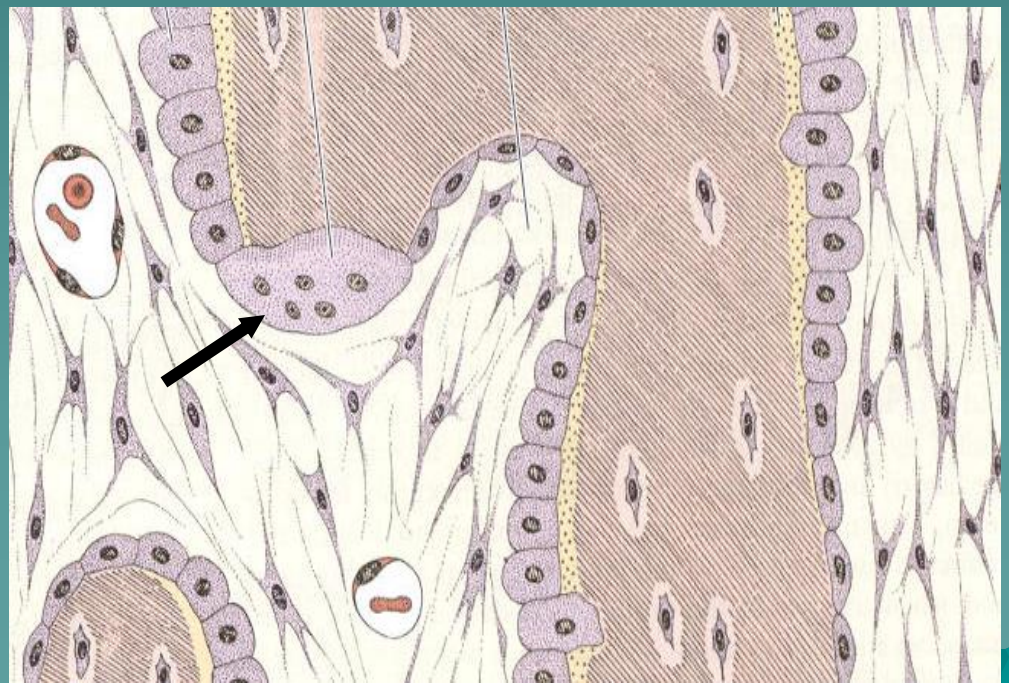


osteoblasts

Osteoclasts :

- They are probably derived from the circulating blood cells (monocytes), but they may also differentiate from the mesenchymal cells in situ.
- Bone resorbing cells that are large and multinucleated cells which can have a dozen or more nuclei.
- They are found against the bone surface, occupying shallow depressions called “Howship’s lacunae” seen as long, shallow troughs and are created due to bone resorption brought about by osteoclasts.
- They have prominent mitochondria, lysozomes, vacuoles and few endoplasmic reticulum.
- The part of the cell in contact with the bone shows a convoluted surface, the ‘ ruffled border’, which is the site of great activity, since here the pieces of bone are broken off and released into the extracellular spaces.
- Ruffled border is surrounded by a clear zone, that has no organelles, but only fine granular cytoplasm with microfilaments

OSTEOCLAST



Bone resorption is thought to be a chemotactic phenomenon, that is initiated by the release of some soluble factor which attracts monocytes to the target site. However, the role of genetic and functional influences cannot be underestimated.

The bone resorption is brought about by three processes. They are :

1) Decalcification

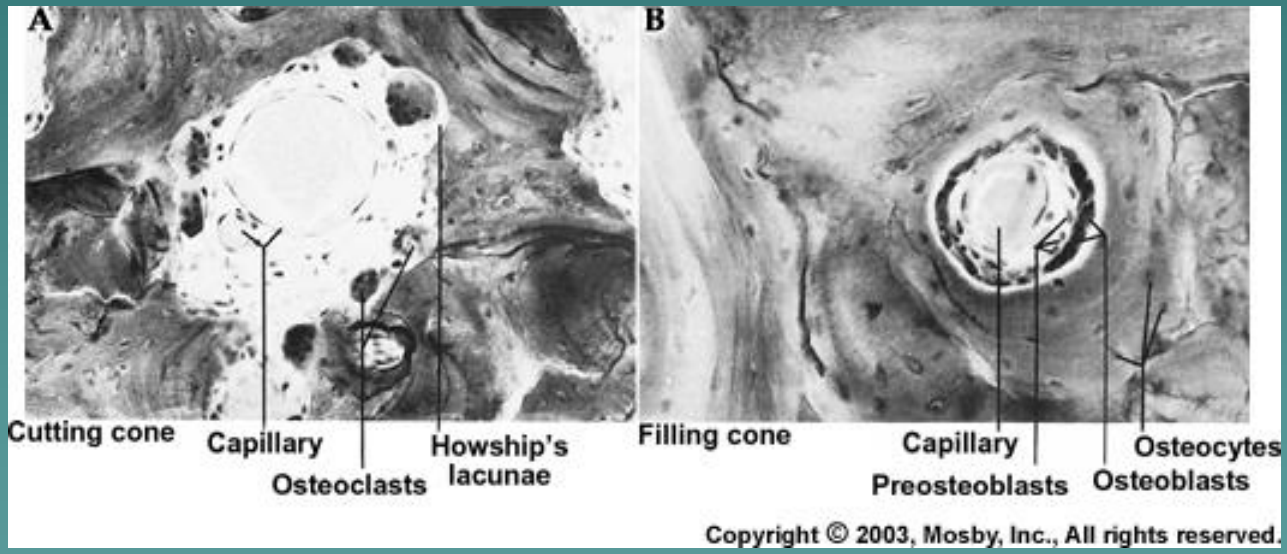
2) Degradation of organic matrix

3) Transport of soluble products to the blood vessels.

INTERNAL RECONSTRUCTION OF BONE :

- The bone in the alveolar process is identical to bone elsewhere in the body and is in a constant state of flux.
- During growth of jaws bone is deposited on the outer surfaces of the cortical plates.
- In the mandible with its thick, compact cortical plates, bone is deposited in the shape of basic or circumferential lamellae. When the lamellae reach a certain thickness they are replaced from the inside by haversian bone. This reconstruction is correlated to the functional and nutritional demands of the bone.

➔ In the haversian canals, closest to the surface, osteoclasts differentiate and resorb the haversian lamellae and part of circumferential lamellae which is replaced by proliferating loose connective tissue. This area of resorption is called the **cutting cone** or the **resorption tunnel**.

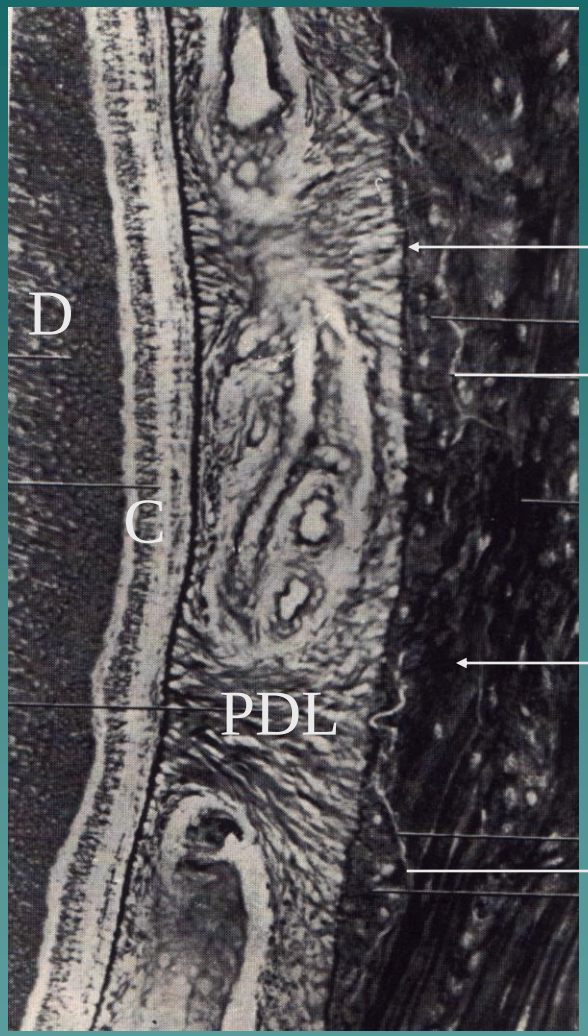


Light micrograph of bone turnover. **A,** Cutting cone in cross section. Large multinucleated osteoclasts resorb an old osteon. **B,** Filling cone in cross section. Uninucleated osteoblasts ring the partially formed osteon.

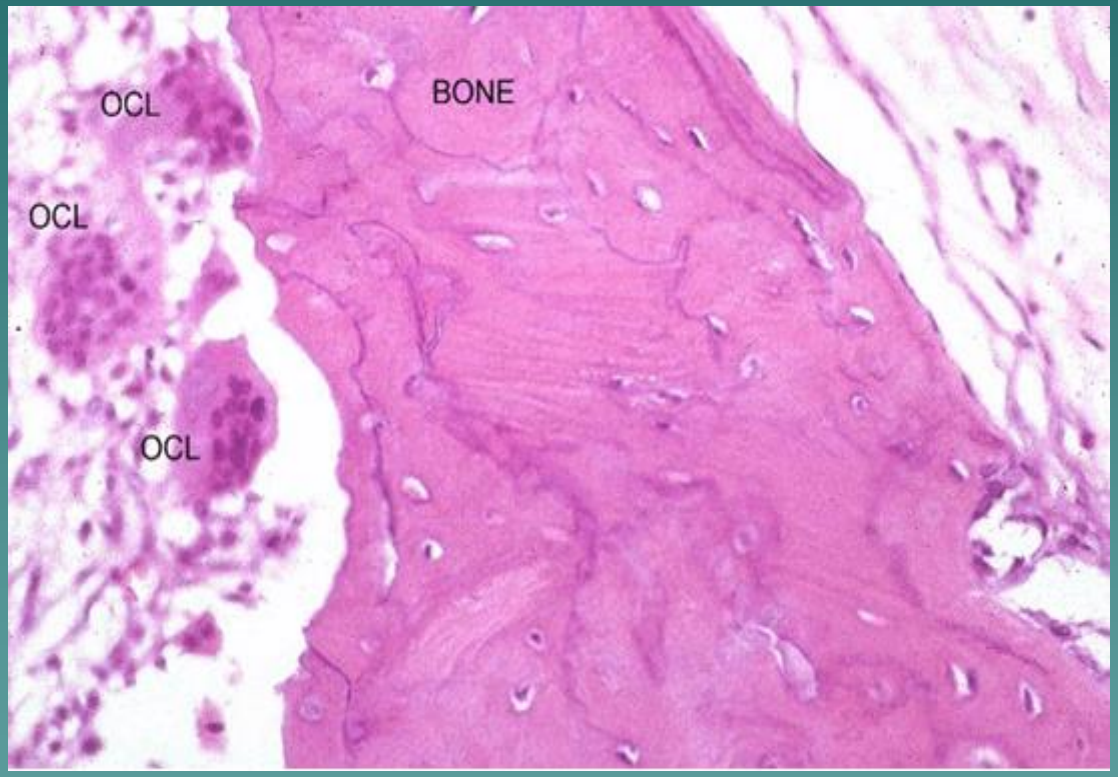
➔ After a time the resorption ceases and new bone is apposed on to the old.

➔ The scalloped outline of Howship's lacunae that turn their convexity toward the old bone remains visible as a darkly stained cementing line, a **"reversal line".**

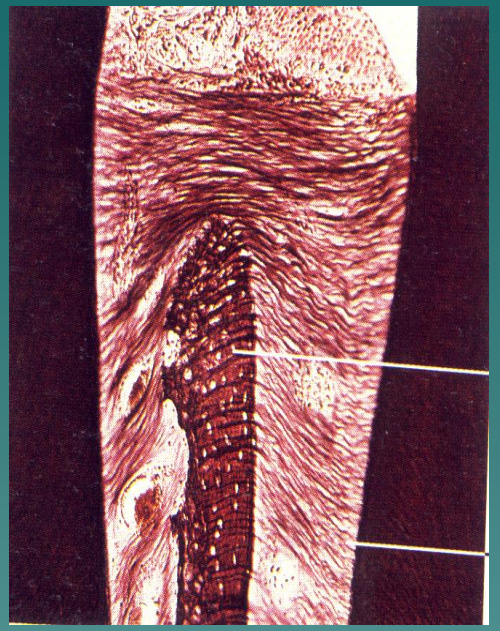
➔ Cementing lines that correspond to a rest period are called "**resting lines**".



Reversal lines



- Resting and Reversal lines are found between layers of bone of varying age.
- Wherever a muscle, tendon or ligament is attached to the surface of bone, sharpey's fibers can be seen penetrating the basic lamellae.
- During replacement of these lamellae by haversian systems, fragments of bone containing Sharpey's fibres remain in the deeper layers. Thus the presence of these lamellae containing these fibres, indicates the former level of the surface.



A-Fibers perforating alveolar bone
B-Fiber perforating cementum

- Alterations in the structure of the alveolar bone are of great importance in connection with the physiologic eruptive movements of the teeth. These movements are directed mesio – occlusally.

- During the mesial drift of a tooth, bone is apposed on the distal and resorbed on the mesial alveolar wall.

- The distal wall is made up almost entirely of bundle bone. However, the osteoclasts in the adjacent marrow spaces remove part of the bundle bone when it reaches a certain thickness. In its place, lamellated bone is deposited.

- On the mesial alveolar wall, the sign of active resorption is the presence of Howship's lacunae containing osteoclasts.
- On this side, bundle bone is present merely as a thin layer, in some areas. This is because mesial drift does not occur simply as a bodily movement.
- Thus resorption does not involve the entire mesial surface of the alveolus at one time.
- Moreover, periods of resorption alternate with periods of rest and repair. It is during these periods that bundle bone is formed, and detached PDL fibers are again secured.
- Islands of bundle bone are separated from the lamellated bone by reversal lines that turn their convexities towards the lamellated bone.

- During these changes, compact bone may be replaced by spongy bone and viceversa

- This type of internal reconstruction of bone can be observed in physiologic mesial drift or in orthodontic mesial or distal movement of teeth.

- In these movements an interdental septum shows apposition on one surface and resorption on the other.

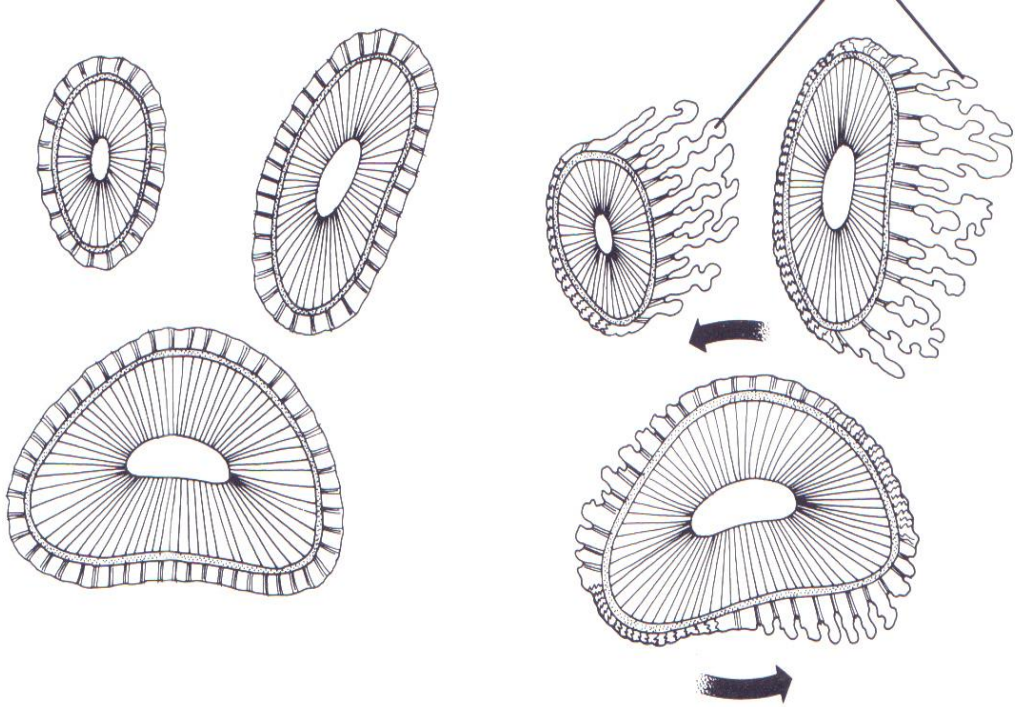
CLINICAL CONSIDERATIONS :

1) Bone, although one of the hardest tissue of human body, is biologically a highly plastic tissue.

- Where bone is covered by a vascularised connective tissue, it is exceedingly sensitive to pressure, whereas tension acts as a stimulus to the production of new bone.

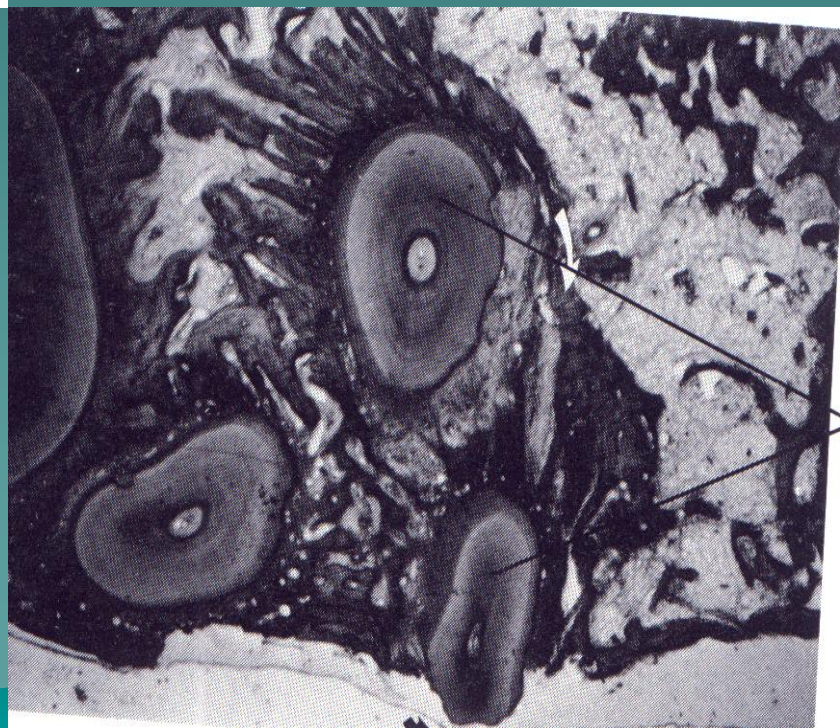
- This biologic plasticity enables the orthodontist to move teeth without disrupting their relations to the alveolar bone.

- Bone is resorbed on the side of pressure and apposed on the side of tension ; thus the entire alveolus is allowed to shift with the tooth.



Observe the bone formed along the trailing root surface and resorption on the advancing bony surface

Histology of rotation of max. molar illustrating loss of bone and bone formation



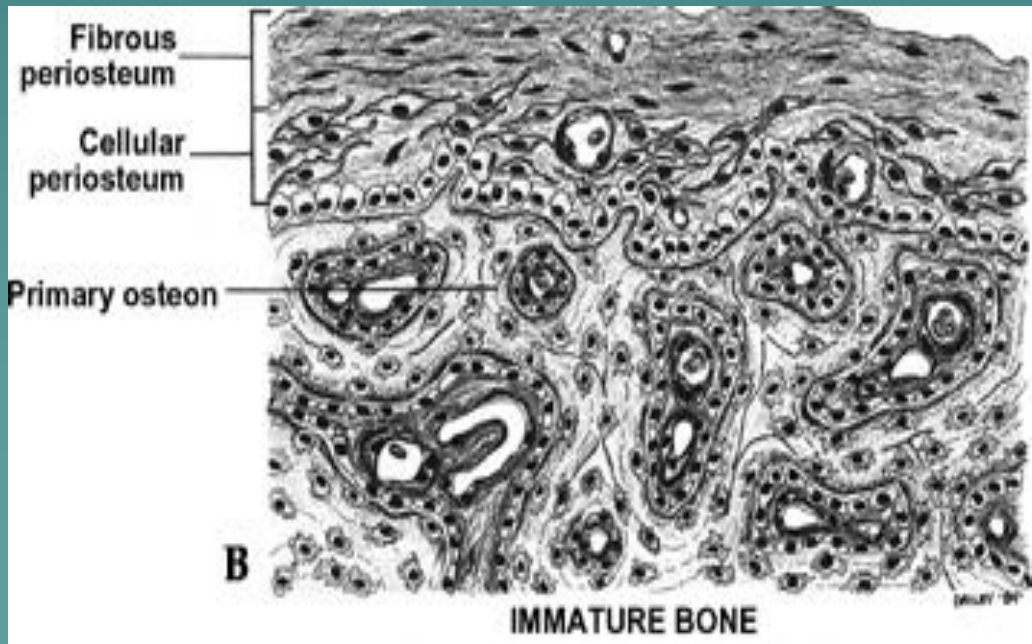
2) The adaptation of bone to function is quantitative as well as qualitative ,whereas increase in functional forces leads to formation of new bone, decreased function leads to a decrease in the volume of bone

- This can be observed in the supporting bone of teeth that have lost their antagonists. Here the spongy bone around the alveolus shows pronounced rarefaction.

- However, the alveolar bone is usu. Well preserved, as it continues to receive some stimuli from the tension of periodontal tissues.

(3) During healing of fractures or extraction wounds an embryonic type of bone is formed which later is replaced by mature bone. The greater number of cells and the reduced volume of calcified intercellular substances render this immature (embryonic) bone more radiolucent than mature bone. This explains why bony callus or sockets of extraction wounds appear radiolucent in roentgenograms , when they are actually filled with immature bone.

Immature bone. The bone is somewhat less cellular and slightly more organized; some primary osteons are forming.



(4) The most frequent and harmful change in the alveolar process is that which is associated with periodontal disease. The bone resorption is almost universal, occurs more frequently in posterior teeth is usually symmetrical is both of horizontal and vertical type and is intimately related to bacterial plaque and pocket formation. Progressive loss of alveolar bone in periodontal disease is difficult to control and once lost this bone is even more difficult to repair or regenerate.

2 mechanisms have been shown to contribute to this process :

- Endotoxins produced by the gram negative bacteria of the plaque lead to an increase in cyclic AMP, which increases the osteoclastic activity.
- A peptide called *osteoclast activating factor* (OAF) found in lymphocytes near the periodontal pocket, is capable of increasing the cAMP and osteoclastic activity and reducing osteoblastic activity at the target site.

(5) In the last few years synthetic materials have been introduced that are intended to replace bone tissue lost through disease or injury.

These materials are of two types:

- The non-resorbable hydroxyapatite
- The resorbable tricalcium phosphate

These are currently being used for the augmentation of alveolar ridges and for filling bone defects produced by periodontal disease.

(6) When the teeth are lost, alveolar process undergoes gradual atrophy. In some instance the resorption may be so severe that the fabrication of a functional prosthesis may become difficult or even impossible

- If during extraction, the root pieces are left in the sockets, the alveolar processes do not undergo considerable resorption. Since this is a difficult process, an alternative procedure, wherein artificial root shaped replicas made of hydroxy-apatite, are being implanted into the empty sockets , has been suggested. But long term studies on this technique are yet to be undertaken.


THANK YOU