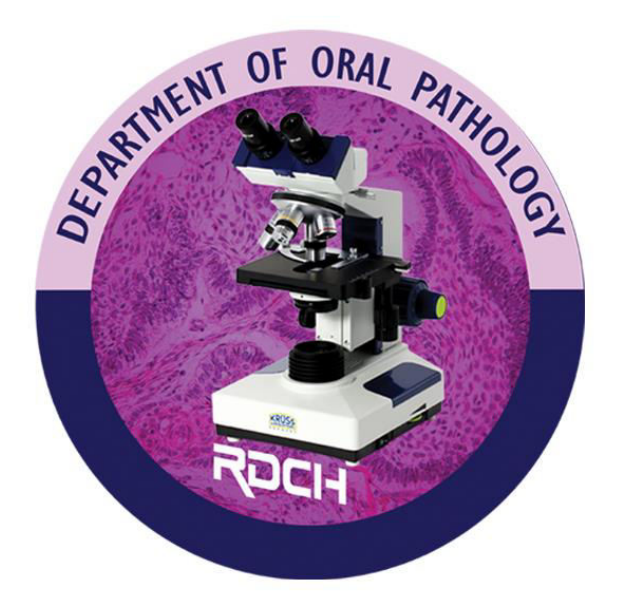
BONE



Temporomandibular Joint

- The area where the craniomandibular articulation occurs is called the temporomandibular joint
- Articulation is defined as a loose joining or connecting together so as to allow motion between the parts.
- When the two objects are the bones of a skeleton, the articulation is called a Joint.
- Bilateral diarthrodial joint

  Atypical synovial joint

  Ginglymoarthrodial joint

CLASSIFICATION

- Fibrous
- Cartilaginous
- Synovial

Fibrous joints

- In fibrous joint 2 bones are connected by fibrous tissue. They are 3 types :

- 1.Sutures: - its function is to permit growth at its articulating surfaces are covered by osteogenic layer responsible for new bone formation.It permits little or no movement.

- 2.Syndesmoses:- Two bony compartments are apart from each other but are joined by an intraosseous ligament.It permits limited movement.

Fibrous joints

- Gomphoses : - it is the joint that gives socketed attachment of tooth to bone by fibrous periodontal ligament.
- Movement is restricted to intrusion and recovery in response to biting force.

Cartilaginous joints

- Primary cartilagenous joint :- bone and joint are in direct apposition.

  eg - costochondral junction

- Secondary cartilagenous :- tissues in articulation occur in sequence as *bone-cartilage-fibrous tissue-cartilage-bone.*

  eg – pubic symphysis

Synovial joints

- They are classified as under :

A. On the number of axis in which bones involved can move – *uniaxail ,biaxail ,multiaxail*.

B. By the shapes of articulating surfaces – *planar , gingylmoid , pivot ,condyloid ,saddle ,ball and socket*.

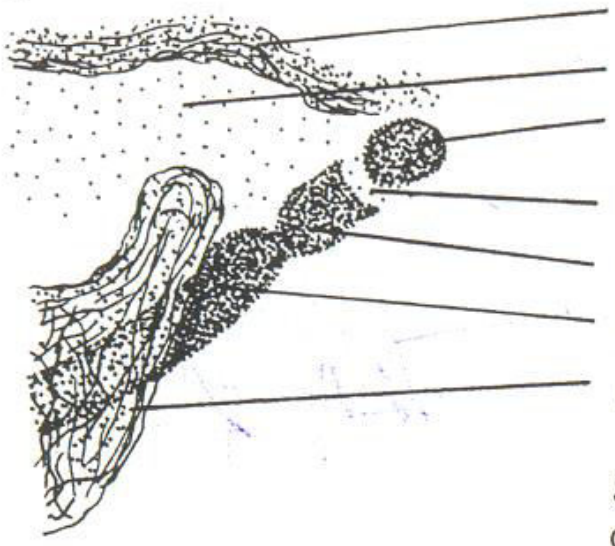
DEVELOPMENT

- PRIMARY JOINT- exists for about 4 MONTHS
- MALLEUS AND INCUS
- SECONDARY JAW JOINT – at about 3 MONTHS of gestation it appears.
- TEMPORAL BLASTEMA
- CONDYLAR BLASTEMA

Fig 55

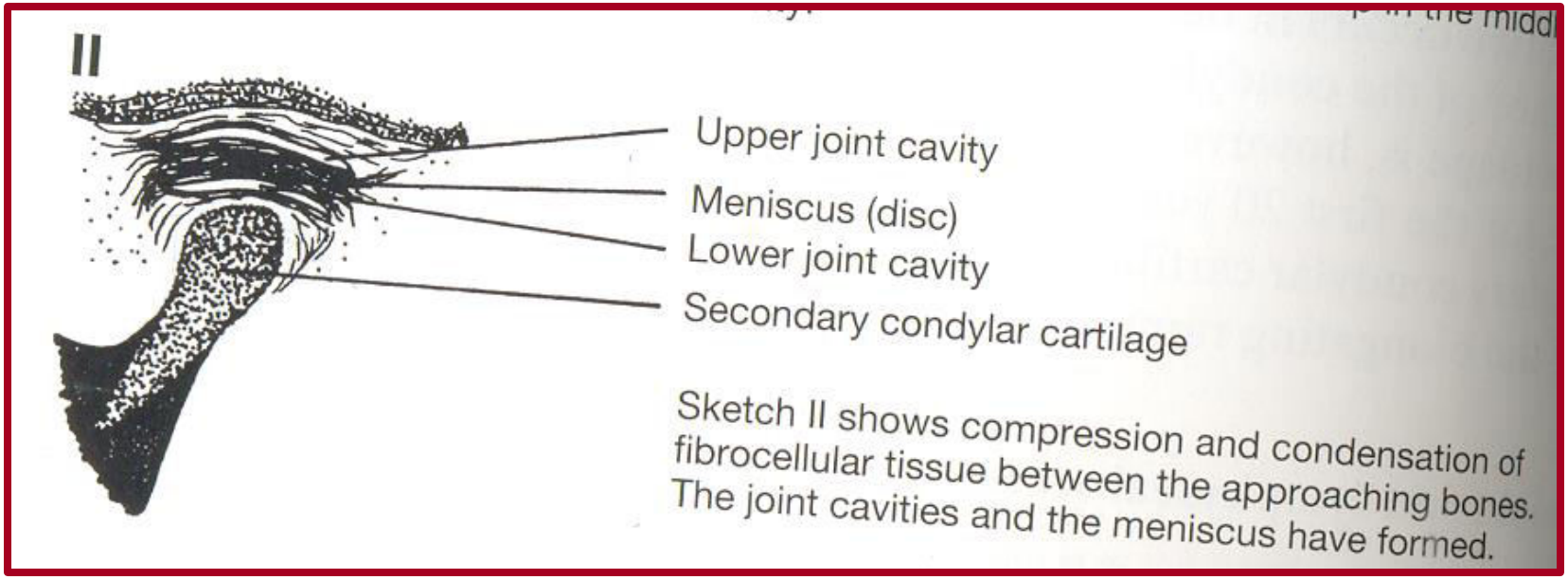
Development of the temporomandibular joint

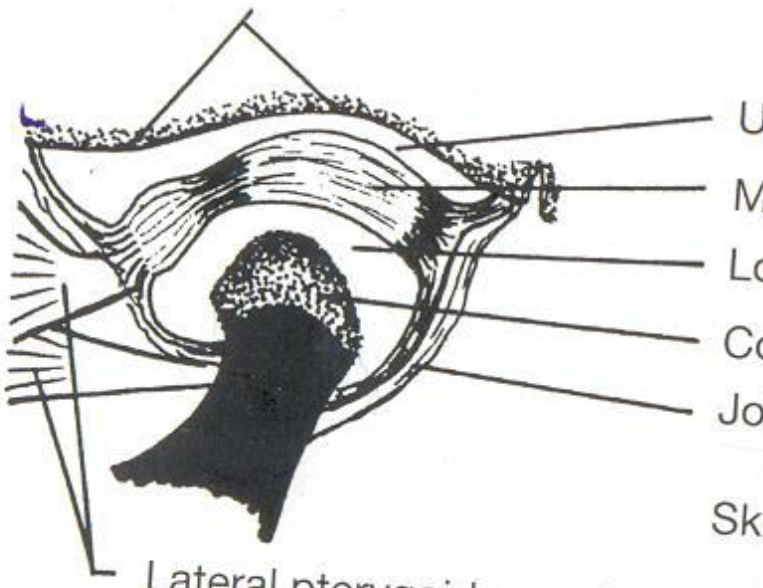
I



Sketch I shows the mandibular and temporal fibrocellular condensations approaching one another. The malleus and incus will be taken up in the middle ear cavity.

II


II
Upper joint cavity
Meniscus (disc)
Lower joint cavity
Secondary condylar cartilage
Sketch II shows compression and condensation of fibrocellular tissue between the approaching bones. The joint cavities and the meniscus have formed.



Sketch III shows the joint soon after birth.

DEVELOPMENT

- Articular Disc:Earliest appearance in 6 week old embryo

- At 7 weeks: the future condyle is still only a condensation of mesenchyme resting on osseous lamella, which forms the mandibular ramus.

- 12 week – condylar growth cartilage makes its 1st appearance and begins to develop a hemi-spherical articular surface

.

- By 13th week – condyle and articular disc having moved up into contact with temporal bone.

DEVELOPMENT

- Only when such articular contact has been made do the joint cavities develop.
- Inferior space appearing first.
- Disc begins to get compressed.
- When central portion of disc is compressed this part becomes avascular.

DEVELOPMENT

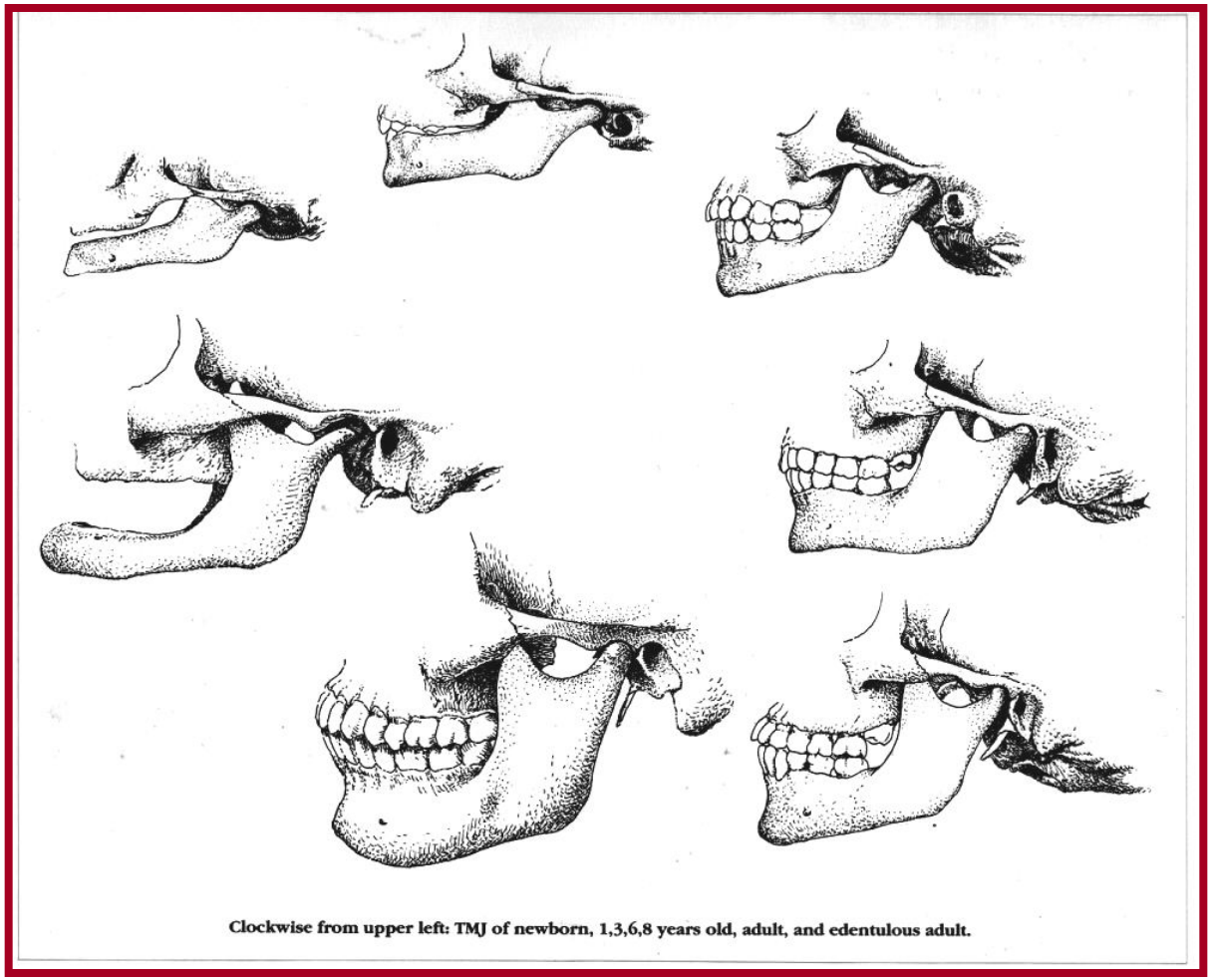
By 26th week:

- **All components of TMJ present except articular eminence.**
- **Meckel's cartilage still extends through GF, but by thirty-first week is transformed into sphenomandibular ligament.**

By 39th week:

- **Ossification of bones in this region has proceeded to the point where; ligament gains its apparent attachment to spine of sphenoid.**

DEVELOPMENT



Clockwise from upper left: TMJ of newborn, 1,3,6,8 years old, adult, and edentulous adult.

FUNCTIONAL ANATOMY

Bony components

Condylar head

Glenoid fossa

Articular eminence

Muscles

Muscles involved in mastication.

Facial muscles.

Muscles of the neck

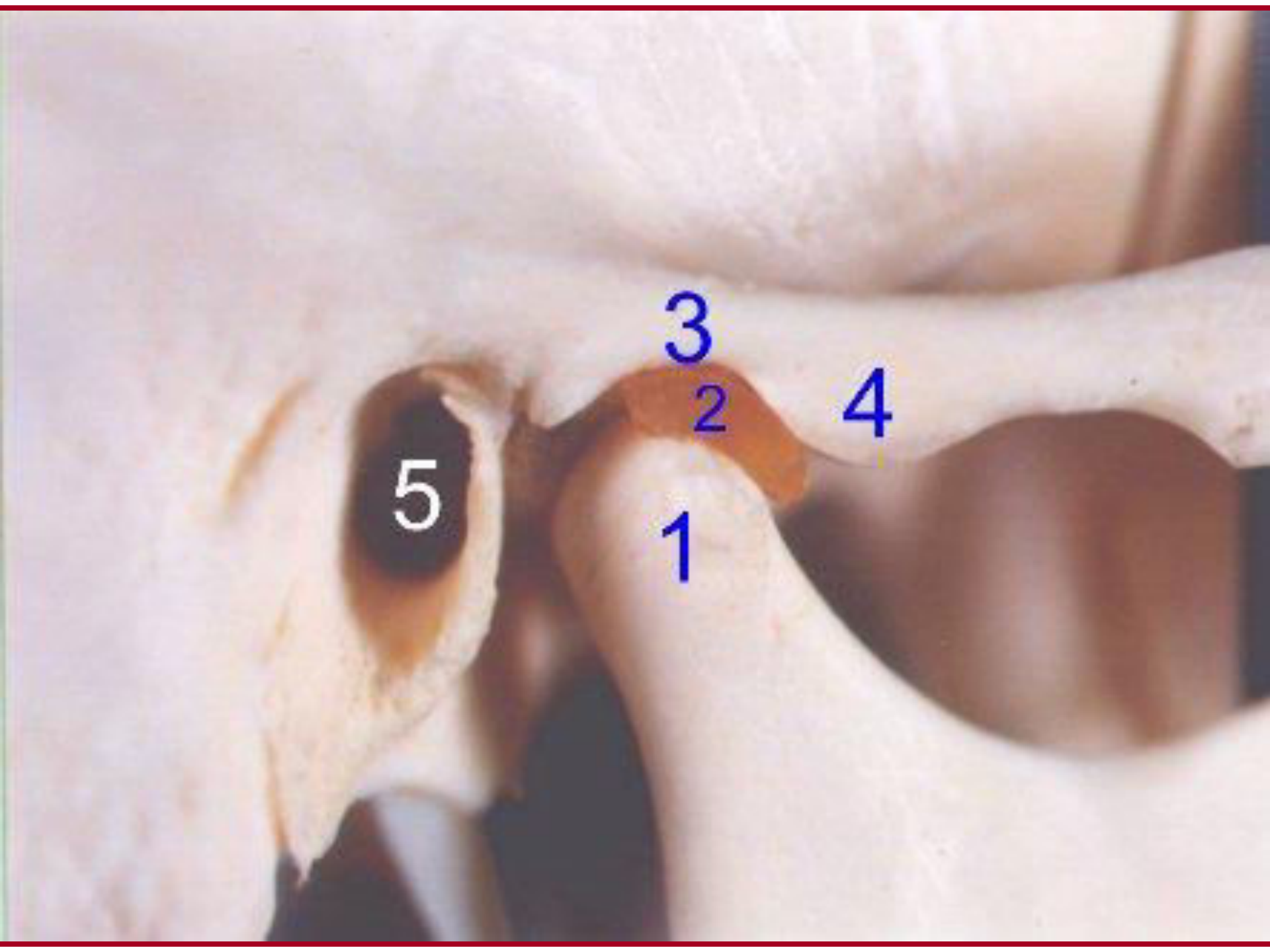
Soft tissue

Articular disc

Joint capsule

Ligaments

Muscles attached to joint


3
2
4
5
1

Condyloid process

- It is the portion of the mandible that articulates with the cranium around which movement occurs
- Anterior view it has a medial and lateral projection s which are called as poles
- ML length - 15 to 20 mm
- AP length - 8 to 10mm.

Condyloid process

- Posterior articulating surface is greater than anterior surface.
- The articulating surface of condyle is quite convex anteroposteriorly and only slightly convex mediolaterally.
- Pterygoid fovea on the antero-medial aspect of the mandibular neck where inferior head and most fibres of the superior head and lateral pterygoid muscle insert on the mandible.

Condyloid process

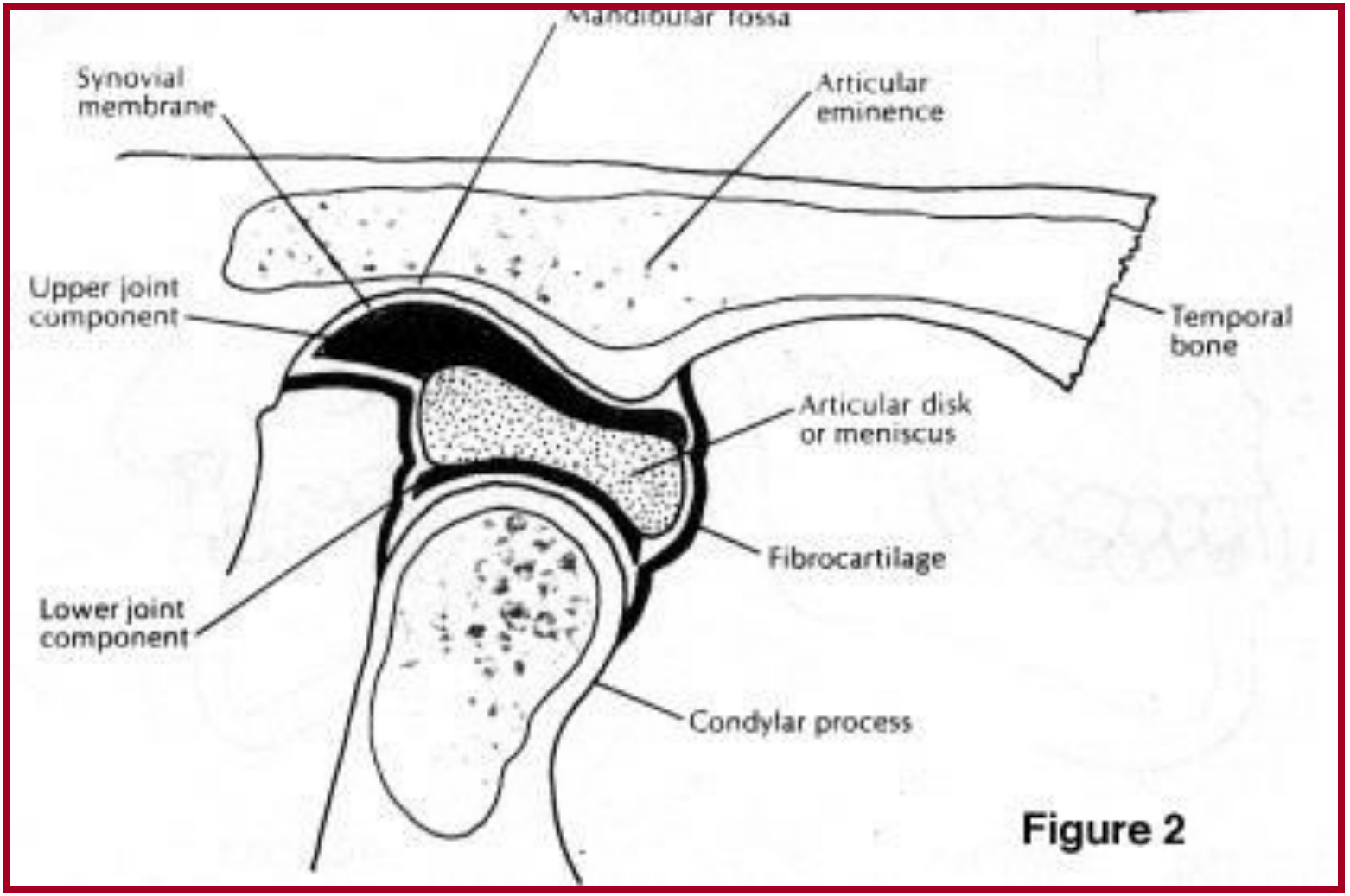
- **A** - Fibrous layer
- **B** - Reserve zone
- **C** - Proliferative zone
- **D** - Hypertrophic zone
- **E** - Calcifying zone
- **F** - Bone

ARTICULAR DISC

- Dense fibrous connective tissue devoid of blood vessels and nerves
- Sagittal plane divided into three regions according to the thickness
- Central area is thinnest and it is called intermediate zone

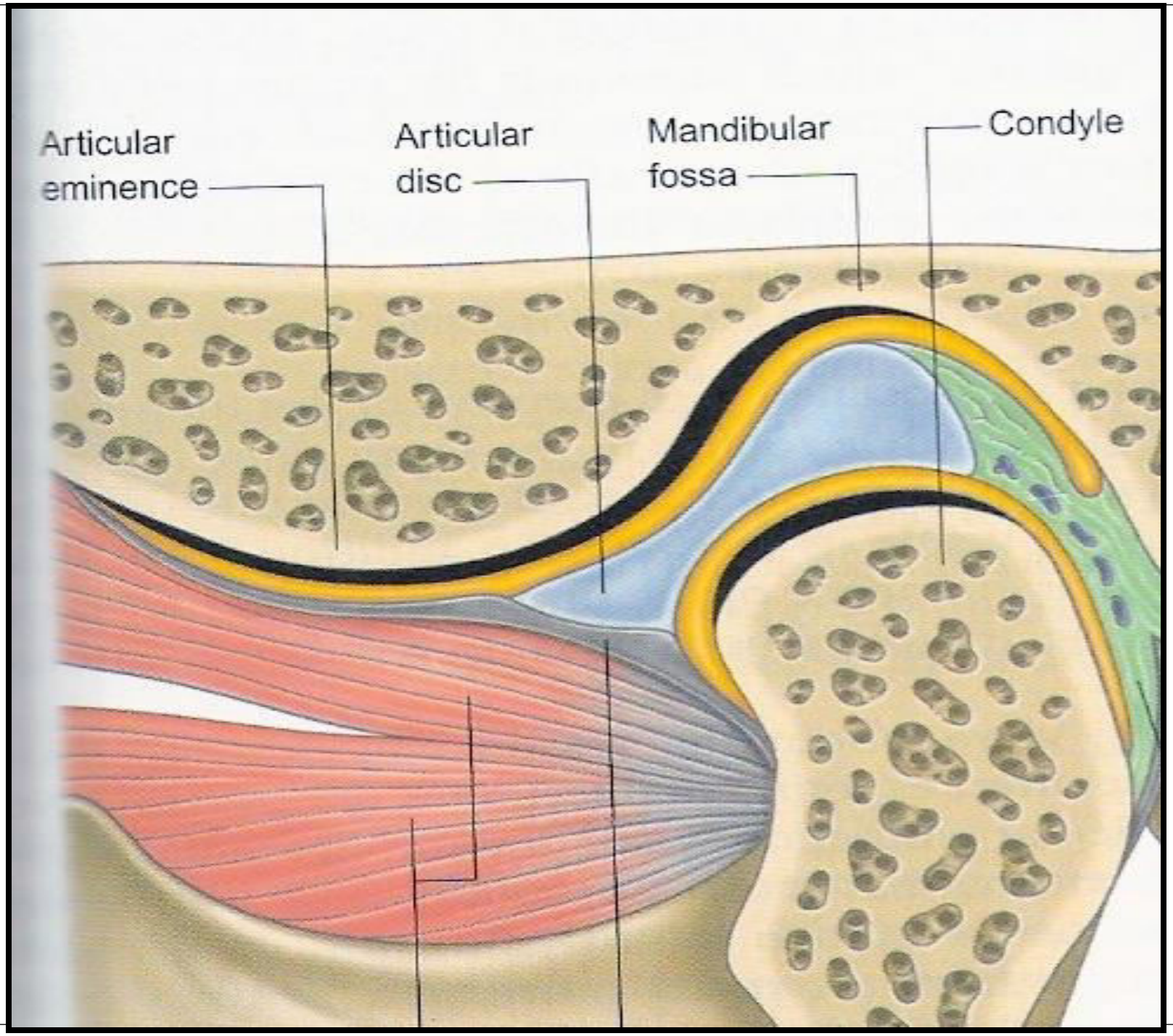
- Anterior is thick
- Posterior is thick
- Articular surface of the condyle located on the intermediate zone of the disc bordered by the thicker anterior and posterior regions
- Shape of the disc governed by the morphology of the condyle and the mandibular fossa

Articular disc



- The articular disc is attached posteriorly to the region of loose connective tissue that is highly vascularized and innervated which is called as retrodiscal tissue or posterior attachments or bilaminar region.

- The articular disc is attached to the capsular ligament not only anteriorly and posteriorly and also medially and laterally this divides the joint into two distinct cavities.

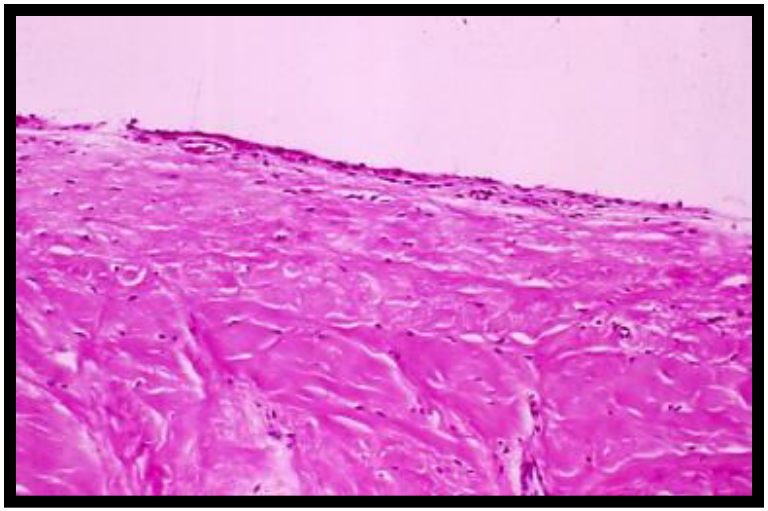

Articular eminence
Articular disc
Mandibular fossa
Condyle

ARTICULAR DISC

"Acres of Collagen"

Aneural & Avascular

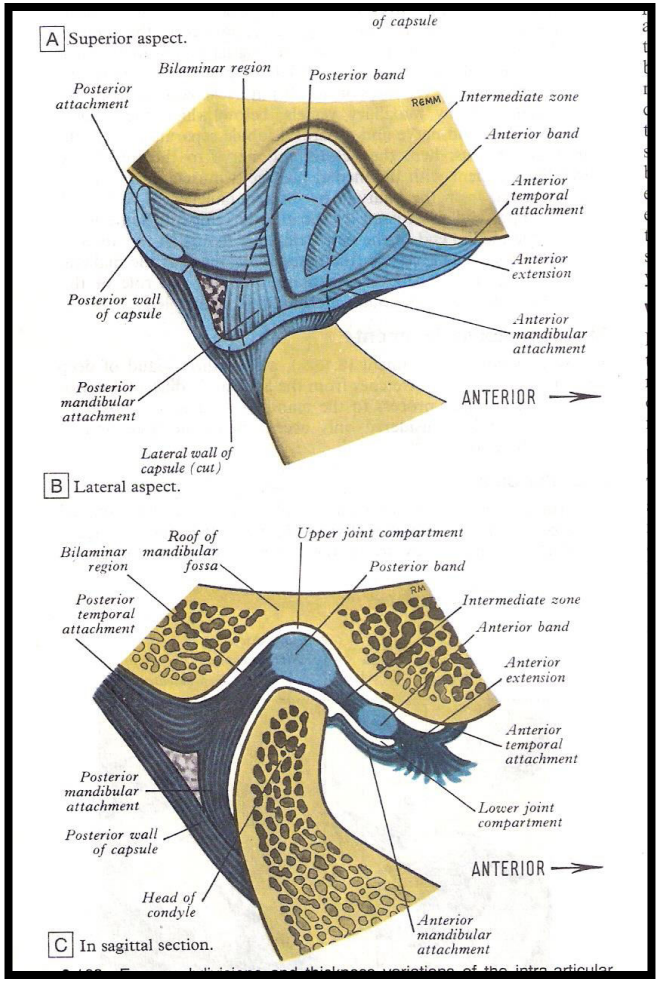
type I collagen present



Capsule

- Seals joint space
- Passive stability
- Anatomically recognizable ligaments
- Extension into joint
- Active stability from proprioception

Joint capsule (attachment)



Ligaments

- As with any joint system, ligaments play an important role in protecting the structures
- The ligaments of joints are made up of collagenous connective tissues which do not stretch.
- They do not enter actively into joint function but instead act as a passive restraining devices to limit and restrict border movements

3 functional ligaments that support the TMJ

- Collateral ligaments
- Capsular ligaments
- Temporomandibular ligament

3 accessory ligaments

- Sphenomandibular ligament
- Stylomandibular ligament
- Retinacular ligament

Collateral ligaments

- Discal ligaments
- They attach the medial and lateral borders of the articular disc to the poles of the condyle
- Medial discal ligament –attaches the medial edge of the disc to the medial pole of the condyle
- Lateral discal ligament-attaches the lateral edge of the disc to the lateral pole of the condyle

- These ligaments are responsible for dividing joint mediolaterally into superior and inferior joint cavities

- The discal ligaments are true ligaments, composed of collagenous c.t fibers –they do not stretch

- Restrict the movement of disc away from the condyle that means they allow the disc to move passively with condyle as it glides anteriorly and posteriorly

- The attachment of discal ligaments permit the disc to be rotated anteriorly and posteriorly on the articular surface of the condyle thus the these ligaments are responsible for the hinging movements of the TMJ.

- The discal ligaments have a vascular supply and are innervated

- This innervation provides information regarding joint position and movement

- Strain on these ligaments produce pain

Anterior view

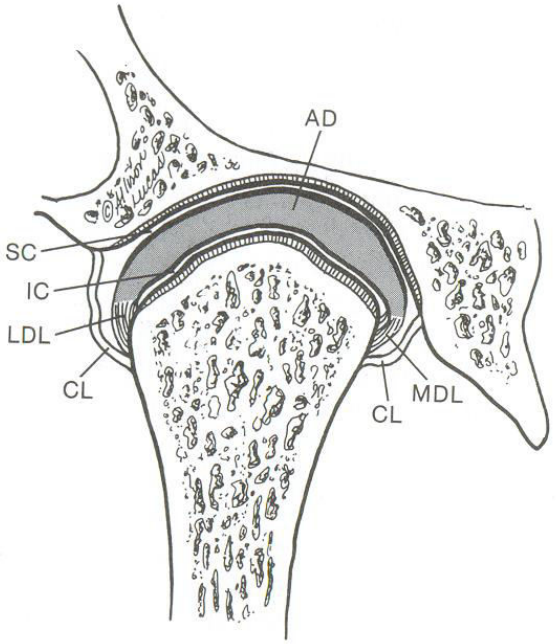


Fig. 1-17 Temporomandibular joint (anterior view) showing collateral ligaments. The following are identified: *AD,* articular disc; *CL,* capsular ligament; *IC,* inferior joint cavity; *LDL,* lateral discal ligament; *MDL,* medial discal ligament; *SC,* superior joint cavity. (Modified from Mahan PE, Kreitizer KL: In Alling CC, Mahan PE, editors: *Facial pain,* ed 2, Philadelphia, 1977, Lea & Febiger, p 203.)

Capsular ligament

- Entire TMJ is surrounded and encompassed by the capsular ligament
- The fibers of capsular ligament are attached superiorly to the temporal bone along the borders of articular surfaces of the mandibular fossa and articular eminence
- Inferiorly attach to the neck of the condyle

- Capsular ligament acts to resist any medial ,lateral or inferior forces that tend to separate or dislocate articular surfaces

- A significant function of the capsular ligament is to encompass the joint ,thus retaining the synovial fluid.

- The capsular ligament is well innervated and provides proprioceptive feedback regarding position and movement of the joint.

Temporomandibular ligament

- The lateral aspect of the capsular ligament is reinforced by strong,tight fibers that make up lateral ligament or temporomandibular ligament.

- The temporomandibular ligament is composed of 2parts

1. Outer oblique portion
2. Inner horizontal portion

- Outer oblique portion-extends from the outer surface of the articular tubercle and zygomatic process posteroinferiorly to the outer surface of condylar neck.

- Inner horizontal portion-extends from outer surface of the articular tubercle and zygomatic process posteriorly and horizontally to the lateral pole of the condyle and the posterior part of the articular disc.

- The inner horizontal portion of TM ligament limits posterior movement of the condyle and disc.

- When force applied to the mandible displaces the condyle posteriorly,this portion of ligament becomes tight and prevents the condyle from moving into the posterior region of mandibular fossa by which it protects the retrodiscal tissues from trauma.

- The inner horizontal portion also protects the the lateral pterygoid muscle from over lenghtening or over extension

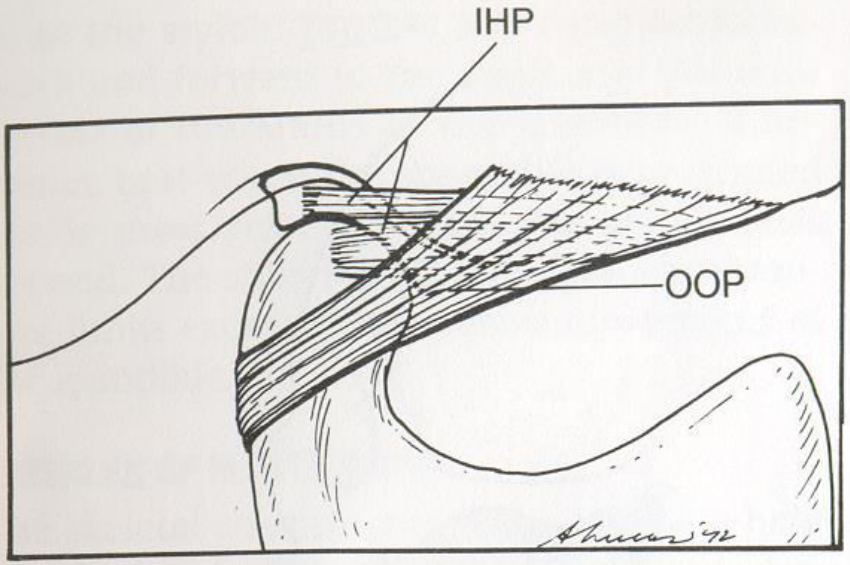


Fig. 1-19 Temporomandibular ligament (lateral view). Note that there are two distinct parts: the outer oblique portion *(OOP)* and the inner horizontal portion *(IHP)*. The OOP limits normal rotational opening movement; the IHP limits posterior movement of the condyle and disc. (Modified from Dubrul EL: *Sicher's oral anatomy,* ed 7, St Louis, 1980, Mosby, p 185.)

RETINACULAR LIGAMENTS

- Recently it has been described in association with TM joint.
- Arises from the articular eminence, descends along the ramus of the mandible.
- Insertion: fascia overlying the masseter muscle at the angle of the mandible.
- As the ligament is connected to the posterolateral aspect of the retrodiscal tissues and contains an accompanying vein.
- Action: It maintains blood circulation during the masticatory movements.

Synovial membrane

- Specialized fringe located at the anterior border of the retrodiscal tissues produces a synovial fluid which fills the joint cavities thus it is termed as a synovial joint.

- Capsule lined on its inner surface by synovial membrane that folds to form synovial villi.

- Membrane does not cover articular disk except for posterior bilaminar region

- Consists of 2 layers

1. Cellular intima
2. Vascular sub-intima -prevents folding of membrane

- Cells forming the cellular intima are of 3 types
- 1.fibroblast like or B-cell type
- 2.macrophage like or A-cell type
- 3.between type A and type B.

Synovial fluid

- Since articular surfaces of joint are nonvascular, the synovial fluid acts as a medium for providing metabolic nutrients to these tissues

- The synovial fluid also serves as a lubricant between articular surfaces during function

- Composition - dialysate of plasma with some added protein of mucin

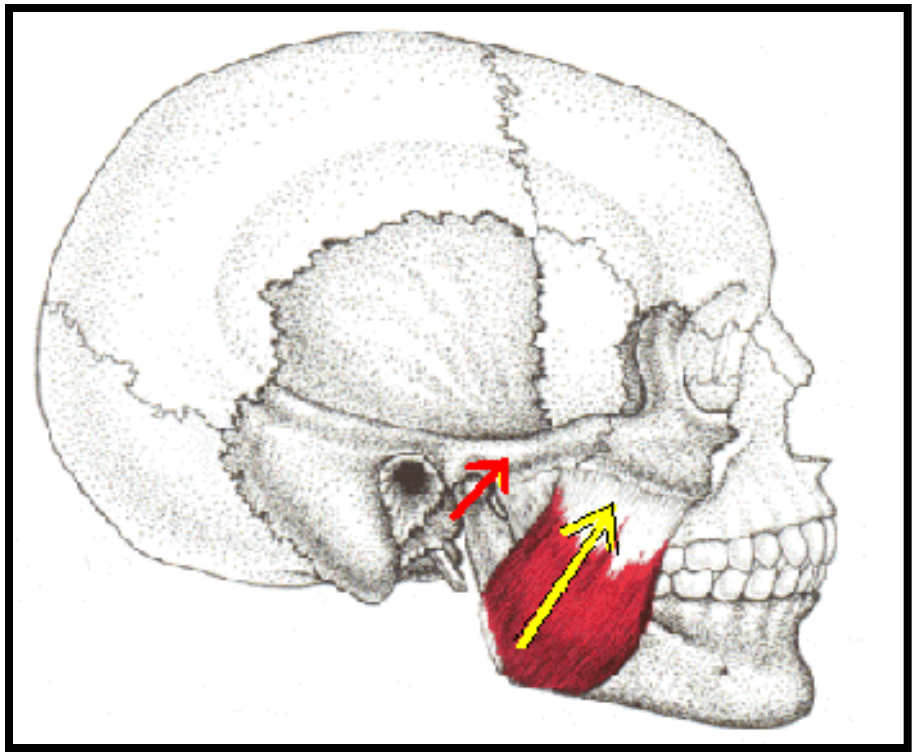
PRIMARY MUSCLES OF MASTICATION

- MASSETER
- TEMPORALIS
- MEDIAL AND LATERAL PTERYGOID

SECONDARY MUSCLES OF MASTICATION

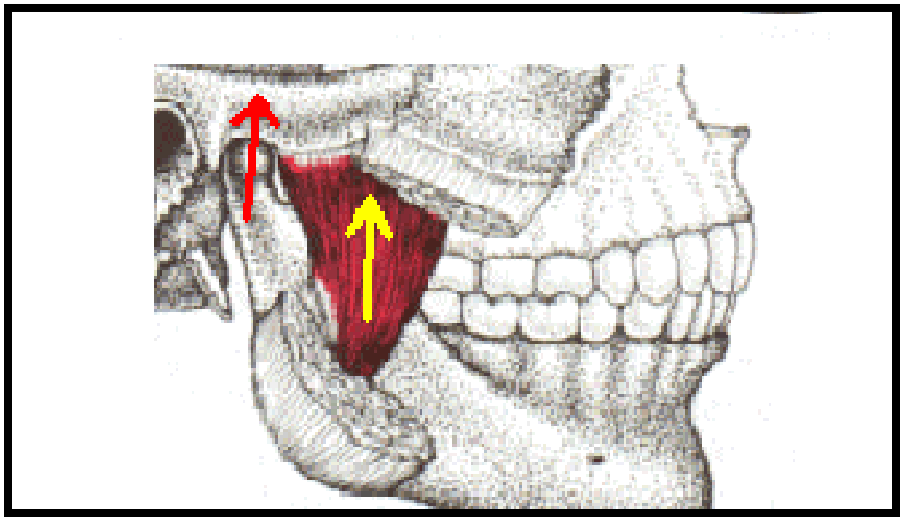
The suprahyoid group of muscles being used as secondary or supplementary muscles they are

- Digastric
- Mylohyoid
- Geniohyoid



Masseter

Elevates mandible
in the direction
of its fibers



<-- Deep segment

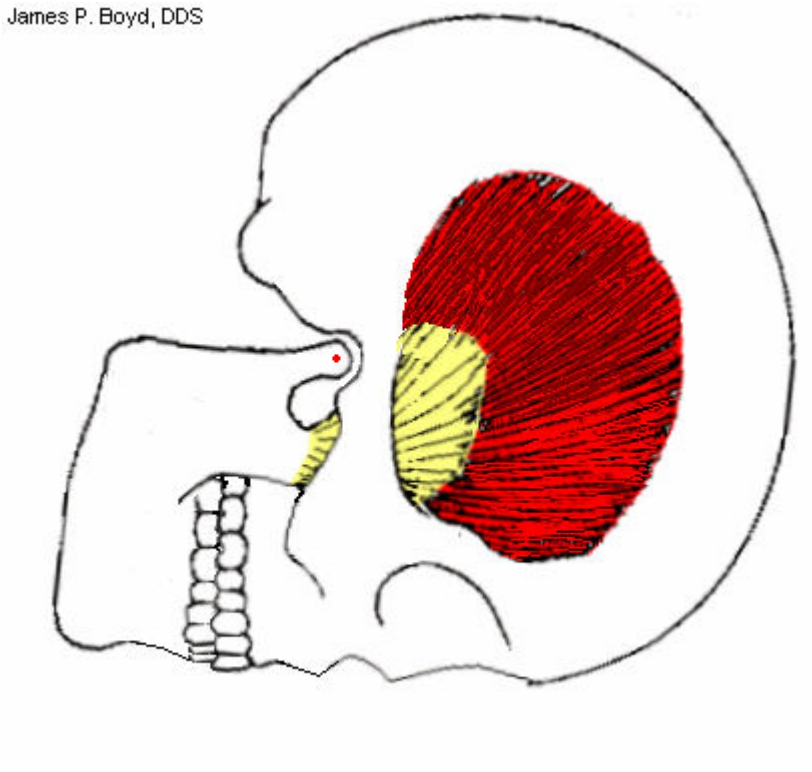
ACTIONS OF MASSETER

Actions:

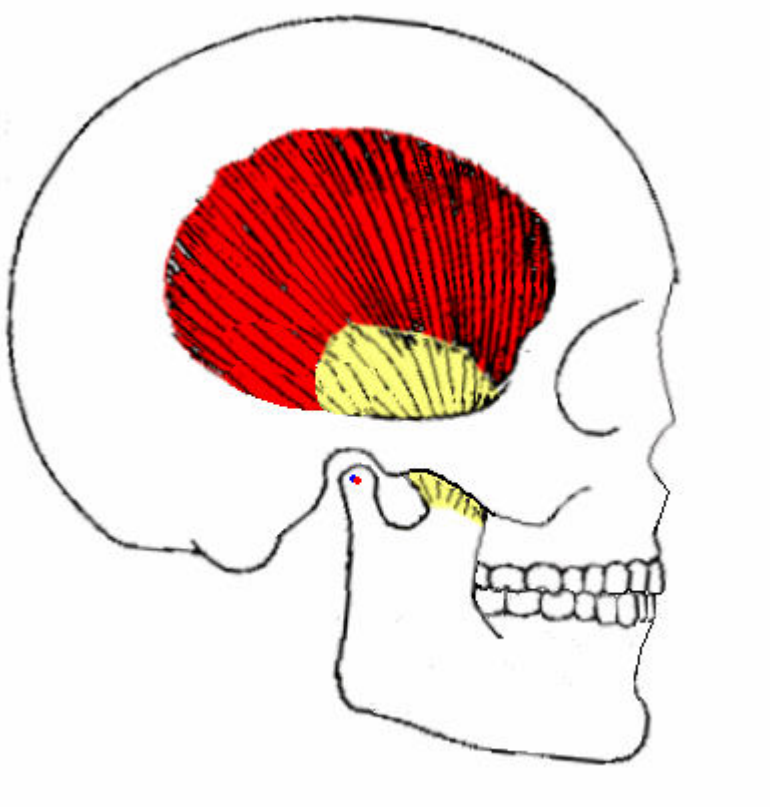
- Elevates the mandible to close the mouth and to occlude the teeth in mastication.
- Its activity in the resting position is minimal.
- It has a small effect in side-to-side movement, protraction and retraction.

ACTIONS OF TEMPORALIS

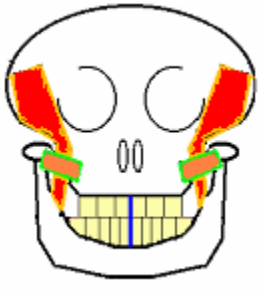
- Elevates the mandible,this movement requires both the upward pull of anterior fibers and backward pull of the posterior fibers.
- Posterior fibers draw the mandible backwards after it has been protruded.
- It is also a contributor to side to side grinding movement.


James P. Boyd, DDS

POSTERIOR FIBER DRAWS MANDIBLE BACKWARDS



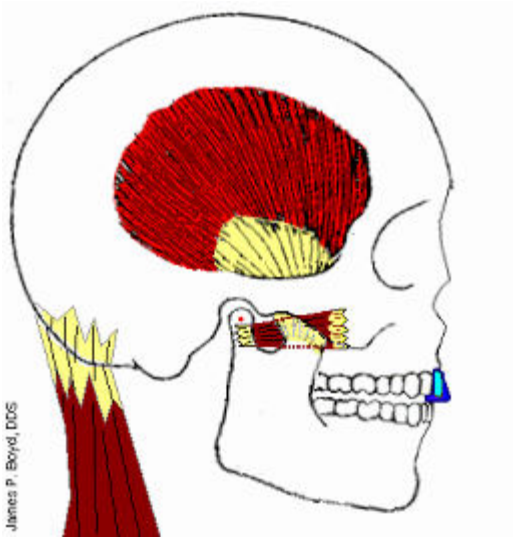
SIDE TO SIDE GRINDING MOVEMENT



Actions of medial pterygoid

- Assits in elevating the mandible
- Acting with the lateral pterygoid they protrude it
- Acting with medial pterygoid of same side advances the condyle ,while the jaw rotates through the opposite condyle(when the medial and lateral pterygoid of the two sides contract alternatively to produce side to side movements of mandible eg chewing)

Medial and lateral pterygoid act together to protrude the mandible



LATERAL PTERYGOID

- ATTACHMENTS It is a short thick muscle with two parts or head

- UPPER head arise from infratemporal surface and infratemporal crest of greater wing of sphenoid bone

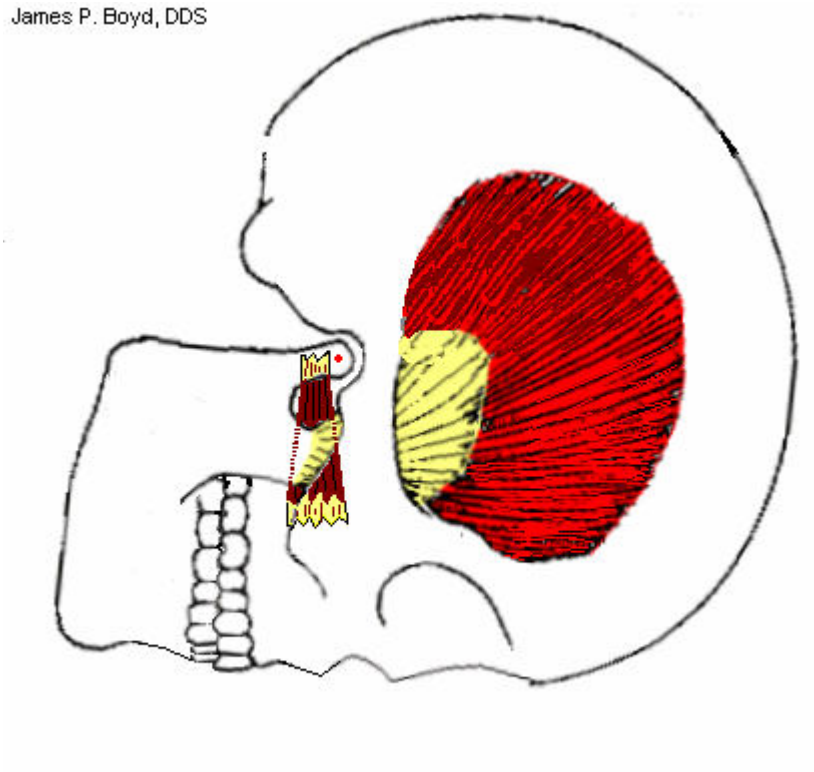
- LOWER head arise from lateral surface of lateral pterygoid plate.

- Its fibers pass backwards and laterally to be inserted into a depression(pterygoid fovea)on the front of the neck of the mandible and into the articular capsule and disc of the temporomandibular articulation.

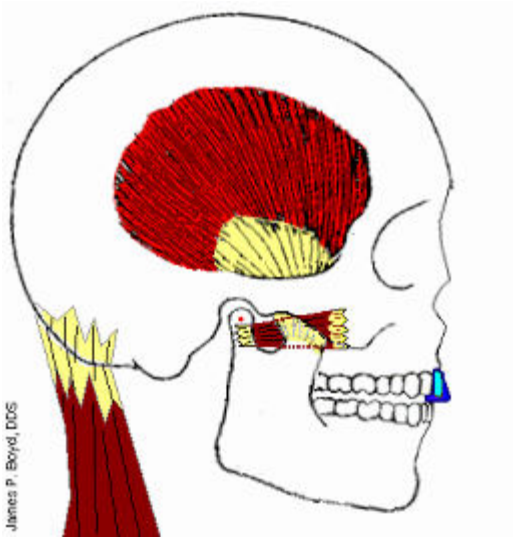
- When the medial and lateral pterygoids of two sides act together they protrude the mandible so that the lower incisors project in front of the other.

- Some authorities have ascribed different actions to the two parts of pterygoid muscle.

- The upper (superior)head being involved in chewing


James P. Boyd, DDS

Medial and lateral pterygoid act together to protrude the mandible



Secondary muscles taking part in the mastication

The 4 primary muscles of mastication are in turn supported or supplemented by few secondary muscles known as SUPRAHYOID GROUP of muscles they are

- DIGASTRIC
- MYLOHYOID
- GENIOHYOID
- STYLOHYOID is other suprahyoid muscle, which does not take part in mastication

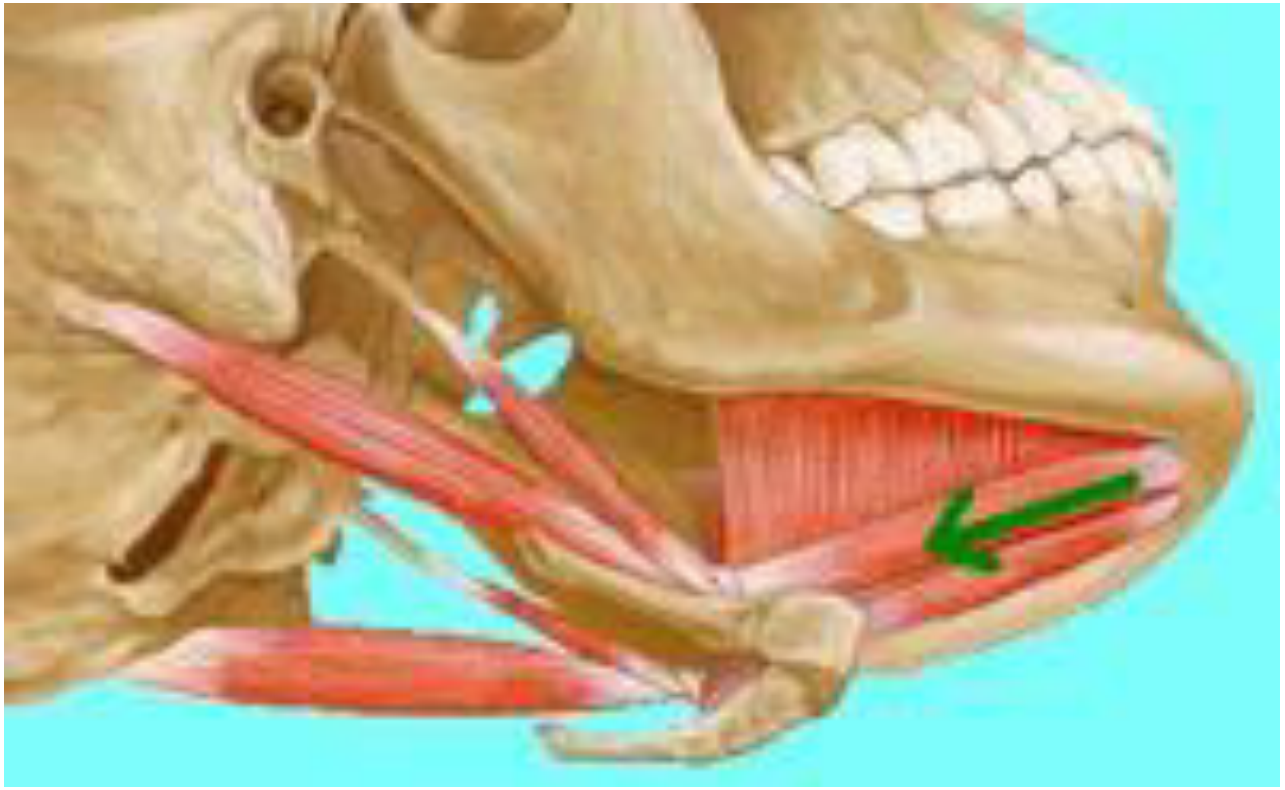
- DIGASTRIC- The muscle has secondary role in mastication as a depressor muscle adding to the action of lateral pterygoid muscle when mouth is to be opened against resistance. Elevation of hyoid bone

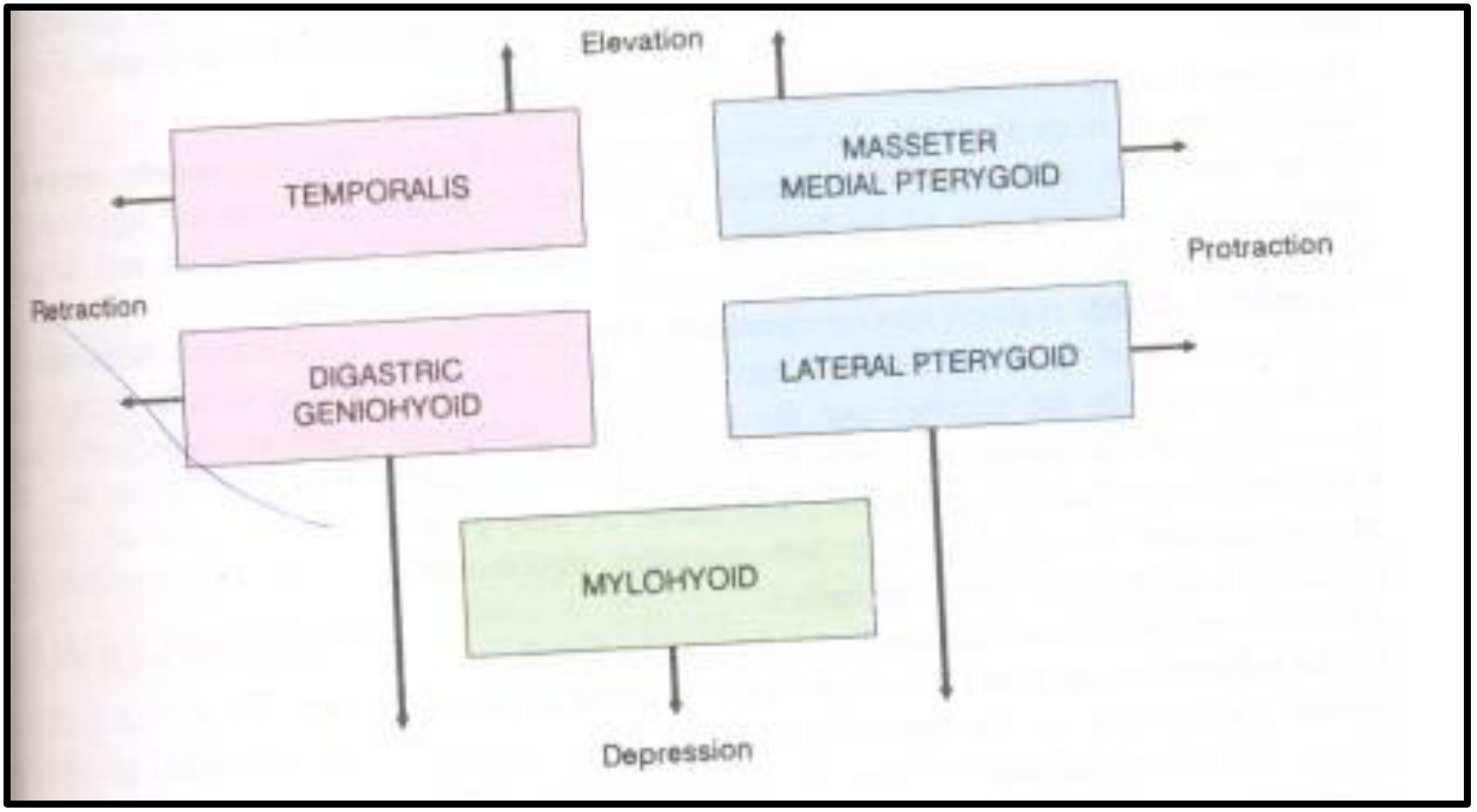
- MYLOHYOID- The secondary role of this muscle is evident as a depressor seen in action when mouth is to be opened against resistance.

- It elevates the floor of mouth to help in degluttition.

- GENIOHYOID- Geniohyoid elevates the hyoid bone and draws it forward, thus acting as a partial antagonist to stylohyoid.

- When the hyoid bone is fixed, it depresses the mandible




Elevation
TEMPORALIS
MASSETER
MEDIAL PTERYGOID
Protraction
Retraction
DIGASTRIC
GENIOHYOID
LATERAL PTERYGOID
MYLOHYOID
Depression

INNERVATION

- Movements of synovial joint initiated & effected by muscle coordination.
- Achieved in part through sensory innervation.

- Hilton's Law:
- The muscles acting on a joint have the same nerve supply as the joint.

- Therefore:
  Branches of the mandibular division of the fifth cranial nerve supply the TMJ (auriculotemporal, deep temporal, and masseteric)

INNERVATION

- 4 Types of nerve endings:
- 1. Ruffini's corpuscles (limited to capsule)
- 2. Pacini's corpuscles (limited to capsule)
- 3. Golgi tendon organs (confined to ligament)
- 4. Free nerve endings (most abundant)

CLINICAL CONSIDERATIONS

- FRACTURES results because of thinness of bone in articular fossa.
- Internal DISC DERRANGEMENT or dislocation.
- DISLOCATION of TMJ
- TMJ ANKYLOSIS
- MYOFACIAL PAIN SYNDROME : consists of

1. Masticatory muscle tenderness
2. Limited opening of mandible < 37 mm.
3. Joint sounds

Theories of mineralisation

INTRODUCTION

- The hard tissues of the body –Bone, Cementum ,Dentin & Enamel are all associated with the functioning tooth.
- Specialized connective tissue
- Collagen (principally Type –I) plays a large role in determining their structure

(Except Enamel)

Organic matrix in Hard tissues

- A hallmark of calcified / mineralized tissues is the various matrix proteins that attract & organize calcium & phosphate ions into a structured mineral phase based on carbonated apatite.

MINERAL

- The inorganic component -mineralized tissues consists of biologic apatite, which is essentially a calcium phosphate salt approximating in composition to *calcium hydroxyapatite*, represented a $\mathbf{Ca_{10}(PO_4)_6(OH)_2}$
- The formula indicates only the atomic content of a conceptual entity known as the ***"unit cell"*** which is the least no of calcium ,phosphate & hydroxyl ions able to establish ionic relationship

- The unit cell of biologic apatite is hexagonal.
- When stacked together, these cells form the lattice of a crystal.
- The no. of repetitions of these arrangement produces crystals of various sizes.

- A layer of water ,***hydration shell*** exists around each crystal.
- Each apatite crystal has three surfaces : crystal interior , crystal surface,& *hydration shell* ,all of which are available for exchange of ions.

$Ca_{10}(PO_4)_6(OH)_2$

- Magnesium & sodium can substitute in the calcium position ,fluoride & chloride in the hydroxyl position ,& carbonate in both the hydroxyl & phosphate positions.
- Fluoride substitution decreases the solubility of the crystals , carbonate increases it .
- Magnesium inhibits crystal growth .

- Ions may be adsorbed to the crystal surface by electrostatic attraction or bound in the hydration layer.
- The apatite crystal can retain its structural configuration while accommodating these substitutions.

- Biologic apatite is build on a definite ionic lattice pattern that permits considerable variation in its composition through substitution ,exchange & adsorption of ions.

MINERALIZATION

Two mechanisms :

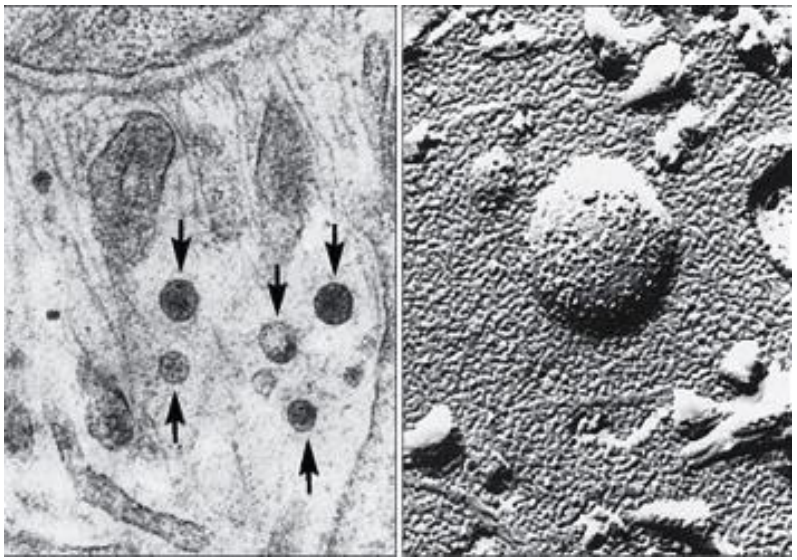
1. **Homogeneous nucleation -**

   Local increase in the concentration of inorganic ions permits a sufficient no. of ionic clusters & crystallites to form.

2. **Heterogeneous nucleation -**

   The presence of nucleating substance allows crystal formation to occur ,in the absence of a locally increased ionic concentration.

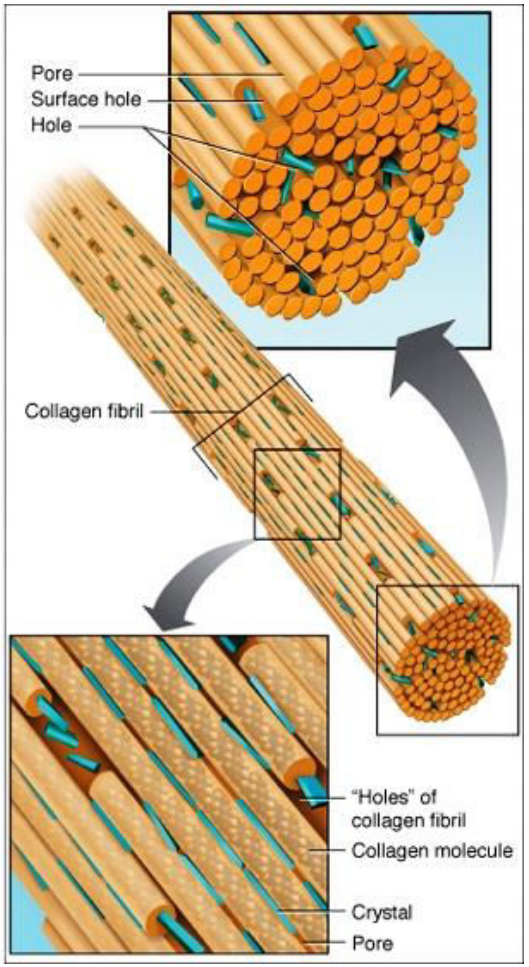
MATRIX VESICLES



- A vesicle is a small membrane -bound structure that buds off from the cell to form an independent unit within the first formed organic matrix of hard tissue.

- The first morphologic evidence of a crystallite is seen within this vesicle .
- The matrix vesicle provides a microenvironment in which proposed mechanisms for initial mineralization exist.

- Matrix vesicle contains alkaline phosphatase ,Ca-ATP- ase , metalloproteinases, proteoglycans ,& anionic phospholipids, which can bind Ca , and inorganic phosphate & thereby forms calcium –inorganic phosphate phospholipid complexes.
- Discovered by Anderson & Bonucci

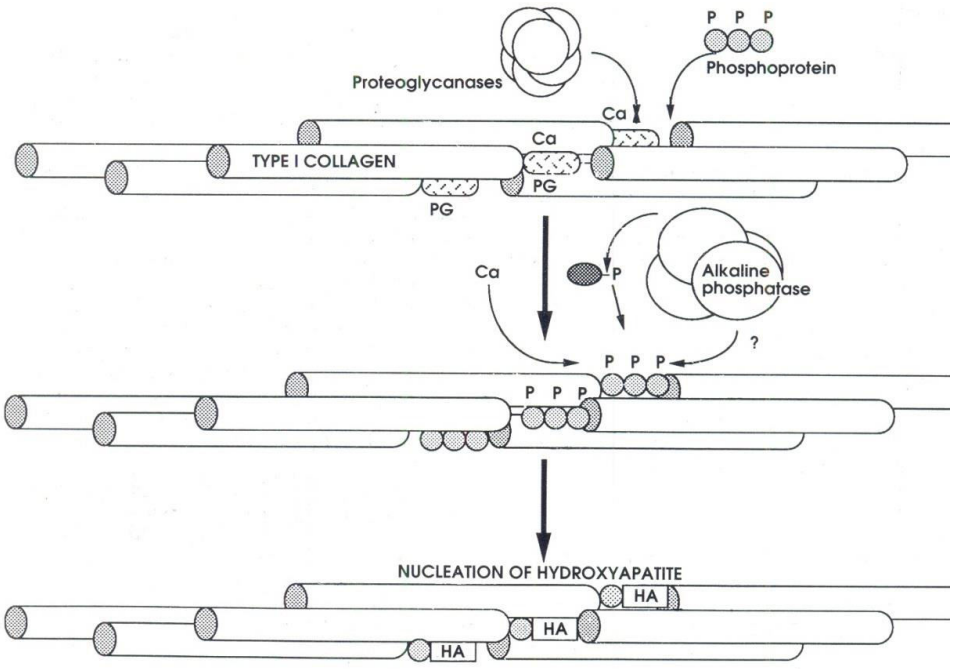

Pore
Surface hole
Hole
Collagen fibril
"Holes" of collagen fibril
Collagen molecule
Crystal
Pore

HETEROGENEOUS NUCLEATION

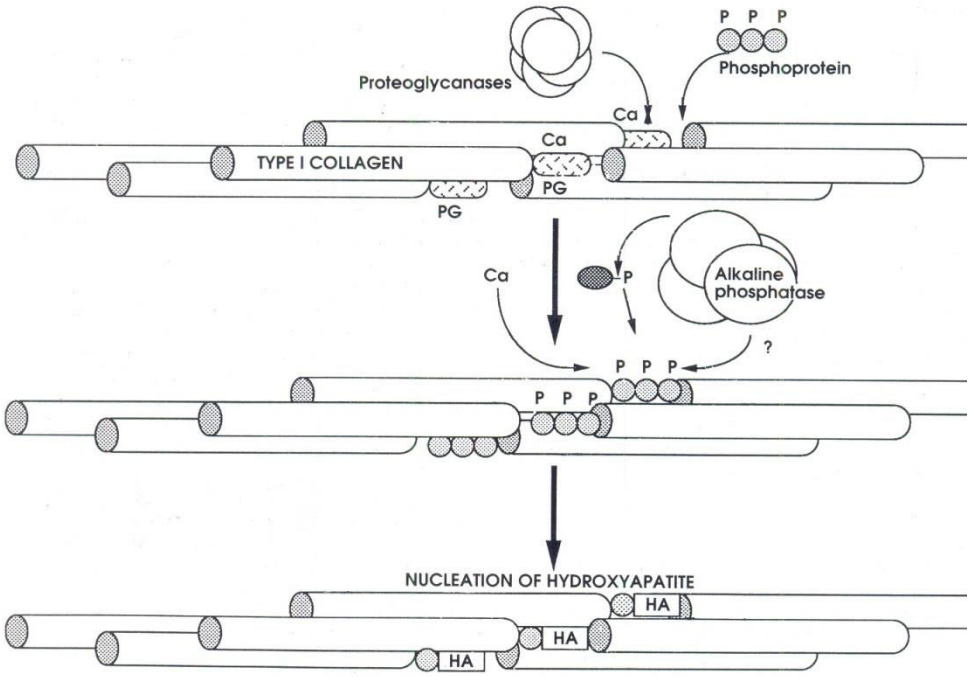
- Deposition of apatite crystals is catalyzed by specific atomic groups associated with the surface, holes & pores of collagen fibrils.
- Regulation of this process is believed to be achieved by noncollagenous proteins.
- 70 to 80 % of mineral is located within the collagen fibril, the rest is located in the spaces between fibrils.

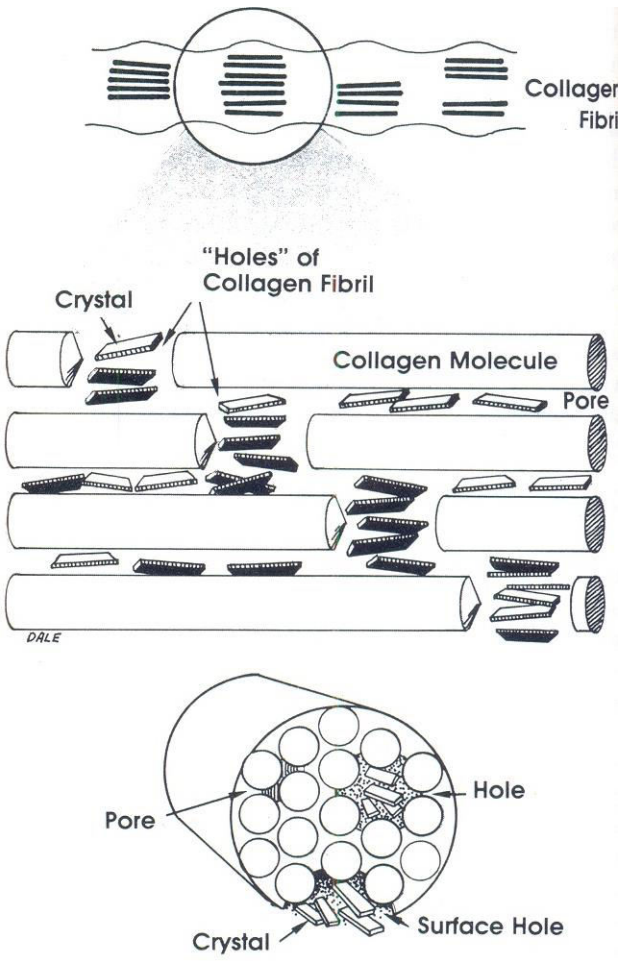
HETEROGENEOUS NUCLEATION

- Collagen fibers formed along secreted non-collagenous proteins (PG).
- Proteoglycanases degrade PGs & allow phosphoproteins to bind to collagen.



- Phosphoproteins immobilizes phosphate & initiate first mineral deposit.
- Alkaline phosphatase dephosphorylate Phosphoproteins

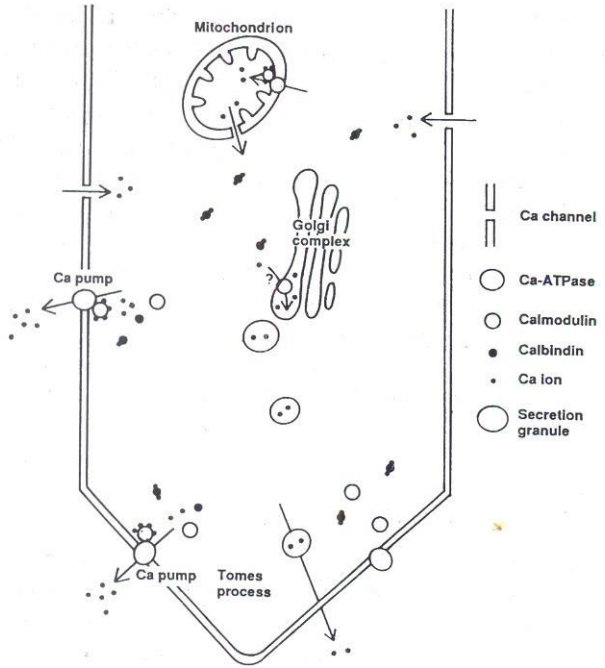


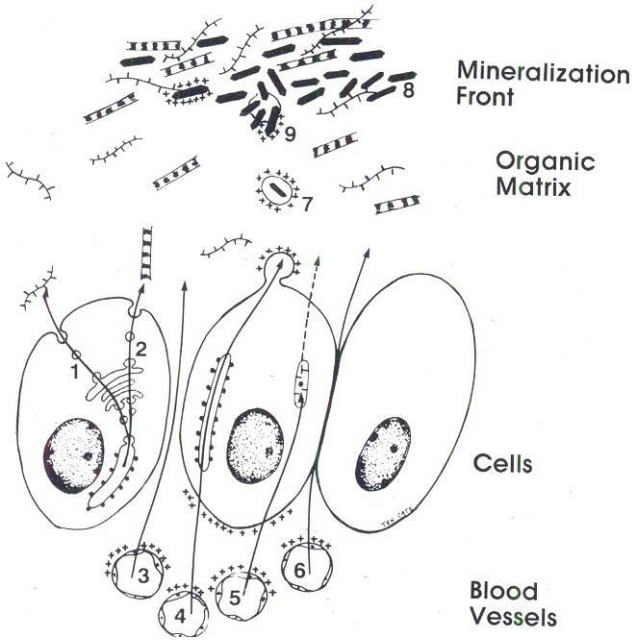


- Localized increase in phosphate ions encourage precipitation of additional calcium –phosphate complex.
- First Hydroxy-apatite crystals
- Mineralization

Transport of mineral ions to mineralization sites

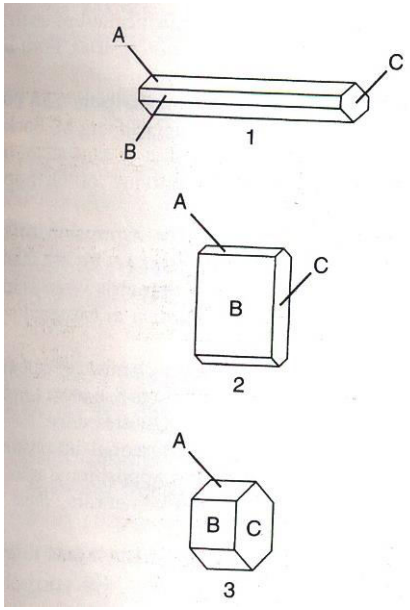
1. Through cell (Intracellular)
2. Between cell (Transcellular)


Mitochondrion
Golgi complex
Ca pump
Ca pump
Tomes process
Ca channel
Ca-ATPase
Calmodulin
Calbindin
Ca ion
Secretion granule


Mineralization Front
Organic Matrix
Cells
Blood Vessels
1
2
3
4
5
6
7
8
9

Crystal growth

- Initial growth of apatite crystal is rapid, occurring in minutes or less, later it slows.
- Increases in size 10-20 times



- The immediate environment of the growing crystal - most important factor which influence the crystal growth
- Non –collagenous proteins can bind selectively to different surfaces of the crystal, preventing further growth,& thereby determine the final size of the crystal

Alkaline phosphatase

- A group of enzymes that have the capacity to cleave phosphate ions from organic substrates at an alkaline pH & thus associated with mineralization.