Chapter

1

Basic Science

Development of the TMJ

There is a lot of controversy about morphological timing for the development of TMJ. Meckels cartilage provide the skeletal support for development of lower jaw and extend from the midline backward and dorsally where it terminate as the malleus and articulate with the incus cartilage.

Temporo- mandibular joint (TMJ) develop as result of mesenchyme condensation of mesenchyme cells separating the developing squamous portion of the temporal bone from the condylar cartilage which form on the dorsal surface of developing condyle.

Once early movements of this early jaw occurs between these two cartilages, and this primary joint exists at 4 months of embryonic development until cartilage ossify (Antonio Nanci, 2008, Ten Cates, Oral Histology).

The most contraversal aspects concern about the moment of the initial organization of the condyle, the squamous part of temporal bone, the articular disc, capsule, cavitation and onset of condylar chondrogenesis.

Recent research confirm about presence of three phases in the development of the TMJ were identified, the first phase is the blast emetic stage at 7-8 week of development which corresponds with the onset of the organization of the condyle and the articular disc and capsule.

During week 8 intra membranous ossification of the temporal squamous bone begins. The second stage is the cavitation's stage at 9-11 week of development, the initial formation of the inferior joint cavity at week 9 at this stage condylar chondrogenesis started and at week 11, the initiation and organization of the superior joint cavity started. The third stage is the stage of maturation started at week 12 of embryonic development. These stages represent the most critical period of TMJ morphogenesis as occurring between 7-11 weeks of embryonic development of humen TMJ.

It seem the formation of the TMJ occurs around 12 weeks in utero when the joint spaces and articular disc developed, at 10 weeks the

component of future fetus joint becomes evident in the mesenchyme between condylar cartilage of the mandible and developing temporal bone, two slits like joint cavities and intervening disc make their appearance in the region by 12 weeks and the mesenchyme around the joint begin to form the fibrous capsule.

Very little known about newly forming muscle during joint formation, but at this stage superior head of lateral pterygoid muscle developed and attached to the anterior portion of the disc, the disc continue posterior through petrotympanic fissure and attach to the malleus of middle ear.

The articulation of the lower jaw with the cranium and upper facial skeleton involves two separate joints and the teeth when in occlusion. The bones involved are mandible, temporal bone, and the joint so it called Temporo- Mandibular joint (TMJ).

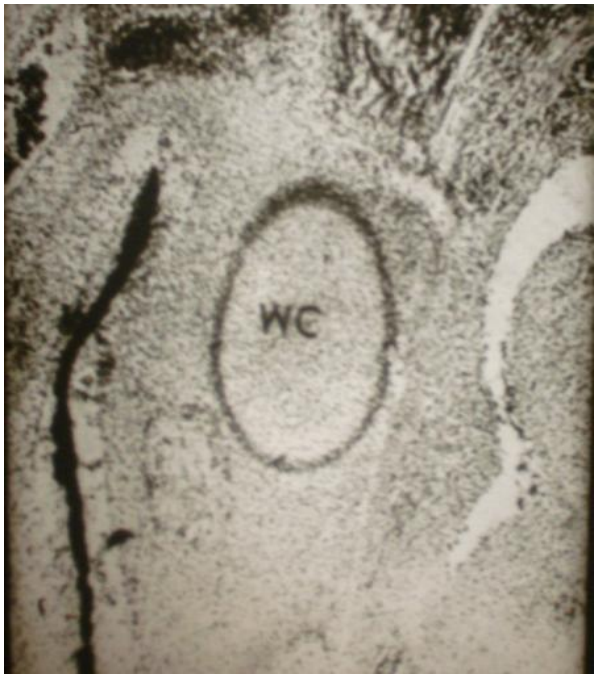
These two bones are united and surrounded by a capsule creating a joint cavity, which is filled by synovial fluid formed by synovial membrane, the capsule extended into these cavity to form the disc which will divide the joint into upper and lower compartments, Also the condyle (the articulating surface of the mandible) can undertake rotary and translator movements, so the TMJ is described as a (synovial sliding-ginglymoid joint).

The TMJ start to develop at 3 months of gestation as a two separate regions of mesenchyme condensation (temporal blastema and condylar blastema), ossification occurs in both of them while they grow toward each other.

The intra membranous ossification commences in the squamous of temporal bone in the 30 CR while differentiation of the cartilage of the mandibular condyle at 50 CR stage.

During ossification, a cleft occurs in relation to condylar blastema which form the lower joint cavity and another cleft occurs in relation to temporal blastema which form the upper joint cavity, with the appearance of this clefts, the primitive disk is formed.

Growth of the condylar cartilage bring the mandible into close relationship with the temporal bone in the 65 CR and the upper and lower joint cavities appear as two slit like spaces in intervening mesenchyme, the articular disc develop ventrally with the lateral pterygoid muscle and dorsally with the peri chonchondrum covering Meckels cartilage and the medial portion of the disc may be developed from the tendon of the lateral pterygoid muscle.



Development of Meckels cartilage during embryonic stage between 10 weeks.

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Anatomy & Physiology of TMJ

The TMJ articulation has many anatomic and functional features that make it unique among all joints of human body and better nominated as cranio mandibular joint and represent the articulation between the lower jaw and base of the skull. It is highly specialized joint, freely movable, contains two cavities, the articular surface covered by fibrocartilage and not by hyaline cartilage, also this articulation carry the teeth whose shape and position deciding influence on some movements and also that restricting influence on the movement of the mandible is exerted by its bilateral articulation with the cranium, so that the left and right TMJ articulation are necessarily complied.

The temporo-mandibular joint (TMJ) is the joint between the mandible head or the condyle and glenoid fossa of the skull bone (Temporal Bone), these bones are held to gather and stabilized and function through a complex group of muscles, ligaments and other soft tissue. The TMJ joints are the only two joint working together in a synchronized fashion together as one unite unlike any other joints in the body and it's the only joint with two compartment separated by inter articular disc and the head of condyle is covered by dense fibrocartilage while other joints the ends covered by hyaline cartilage. The TMJ working through a series of complex reflexes through coordination by coming together of the upper jaw teeth and lower jaw teeth accompanied by surrounding periodontal ligaments attachment, nerves and surrounding bone and gum tissue and teeth during opening and closing cycles of chewing as active movements and by swallowing, breathing, talking, whistling, kissing, sucking and resting mode as passive movements this occurred through a series of reflexes.

The TMJ is a synovial joints of left and right connected by the main body of the mandible and ramus on each side, the two condyles represent the superior bony part of the mandible that articulated with the base of skull by two glenoid fossi and the joint located just in front of the auditory meatus, condyle movements are unique and can move and able to swing and rotate within the fossa but its movements limited by the surrounding ligamentous attachments such as TMJ ligaments and

surrounding muscles.

The condyle formed from head and neck, the diameter of condyle head is 15-20mm in the mediolateral and 8-10mm in the posterior anterior dimension and varies in shape and size, the superior surface often flat but strongly concave in anterior-posterior and slightly convex in medio-lateral direction, the articular surface of growing condyle is covered by fibrous tissue and became thin in the posterior side and applied directly to sub articular bone, over the convexity of the condyle, there is a layer of fibro cartilage between the surface dense fibrous tissue and sub articular bone and the thin line of zone of cells of proliferative layer usually appear between the fibrocartilage and the articular layer. This layer is active in the early years of life.

Sagittal ground section of the TMJ shows the fibro-cartilage layer covering the head of the condyle and anterior wall of glenoid fossa and articular eminence.

And in old people hardly to distinct but keep for repair and remodeling according to Blackwood 1976.

The articular disc (Meniscus) oval in shape is a thin elastic fibrous tissue or ligamentous tissue which is an extension of the capsule and act

as a cushion or shock absorber between the condyle head and base of skull. The articular disc attached interiorly by fine muscles fibers of upper portion of lateral pterygoid muscle and surrounding ligaments that help and assist in positioning the disc over condyle head, they move within the joint compartment during functional movements and resting modes but during jaw function and pressure action on the disc, synovial fluid released into the joint cavities for lubrication of the joints and act as shock absorbers, the presence of glenoid fossa in temporal bone as a concavity in which the condyle sit and the disc separate between the condyle and glenoid fossa, the disc slide with the mandible to provide quiet movements and act as a cushion to the heavy and powerful masticators movements as generated by powerful and strong muscles of mastication. The functional movements of the TMJ considered as the most complex joint due to rotational and sliding movements and an infinite range of combined movements and function unlike other joint in the body one of the interesting movements of the TMJ, during mouth opening a rotational movements occur within the lower jaw and meniscus but during wide opening of the mouth a second movements occur called transitional or forward and downward sliding movement of the disc and the jaw, other movements as excursion masticators movements.

The disc is oval in shape, the central part is thin and avascular collagen and thick at the posterior and anterior margin with the ability to stabilize the condyle against articular eminence, the posterior attachment of the disc is split into 2 strata of fibers and in between these strata there is a loose areolar connective tissue, the superior one attached to the squamo-tympanic tissue and composed of elastin (rather than collagen) while the inferior strata blend with the periostum of the posterior surface of the condyle. The disc is very vascular and contains elastic, fatty tissue and numerous vascular bed called some times as vascular knee other they call it as retro discal pad, the disc is tightly attached at the medial and lateral border of the condyle and its attachment posteriorly elastic and work as recoil. At birth the disc and articular surface is vascular but the central part of the disc became avascular at age of 3-5 years.

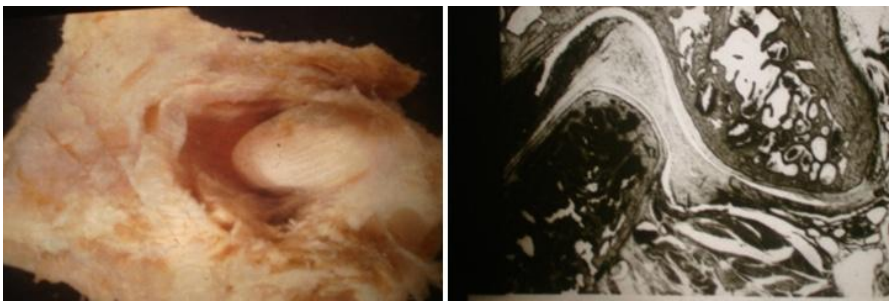
At birth the disc and articular surface of the condyle were vascular, but the central part of the disc became a vascular at age of 3-5 years, the disc

attached to the anterior edge of articular eminence above and to articular margin of the condyle and to the superior fibers of lateral pterygoid muscle below, it consist of anterior band, intermediate zone, posterior band and bilaminar band or strata.

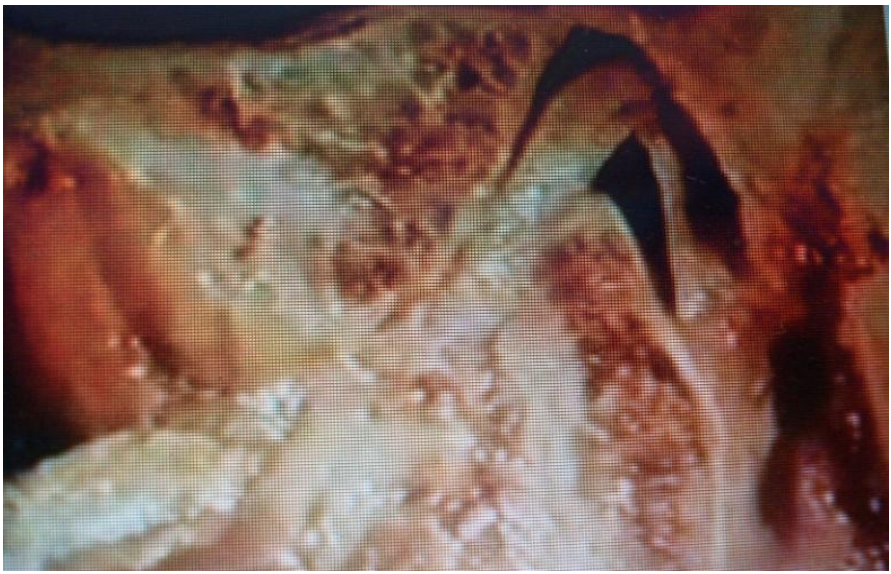
The joint capsule, there is no capsule of the medial half of the anterior aspect of the TMJ, the synovial membrane lining the anterior wall of superior cavity and supported only by loose areolar tissue other researchers stated that anteriorly and posteriorly the capsule is thin but strengthen medially and laterally by capsular ligaments, the lack of tough capsular ligaments anteriorly and as loose areolar tissue will assist the hyper transalation of the condyle and may be the cause of recurrent subluxation and dislocation of the condyle also this structure of the capsule prevent traumatic injuries to synovial lining and lateral pterygoid muscle attachment.

The synovial lining of the capsule form villi and the posterior villi forms as folds of synovial membrane and the synovial tissue of the inferior cavity is also folded into villi and in the inferior portion of the cavity, the meniscus project into the villi to form a heal like process of tissue which allow the disc to rotate posteriorly as the condyle translate forward, these villi may control the lubrication of synovial fluid and the synovial membrane provides sero-mucinous lubrication for the joint and protein to nourish the avascular fibro cartilage.

In sudden load exerted on TMJ, lubrication occurred by the squeeze film, sufficiently viscous to be squeezed out slowly to persist for long enough to support the load applied for a shorter time, it seem under sustained low load a self-gene rated fluid film is formed and under sustained high load the nature of lubrication. The nature of lubrication is boundary rubbing take place between the layers of large molecules adsorbed on the cartilage surfaces and failure of lubrication cause damages to the cartilaginous part of the TMJ, UN Sworth Et Al 1975, and such et al 1975.



Two sections the right one showing the head of condyle after turning up the disc and the left sagittal section of the TMJ showing posterior band of the disc on top of the condyle, intermediate zone and anterior band anteriorly and lateral pterygoid attachment.



Sagittal section of TMJ cadaver showing the glenoid fossa disc and head of the condyle.

Ligaments of the TMJ

The ligaments of the joint are strong, tough, rope like connective tissue fibers, they connect between the condyle and glenoid fossa to each other,

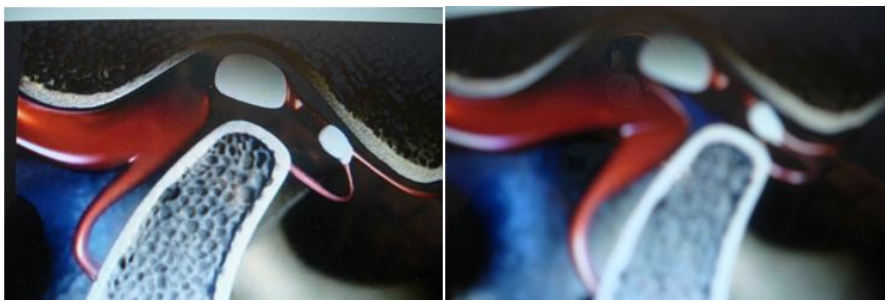
they are two type of ligaments, one called primary ligament and two secondary ligaments.

The primary ligaments are the temporo-mandibular ligament, which consist of two parts, the outer oblique portion (OOP) and inner horizontal portion (IHP).

The two minor or secondary ligaments are the stylomandibular ligaments and a sphenomandibular ligament, these ligaments has no role directly to any part of the TMJ but rather a supportive tissue to the capsule. They are accessory ligaments, but they are important because they define the border movements.

Functional Movements of the TMJ

During TMJ movements only the lower jaw moves, muscles attached to the bones and joint allow a variety of movements including passive movements such as yawing, talking, singing, shouting, sucking and smoking and an active masticators movements. The specific mechanics of proprioception in them involve four receptors. Ruffini ending functions as static mechano receptors which position the mandible. Pacinian corpuscles are dynamic mechano receptor which accelerates movements during reflexes. Golgi tendon organs function as static mechano receptors for protection of ligaments around the TMJ. Free nerve endings are the pain receptors for protection of them itself. These sophisticated joints can move up and down and side to side in a wide range of motion in a healthy jaw with no pain or discomfort.



Illustrations from internet showing the dynamic movements of the disc with the head of the condyle from internet inTMJ anatomy.

Nerve Supply

Sensory innervations of TMJ are derived from sensory branch of Trigeminal nerve V3, the motor branch of the nerve supply muscle of mastication.

Blood Supply

From the superficial temporal branch of external carotid artery other branches may contribute in blood supply of the TMJ such as, deep auricular artery, anterior tympanic artery, ascending pharyngeal artery and maxillary artery.

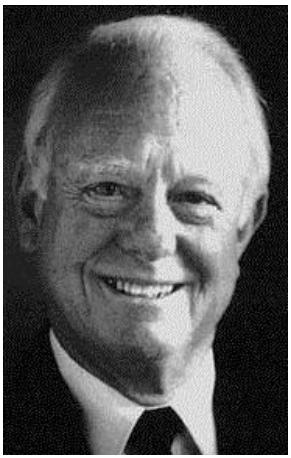
There are no innervations or vascularization within the central portion of the articular disc.

Articular Remodeling

Remodeling mechanisms in the articular surfaces occurred during life continuously and three types of remodeling take place:

1. Progressive remodeling, by addition of tissue to the joint surface to increase the vertical dimension.
2. Regressive remodeling, by this mechanism the tissue removed to end with decrease of the vertical dimension of the articular surface.
3. Prephral remodeling, by this mechanism of addition of tissue to the margins of articular surfaces may be found as lipping or osteophyte formation in osteoarthritic disease, these changes occur to compensate the occlusal wear and loss of teeth, this remodeling is a pathological remodeling.

Growth of TMJ



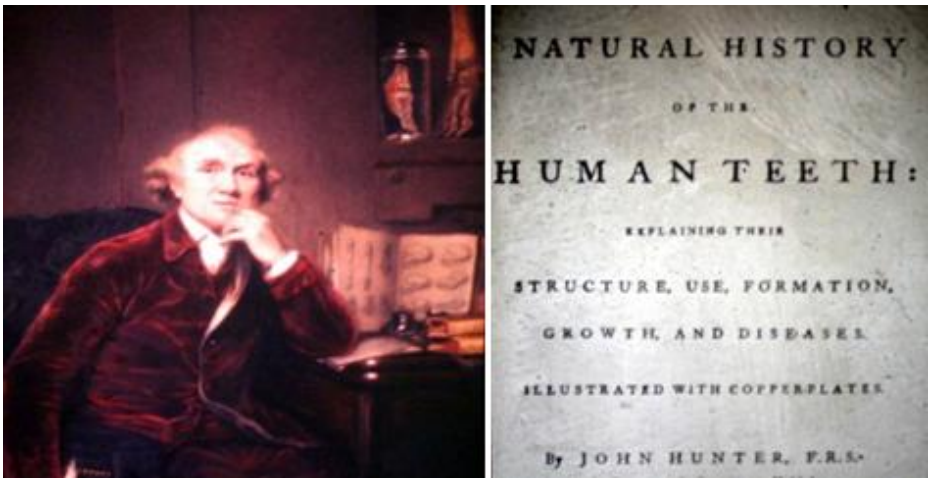
D. E. Poswillo, 1988 (1927-2003)

The human mandible has no one design for life. Rather, it adapts and remodels through the seven stages of life, from the slim arbiter of things to come in the infant, through a powerful dentate machine and even weapon in the full flesh of maturity, to the pencil-thin, porcelain like problem that we struggle to repair in the adversity of old age.

The mandible develop from the tissues of the first brachial (pharyngeal) arches, within mandible process, which formed from embryo genic neural crest cells that originate in the mid-and hindbrain regions of the neural folds.

These cells migrate ventrally to form mandible (and maxillary) facial prominence, where they differentiate into bones and connective tissues.

The mandible is a membranous bone which means that it's formed directly in mesenchyme with no cartilaginous precursor. During the sixth week of intra uterine life a single ectomesenchyme condensation for each half of the mandible arises in the bifurcation of the inferior alveolar nerve (mental and incisive branches bifurcation), after one week these ectomesenchyme condensation will undergo ossification to form two separate intra membranous ossification which will give rise to the first bones of the mandible, from this centre of ossification bone formation spread rapidly superiorly and inferiorly to the symphesial region to form the body and the ramus of the mandible.



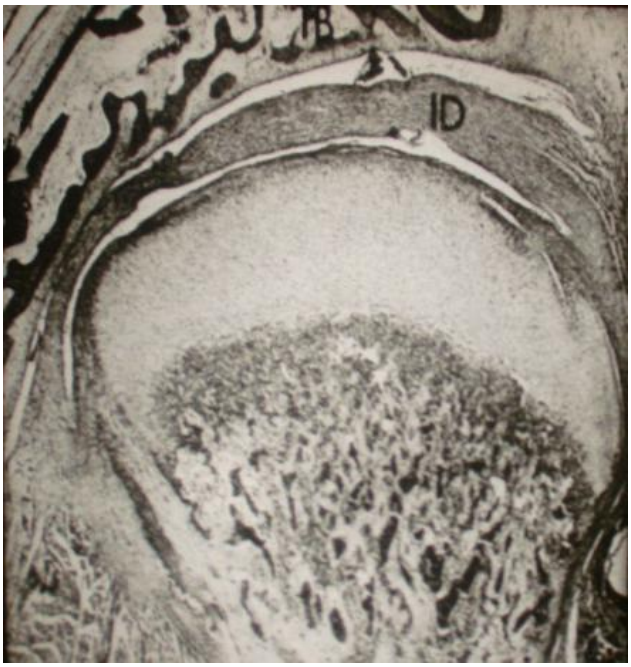
John Hunter 1772-1773.

At 10 weeks the rudimentary mandible is formed almost entirely by these membranous ossifications. After these periods the development is a matter of growth and remodelling (turnover) by apposition and resorption to take the final shape of the mandible. Control of mandible growth is influenced strongly by a combination of two theories mechanisms.

The Condylar Growth Centre Theory

This theory was mentioned by John Hunter (1772) in his (book the teeth) suggests that the mandible growth occurs in response to activity of the growth centre located in the mandible condyle. This secondary (growth) cartilage appears during the 12th week of development and a thin layer of this cartilage persists.

Until the end of the second decade of life, it provides a mechanism for growth in the same way as the epiphysis cartilage does in the limbs and also provides continuous growth, repair and remodelling.



Sagittal section of the of new borne baby of the TMJ, condyle showing post natal growth with active mesenchyme stem cells and cartilaginous bone cells formation.

The Functional Matrix Theory

Moss 1962, suggested the mandibular growth occur in response to functional forces and demands imposed by functional matrix of muscles of mastication, so that the mandible growth appears to occur via a condylar growth and bone adaptation secondary to the functional forces exerted by normal muscle activity.

The author believe there is no single theory control the growth of the mandible and mid face and both theories of primary growth centre in the condyle and theory of functional demands of periosteal matrix of the bone work together to achieve proper growth of the mandible and mid face, this statement based on experimental and clinical studies.

We learned from John Hunter how to use animal models for improving our surgical techniques for benefit of humanity and to contribute to science.

Post Natal Growth

After birth there is very rapid growth of all component of the TMJ, the condyle grow by endo chondral ossification. The condyle cartilage showed three distinct zones, the articular, and the proliferative and hypertrophic zone:

The articular zone consist of dense fibrous tissue and collagen fibres arranged in parallel direction, the proliferative zone consist of small round cells with mitotic activity to provide the main growth centre of the condyle and the cells of this zone differentiate to chondroblast and chondrocyte of hypertrophic zone while in hypertrophic zone, there is cartilage matrix which is secreted by the cells, and became hypertrophic and the cartilage matrix mineralized and ultimately resorbed and replaced by endochondral bone.

Structure of Adult Joint

The condyle is elliptical in shape, the largest diameter being medio-lateral and the shortest is anterio-posterior, the articular surface as in the growing condyle is covered by fibrous tissue, the fibro cartilage layer is between the surface fibro articular layer and the sub articular bone, the proliferative zone appear as a thin line of cells along the line of junction between the fibro cartilage and the articular layer, the zone cells are capable for proliferation at any time and play an important role in remodelling and repair of the articular surface.

(1) Temporal Bone

The glenoid fossa extend from the anterior margin of the squamous-tympanic fissure to the tubercle of the articular eminence bounded medially by the suture between the squamous portion of temporal bone and the great wing of sphenoid, the bone of articular fossa is thin and covered by thin layer of fibrous tissue, the articular eminence is much thicker, there is a layer of fibro cartilage between the surface fibrous articular zone and the bone, the proliferative zone is less well defined.

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