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Otomandibular Ligaments: Anatomical Exploration and Clinical Application in Humans

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ABSTRACT

Ligamentous structures connecting the middle ear and temporomandibular ligament (TMJ) are called as Otomandibular ligaments (OML). Most of the anatomists believed that OML has two parts: malleomandibular ligament (MML) and Discomallear ligament (DML). Both of these ligaments pass through the bony fissure which runs from TMJ to the tympanic cavity, called as Petrotympanic fissure (PTF). Anatomical connection between TMJ and middle ear persists mainly due to continuation of common Meckel's structure through petro tympanic fissure (PTF). Embryological origin of the MML and DML is debatable but basically, they originates from the first arch. Though they do not play important role in primary movement of TMJ, joint dislocation, anterior disc displacement and hypermobility could happen due to stretching of the DML. MML provides the mechanical support to the head of malleus and forms a movable unit, which acts as suspensory structure for the ossicular chain. Therefore, structural alteration in the MML may plays an important role in affecting middle ear function. The disruption of MML during chronic infection or surgical release of malleus head fixation may affects middle ear sound transmission and results in conductive hearing loss. Shortening of DML by laser coagulation which permits its tightening has been suggested for the treatment of the anterior displacement of the disc. This shortening technique reduces the articular movement range, due to which it was also indicated in the treatment of recurrent temporomandibular dislocations.

Keywords: *Temporomandibular joint, embryology, joint dislocation, temporomandibular joint disc, Otomandibular Ligament.*

INTRODUCTION

Both ontogenesis and phylogenesis explain special links between mandible and ear, particularly between temporomandibular ligament (TMJ) and middle ear. Thin fibrous bands connect the articular disc of TMJ with the malleus of the middle ear. These fibrous bands have been named as Otomandibular ligaments. These bands had also been named with various terminologies like discomallear ligament (DML), tiny ligament, anterior ligament of malleus, malleomandibular ligament (MML) and sphenomandibular ligament (SML).[1-3] Though the naming of these fibrous bands have created debate whether these structures are same or different, but it is now accepted that MML and DML are different structures, which course differently and act on mandible differently.[4]

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Mandible and ossicular chain of middle ear are the derivatives of ventral and dorsal parts of first branchial arch (Meckel's cartilage) respectively and partially join the second branchial arch (Reichert's cartilage) caudally.[4,5] Anatomical connection between TMJ and middle ear persists due to continuation of vascular, nervous and ligamentous structures between both of these. This connection mainly survives due to continuation of common Meckel's structure through

petro tympanic fissure (PTF).[6] These ligaments particularly DML is not described in anatomy textbooks or in anatomical terminology. However, it is included in books like arthroscopy of TMJ and TMJ disorders.[7] According to Rodríguez-Vázquez et al., the DML has two portions: one tympanic, related to the anterior ligament of the malleus; and another extratympanic, which is one of the intrinsic ligaments of the TMJ.[8]

The pioneer workers like Rees, Pintos and Loughner discovered this direct connection between middle ear and TMJ by the dissection studies. DML was first described by Dr. Rees in 1954 as a fibrous band which arises from the tendon of lateral pterygoid (LP) and passes through the PTF and finally attached to the malleus.[2] The DML is a free ligament, lying between the malleus and the TMJ.[9]

In 1962, Pintos claimed that DML is not the viable link between TMJ and middle ear on the basis of his finding on dissection. He concluded that DML attaches to the wall of PTF or dissipates with development so cannot be a viable link. Rather, he suggested another ligament, anterior malleolar ligament (AML) which attaches itself to the anterior process of neck of malleus and passes through PTF to join the retrodiscal tissue of the disc and joins with the SML.[10,11] Existence of this ligament was explained as the connection between ear related symptoms and TMJ disorders.[12] By various authors, these ligaments were exposed to various traction and stretching tests in the cadaveric studies to discover whether they were responsible for mallear mobility by experimental simulation of discal or condylar translation.[11,13]

ANATOMICAL FEATURES

Existence of two ligaments between TMJ and middle ear (Otomandibular ligaments) is emphasized by anatomist, embryologist and evolutionist. These two ligaments are named as Discomallear ligament (DML) and malleomandibular ligament (MML).[14-16] Both of these ligaments pass through the bony fissure which runs from TMJ to the tympanic cavity, called as Petrotympanic fissure (PTF) or Glaserian fissure. Laterally, the Glaserian fissure lies between tympanic and squamous part of temporal bone. Medially, it is divided into anterior portion (petrosquamous part) and posterior portion (petrotympanic part) by the lower extension of tegmen tympani which is the portion of petrous part of temporal bone [Figure 1].[17]

The DML begins at the posterior band of TMJ disc, it runs posteriorly within joint cavity toward the bilaminar zone of the disc, then in the superior retrodiscal lamina.[18] The ligament then passes through the lateral part of PTF, while doing so, some of the fibers appear to insert themsleves on the sides of PTF. After passing through the PTF, it courses through the middle ear and finally fixes itself on the anterior process of malleus. During its attachment to the malleus it may or may not joins the fibers of MML.[17] MML attaches itself at the level of anterior process of malleus in the middle ear cavity and with the lingula of the mandible via sphenomandibular ligament (SML).[19,20] The exact nomenclature of this ligament is not obvious but in majority of literature, it is synonymously called as sphenomandibular ligament or anterior ligament of malleus or tympano-mandibular ligament.[21] The doubt about naming this ligament is more likely due to different conclusions made about its proximal attachment. Renowned text book, including Gray's anatomy (2016), states that the majority of the fibers of the SML attach to the spine of the sphenoid bone, hence the name sphenomandibular ligament.[22] Some other authors concluded that this ligament has no intermittent attachments and is therefore should be named as malleomandibular ligament, extending from malleus to lingula of the mandible.[5,13,17]

MML lies medial to the DML. It runs horizontal, oblique anterior and medially in the middle ear cavity before it reaches to the Glaserian fissure. In the Glaserian fissure, it lies in the medial part of PTF which forms a bony canal called as Huguier's canal by the progressive closure of the bony ridges, through which along with MML, chorda tympani nerve and anterior tympanic artery also exit from the middle ear.[17,23] After its exit from the PTF, it follows a vertical course medial to the TMJ extra-articularly. Then by it runs downward along the medial side of ramus of mandible. Finally MML splits into two bundles and inserts on the both sides of the mandibular foramen on the lingula of mandible.[17] MML is the new name given for the AML, which is actually a tympanic part of the SML which passes through the PTF. [24]

EMBRYOGENESIS

Embryological origin of the MML and DML is debatable. Basically, they originate from the first arch. As suggested by Pinto, the DML is an embryological

remnant of the external pterygoid muscle; it is located more laterally to the AML and inserts into the postero-supero-medial part of TMJ capsule and retrodiscal portion of the TMJ disc.[11] At 14weeks, the DML composed of numerous fine fibrous fibers with faint appearance in transverse and coronal sections. At 14 weeks, the DML, extending posteriorly from the TMJ disc and capsule through the squamotympanic fissure, joined the malleus [Figure 2].[20]

In the fetus and the newborn, the Glaserian fissure (PTF) is open. During the early phase of growth and development, while the tympanal ring grows into a half-cylinder, the Glaserian fissure closes progressively to form canal, trapping MML.[17,25]

The malleomandibular ligament (MML) represents the fibrous remnant of Meckel's cartilage, around which the mandible develops by induction. After giving rise to the incus and the malleus, Meckel's cartilage resorbs itself progressively and finally disappears around the last trimester of intrauterine period, except for a remnant of its sheath which becomes the MML.[17] This ligament runs through the canal formed by the progressive closure of PTF as described by Huguier along with the chorda tympani and the anterior tympanic artery.[26]

PHYLOGENESIS

Evolution from aquatic life to terrestrial life had induced dramatic modification in TMJ. Unlike mammals, reptilian has lower jaw composed of several bones arranged in sagittal plane, the last bone articulates with the square bone (cranial bone) to form equivalent joint called as quadrato-articular joint. In mammals (including man) the lower jaw has only one bone, which articulate with the cranial bone to form the temporomandibular joint (TMJ).[17] TMJ is one of the last joints in the body to develop and occupies unique place by development and function. In evolutionary terms, it is a new joint which has replaced the joint between the malleus and incus. Unlike most other synovial joints, it develops from two separate intra-membranous elements (blastema) which grow toward one another.[24,27] Malleus, which develops from the temporal blastema of first pharyngeal arch and condyle of mandible which develops from the condylar blastema of same arch are connected with the fibrous connection, which was named as DML by Rees (1954). Same structure (DML) was described as the vestigial remnant of first pharyngeal arch by other authors.[28,29]

FUNCTIONAL ASPECT OF LIGAMENTS

The function of DML is always remain as controversial. According to Mérida-Velasco et al., it may acts on the incudomallear articulation at the end of the embryonic period to execute the first buccal movements.[30] Other authors have also suggested that the DML was unnecessary after the complete cavitation of the TMJ, and that it diminishes gradually after the development of TMJ.[9] Recently, Rodriguez-Vázquez et al. (2011) reported that DML may participates in closing of the middle ear by descent of tegmen tympani.[8]

TMJ dislocation, anterior disc displacement and hypermobility could happen due to stretching of the DML.[16] In normal physiological movement of TMJ, however, DML does not play any important role to limit the anterior movement of the disc. But in extreme movement like maximum opening and protrusion, its tightening effect can restrict the anterior displacement of disc.[17,31,32]

MML provides the mechanical support to the head of malleus and forms a movable unit, which acts as suspensory structure for the ossicular chain. Therefore, structural alteration in the MML may plays an important role in affecting middle ear function.[33]

When mouth is closed and mandible is in rest position, MML is found to be relaxed and thin and becomes tight and extends sagittally only during opening of the mouth. Unlike its usual functional importance, the MML is often drawn in text book as being taut and bulky between cranial base and lingula of the mandible. If it existed as usually described, it would be impossible to open the mouth.[17]

Study by Sencimen M et al found that when traction and tension tests were applied to the MML and DML to observe their effect on malleolar movement; application of tension to part of the DML resulted in no movement of the malleus. When the MML was overstretched, significant movement of the malleus was observed in around 33 % of cadavers.[34]

HISTOLOGICAL FEATURES

A number of researchers supposed that these ligaments were comprised of collagenous fibers.[13] whereas, the others supported that only fibro-elastic fibers could transmit traction forces of TMJ and cause mobility of the malleus.[8,11]

In the study conducted in Turkey, on 15 adult skulls, fixed in a formalin solution, with undamaged TMJs. The AML was found to be rich in collagenous structure, running as both thin filaments structure and also as thick bands dispersed in denser fashion. However, evidence supporting presence of elastic fibers was found in none of the examined sections. Thick collagen bands were found to be rich in nuclei of fibrocytes and collagenous filaments. Presence of capillary lumens were also obvious in between collagen bands.[23] SML was also consisted of collagen fibers as main constituent, which run in parallel fashion forming the bundles. Presence of adipose cells and capillary lumens were also noted adjacent to the collagen fibers [Figure 3].[23]

Main structural component of the DML is also collagen fibers forming the bundles but Sencimen reported one specimen which was harvested from the part in between PTF and articular disc having elastic fibers dispersed as cotton-bowls surrounded by bundles of collagen fibers. However, no evidence of elastic fibers was found in the part of the DML harvested from in between the malleus and petrotympanic fissure.[23] Study done by Valesco et al among 15 cadeveric specimen showed that extra-tympanic portion of the DML in all the specimens was composed of collagen fibres together with abundant elastic fibres. Both types of fibres were arranged in similar fashion in anteroposterior direction.

CLINICAL APPLICATION

Usually they do not involve in the otologic manifestations of the temporo-mandibular joint,[16] however TMJ disorders may stretch the DML and part of MML affecting the middle ear structural balance. Though less likely, but it seems that otic symptoms like tinnitus, dizziness, otalgia and hypoacusis which correspond to the altered ossicular spatial relationship (middle ear pathologies) can also be caused by the pathologies of the masticatory system including TMJ.[31,35-37]

It had been found that prevalence of tinnitus increases two to three times in presence of TMD. Several studies had investigated whether DML and MML cause otological symptoms which could occur due to tension of DML and movement of malleus in anterior disc displacements with reduction. Other incidents like TMJ surgery as a result of excessive inferior movement of the condyle and extreme stretching of the ramus during distraction osteogenesis may cause tension in the MML which may initiate otological symptoms like pain and tinnitus.[34] The disruption of MML during chronic infection or surgical release of malleus head fixation may affects middle ear sound transmission and results in conductive hearing loss.[33] The excessive traction of this ligament through TMJ surgery could happen in the circumstances if a MML ligament has almost no or very few attachments with the sphenoid bone, which is the most frequent anatomical situation, and a wide Hugier's canal.[5,17] Disruption of the articulation between malleus and incus during condylotomy and dislodgement of the stapes from the oval window during arthroscopic procedure done for TMJ surgery is the major complication that resulted in deafness (partial or total) on the same side of ear. Abnormal tension on the MML and DML was taken as the factor causing such complications.[10,34]

In infants, the remaining connection between the temporomandibular joint and the middle ear explains the risk of temporomandibular arthritis in cases of otitis or mastoiditis.[17]

SURGICAL IMPLICATIONS

The DML appears as 'sheet covered rope' or oblique protuberance (as suggested by Cheynet, 2003), covered by superior retrodiscal synovial membrane.[17,38] One of the mechanism which causes the disunity between condyle and TMJ disc could be the stretching of the DML by constitutional or acquired hyperlaxity. Shortening of this ligament by laser coagulation, which permits its tightening has been suggested for the treatment of the anterior displacement of the disc.[34,39] This shortening technique reduces the articular movement range, due to which it was also indicated in the treatment of recurrent temporomandibular dislocations.[17,31]

Forced oral opening, forced distraction of the mandible (during temporomandibular surgery), temporomandibular disarticulation or violent trauma with excessive traction on this ligament through the mandibular displacement may result in ossicular dislocation. Such dislocation of the ossicular chain will be more common in two conditions: the MML that has no or few attachments with the sphenoid spine, which would be the most frequent anatomical situation and a rather wide Glaserian fissure or Huguier's canal.[17,34]

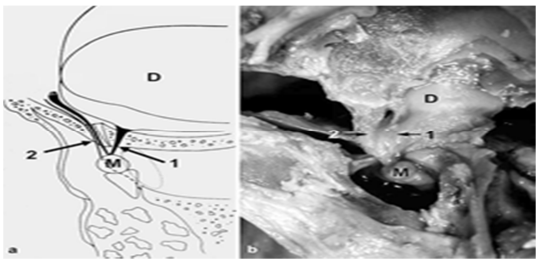

Figure 1: Schematic (a) and Anatomical dissection (b) view of discomallear and malleomandibular ligaments.

Explanation (foot note): D: Disc; M: Malleus; 1: Discomallear ligament. 2: Malleomandibular ligament (Source: cheynet, Guyot, Richard, Layoun, and Gola, 2003).

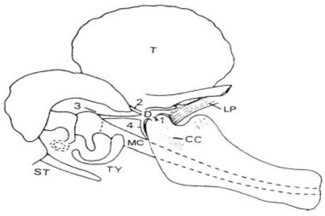

Figure 2: Embryogenesis of Otomandibular ligaments.

Explanation (foot note): T: Temporal bone; CC: Condylar growth cartilage; D: Disc; ST: Styloid process; TY: Tympanic part of the temporal bone; MC: Meckel's cartilage; LP: Lateral pterygoid muscle; 1: Discal collateral ligament; 2: superior retrodiscal lamina; 3: Discomallear ligament; 4: Inferior retrodiscal lamina (Source: cheynet, Guyot, Richard, Layoun, and Gola, 2003).

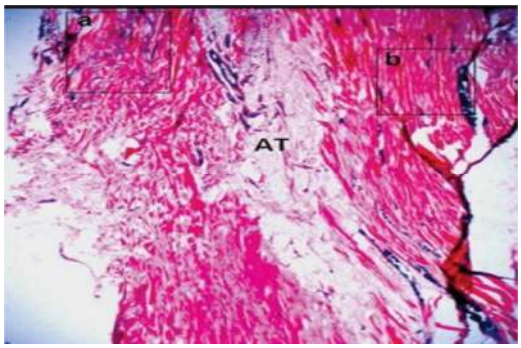

Figure 3: Microphotograph containing unit of sphenomandibular ligament and Discomallear ligament.

Explanation (foot note): a: The DML is running at the left section. Elastic fibers are supernumerary in the 'a' square; b: The SML consisted of collagen fibers is indicated by the 'b' square. Two ligaments are separated with an areolar adipose tissue (AT) (X2.5). (Source: Sencimen et al, 2009)

CONCLUSION

The DML and the MML should be considered as two different ligaments connecting TMJ with the middle ear. These ligaments are intrinsic ligamentous structures of the TMJ with no important function in primary movement of TMJ. The ossicles of the middle ear can be mobilized unpredictably to some extent due to excessive movement the condyle inferiorly. Surgeons should be aware of these complications during open TMJ surgery and prevent excessive stretching of the mandibular condyle inferiorly.

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