Lateral Pterygoid Muscle and the Temporomandibular Disc

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This anatomic study examines the attachment of the lateral pterygoid muscle to the capsule and disc of the temporomandibular joint. The anatomy of the temporomandibular joint and its surroundings, in particular the insertion of the superior head of the lateral pterygoid muscle, was studied by dissection and conventional histologic techniques. The material consisted of 16 cadaver specimens from individuals 60 years or older. The results showed that only a part of the superior head of the lateral pterygoid muscle is attached to the anterior portion of the capsule, which, in turn, is firmly attached to the disc, giving the impression that the muscle and the disc are directly connected. All specimens showed attachment of the superior head of the lateral pterygoid muscle to the anterior medial portion of the capsule, but they showed varying degrees of attachment to the lateral aspect of the temporomandibular joint capsule. The remaining part of the superior head of the lateral pterygoid muscle attached to the mandibular condyle. Serial sectioning in no instance showed direct insertion into the disc of the fibers of the superior head of the lateral pterygoid muscle.
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The anatomy of the temporomandibular joint (TMJ) has long been the cause of debate not only with respect to its role in the etiology of joint pain, but also as to whether the superior head of the lateral pterygoid muscle (SLP) is attached to the disc or to the condyle of the mandible and contributes to disc displacement and joint pain. It is not in the scope of this paper to provide a comprehensive review of the attachment of the lateral pterygoid, but rather to look, without preconceived ideas, at the attachment of the SLP.

McDevitt[1] and Kaplan and Assael[2] believed that the upper fibers of SLP are attached to the disc and capsule, especially to the medial aspect, and the lower fibers are blended with those of the inferior head and attached to the neck of the mandible. There are still, however, different camps of opinion; one believes that the SLP is not attached to the disc,[3–7] although a small proportion of the fibers are attached to the anterior part of the capsule and hence are attached either directly or indirectly to the condyle and not the disc itself. The other camp describes the SLP as attached directly to the disc and the condyle.[8–14] It is also believed that the SLP is attached only to the anterior border of the capsule and to the disc.[15] All investigators agree on the anterior attachment of the SLP to the periosteum of the infratemporal fossa lying on the greater wing of the sphenoid bone as far anteriorly as the infraorbital fissure. Why this confusion exists is unclear because the studies involve both macroscopic and microscopic examinations of the muscle in relation to the joint. According to McDevitt[1] and Carpentier et al,[9]

there is a portion of the infratemporal fossa up to 10 mm anterior to the capsular attachment on the base of the skull, where the muscle does not attach to the overlying periosteum. It is through this space that the nerve to the masseter muscle and the anterior and posterior deep temporal nerves pass.[12]

The aim of this investigation was to determine the anatomic relationship between the lateral pterygoid muscle and the disc of the TMJ and to discover if the muscle is attached directly to the disc and/or to the capsule, as well as to the condyle of the mandible. In addition, this paper looks at how the confusion in the literature might have developed.

Materials and Methods

Eighteen specimens were collected, equal numbers from the right and left sides of embalmed cadavers of individuals aged 60 to 90 years used in the medical dissection room of the Department of Anatomy, School of Biomedical Science, Queen's University, Belfast, Northern Ireland. Eleven of the specimens were from edentulous individuals, and seven specimens were from individuals who had partial dentitions. The zygomatic arch had been removed in all cases, and the ramus of the mandible had been sectioned during the earlier dissection.

In this study, three different approaches were used to examine the anatomy of the TMJ.

1. Gross dissection was performed on a tissue block taken from the cranial skeleton that included the middle cranial fossa superiorly and the inferior head of the lateral pterygoid muscle caudally. Dissection was performed with a dissection microscope to improve precision and to minimize damage to the tissues.
2. Histologic sections were made of identical undissected tissue blocks containing intact TMJ complexes.
3. Histologic sectioning was performed on the dissected specimens of disc, capsule, and muscle.

During the removal of the tissue blocks, care was taken to ensure that previous dissection had not damaged the disc or capsule and that it had not progressed deep enough to expose the lateral pterygoid muscle. To remove the specimens, two sections were made in the coronal plane: one posterior to the external acoustic meatus, the other anteriorly through the maxillary antrum. The specimen was then released by sectioning through the cranial base in a parasagittal plane just lateral to the cavernous sinus to join the other two cuts. Soft tissue inferior to the cranial base was sectioned in a transverse plane inferior to the floor of the maxillary antrum.

Ten of the 18 specimens were dissected in an identical manner. The dura mater was removed from the floor of the middle cranial fossa, and the foramen ovale and spinosum were clearly identified. The squamous part of the temporal bone was removed, leaving the pericranium intact. Surrounding bone was then removed carefully, leaving the mandibular division of the trigeminal nerve and the middle meningeal artery intact. As the dissection progressed, the condylar fossa was removed, leaving the pericranium intact. The pericranium was incised anterior to the stem of trigeminal nerve without damaging nerve or muscle. In this way, the SLP, its attachments to the capsule of the TMJ, and any nerves lying superior to the lateral pterygoid were exposed. Part of the muscle attached anteriorly to the cranial base was damaged slightly in the process. After recording all findings, the pericranium superior to the TMJ disc was incised. The disc was mobilized medially, posteriorly, and laterally. Next, the capsule was incised anteriorly where it was attached to the mandibular condyle. The capsule was elevated, and the fibers of the lateral pterygoid muscle attached to this part of the capsule were teased apart to remove a specimen consisting of disc, attached capsule, and fibers of lateral pterygoid. The resultant specimen was then processed for wax histology.

The other group of eight specimens was processed undissected for histologic sectioning. Due to the size of the blocks of tissue, six were cut in a parasagittal plane on a microtome at a thickness of 60 to 150 µm. Each section was serially mounted for examination after staining with one of the following standard histologic stains: Masson stain and Mallory's trichrome stain; alcian blue and van Geison's solution of trinitrophenol and acid fuchsin; hematoxylin-eosin stain; or Weigart's elastic stain.[16,17] The Masson stain and Mallory's trichrome stain were used for identification of muscle and collagen, the alcian blue and van Geison's solution for hyaline cartilage and collagen, and the hematoxylin-eosin stain or the Weigart's elastic stain to identify elastic fibers. The final two specimens were split prior to histologic processing to ensure that the histologic sectioning was performed parallel to the direction of the muscle fibers of the SLP. These sections were therefore in a plane angled approximately 26 degrees to the sagittal plane, and the sections were stained with Mallory's stain.

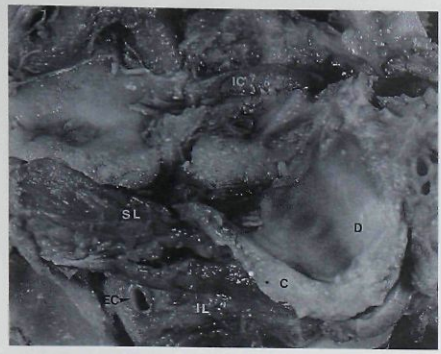

Fig 1 Superolateral view of the left temporomandibular joint and lateral pterygoid muscle from a 75-year-old male. Superior surface of temporomandibular disc (D), internal carotid artery (IC), lateral pterygoid superior head (SL) and inferior head (IL), joint capsule cut (C), branch of external carotid (EC). (Original magnification × 3.)

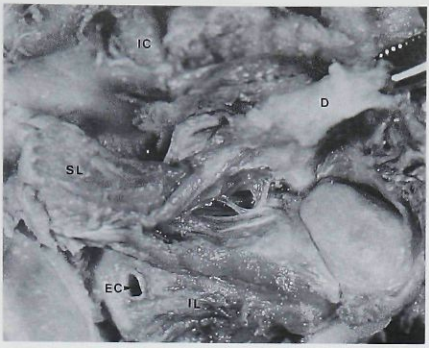

Fig 2 Superolateral view of the temporomandibular joint and lateral pterygoid muscle seen in Fig 1 with the temporomandibular disc reflected superiorly and medially. Superior surface of temporomandibular disc (D), internal carotid artery (IC), lateral pterygoid superior head (SL) and inferior head (IL), branch of external carotid (EC). (Original magnification × 3.)

Results

Lateral Pterygoid

The gross examination, later confirmed histologically, showed that only a part of the SLP was attached to the anterior part of the capsule, which, in turn, was attached to the temporomandibular disc (Figs 1 and 2). The size of this portion varied considerably from specimen to specimen. The remainder of the superior head was attached to the condyle of the mandible. In all specimens, the muscle was clearly attached to the medial half of the anterior aspect of the capsule. Attachment to the lateral half of the anterior aspect of the disc/capsule demonstrated a greater degree of variability. In some cases no attachment was observed. Other cases showed as much as two thirds of the fibers attached to the lateral aspect of the capsule.

The muscle was firmly adherent to the capsule as was the disc, giving the clear impression that muscle and disc were directly connected (Fig 2). To confirm this, several specimens selected at random were examined histologically. In no section were muscle fibers clearly seen attached directly to the disc in large numbers. The collagen bundles from the muscle passed into the capsule curving inferiorly to blend with those of the capsule and similar fibers from the disc (Fig 3a). This was confirmed when whole joint complexes were viewed in the oblique, rather than sagittal, plane. While the majority of the SLP fibers were sectioned along the length, the most cranial ones were not (Figs 3b and 3c). From these figures, it is apparent that although a few of the most cranial fibers have connections to the anterior aspect of the disc, most form tendinous bands reinforcing the anterior aspect of the capsule, and hence, the superior aspect of the condylar fovea.

This arrangement is not obvious in the standard sagittal plane of sectioning (Fig 4). Studied serially, the sagittal plane of sectioning gives the impression that the SLP attaches to the anterior aspect of the disc even though the fibers have been sectioned. In this oblique plane, a triangular fold of the capsule, not seen in sagittal sections, is between the inferior aspect of the disc and the condyle. The tendons of the SLP are intimately associated with this fold, which could be a result of a forward displacement of the condyle prefixation. Muscle fibers from the lateral pterygoid were attached to the mandible in a laminar fashion, blending with those from the SLP lying superior and therefore closer to the TMJ than fibers from the inferior head. There appeared to be two distinct muscles that shared a common area of attachment to the anterior of the mandible.

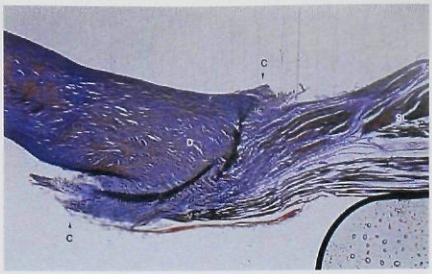

Fig 3a Histologic section (100 μm thick) of the specimen in Fig 2. Temporomandibular disc (D), joint capsule cut ends (C), and superior head of lateral pterygoid muscle (SL). (Mallory's trichrome stain, original magnification × 20.)

Fig 3b Histologic section (100 μm thick) from an 86-year-old female. Temporomandibular disc (D), joint capsule (C), superior lateral pterygoid muscle (SL), inferior lateral pterygoid muscle (IL). (Mallory's trichrome stain, original magnification × 11.)

Fig 3c Higher magnification of histologic section (100 μm thick) shown in Fig 3b. Temporomandibular disc (D), joint capsule (C), superior lateral pterygoid muscle (SL), inferior lateral pterygoid muscle (IL). (Mallory's trichrome stain, original magnification × 23.)

Fig 4 Histologic section of temporomandibular joint (100 μm thick) in a 72-year-old male. Temporomandibular disc (D), mandibular condyle (C), superior head of lateral pterygoid muscle (LP), squamotympanic recess (ST), blood vessel in lateral pterygoid muscle (BV). (Masson stain, original magnification × 10.)

Mandibular Nerve

In all specimens, a number of nerve branches were in the space posterior to the cranial attachment of the lateral pterygoid and the base of the skull. Usually three main nerve trunks were seen macroscopically (Figs 5a and 5b), all radiating laterally from the foramen ovale. The most anterior trunk was at the lateral aspect of the SLP no further anteriorly from the anterior aspect of the capsule than the maximum anteroposterior distance of the TMJ space. The most posterior branch was an average of 3 mm from the anterior aspect of the joint capsule (range, 0 to 10 mm). These branches were in addition to the main trunk of the mandibular division that passed on the medial aspect of the lateral pterygoid muscle.

Other Observations

Both macroscopically and histologically, numerous blood vessels were noted in the area, lying predominately posterior and slightly inferior to the condyle of the mandible. Several specimens demonstrated a high degree of vascularity within the lateral pterygoid muscle itself just anterior to the joint. The disc was attached posteriorly to the squamotympanic fissure (Fig 4), and elastic fibers were within the tissues attached to the posterior edge of the disc.

Fig 5a Superior head of the lateral pterygoid muscle (SL) viewed from the middle cranial fossa in a 70-year-old male, dissected in situ (before removal of tissue block). Trigeminal nerve and ganglion (TG), mandibular division of trigeminal nerve and branches (M), internal carotid artery (IC), basilar artery (B), optic nerve (O), temporalis (T). (Original magnification × 2.)

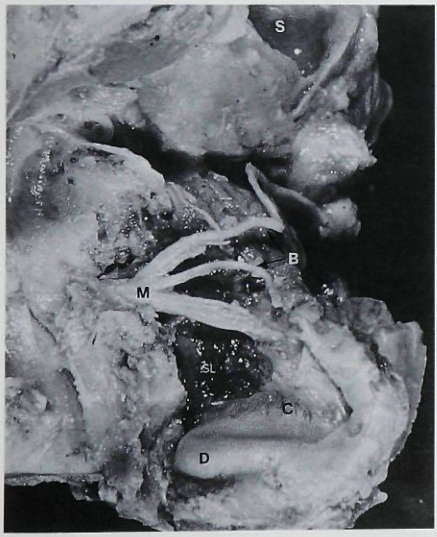

Fig 5b Superior head of the lateral pterygoid muscle (SL) viewed from the middle cranial fossa of an 86-year-old female. Mandibular division of trigeminal nerve (M) and branches (B), superior aspect of temporomandibular disc (D), joint capsule sectioned (C), floor of maxillary sinus (S). (Original magnification × 2.)

Discussion

Our work supports the concept that on a macroscopic level, the superior fibers of the lateral pterygoid muscle appear to attach directly to the disc.[1,2,8–12] On the microscopic level, however, the muscle fibers do not have their primary attachment directly to the disc but rather to the condylar fossa and the anterior aspect of the joint capsule. This supports the observations of several investigators.[4–7,13,14,18] We found a firm adhesion between disc, capsule, and muscle—an arrangement that functionally allows them to act as an integral unit. This finding is in agreement with the observations of Okeson[19] and others.[15] Why has there been this preponderance of differing reports? We believe this is a result of the approach to studying the TMJ structures. In studies that involve macroscopic investigation, the SLP is observed to be attached to the disc, as was clearly seen in the present study. Unless these observations are followed up with a histologic section of the prepared muscle disc complex with the tendons attached directly to the capsule, it is not observed that the tendons of the muscle fiber, as a rule, do not pass through to attach directly to the disc. On the other hand, histologic studies are usually performed with resultant sections in the sagittal, coronal, and horizontal planes. Using such an approach, it is impossible to include an intact muscle fiber passing all the way from the striated muscle fiber to the tendon to the ultimate point of attachment, a point also noted by Meyenberg et al.[5] In addition, most sections are thick, frequently in excess of 600 μm thick; therefore, histologic detail is extremely difficult to follow. We looked at sections with an average thickness of 100 μm. In the standard planes of sectioning, laterally we could report no attachment to the disc and capsule, and medially we could report that all of the SLP attached to the disc. This was in part due to being unaware of the frequent absence of the SLP attaching to the lateral aspect of the TMJ and being unable to trace a single fiber from muscle to point of attachment. The resultant interpretation, therefore, would be that the muscle fibers of SLP pass in three dimensions from the greater wings of the sphenoid: posteriorly, inferiorly, and laterally. There is no spiraling or twisting of the muscle fibers. It was only through the axis parallel to the muscle fibers at approximately 26 degrees to the sagittal plane that such could be traced.

Functionally, however, it is important to include the observation that the SLP is firmly adherent to the capsule, and hence the disc, medially. Laterally

there is the attachment to the fascia of the masseter muscle.[10,14,20,21] From the attachment of the SLP it could be deduced that it would tend to pull the disc in an anterosuperomedial direction, thus maintaining contact with the condylar fossa and the eminence on the base of the skull. The lateral attachment to the masseter may reduce any medial displacement of the disc. In effect, it would be expected to be active on closure as has been demonstrated with electromyographic (EMG) studies.[13,22,23] Even though the SLP muscle fibers are oriented in an anteromedial direction, it is hard to believe that this would allow the disc in patients with temporomandibular disorders to be displaced in an anterior and medial direction since they also attach to the condyle. Perhaps its role is to prevent the capsule and disc from moving posteriorly during closure, providing a tethering effect upon the disc and capsule during closing, and stabilizing the complex, as has been suggested by Tanaka as cited by Okeson.[19]

Biomechanic analysis[24] and EMG studies of the SLP muscle have shown that this muscle is actively involved during jaw closing,[25–30] and in clenching in retruded position of the mandible.[3,31] It is possible that the superior part of the muscle may be functioning not as a primary closing and clenching muscle during retrusion, but instead as a stabilizing muscle for the mandible during these functions. The muscle thus is active and builds tension as it lengthens, stabilizing the disc/condyle complex on closing.

The lateral pterygoid muscle has been described as two muscles with an inferior head and a superior head with different functions.[1,7,24,26,28] The superior head is said to be involved in moving the mandible from side to side in the grinding process while keeping the teeth close together.[1,19,26,30] The inferior head instead functions to separate the teeth, such as when the mouth is opened, or to pull the mandible to the contralateral side. It would seem important in the grinding process that the condyle and disc remain in close proximity, which supports these functions of the muscle. It is conceivable that the muscle pulls in a medial direction because the muscle fibers have no attachment to the lateral aspect of the disc. Instead, fibers from the temporalis muscle are attached here.[1] Carpentier et al,[9] however, found that the SLP tends to deflect the disc backward and upward, and they reported no independent action of the two heads of this muscle.

In our specimens, we observed several large nerves lying anterior to the joint capsule. These nerves were frequently in direct contact with the capsule itself. It has been suggested that they may be involved in entrapment, but few authors seem to consider this a possibility.[32] One may speculate that damage to muscle fibers of the SLP would result in swelling of the muscle, which could possibly cause the muscle to press upward on the nerve fibers. This pressure on the nerve could result in loss of function, pain, or numbness, especially when the condyle moves in an anterior direction. Such a movement might further compromise the space for the nerves. In this project, it was not possible to determine if the nerves were motor, sensory, or a combination, nor could the ultimate destination of these nerves be determined. Although motor dysfunction should be easily detected clinically, sensory dysfunction, especially proprioceptive loss, is not so readily discernible.

Conclusion

The results of this gross anatomic and histologic study of the TMJ anatomy supports the idea that the SLP does not attach directly into the disc, but rather to the anterior aspect of the TMJ capsule. However, the firm connection between the capsule and the disc at this point strongly suggests that the muscle would conceivably influence the movements of the disc. The possible role of the SLP in displacement of the disc is still unknown and further research is needed.

Acknowledgments

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Resumen

Músculo pterigoideo lateral y el disco temporomandibular

Este estudio anatómico examina la inserción del músculo pterigoideo lateral a la cápsula y disco de la articulación temporomandibular (ATM). La anatomía de la ATM y sus alrededores, en particular la inserción de la cabeza superior del músculo pterigoideo lateral, fueron estudiadas por medio de técnicas de disección y de histología convencional. El material consistió de 16 especímenes de cadáveres de individuos de ≥ 60 años de edad. Los resultados indicaron que sólo una parte de la cabeza superior del músculo pterigoideo lateral está adherida al la porción anterior de la cápsula que a su vez está firmemente adherida al disco, dando la impresión de que el músculo y el disco están conectados directamente. Todos los especímenes mostraron una inserción de la cabeza superior del músculo pterigoideo lateral a la porción media anterior de la cápsula, pero diversos grados de inserción al aspecto lateral de la cápsula de la ATM. La parte remanente de la cabeza superior del músculo pterigoideo lateral está adherida al cóndilo mandibular. El seccionmiento consecutivo en ningún momento demostró que existiera una inserción directa de las fibras de la cabeza superior del músculo pterigoideo lateral, dentro del disco.

Zusammenfassung

M. pterygoideus lateralis und Kiefergelenksdiskus

Diese anatomische Studie prüft die Insertion des M. pterygoideus lateralis an der Kapsel und am Diskus des Kiefergelenks. Die Anatomie des Kiefergelenks und seiner Umgebung, insbesondere die Insertion des Caput superior des M. pterygoideus lateralis, wurde durch Sektion und konventionelle histologische Techniken studiert. Das Material bestand aus 16 Präparaten von Personen, welche 60 Jahre oder älter waren. Die Resultate zeigten, dass nur ein Teil des Caput superior des M. pterygoideus lateralis mit dem vorderen Anteil der Kapsel verbunden ist, welche ihrerseits fest mit dem Diskus verbunden ist, was den Eindruck einer direkten Verbindung des Muskels mit dem Diskus hervorruft. Alle Präparate zeigten eine Verbindung des Caput superior des M. pterygoideus lateralis mit dem anterioren medialen Anteil der Kapsel, jedoch unterschiedliche Grade der Befestigung am lateralen Anteil der Kiefergelenkskapsel. Der verbleibende Teil des Caput superior des M. pterygoideus lateralis ist mit dem Condylus verbunden. Serienschnitte zeigten in keinem Fall eine direkte Insertion von Fasern des Caput superior des M. pterygoideus lateralis in den Diskus.