Parasagittal Magnetic Resonance Imaging of the Lateral Pterygoid Muscle: A Preliminary Study

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Ten anatomic territories, including both lateral pterygoid muscle and temporomandibular joint heads, were explored with magnetic resonance imaging in subjects with no dysfunctional disorders. The sequence used was one of inversion-recovery, supplemented with image contrast reversal for better visualization. The muscles were observed in the resting position and in dynamic relation. Slice plane definition provided information on the anatomic variations of the superior head and on the muscle-articular junction, in particular on the fascicular aspect of the superior lateral pterygoid muscle and on the differentiation between condyle insertions under effort. The choice of technique and the results are discussed. Avenues are opened for the exploration of muscles utilizing magnetic resonance imaging.
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Magnetic resonance Imaging (MRI) is a choice imaging technique for muscular exploration, and a number of studies have already focused on MRI imaging of human masticatory muscles. Seltzer and Wang[1] compared the respective advantages of computed tomography and MRI for studying normal and pathologic masseter muscles. Other authors[2–4] have underlined the usefulness of MRI in the visualization of masticatory muscle disease, and more globally, disorders of the human orofacial complex.[5] In a more specifically anatomic perspective, Ralph et al[6] tried to visualize, using different slice planes, the gross anatomy of the rabbit masseter muscle, in particular the deep masseter. Anatomic-functional studies have been conducted in humans to assess the orientation of the masticatory muscle,[7] to measure the variation of jaw muscle surface under occlusal force,[8] or to reconstruct three-dimensional outlines of the masticatory system.[9] Other investigators[10] compared MRI images of the lateral pterygoid muscle with those from cryosectional anatomy. Yang et al[11] recently explored the disc and pterygoid muscle under low field using a surface coil, which evidenced a change in angle between the lateral pterygoid muscle and the sagittal plane during mouth opening. Nonetheless, most studies describing the lateral pterygoid muscle, either generally or specifically, did not focus on the peculiarities observed or the relation of the muscle to the anterior insertions and to the condyle and the temporomandibular joint (TMJ). This paper describes these aspects by comparing images of the muscle at rest with those obtained in isometric contraction.

Materials and Methods

The study included 10 musculoarticular areas of healthy subjects (eight men and one woman) whose mean age was 27 years. Clinical examination did not reveal any craniomandibular disorders nor any muscular spasms. Images were obtained with a whole-body 1.5-Tesla Magnetom Siemens device with a proton resonance frequency of 63 MHz. The antenna used for transmission and reception was a circular polarization head coil. A first series of coronal sections was performed with a flash sequence (repetition time [TR] 150 ms, echo time [TE] 10 ms, α = 60 degrees: acquisition [acq] time 42 seconds) to locate the joint. A second series of axial contiguous sections (slice thickness 5 mm) was then performed from a T1-weighted spin-echo sequence (TR 600 ms, TE 15 ms, field of view [FOV] 230, matrix size [MS] 256 x 256, acq time 2.33 minutes). The slice that best showed the oblique mass of the lateral pterygoid muscle was selected, and a third series of parasagittal sections, ie, oriented along the muscle main axis (Fig 1) was performed from an inversion recovery (IR) sequence (TR 2700 ms, TE 26 ms, inversion time [TI] 80, FOV 230, MS 256 x 256, acq time 11.31 minutes; slice thickness 3 mm; pixel size 0.9 mm). The reversal time was optimized to obtain the best possible contrast between the muscle and the surrounding tissue, the examination window (larger than usually used for TMJ observation) being framed around the muscle. Image contrast inversion on the screen further improved the individualization of the muscular bundle. For each exploration, two mandibular positions were defined: the rest position with lips closed and the subject taking the most relaxed stance as possible, and an isometric contraction position with the subject clenching the teeth on an 11-mm-thick elastomer wedge interposed between the incisors. For each area explored, nine adjacent sections were performed to select in each case the slice that best showed the two heads and the junction of the muscle, the mandibular neck, and the TMJ.

Results

The TMJ-muscle assembly was well defined (Fig 2a), as was the pterygoid muscle insertion. The rocket-shaped morphology and the orientation of the superior head (SLP) in relation to neighboring structures was precisely defined, although in most cases (7 of 10) individualization of the two heads from the condyle was not visible in the rest posi-

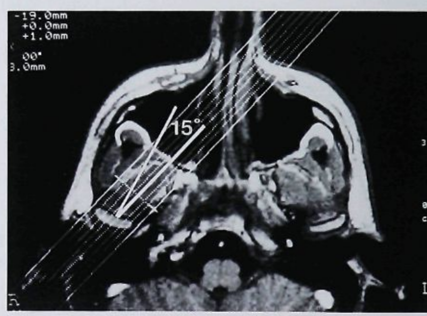

Fig 1 Slice angle in relation to the parasagittal articular plane. Thin line: parasagittal plane perpendicular to the main condylar axis. Thick line: slice plane along the muscle axis (angular difference = 15 degrees).

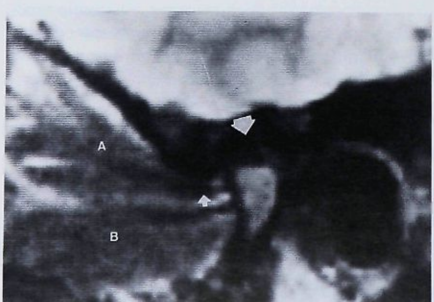

Fig 2a Muscle-articular IR visualization. A, SLP; B, ILP; large arrow, disc; small arrow, pterygoid muscle insertion.

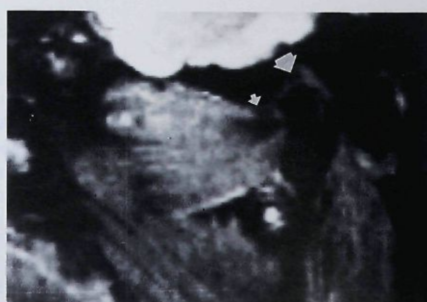

Fig 2b Disc in dynamic position. Large arrow, posterior band of the disc; small arrow, anterior band of the disc.

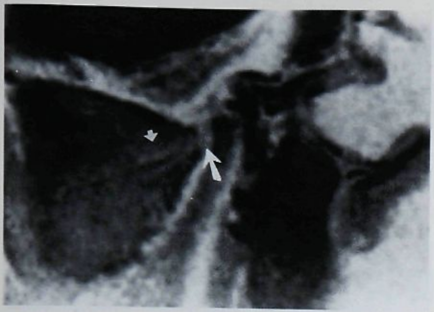

Fig 3a Undifferentiated aspect of the two heads at the level of the pterygoid muscle insertion (small arrow). Large arrow, ILP insert (compare with Fig 4b).

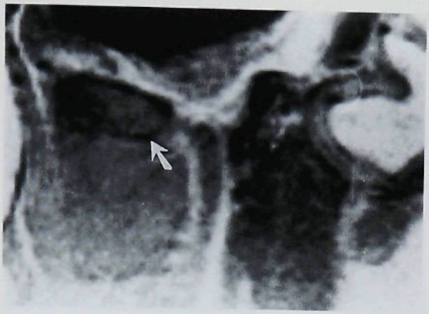

Fig 3b Individualization of the two heads and morphologic transformation of the SLP arrow (idem Fig 2b).

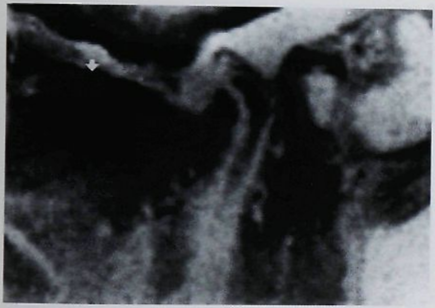

Fig 4a Underdeveloped SLP (arrow).

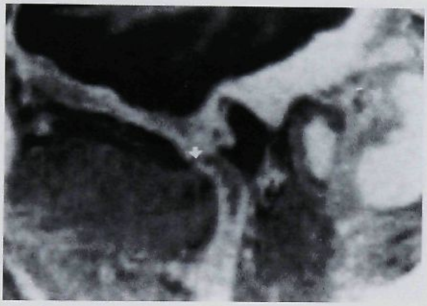

Fig 4b SLP individualization and evidencing of an articular insertion (arrow).

tion, and the disc disappeared under contrast inversion (Figs 3a and 3b). Some morphologic peculiarities were apparent: a narrow SLP (Fig 4a) or clearly divergent orientation from the inferior head (ILP) (Fig 5a). Two slices revealed a spreading (fanning out) of the anterior part of the SLP, the fleshy fascicles appearing separated by interaponeurotic spaces (Fig 2a and 6a) . On one of the slices (Fig 7a), the SLP, while wholly differentiated from the ILP, revealed the individualization of a very fine insertion horizontally directed to the disc and the upper part of the condyle.

Muscle contraction on the wedge provided a more differential view of the anatomic elements, especially the disc, because of the slight maladjustment of articular parts (Fig 2b). The SLP activity was reflected by a shortening of the fleshy mass (Fig 4b), individualization of the two heads (Figs 3b, 4b, and 6b), and the disappearance of the interfascicular spaces (Figs 5b and 6b). Two images individualize the muscular bundles directed toward the anterior part of the disc (Figs 4b and 7b).

Discussion

In earlier studies, muscle visualization was obtained with a surface coil; it is well known that surface coils generally provide a better signal than head coils when used with superficial organs. However, this sensitivity decreases dramatically with depth, and at the pterygoid location, medial in relation to the TMJ, the intensity is improved with a head coil. In addition, circular polarization

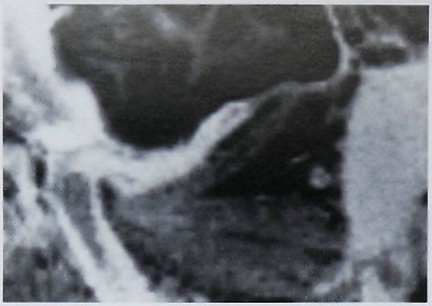

Fig 5a SLP diverging orientation.

Fig 5b Morphologic modification in dynamic relation.

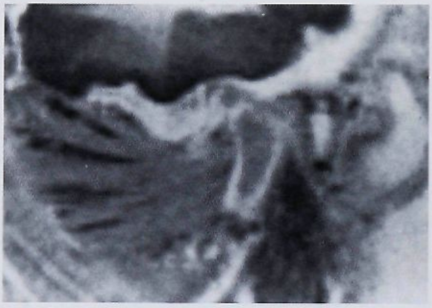

Fig 6a Multibundle aspect of the muscle anterior insertions.

Fig 6b Disappearance of interfascicular spaces in dynamic relation and SLP individualization.

Fig 7a Revelation of SLP muscular bundle with articular destination (arrow).

Fig 7b Bundle individualization in dynamic relation (arrow).

increases the sensitivity of the head coil and permits the number of averages, and hence the acquisition time to be reduced compared to linear polarization. The head coil choice is a technical option that probably had some bearing on the results obtained from exploring the lateral pterygoid muscle.[12] The choice of an IR sequence, already used by Lam et al,[5] also significantly differentiated the anatomic constituents of the area explored. This differentiation was yet enhanced by contrast reversal at the image level. Last, to prevent morphologic errors, the quality of the device (signal homogeneity and geometric distortion) was checked beforehand using a protocol developed under the COMAC-BME[13] joint European venture.

Finding the best slice plane is one of the determining factors in obtaining the best tissular definition possible. Earlier studies reported sagittal slices that did not follow the muscle main axis. This axis, as evidenced on the axial section, determines a 15-degree angle with the selected plane[14] perpendicular to the main condylar axis, which is already very different from the true sagittal plane. Therefore, the muscle axis has to be precisely determined, and it is from that orientation that slices, especially the medial slices, will provide the most data on the muscle-articular junction.

With regard to anatomy, this study mainly reveals the morphofunctional aspect of the SLP. The ILP indeed appears as a relatively homogeneous muscle mass and reflects a less scattered anterior insertion on the outer surface of the lateral pterygoid plate. The SLP images show wide differences in the orientation of heads, sometimes diverging greatly from the ILP (Figs 5a and 5b). However, the main peculiarity in rest position is the presence of several fleshy fascicles anteriorly.[15] These may be anatomic variations resulting from the depth of the slice, because slice planes are almost identical from one subject to another. They would not be artifacts resulting from slice thickness, since these would tend to alleviate differences rather than enhance them, nor would they be examination artifacts, the bundles being visible both on rest and dynamic images. This visualization was probably due to the differentiation of anterior insertions, some of the fibers binding to the lateral plate of the pterygoid process, others inserting more laterally on the infratemporal surface of the greater sphenoid wing.

Muscle visualization was particularly interesting in the dynamic position because the stress exerted on the wedge induced a tensing of the fibers. This was reflected by the disappearance of interaponeurotic spaces and the morphologic differentiation of the two heads (reduced axial diameter and increased vertical diameter, a reflection of the myogenic activity). The activity of the SLP does not contradict the results from electromyographic studies,[16,17] which describe reciprocal activity at the level of both heads. This activity is due to the action exerted on the wedge, which in fact corresponds to a slightly propulsive clenching. In some cases, even under contraction, the muscle surface remains very small and hardly changes. A parallel can be drawn between this observation and the findings of Gill,[18] who highlighted the small proportion of microfibrillae in the SLP. Both Gill[18] and Honee[19] suggest that there is a predominance of fibrous tissue in the SLP compared to contractile tissue: the SLP may not constitute real muscle tissue, its structure resembling more that of a tendon.

The dynamic position mainly evidenced the pterygoid muscle insertion and the two heads, undifferentiated in the rest position and individualized in the dynamic position. Such a noncoaptation of the various joint tissues may also define the muscloarticular junction and more specifically at the SLP level, the possible presence of an articular fascicle. This would be an in vivo confirmation of earlier histologic studies.[20,21]

Conclusion

Further studies should define more precisely the methodologic modalities (better definition of the opening movement; superimposition of IR and contrast reversal images to study the pterygoid-disc junction). While not a replacement for the classic techniques to evidence the fineness of the tissue connections, MRI is an effective process for investigating muscle anatomy and function because it is the only imaging technique that makes a satisfactory exploration of this type of tissue possible. All techniques have their limitations, and it is difficult to contemplate reducing slice thickness without altering acquisition time and increasing noise. However, recent advances in imaging techniques with availability of the third dimension may open novel avenues for investigation of muscles.

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Resumen

Estudio preliminar sobre las imágenes de resonancia magnética parasagitales del músculo pterigoideo lateral

Se exploraron los territorios anatómicos, incluyendo el músculo pterigoideo lateral y las cabezas de la articulación temporomandibular, por medio de imágenes de resonancia magnética (IRM) en personas que no presentaban desórdenes disfuncionales. La secuencia que se utilizó fue la de inversión-recuperación, suplementada con la inversión del contraste de imágenes para una mejor visualización. Los músculos fueron observados en la posición de reposo y en relación dinámica. La definición de los cortes de los planos suministró información sobre las variaciones anatómicas de la cabeza superior y sobre la unión músculo-articulación, particularmente sobre el aspecto fasicular del músculo pterigoideo lateral superior y sobre la diferenciación entre las inserciones del cóndilo bajo esfuerzo. Se discuten la elección de la técnica y los resultados. Se descubren avenidas para la exploración de los músculos utilizando IRM.

Zusammenfassung

Darstellung des M. pterygoideus lateralis mittels parasagittaler kernspintomographischer Aufnahmen: Eine Voruntersuchung

Zehn anatomische Regionen, welche Kondylen und Mm. pterygoidei laterales einschlossen, wurden bei Probanden ohne Myoarthropathien des Kausystems mittels Kernspintomographie untersucht. Dabei wurde eine Inversion-Recovery-Sequenz verwendet, welche zur besseren Darstellung mit einer Bildkontrastinversion ergänzt wurde. Die Muskeln wurden in Ruhe und während einer isometrischen Kontraktion abgebildet. Die Wahl der Schnittflächen gab Auskunft über die anatomischen Variationen des oberen Kopfes des Muskels sowie über die Form der muskulo-artikulären Insertion, insbesondere über die faszikuläre Form des oberen Kopfes des M. pterygoideus lateralis und über die Unterschiede zwischen den Insertionen am Kondylus während der Kontraktion. Die Auswahl der Technik und die erhaltenen Resultate werden besprochen. Wege zur Erforschung von Muskeln mit Hilfe der Kernspintomographie öffnen sich.