RESEARCH

Evaluation of the lateral pterygoid muscle using magnetic resonance imaging

SM D'Ippolito^{*1}, AM Borri Wolosker², G D'Ippolito², B Herbert de Souza² and M Fenyo-Pereira³

¹Department of Oral Diagnosis, Faculty of Dentistry, University of São Paulo (USP), São Paulo, Brazil; ²Department of Imaging Diagnosis, Federal University of São Paulo (UNIFESP), São Paulo, Brazil; ³Section of Radiology, Department of Stomatology, Faculty of Dentistry, University of São Paulo (USP), São Paulo, Brazil

Objectives: The aims of this study were to evaluate the visibility of the lateral pterygoid muscle (LPM) in temporomandibular joint (TMJ) images obtained by MRI, using different projections and to compare image findings with clinical symptoms of patients with and without temporomandibular disorders (TMD).

Methods: In this study, LPM images of 50 participants with and without TMDs were investigated by MRI. The images of the LPM in different projections of 100 TMJs from 35 participants (70 TMJs) with and 15 participants (30 TMJs) without clinical signs and symptoms of TMD were visible and analysed.

Results: The oblique sagittal and axial images of the TMJ clearly showed the LPM. Hypertrophy (1.45%), atrophy (2.85%) and contracture (2.85%) were the abnormalities found in the LPM. TMD signs, such as hypermobility (11.4%), hypomobility (12.9%) and disc displacement (20.0%), could be seen in TMJ images. Related clinical symptoms, such as pain (71.4%), articular sounds (30.4%), bruxism (25.7%) and headache (22.9%), were observed.

Conclusions: Patients with TMD can present with alterations in the LPM thickness. Patients without TMD also showed alterations, such as atrophy and contracture, in TMJ images. Recognition of alterations in the LPM will improve our understanding of clinical symptoms and pathophysiology of TMD, and may lead to a more specific diagnosis of these disorders.

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Introduction

Temporomandibular disorder (TMD) is a general term that includes a series of clinical alterations involving the temporomandibular joint (TMJ) and structures related to it, such as the masticatory muscles. These muscles are frequently related to TMD since they receive an overload, usually caused by parafunctional habits and occlusal disorders, so that clinical manifestation of this condition is translated into pain.^{1–4} The lateral pterygoid muscle (LPM), one of the most important muscles in the physiology of mastication, is directly

connected to the TMJ and participates in the movements of opening, closing, laterality and mandibular protrusion. It is deeply localized to both the mandibular branch and temporal muscle, which makes its evaluation difficult.⁵ Palpation of LPM is not possible owing to the topographic localization of its lower head.^{6,7} A small portion of the upper fibres of the LPM are inserted into both the articular capsule and articular disc of the TMJ, giving stability to the set and directly influencing articular disc position during mandibular movements.^{8,9} MRI is a powerful tool for evaluation of changes in the articular structure and masticatory muscles,^{11,12} but there are few MRI studies dedicated to the evaluation of changes in the LPM, such as hypertrophy, atrophy or muscle contracture associated,

*Correspondence to: Silvia D'Ippolito, Rua Prof Filadelfo Azevedo, 617, apt. 61, 04508-011, São Paulo, SP, Brazil; E-mail: silvia.dippolito@uol.com.br
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or not, with articular disc displacement.¹³ MR images obtained in the oblique sagittal planes allow for a detailed observation of the LPM, articular disc, and mandibular head and fossa in the same image and beside a complete observation of, and the relationship between, the structures.^{12,14} MR imaging in adult patients before and after mouth opening has suggested that volume changes occur in masticatory muscles between mouth opening and closing and that there is a difference between the changes in muscle volume. Although only small changes were observed in the masseter and medial pterygoid muscles, LPM volume significantly decreased during mouth opening.¹⁶ Understanding the changes in the LPM images will help the clinician to understand better the clinical symptoms and allow for more accurate diagnosis of TMD, and therefore plan more effective treatment.

The purpose of this study was to evaluate the visibility of the LPM in TMJ images obtained by MRI, using different projections, and to compare image findings with the clinical symptoms of patients with and without TMD.

Materials and methods

The present study was approved by the ethics committee of the São Luiz Hospital (São Paulo, Brazil). All patients approved and gave consent for their participation in the study.

A prospective and paired study was carried out involving private clinic patients with suspected TMD and whose examination was requested for diagnostic purposes. The study group consisted of 50 participants (100 TMJs), 38 females and 12 males. The group was subdivided into symptomatic patients (35 individuals) and asymptomatic (control) volunteers (15 individuals).

Myofascial pain, limitation in mouth opening, articular sounds and bruxism were considered as clinical symptoms of TMD. The anterior muscle function test (toothpick test) was used to examine the LPM. The patients were asked to bite a toothpick using the protruded central incisor teeth for 1 min and were then evaluated for pain according to the protocol used at the Head Institute, UNIFESP (São Paulo, Brazil).¹⁷

The images were obtained at the Service of Imaging Diagnosis of the São Luiz Hospital (São Paulo, Brazil) by means of a super-conductive magnetic resonance system (Giroscan NT10 model, Philips Medical Systems, Eindhoven, the Netherlands), which was operated with a magnetic field of 1 T, gradients of 15 mTseg⁻¹ and a head coil. Detailed sequences parameters are shown in Table 1.

A mouth opener developed by Burnett Bidirectional (TMJ device; produced by Medrad Inc, Indianola, PA), and provided by Philips Medical Systems, was used to obtain the image sequences with maximal mouth opening. This mouthpiece had non-ferromagnetic properties, allowed wide opening of the mouth (≤ 55 mm), caused an audible click sound for each millimetre increase and was placed between the front teeth of the patient to keep the mouth in a maximum opening position at the moment of acquisition of the sagittal images.¹⁸

All patients were submitted to bilateral MRI examination of the TMJ. After the TMJ images were obtained, measurements (in mm) of the LPM were performed using a workstation. Axial and T_1 and T_2 sagittal sections with closed and open mouth, respectively, were selected because the muscles were most visible and represented different times during examination. Thickness and height of the LPM were measured in axial and sagittal sections, respectively, during mouth opening and closing. To determine whether differences between the measurements were statistically significant,

Table 1 Main parameters of the MRI sequences used in the assessment of patients

	<i>Loc 1</i>	<i>Loc 2</i>	<i>Sag PD</i>	<i>Sag T₂</i>	<i>Cor T₁</i>	<i>Sag T₁ open mouth</i>	<i>Sag T₂ movie</i>
Pulse sequence	FFE*	FFE*	SE	TSE	TSE	TSE	FFE*
Coil	Head	Head	Head	Head	Head	Head	Head
Slice section	Axial	Coronal	Sagittal	Sagittal	Coronal	Sagittal	Sagittal
TR (ms)	128	56	1000	2913	460	652	50
TE (ms)	7	7	15	120	14	13	14
TI (ms)	—	—	—	—	—	—	—
Matrix	256 × 256	256 × 256	256 × 512	256 × 512	256 × 512	256 × 512	256 × 512
Slice thickness (mm)	4.0	6.0	3.0	3.0	3.0	3.0	1.5
Gap	0.4	1.0	0.3	0.3	0.3	0.3	—
Number of slices	9	4	6	6	6	6	10
Number of acquisitions	1	1	2	2	2	2	1**
Acquisition time (min)	00:16	00:07	3:26	2:40	3:15	2:15	2:37
Fat suppression (SPIR)	No	No	No	No	No	No	No
Flip angle (°)	50	50	90	90	90	90	15
FOV (mm)	200	200	180	120	130	110	120

Cor, coronal; FFE, fast field echo; FOV, field of view; Loc, locator; PD, proton density; Sag, sagittal; SE, spin echo; SPIR, spectral presaturation with inversion recovery; TE, echo time; TI, inversion time; TR, repetition time; TSE, turbo spin echo; *Gradient-echo; **Dynamic scan-4

LPM values in each sequence of MR images of the right and left sides of the same patient, and of the groups with and without TMD, were compared.

The images were interpreted by two independent observers who were both experts in MRI of the TMJ. The images of the LPM, their morphology, insertions and alterations were evaluated. Muscle image measurements were performed on a workstation. Measurements of the muscle on the side affected by TMD were compared with those of the contralateral muscle and with measurements of the LPM in participants without symptoms of TMD.

Measurement of the LPM was performed only when both muscle heads had sharp images and were present in at least two sections of each sequence. The muscle was considered to be hypertrophic when it was enlarged in size and has a homogeneous signal in MRI sequences, which appeared as a convex curve in the medial portion of the upper or lower muscle border in the sequences of sagittal sections. The LPM was considered to be atrophic when it presented fatty replacement tissue with high-intensity signal in wide areas of the muscle and with no change in size, proton-density (PD) and T_2 weighted images. In these images, contracture of the LPM presented as fibrosis appearing as areas of low-intensity signal in PD and T_2 weighted images (Figure 1).^{12,13}

To determine whether the patient with TMD exhibited displacement in the articular disc (ADD) and whether it presented with (ADDWR) or without reduction (ADDWoR), the position of the articular disc was also considered.

Mouth opening was considered maximal when the limit of jaw opening ranged from 40 to 60 mm,¹⁹ depending on age, gender and size of the participant. Amplitudes of maximal jaw opening lower than 40 mm were considered to be a limitation in mouth opening. The degree of mobility of the mandible head was classified into normal, hypomobility and hypermobility. In the MR images, mobility of the mandible head

was diagnosed by keeping the mouth in its maximal opening position and measuring the distance between the mandible head and the articular tubercle apex.²⁰ The mandible head was considered to have hypomobility or limitation when its movement ranged from 0° to 90°. In this case, the mandible head did not reach the articular tubercle apex. The mandible head was considered to have normal mobility when its movement ranged from 90° to 120° in relation to the articular tubercle. The mandibular head was considered to have hypermobility when its translation exceeded the articular tubercle apex (>120°).²⁰

The statistical analysis for quantitative variables was done by summary measures such as mean and standard deviation. The qualitative variables were analysed by calculating the absolute and relative frequencies (percentage).

Statistical evaluation of the data was performed using SPSS 11.0 software for Windows (SPSS Inc, Chicago, IL) including Pearson χ^2 test and Fisher's exact test (and its extension). The Student's *t*-test for independent sample was selected for comparing the differences between the groups.

A probability value of less than 5% ($P \leq 0.05$) was considered a significant difference.

Results

29 of the 35 patients (82.9%) with clinical signs of TMD were female and 6 (17.1%) were male, which is in agreement with the higher prevalence of TMD in women. The group without TMD was formed of 9 (60.0%) female and 6 (40.0%) male patients.

Distribution of the symptoms among patients with affected sides (right, left or bilaterally) was homogeneous in the group with TMD. Pain (71.4%), clicking (30.4%), bruxism (25.7%) and headache (22.9%) were the most common symptoms reported

Figure 1 (a) atrophy; (b) hypertrophy; (c) contracture

Figure 2 Distribution of axial measurements of lateral pterygoid muscle (mm) into patient groups and gender. TMD, temporomandibular disorders

by patients. Crackling and limitation in mouth opening occurred at clinical examination in a much lower percentage.

Localized or undefined myofascial pain was undoubtedly the most common complaint among patients with TMD and the frequency was statistically significant ($P < 0.001$).

On average, the inferential results of the statistical tests revealed that the measurements on the right and left sides were statistically similar for the axial ($P = 0.383$) and T_1 and T_2 sagittal sections, with left a closed ($P = 0.327$) and open ($P = 0.807$) mouth, respectively. On average, groups with and without TMD showed statistically similar measurements for the axial ($P = 0.129$) and T_1 and T_2 sagittal sections with left a closed ($P = 0.116$) and open ($P = 0.134$) mouth, respectively (Figure 2).

Morphological alterations found included atrophy, hypertrophy, contracture and muscle tenderness. Normal morphology in the group with TMD was observed in 91.4% and 88.6% of the muscles on the right and left sides, respectively and in 100% of the muscles in the group without TMD (Figure 3).

Since ADD in patients with TMD is common,^{21–25} frequency of ADD was analysed in our sample. No participants in the group without TMD presented images of ADD, and only a low percentage (between 17.2% and 22.9%) of the patients with TMD presented images consistent with some type of ADD (with or without reduction) on the right or left sides. These results were statistically non-significant (Figure 4).

It is important to emphasise that although there were patients with a type of ADD, change in mobility of mandibular head (Figure 5) and change in LPM morphology in the group with TMD, both subgroups showed the same statistical distribution of ADD ($P = 0.815$), mandibular head mobility ($P = 0.189$) and LPM morphology ($P > 0.999$).

In the T_1 , T_2 and axial sections, when LPM measurements were compared with those of ADD; mandible hypomobility and hypermobility and LPM morphology, it was observed that measurements obtained in the axial ($P = 0.082$) T_1 and T_2 sagittal sections with closed ($P = 0.276$) and open ($P = 0.381$) mouth, respectively, were not related to mobility on the

Figure 3 Distribution of lateral pterygoid muscle morphology into patient groups and face sides. TMD, temporomandibular disorders

Figure 4 Distribution of anterior disc displacement into patient groups and face sides. ADDWR, anterior disc displacement with reduction; ADDWoR, anterior disc displacement without reduction; TMD, temporomandibular disorders

right side. Regarding LPM morphology, the results show that the mean values for the groups are statistically similar to those of T_1 and T_2 sagittal sections with closed ($P = 0.219$) and open ($P = 0.129$) mouth; however, the axial mean value for the group with TMD is higher than that of the group without TMD ($P = 0.006$), and the axial measure was related to the type of ADD ($P = 0.037$) also on the right side.

The measurements on the left side were also compared and revealed that the axial ($P = 0.295$) and T_1 and T_2 sagittal values with closed ($P = 0.122$) and open ($P = 0.440$) mouth positions are not related to ADD. Regarding mobility, only the axial measurement has a relationship with this type of alteration ($P = 0.040$).

Owing to the high rate of pain and clicking observed at the clinical examination of patients with TMD, the measurements obtained from the LPM images were related to these data; however, the mean values for LPM of the symptomatic and asymptomatic groups were statistically similar. The three groups (with TMD, without clicking; with TMD, with clicking; without TMD,

without clicking) showed mean values statistically similar for the axial ($P = 0.274$) and T_1 and T_2 sagittal measurements with closed ($P = 0.132$) and open ($P = 0.071$) mouth positions. The other three groups (with TMD, without pain; with TMD, with pain; without TMD, without pain) also presented mean values that were statistically similar for the axial ($P = 0.316$) and T_1 and T_2 sagittal measurements with closed ($P = 0.182$) and open ($P = 0.151$) mouth positions.

Discussion

At clinical examination, the anterior muscle function test, also known as the LPM test, was performed in all patients to assess presence of pain that, according to the Research Diagnostic Criteria of Dworkin and Le Resche,¹⁷ could mean impairment of the LPM. In the LPM test, it was observed that 100% of the patients without TMD and 28.6% of the patients with TMD showed negative and positive results, respectively,

Figure 5 Distribution of mandible head mobility into patient groups and face sides. TMD, temporomandibular disorders

Figure 6 Sagittal sections: (a) closed mouth; (b) open mouth

indicating that the LPM could present some alteration or relationship with TMD. This result was statistically significant when groups with, and without, TMD were compared ($P = 0.022$).

Both heads of the LPM were clearly observed in all sequences of the MR images analysed, showing that this diagnostic method is efficacious and confirming what was described by several authors (Figure 6).^{5,12,13,15,16,26,27}

Muscle shortening during mouth opening was observed in all the LPMs analysed, revealing a decrease in its volume during mandible movement.^{16,28}

Few morphological alterations found in the group with TMD had prevalence of muscle atrophy and contracture and were statistically non-significant.

Since the LPM is mainly inserted in the pterygoid fovea of the mandibular head, its mobility was also evaluated. Presence of hypomobility or hypermobility was observed in the open and closed mouth images, including the sequences of pseudodynamic MRI, which permits the observation of the mandibular head from the position of occlusion to that of maximal mouth opening.

Patients' complaints, such as pain and clicking, had a higher frequency either bilaterally or on the left side. In addition, presence of hypermobility in the mandibular

head was more frequent on the left side. Therefore, we hypothesize that an increase in thickness of the LPM observed in the axial sections on the right side would occur owing to an overload of the contralateral muscle during exacerbated movements of the mandibular head.

We conclude that in patients with TMD, measurements of the LPM in the axial sections are related to ADD ($P = 0.037$) and morphological alterations in LPM ($P = 0.006$) on the right side, and to hypermobility of the mandible head on the left side. These results indicate that thickness of the LPM is increased when related to ADD and hypermobility, and this could mean a kind of compensation, overload or hyperactivity of the muscle when these dysfunctions are present.

The presence of TMD can cause an alteration in the thickness of the LPM. Muscle atrophy and contracture are the most frequent types of morphological alteration.

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