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Enhancing morphological understanding of the lateral pterygoid muscle for orofacial pain treatment: a cadaveric study

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ABSTRACT

Aims: Injections to the lateral pterygoid muscle (LPM) have gained popularity for managing orofacial pain. Techniques like ultrasonography (USG), electromyography (EMG), and arthroscopy help prevent improper injections and tissue trauma during the procedure, but they require practitioner expertise and experience. Arthroscopy, while precise, is invasive. Blind injections are simpler and convenient for outpatient settings, but their safety is debated. This study examines the anatomical traits of the area of the injection to contribute to the safety and efficacy of these injections for temporomandibular-related orofacial pain.

Methods: The LPM consistently displayed two distinct bellies-superior and inferior-in 16 dissections of 8 cadavers. We measured lateral pterygoid plate (LPP) depth and length, pterygomaxillary angle, superior and inferior head vertical length, superior and inferior head thickness, distance between zygomatic arch and mandibular notch, and distance between superior border of inferior head and mandibular notch.

Results: Significant correlations were found between distances, thicknesses, and lengths of the muscle heads, indicating critical anatomical relationships relevant for safe injections. The mean age of cadavers was found as 79.00±1.78 years (In this article, the '±' notation corresponds to the standard deviation). The average depth and length of the LPP were 43.47±3.34 mm and 15.61±1.09 mm, respectively. The distance from the zygomatic arch to the mandibular notch was 10.76±0.39 mm, whereas the distance from the superior border of the inferior head to the mandibular notch was 6.74±0.29 mm. Significant associations were found between the distance from the zygomatic arch to the mandibular notch and both the thickness and length of the superior head (p=0.011 and p=0.005). Correlations were also observed between the distance from the superior border of the inferior head to the mandibular notch and the thickness of both heads (p<0.001 and p=0.045).

Conclusion: A greater distance from the zygomatic arch to the mandibular notch, as well as from the superior border of the inferior head to the mandibular notch, may potentially improve the safety and ease of injections into the LPM. Our study, therefore, provides insights to the anatomical traits of the region and contributes to safety of blind LPM injections to treat temporomandibular-related orofacial pain.

Keywords: Lateral pterygoid muscle, orofacial pain, temporomandibular joint, temporomandibular pain, cadaveric study

INTRODUCTION

The lateral pterygoid muscle (LPM) is essential for various temporomandibular joint (TMJ) movements, such as protrusion, depression, and mediotrusion, which facilitate TMJ opening and lateral motion.[1] Dysfunction of the pterygoid muscles can lead to TMJ dislocation,[2] mandibular issues such as restricted jaw movement and TMJ clicking, as well as temporomandibular pain. Temporomandibular disorders (TMD) encompass issues affecting the masticatory muscles and TMJ, with a prevalence of 12% to 17% in the general population.[3-5] Notably, hyperactivity of the LPM is linked to TMD, and targeted injections into this muscle can help manage associated pain. This hyperactivity may also contribute to degenerative changes in the TMJ[4] and is often associated with dislocation due to excessive forward condylar movement.[2,6] Patients frequently display habits like nocturnal clenching and grinding, leading to muscle tenderness and limited movement from increased masseter activity.[5,7] Hence, injections in these muscles have been a longstanding approach for the treatment of orofacial pain.

The success of the injection may serve for both as diagnostic and therapeutic measures for patients experiencing orofacial pain.[8] Administering the injection into the muscle is uncomplicated and can be performed on outpatient basis with minimal risk of complications. Injections can be delivered via intraoral.[8] or extraoral routes, although the deep location of the LPM can make this challenging. In the event of the inadvertent injection or unintentional spread of the drug to neighboring muscles, complications such as difficulties in

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swallowing or speaking may arise.[9] Hence, to ensure both safety and efficacy, guided techniques using ultrasound, MRI, CT, electromyography (EMG), nerve stimulation and arthroscopy are recommended, although blind application is also a viable option.[5,8-11] Similar to other interventional pain treatments, ultrasound guidance is essential for preventing tissue trauma and ensuring accurate needle placement with real-time imaging, minimizing unnecessary costs and pain for the patient.[12]

Ultrasound-guided (USG) techniques provide visualization of medication spread, allowing for precise administration and reduced local anesthetic dosages. Asking the patient to open their mouth creates space between the coronoid process and the zygomatic arch, facilitating effective visualization for experienced clinicians. Electromyography (EMG) assists by inducing muscle movement, confirming correct needle placement. However, EMG carries a risk of damaging nearby structures like the maxillary artery and long buccal nerve.[8] Therefore, clinicians must be proficient in USG and EMG techniques to ensure the safety of LPM injections. While arthroscopy offers real-time imaging, it is more invasive than other techniques and requires inpatient settings. It also envolves longer treatment durations and higher costs. Thus, arthroscopy should be considered only after other methods have proven ineffective.

The blind extraoral technique requires precise knowledge of the infratemporal fossa, particularly the inferior head of the lateral pterygoid muscle, which exhibits minimal anatomical variation.[13] For injection, the clinician palpates bony landmarks with the jaw opened at least 20-30 mm wide. The entry point is 35 mm from the external auditory canal and 10 mm below the zygomatic arch, with the needle angled 15° upward toward the upper molars to reach the inferior head of the lateral pterygoid.[13] The extraoral route is ideal for blind injections, providing a safe and effective method with a direct path to the muscle. This approach can also be done in an outpatient setting.[6] The aim of this study is to analyze the anatomy of the area to ensure safer injections for treating orofacial pain from the temporomandibular region.

METHODS

Ethics

Conducting scientific studies on cadavers or cadaveric body parts do not require ethical approval. The authors would like to express their sincere gratitude to the donors and their families for their contribution to education and science. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Anatomy

The extraoral technique requires a detailed understanding of the anatomical structures within the infratemporal fossa.[13] The medial and lateral pterygoid muscles are key contributors to orofacial pain, with the LPM playing a central role in both jaw opening and closing. Located laterally in the infratemporal region, the LPM cannot be palpated due to its position on the pterygoid plate.[13] Accurate knowledge of its origin (sphenoid bone and pterygoid plate) and insertion points (condylar process and TMJ capsule) is essential for effective injection. The muscle has two bellies-superior, responsible for TMJ closure, and inferior, involved in jaw opening and protraction (Figure 1, 2). Surrounding structures, including the maxillary artery, pterygoid venous plexus, and long buccal nerve, must be carefully considered to prevent complications such as bleeding during injection.[8]

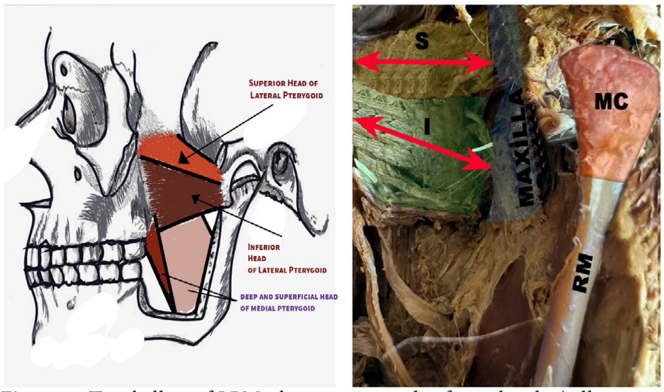

Figure 1. Two bellies of LPM; the superior and inferior head. a) illustrates the superior and inferior head. b) illustrates the length of superior and inferior heads

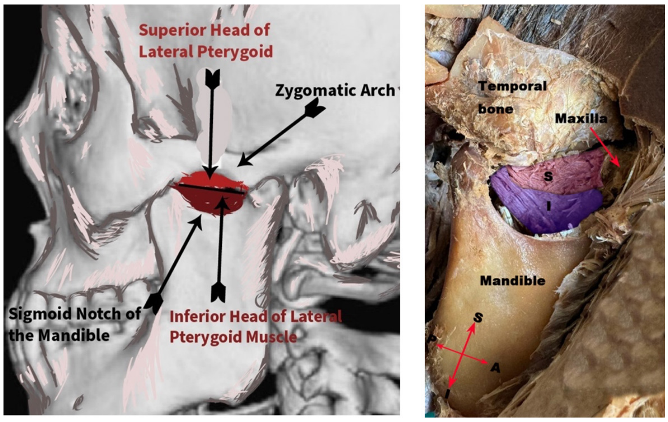

Figure 2. Location of the muscle between zygomatic arc and sigmoid notch of the mandible

To achieve a safe injection for orofacial pain patients, we dissected 8 cadaver heads, examining 16 LPM and surrounding structures, including the LPP, maxillary artery, long buccal nerve, and external auditory meatus. We thoroughly examined the LPM and its surrounding structures to identify anatomical variations that could affect injection safety. Key structures assessed included the LPP, mandibular condyle, sphenoid bone, maxillary artery, and pterygoid venous plexus, particularly due to the bleeding risks in blind injections.

This study was performed on 16 side of eight formalin-fixed cadaver heads. There was no history of surgery or trauma in the dissected area of the used cadavers. All measurements were obtained using a digital caliper (Digimatic caliper, model no: CD-15APXR; Mituyoto Corporation, Kanagawa, Japan) and by aid of a Kirshner-wire. Measurement of each parameter was performed twice and the mean results were calculated. In order to reduce variability, the first and second measurements were performed consecutively with minimal time between them.

To optimize extraoral (blind) injections, we measured the mean depth and width of the LPP and noted the locations of the maxillary tuberosity and tragus. We also assessed the LPM, focusing on the thickness and length of its superior and inferior heads. Measurements were taken from the midpoints of each belly, with the lengths determined by the origin (sphenoid bone) and insertion (condylar process) points.

Statistical Analysis

For the statistical analysis of the dry bone measurements, SPSS software version 23.0 (IBM Corp., Armonk, NY, USA) was used. Descriptive data were summarized as means and standard deviations (Stds). The Mann Witney U test was used for side comparison and $p<0.05$ was considered statistically significant. Correlation analysis between measurements was performed using the Spearman correlation test, and $p<0.05$ was considered statistically significant.

RESULTS

In all dissections conducted on both sides of 8 cadavers (totally 16 dissection), the LPM consistently displayed two distinct bellies-superior and inferior. The mean age of the cadavers found as 79.00±1.78. We measured the minimum, maximum and mean measurements for the following parameters and the data obtained are presented in Table:

Table. Descriptive statistics for the 16 dissections of the lateral pterygoid plate

	n	Min	Max	Mean	SD
LP plate depth	16	36.82	47.89	43.47	3.34
LP plate length	16	14.65	18.02	15.61	1.09
Superior head thickness	16	6.01	7.09	6.63	0.43
Inferior head thickness	16	10.98	12.96	12.00	0.54
Superior head length	16	12.01	12.96	12.53	0.37
Inferior head length	16	17.45	19.63	18.54	0.58
Distance between zygomatic arch and mandibular notch	16	10.30	11.63	10.76	0.39
Distance between superior border of inferior head and mandibular notch	16	6.23	7.02	6.74	0.29
Pterygomaxillary angle	16	168.00	181.00	174.37	4.33
%Age	16	76.00	81.00	79.00	1.78
Valid n (listwise)	16				

Min: Minimum, Max: Maximum, SD: Standard deviation

- Depth of the LPP
- Length of the LPP
- Pterygomaxillary angle
- Thickness of the two heads of the LPM
- Lengths of the two heads of the LPM
- Distance between zygomatic arch and mandibular notch
- Distance between superior border of inferior head and mandibular notch

The mean depth of the LPP from the skin surface was 43.47±3.34 mm, while its mean length was 15.61±1.09 mm. The mean vertical lengths of the superior and inferior heads at their insertion to the sphenoid bone were 12.53±0.37 mm and 18.54±0.58 mm, respectively. Additionally, at the midpoint of the muscle, the mean thicknesses of the superior and inferior heads were 6.63±0.43 mm and 12.00±0.54 mm, respectively.

The distance between the zygomatic arch and the mandibular notch (Figure 2, 3, 4a) was 10.76±0.39 mm, while the distance between the superior border of the inferior head and the mandibular notch was recorded as 6.74±0.29 mm.

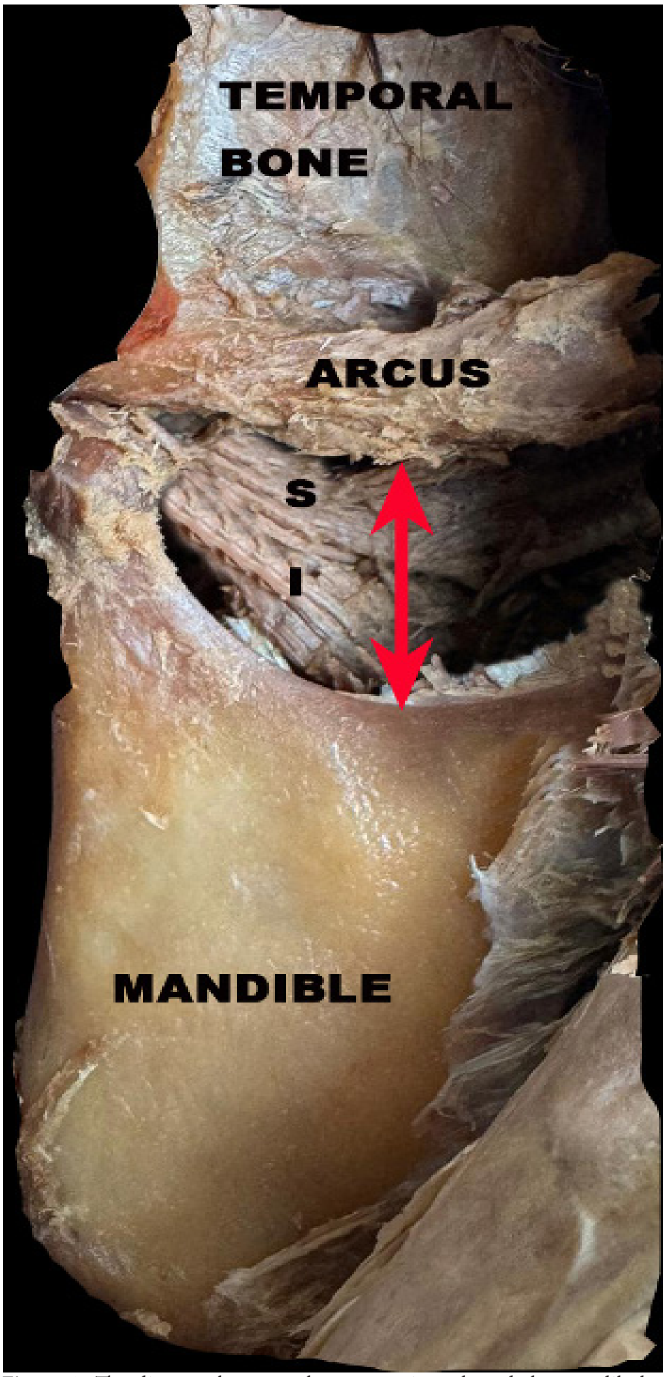

Figure 3. The distance between the zygomatic arch and the mandibular notch

There were statistically significant associations between the distance from the zygomatic arch to the mandibular notch and both the thickness and length of the superior head (p=0.011 and p=0.005, respectively). Similarly, significant correlations were observed between the distance from the superior border of the inferior head to the mandibular notch and the thickness of both the superior and inferior heads (p=0.000 and p=0.045, respectively). Furthermore, a notable correlation was seen between the pterygomaxillary angle and the thickness of the inferior head (p=0.016).

DISCUSSION

It is well-established fact is that dysfunction of the pterygoid muscle is directly correlated with pain, significantly impacting patients' quality of life and causing functional disability.[14] Pain influences muscle function by reducing agonist activity and increasing antagonist muscle activity.[15] These alterations in muscle activity represent a protective adaptive mechanism aimed at preventing potential further injury. These changes in muscle activity are the protective adaptation mechanism for preventing possible advanced injury. Pain typically involves the masticatory muscles and the preauricular region. In case of the presence of adjacent muscles, symptoms may be accompanied by headache and neck pain.[5,16]

The abnormal activity of LPM is often associated with orofacial pain, a common occurrence in TMD patients.[4] TMD patients are characterized not only by pain but also by symptoms such as joint limitation and joint clicking, which are prominent features of the condition.[4,5,17] While LPM injection is considered to be generally safe, similar to any pain management injection, it carries a risk of bleeding. This is due to the proximity of the LPM to the maxillary artery (Figure 4b) and the pterygoid venous plexus. Inadvertent diffusion of the drug to closely located muscles may result in transient dysphagia, pain during chewing, nasal regurgitation, and dysarthria.[6] There are known recommendations for ensuring safe injections, including practices, such as aspirating during injection and promptly halting the procedure if blood is observed during aspiration.[6,17] The primary goal of this study is to conduct a thorough examination of the anatomical features within the specified region. This analysis aims to guarantee the safe administration of injections for alleviating orofacial pain stemming from the temporomandibular area.

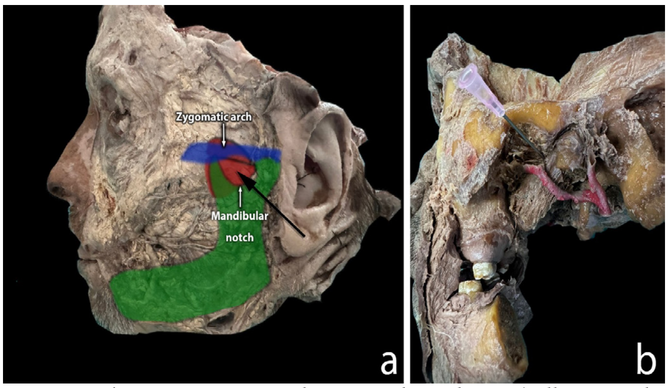

Figure 4. The injection site is shown on the cadaver. a) illustrates the injection area on the cadaver's face, while b) provides a more detailed view of the same region

The LPM is unique among the masticatory muscles as it is the sole muscle capable of depressing the mandible. The LPM also plays a role in controlling protrusion and unilateral movement of the lower jaw. Functionally, the upper head of the LPM serves as an effective stabilizer for the condyle during the closing phase.[13] The other masticatory muscles contributing to chewing and speech include the medial pterygoid, masseter, and temporalis muscles.[18] As the safe injection of the LPM involves targeting its main muscle bulk, this procedure may pose challenges for clinicians due to its deep-seated location. To address concerns regarding muscle depth, it is worth noting that our study determined the mean depth of the LPP from the skin surface to be 43.47±3.34 mm. In several studies, the LPM was found to be located at a depth of 3-4 cm consistent with our results.[6,17] Kucukguven et al.[17] reported the average depth of the LPP from the skin surface as 49.9±2.2 mm in a total of 20 cadaver half-heads. Given that over 50% of TMD patients have musculoskeletal issues as a significant source of the disease, the success of LPM injection can serve as a valuable diagnostic tool for identifying the source.[19]

The superior head of LPM primarily functions in TMJ closure, while the inferior head LPM is chiefly responsible for jaw opening and protraction. Prior research regarding the two bellies of the LPM reveals the predominance of the inferior head over the superior head in terms of size.[1] Consistent with existing data, our study confirms that both the thickness and length of the inferior head exceed those of the superior head. Specifically, we measured the thickness of the superior and inferior heads at 6.63±0.43 mm and 12.00±0.54 mm, respectively. Similarly, the length of the superior and inferior heads was recorded at 12.53±0.37 mm and 18.54±0.58 mm, respectively.

Our results revealed a mean typical pterygomaxillary angle of 174.37±4.33 degrees. Another study demonstrated comparable results, showing a mean typical pterygomaxillary angle measurement consistent with ours, at 168.3±15.8 degrees.[17] This average measurement may assist clinicians in gauging needle alignment along the LPP for accurate extraoral injections. Given the significant correlation observed between the pterygomaxillary angle and the thickness of the inferior head, we conclude that using the correct injection angle can improve the safety of the procedure.

Since muscle abnormalities associated with TMDs impact the function of the LPM, it is important to recognize that the muscle thickness may be altered as a consequence. Muscle contraction due to spasm, edema, or both could theoretically result in increased muscle belly thickness, while atrophy might lead to a relative decrease in thickness.[20] Our findings indicate that the thickness of the superior and inferior heads are 6.63±0.43 mm and 12.00±0.54 mm, respectively. In another study, the reported thickness for the superior and inferior heads were 3.1±1.2 mm and 10.2±1.8 mm, respectively.[17] Differences in the mean measurements of LPM head thickness across studies suggest the presence of the aforementioned issues, such as spasm, edema, and atrophy. Clinicians should be mindful of this potential variability when administering injections.

Our findings reveal that the mean distance from the zygomatic arch to the mandibular notch is 10.76±0.39 mm. We observed significant associations between this distance and both the thickness and length of the superior head. Moreover, the average distance from the superior border of the inferior head to the mandibular notch measures 6.74±0.29 mm. As previously stated, significant correlations exist between this distance and the thickness of both the superior and inferior heads. Therefore, an increase in both distances-specifically, the mean distance from the zygomatic arch to the mandibular notch and the distance from the superior border of the inferior head to the mandibular notch-could potentially enhance the safety and accessibility of injections into the LPM.

Limitations

While this study discusses the advantages and disadvantages of various injection techniques (ultrasound-guided, EMG, arthroscopy, and blind injections, it lacks experimental data that directly compares these techniques, as we focused on the results of cadaver examinations. Such comparative studies are essential for determining which technique is the safest and most effective. The advanced age of the cadavers and their formalin fixation may partially limit the clinical applicability of the findings obtained from the cadaver morphological structures in living tissues, which should be taken into consideration as an additional limitation. Thus, this limitation highlights the need for future research to include direct comparisons to provide clearer guidance on best practices in clinical settings.

CONCLUSION

The blind injection technique has advantages of being simple, fast, and convenient to be applied in outpatient clinic. Yet, similar to other injections administered with a blind technique, the blindly performed LPM injection is also subject to controversy regarding its safety. However, the notable advantages warrant a detailed discussion of its safety in this study. LPM injection is a minimally invasive treatment option for orofacial pain management. Our study demonstrates that blind LPM injections can be safe for treating TMDs, particularly when clinicians possess a thorough understanding of the region's anatomy. Furthermore, we believe that designing prospective clinical studies should provide practical guidelines for clinicians to implement these findings in their practice, ensuring that our research translates effectively into clinical applications.

ETHICAL DECLARATIONS

Ethics Committee Approval

Conducting scientific studies on cadavers or cadaveric body parts do not require ethical approval. The authors would like to express their sincere gratitude to the donors and their families for their contribution to education and science.

Informed Consent

Since this was a cadaver study, written informed consent was not required.

Conflict of Interest Statement

The authors declared no conflicts of interest.

Financial Disclosure

The authors stated that this study received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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