Bratislava Medical Journal
https://doi.org/10.1007/s44411-025-00363-7

RESEARCH

# Precise Dry Needle Insertion Point and Approach to the Lateral Pterygoid Muscle: A Cadaveric Study

Şeyma Hiçyılmaz[1] · Ayla Tekin[1] · Özgür Çakır[2] · Gür Akansel[2]

Received: 5 July 2025 / Revised: 13 September 2025 / Accepted: 18 September 2025
© The Author(s), under exclusive licence to the Faculty of Medicine, Comenius University in Bratislava 2025

## Abstract

**Aim** Temporomandibular joint disorders are a common cause of chronic orofacial pain and often involve the lateral pterygoid muscle (LPM). However, dry needling is limited by poor palpation reliability and difficult-to-standardize intraoral or imaging guidance. This cadaveric study aimed to define an optimal extraoral insertion point, angle, and needle length for safely reaching the LPM. Methods: Sixteen adult cadaver heads (10 males, 6 females; 32 sides) were studied. Dissections performed on one side guided contralateral needling, assuming morphological symmetry. A safe insertion point 17 mm perpendicularly below 3/5 of the canthal-tragus line, with optimal angles of 15° and 90°, was identified. Anthropometric measurements and computed tomography confirmed needle length and angles. Results: Sex-related differences were found in anthropometric measurements, while no significant right–left differences were observed. At 15°, the median length to the LPM was 43.45 (41.24–46.03) mm in males and 40.93 (40.25–42.38) mm in females ($p = 0.031$); at 90°, 44.08 (42.66–45.48) mm in males and 39.95 (39.34–40.46) mm in females. At both angles, needle length differed significantly between sexes ($p < 0.05$), but not between sides ($p > 0.05$). Conclusion: From the specific insertion point determined in the study, the LPM can be reached at 15° and 90° angles, with median lengths of 43.45 (41.24–46.03) mm and 44.08 (42.66–45.48) mm for males, and 40.93 (40.25–42.38) mm and 39.95 (39.34–40.46) mm for females, respectively. We found that the LPM could be reached at the same angles but with different needle lengths between sexes.

**Keywords** Lateral Pterygoid Muscle · Dry Needling · Temporomandibular Disorders · Cadaver · Anthropometric Measurement

## 1 Introduction

Temporomandibular disorder (TMD) is the most common form of chronic orofacial pain and is a clinical condition characterized by pain and dysfunction in masticatory muscles and temporomandibular joints (TMJ) [1, 2]. Although this condition is common, it has various symptoms defined by pain in the preauricular region that changes the dynamics of the movement of the jaw [3, 4]. The etiology of TMD is multifactorial [5, 6]. One factor is dysfunction of the lateral pterygoid muscle (LPM) [7], which is deeply located in the infratemporal fossa (Fig. 1). In addition, morphological changes, such as atrophy, contracture, and hypertrophy have been reported in the LPM of some patients with TMDs [8]. Therefore, in the management of TMD, various treatments to improve the impaired LPM function may be required.

Since the LPM is a deep-seated muscle, palpation and manual treatment are challenging [9]. It has been reported that the lower head of the muscle cannot be palpated because

This study was previously presented as an oral presentation at an international congress, based on preliminary findings obtained from a smaller number of head cadavers. However, due to organizational issues related to the congress, the study was not published in any abstract book, proceedings, or other formal publication. The current manuscript represents a substantially expanded and revised version of that preliminary work. Therefore, the data and findings presented here have not been published or publicly disseminated in any form.

✉ Ayla Tekin
ayla.tekinorha@kocaeli.edu.tr

Şeyma Hiçyılmaz
seyma_hcylmz@hotmail.com

Özgür Çakır
ozgur.cakir@kocaeli.edu.tr

Gür Akansel
gur.akansel@kocaeli.edu.tr

[1] Faculty of Medicine Department of Anatomy, Kocaeli University, Umuttepe Campus, 41001 İzmit, Kocaeli, Turkey

[2] Faculty of Medicine Department of Radiology, Kocaeli University, Umuttepe Campus, 41001 İzmit, Kocaeli, Turkey

Published online: 26 September 2025

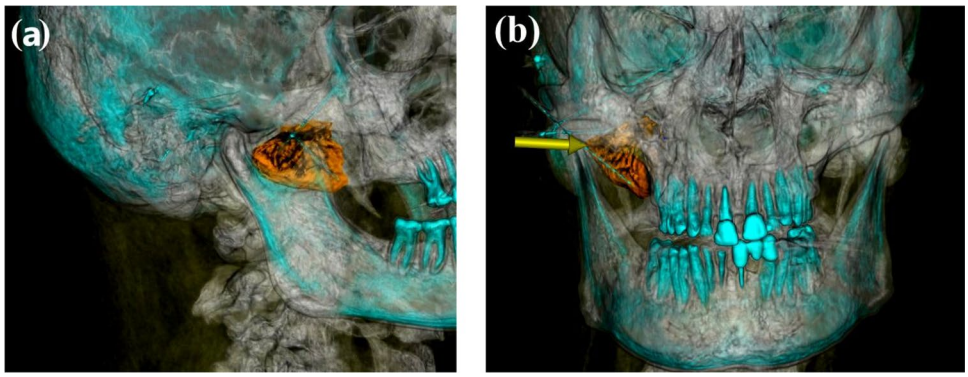



**Fig. 1** The lateral pterygoid muscle demonstrated in orange color; (a) lateral view (b) anterior view

of its anatomical position [10]. Therefore, for diagnosis and treatment of the LPM, various invasive methods have been used, including electromyography, acupuncture, dry needling, botulinum toxin, and trigger point injections [11, 12]. Dry needling is one of these therapeutic tools, which involves inserting a thin needle through the skin into the muscle's trunk or near the tendon [13], or to reach deeper structures [9]. Gonzalez-Perez et al. reported that dry needle applied to the LPM was therapeutically effective in patients with myofascial pain [14].

Systematic reviews published in 2019 and 2021 reported that dry needling can reduce pain intensity and increase pressure–pain thresholds in patients with TMD, although most studies targeted superficial masticatory muscles, and the overall quality of evidence was low [15, 16]. More recent reviews and meta-analyses (2023–2024) have reinforced these findings, showing that dry needling achieves comparable effects to manual therapy in reducing pain and improving jaw function [17, 18]. Nevertheless, heterogeneity across trials and limited data for deep muscles such as the lateral pterygoid continue to weaken the strength of recommendations, highlighting the need for cadaveric and anatomical studies to define precise and safe insertion parameters [19]. The number of studies examining the reliability and accuracy of applying needles from the skin surface to a deeply located muscle is limited. Mesa-Jiménez et al. reported a method for dry needling the LPM in two head cadavers [13]. However, precise skin placement for the needle before making the insertion was not reported. In invasive techniques, such as dry needling, the goal is to reach the targeted muscle with the correct approach to avoid damaging the surrounding neural and vascular structures [20]. Intraoral approach is one of the methods to reach the muscle. The needle needs to be inserted in the mucobuccal fold near the upper molar teeth [21–23] and EMG monitoring, MR guided navigation or ultrasound are required for the treatment [24, 25]. However, due to a lack of experience, intraoral techniques may be challenging and ineffective in cases of locked jaws [21]. Extraoral approach also include several methods to reach the LPM and may not require additional costs [21, 26].

In recent years, ultrasound-guided botulinum toxin or injection studies have demonstrated that safe and effective access to the LPM is possible; however, these methods are costly, require specialized equipment, and may not be feasible in routine clinical practice [27–29]. Moreover, ultrasound visualization of the LPM is technically demanding [28]. Therefore, establishing a reproducible and safe extraoral approach without relying on advanced imaging is clinically important, and anatomical studies are needed to provide reliable reference points and standardized insertion parameters for dry needling of the LPM. The present cadaveric study aims to define reproducible extraoral insertion points, angles, and needle lengths to safely reach the lateral pterygoid muscle by combining anthropometric measurements with radiological confirmation, thereby providing practical parameters applicable in clinical practice.

## 2 Methods

The study was performed with sixteen adult skull cadavers (10 men and 6 women; 66.5 [60.75–79.25] years in males and 64 [59.5–68.25] years in females) whose skin was intact.

The inclusion criteria for the cadavers were: (1) that they should have an opening mouth; and (2) have integrity of the face, including bone structure and LPM. In addition, cadavers with deformation of the TMJ and surrounding structures were not included in this study.

### 2.1 Dissection Phase

Cadavers were preserved in a 37.5% formaldehyde solution and labeled for identification. First, the Superficial Musculoaponeurotic System (SMAS) of the right side of each cadaver was dissected. The skin was removed with a scalpel without damaging the underlying structures. The projection of the mandibular notch to the skin was determined using a steel wire, and attempts were made to reach the muscle with double-pointed 100 mm needles inserted with multiple different angles. After the needles were placed, the SMAS layer

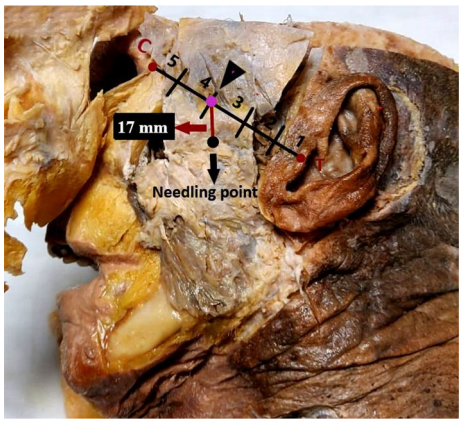



**Fig. 2** Determination of the insertion point. Canthal-tragus line (CTL)

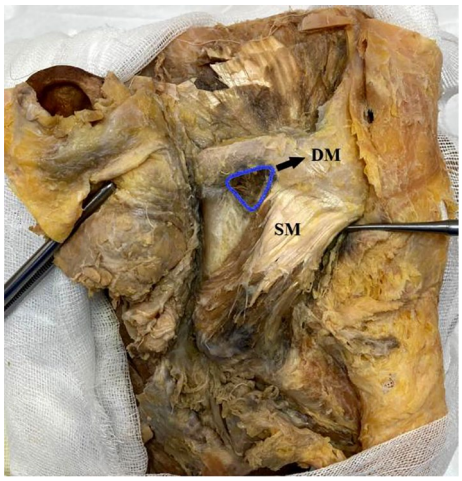



**Fig. 3** The masseter muscle. DM deep part of the masseter muscle, SM superficial part of the masseter muscle

was closed over them, and computed tomography (CT) was used to identify the needles that reached the muscle and the length of these needles. After several essay the most suitable insertion point to reach to the LPM was found by descending 17 mm perpendicularly from the point located at 3/5 of the canthal-tragus line (CTL), starting from the tragus, identified a safe position at the mandibular notch (Fig. 2). Together, the most suitable angles for accessing the muscle were found to be 15° and 90°.

Anatomical structures were identified, then the masseter muscle was revealed (Fig. 3).

Afterward, the masseter muscle and surrounding tissues were dissected from the attachment point in such a way that their integrity was not impaired. Before total dissection, some anthropometric measurements were made with an electronic caliper. The condylar process-gonion distance (Pcl-Go), the coronoid process-gonion distance (Pco-Go), the distance between the anterior part of the coronoid process to the posterior part of the condylar process (Pcl-Pco) were measured and the CTL was identified.

Furthermore, to reach the LPM, the zygomatic process of the temporal bone and the coronoid process of the mandible were cut with a bonesaw. The temporal muscle, located under these structures, was removed from the bone structure, so that the LPM was exposed. During this dissection, care was taken not to damage the maxillary artery, which continued its course under the mandible (Fig. 4).

## 2.2 Proof of the Needling Phase

The CTL line was drawn on the skin over the left side of each cadaver. Sterile stainless-steel needles, 50 mm in length, with a plastic cylindrical guide were used for the needling process. With these needles, needling was performed from the insertion point (the point obtained by descending

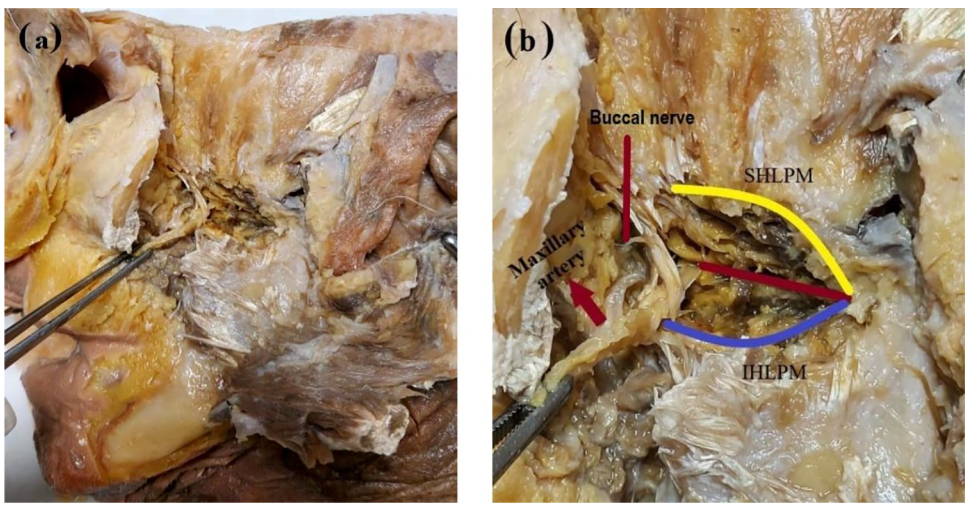



**Fig. 4** Dissection stages: **a** Image of the lateral pterygoid muscle (LPM); **b** Maxillary artery and buccal nerve between the superior head of lateral pterygoid muscle (SHLPM) and inferior head of lateral pterygoid muscle (IHLPM)

17 mm perpendicularly from 3/5 of the CTL starting from the tragus) identified during the dissection phase and controlled by CT using two different angles:

The needle was inserted at an angle of 15°, from anterior to posterior, towards the condylar process.
The needle was applied perpendicularly to the skin surface (90°).

The length of the needle reaching the muscle was measured by CT, and the insertion point was verified (Fig. 5).

To expose the LPM and to obtain anthropometric measurements, the same dissection phases were also applied on the left side. All CT images were taken with Toshiba Aquilion 64 and Toshiba Activion 16 Multislice CT. In this study all lengths were calculated in millimeters (mm) for anatomical measurements.

### 2.3 Statistical Analysis

An analysis of the data obtained was performed with IBM SPSS, version 22.0 (IBM Inc., Armonk, NY, USA). Normal distribution of the data was assessed by the Shapiro Wilk test. Comparisons between males and females were performed using the Mann–Whitney U test for non-normally distributed variables. For right–left comparisons, the Wilcoxon signed-rank test was applied. A $p < 0.05$ was considered statistically significant.

## 3 Results

A total of sixteen adult head cadavers, ten men, and six women were included in the study. The median age of the men was 66.5 (60.75–79.25) years and this was 64 (59.5–68.25) years for women, with no significant difference between groups ($p = 0.368$). All identified LPM were two headed. The median values of these parameters were calculated both for total hemi face and sexes. All anatomical data, shown as median (IQR), measured for a total of 32 sides (including right and left for sixteen head cadavers), are given in Table 1. Anthropometric measurement values were compared between sexes (Table 1).

Based on the total values, the Pcl-Go distance was significantly higher in males compared with females ($p < 0.001$). For the Pco-Go distance, no significant difference was found between males and females ($p = 0.313$). The Pcl-Pco distance was slightly higher in males than in females, but this difference was not statistically significant ($p = 0.056$). The canthal–tragus line (CTL) values were significantly greater in males than in females ($p = 0.031$). The data obtained were compared between the right and the left side of each head and no statistically difference was found between them. Namely the same application can be applied on each side (Table 1).

Considering the total values, at 15° needle insertion, the median length was 43.45 (41.24–46.03) mm in males and 40.93 (40.25–42.38) mm in females, with the difference being statistically significant ($p = 0.031$). At 90° needle insertion, the median length was 44.08 (42.66–45.48) mm in males and 39.95 (39.34–40.46) mm in females; this difference was also statistically significant ($p = 0.001$) (Table 2).

At 15° needle insertion, no significant difference was found between the right and left sides in males ($p = 0.353$). Similarly, in females, no significant right–left difference was observed ($p = 0.589$). At 90° needle insertion, no significant difference was detected between the right and left sides in males ($p = 0.739$). In contrast, in females, a statistically significant difference was found between the sides, with the left side being greater ($p = 0.041$) (Table 2).

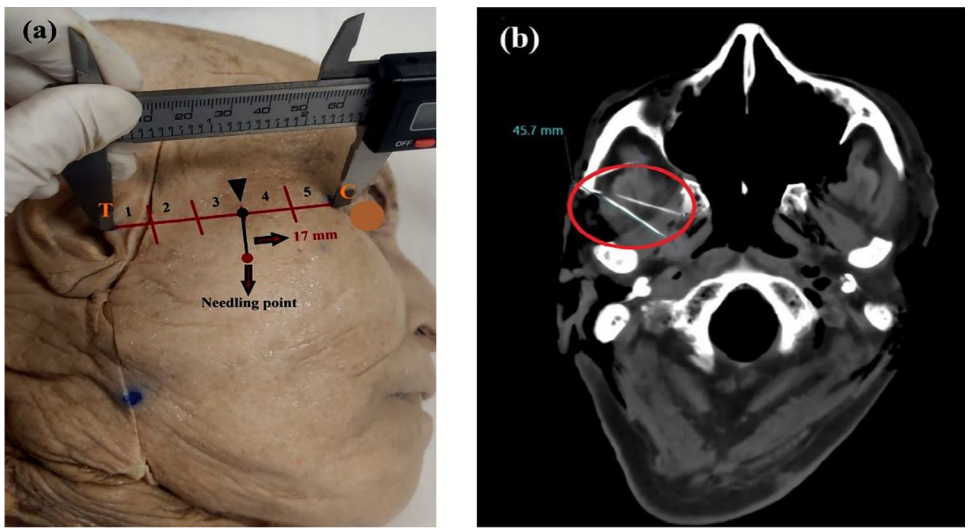



**Fig. 5** Needling application: **a** Insertion point from the canthal-tragus line (CTL); **b** Length of needle which reach the LPM

**Table 1** Median values of anthropometric measurements according to sexes

| Age | Male (n = 10) | | Female (n = 6) | | |
|---|---|---|---|---|---|
| | Median (IQR) | | Median (IQR) | | P (Male vs Female) |
| | 66.5 (60.75–79.25) | | 64 (59.5–68.25) | | 0.368 |
| | | P (Right- Left) | | P (Right- Left) | |
| Pcl-Go (Right) | 62.15 (58.40–65.55) | 0.138 | 55.35 (54.44–55.67) | 0.420 | |
| Pcl-Go (Left) | 66.99 (58.91–68.43) | | 55.33 (54.53–56.08) | | |
| Pcl-Go (Total) | 59.00 (58.01–67.78) | | 55.45 (54.99–56.40) | | 0.000 |
| Pco-Go (Right) | 66.42 (64.73–70.63) | 0.300 | 66.24 (59.35–66.83) | 0.225 | |
| Pco-Go (Left) | 66.96 (63.62–68.45) | | 64.80 (59.58–66.75) | | |
| Pco-Go (Total) | 66.75 (63.15–70.75) | | 65.33 (59.47–66.81) | | 0.313 |
| Pcl-Pco (Right) | 43.22 (42.31–43.71) | 0.353 | 40.68 (39.88–41.64) | 0.589 | |
| Pcl-Pco (Left) | 43.55 (43.38–43.71) | | 41.10 (40.00–42.39) | | |
| Pcl-Pco (Total) | 43.13 (41.45–43.56) | | 41.28 (39.94–42.43) | | 0.056 |
| CTL (Right) | 76.10 (69.90–78.95) | 0.088 | 69.20 (68.77–69.74) | 0.583 | |
| CTL (Left) | 69.77 (68.93–74.26) | | 69.18 (68.61–71.12) | | |
| CTL (Total) | 73.52 (70.20–80.80) | | 69.82 (68.87–70.78) | | 0.031 |

*Pcl-Go: Distance between the condylar process and gonion, Pco-Go: Distance between the coronoid process and gonion, Pcl-Pco: Distance between posterior of the condylar process and anterior of the coronoid process, CTL: Distance Between the canthus and tragus

**Table 2** Median length of needle insertion to reach the LPM

| | Male (n = 10) | | Female (n = 6) | | |
|---|---|---|---|---|---|
| | Median (IQR) (mm) | P (right-left) | Median (IQR) (mm) | P (right-left) | P (male–female) |
| 15° N.A (Right) | 44.45 (42.25–45.28) | 0.353 | 40.90 (39.35–42.65) | 0.589 | |
| 15° N.A (Left) | 43.00 (41.55–44.43) | | 41.85 (41.08–42.55) | | |
| 15° N.A (Total) | 43.45 (41.24–46.03) | | 40.93 (40.25–42.38) | | 0.031 |
| 90° N.A. (Right) | 44.45 (42.80–45.43) | 0.739 | 39.25 (38.98–39.50) | 0.041 | |
| 90° N.A. (Left) | 43.90 (41.85–46.08) | | 40.65 (39.63–41.50) | | |
| 90° N.A (Total) | 44.08 (42.66–45.48) | | 39.95 (39.34–40.46) | | 0.001 |

*15° N.A: 15° Needling Angle; 90° N.A: 90° Needling Angle

## 4 Discussion

As the LPM plays an important role in the orofacial system as mastication or articulation [26, 30] it is one of the key muscles that may cause pain in the TMJ. The deep placement of the LPM requires invasive methods, such as dry needling, to reach the muscle to reduce the severity of pain and increase functional recovery [31]. Review of the literature revealed that there were few studies examining optimal needle insertion to treat dysfunction of the LPM. Furthermore, to standardize the application point of the dry needle and all measurements, several anthropometric evaluations were performed in the present study. The condyloid process and the gonion are important anatomical structures that can be palpated outside the skin. These anatomical structures are used as reference points for the determination of head and face types in both medicine and dentistry [32]. However, the deeper coronoid process is also an important anatomical point. Together with the condyloid process, it forms the mandibular notch and delimits a specific area [32]. In order to avoid adverse events during needling, the needle should be applied from this area, close to the coronoid process [33].

In recent years, the application of dry needling to the LPM has gained increasing attention in the management of TMJ disorders, particularly those associated with myofascial pain. Randomized controlled trials and systematic reviews have provided growing evidence supporting its clinical utility. Menéndez Torre et al. conducted a study comparing dry needling with manual therapy techniques and found no statistically significant differences between the

two interventions in terms of pain reduction. Nevertheless, both approaches demonstrated efficacy in reducing orofacial myofascial pain within a short-term follow-up period of 1 to 3 months. These findings suggest that dry needling may offer comparable benefits to manual therapy in the acute management of TMJ-related pain [34]. Complementary findings were reported by Dib Zakkour et al., who investigated the use of dry needling in the masseter muscle for the inactivation of active myofascial trigger points. Their results indicated notable improvements in facial pain, maximum mouth opening, and symmetry of mandibular movement, highlighting the functional benefits of this intervention beyond mere pain relief [35]. Although dry needling has been generally recognized as an effective treatment modality for orofacial pain syndromes, systematic reviews have underscored the need for higher-quality clinical trials with more robust methodological frameworks. This is essential to establish consistent treatment protocols and to better understand long-term outcomes [36].

In a study conducted with CT, the mean Pcl-Go distance was 62.01 ± 5.19 mm in men and 55.13 ± 4.83 mm in women, and the mean Pco-Go distance was 63.95 ± 5.28 mm in males and 55.67 ± 5.30 mm in females [37]. In another study using a caliper, the mean Pcl-Go distance was 60.67 ± 5.32 mm in men and 54.46 ± 4.97 mm in women, while the mean Pco-Go distance was 61.68 ± 5.45 mm in males and 54.89 ± 3.54 mm in females [38]. In another study, the Pcl-Go distance was 65.96 ± 6.16 mm in men and 58.24 ± 4.32 mm in women [39]. In the present study, the median of the Pcl-Go distances was 59.00 (58.01–67.78) mm in men and 55.45 (54.99–56.40) mm in women and for the Pco-Go distances these were 66.75 (63.15–70.75) mm in men and 65.33 (59.47–66.81) mm in women. When compared with previous CT and caliper studies, the Pcl-Go values in our study were slightly lower in men and similar in women, while the Pco-Go values were higher in both sexes, especially pronounced in men. These differences may be due to sample characteristics, technical differences in measurement methods, and craniofacial variations between populations. In contrast, Abofakher et al. reported the mean distance of the Pco-Go to be 58.61 ± 6.78 mm in men and 53.97 ± 5.26 mm in women. The reason for these smaller measurements was that they used a younger and tighter age range (18–25 years) [40].

In terms of Pcl-Pco measurements, Dong et al. reported this to be 45.41 ± 3.73 mm in men and 41.99 ± 2.67 mm in women [39] while Cappella et al. reported 41 ± 5 mm in men and 38 ± 3 mm in women [41]. In another study using a caliper, these measurements were 43.57 ± 3.06 mm in men and 40.96 ± 2.93 mm in women [33]. In the present study, the Pcl-Pco measurements were 43.13 (41.45–43.56) mm in men and 41.28 (39.94–42.43) mm in women. Overall, the Pcl-Pco values obtained in this study are largely consistent with those reported in the literature. Minor variations may be related to sample size, population characteristics, or measurement techniques. These findings support the anatomical reliability of using the Pcl-Pco as a reference measurement, while also highlighting the need for further studies in larger and more diverse samples.

Furthermore, one of the important landmark lines used for skull anthropometric and radiologic measurement is the CTL. In a study with 11 adult cadavers, Talaat et al. reported the median canthal–tragus distance as 72 (65–83) mm without specifying sex [42]. In the present study, the total canthal-tragus distance was 73.52 (70.20–80.80) mm in men and 69.82 (68.87–70.78) mm in women. These results are comparable to the values reported in the literature. In another study on cadavers, the canthal-tragus distance was 72.55 ± 0.76 mm on the right side of the face and 69.55 ± 0.57 mm on the left side when measured by caliper, without reporting sex differences. [43] In the present study, the right and left canthal-tragus distances were 76.10 (69.90–78.95) mm and 69.77 (68.93–74.26) mm in men, and 69.20 (68.77–69.74) mm and 69.18 (68.61–71.12) mm in women, respectively. Once again, the measurements of the present study were in keeping with previously reported data. However, there are few published cadaveric data for this parameter and more data is required.

The anthropometric data was then used to identify the optimal insertion point for a needle when attempting to access the LPM. Kucukguven et al. tested a new and effective extraoral injection method on 20 cadaver heads, taking into account the different shapes of the LPM and other structures nearby. They targeted the lamina lateralis of the os sphenoidale to reach the LPM. To reach this point, an average distance of 49.9 ± 2.2 mm was covered with a 0.36 × 50 mm hypodermic needle [44]. Rodríguez-Gimillo et al. evaluated the spread of botulinum toxin injection in the LPM under ultrasound guidance. A 0.64 × 50 mm needle, using an out-of-plane approach, injected 1 ml of 0.25-Methylene blue dye into the LPM of a fresh human cadaver. The muscle was then dissected and examined to evaluate the spread of the dye, and it was determined that the dye reached the muscle heads [45]. Mesa–Jiménez et al., in their study with two cadavers, focused on the accuracy of needling applied to the superior and inferior head of the LPM [14]. They reported that 50–60 mm long steel needles were suitable for reaching the inferior head and they mentioned that they reached the muscle when the needle was advanced between the condylar process and the coronoid process, under the zygomatic process, at an angle of 15° in the anterior–posterior direction towards the TMJ. In recent years, several studies have examined the technical details of needle insertion into the lateral pterygoid muscle (LPM). Nakazawa et al. described an ultrasound-guided out-of-plane approach targeting the anterior and medial edge

of the mandibular condyle, with the needle advanced at a 45–60° angle and an additional 10–20° posterior orientation [46]. Vas et al. identified the mandibular notch (sigmoid notch) as the entry point and, under ultrasound guidance, inserted 40-mm needles perpendicularly (90°) to reach the LPM [47]. Borghol et al. used the extraoral line between the zygomatic arch and the mandibular notch, reporting that the muscle lies approximately 35 mm beneath the skin and recommending a 35-mm needle [48]. Al-Tairi et al., based on computed tomography measurements, did not define a direct anatomical entry point, but suggested that the LPM could be reached at a depth of 30–40 mm using a perpendicular (90°) insertion from the skin [49]. These approaches highlight the importance of precisely defining the entry point, needle angle, and needle length to achieve safe and reproducible access to the LPM. Three studies investigating accessing the targeting trigger points of the LPM with dry 0.25 × 40 mm needles, inserted with a perpendicular (90°) angle lateral to the mandibular notch and just below the zygomatic process. However, they did not use imaging methods to confirm the needle successfully reaching the muscle. Furthermore, evaluations were based on positive feedback from patients, such as decreased pain, increased range of motion of the jaw and local twitch response [32, 50, 51].

In the present study, the authors found a specific point on the skin to apply the dry needle. By descending 17 mm perpendicularly from 3/5 of the distance of the CTL from the tragus, it was possible to gain access to a safe area between the condylar-coronoid process and the zygomatic process. From this point, the insertion of the needle can be done at two different angles, 15° or 90°. When the CT measurement was made, the median length of the needle to reach the LPM was 43.45 (41.24–46.03) mm in men and 40.93 (40.25–42.38) mm in women when inserted at 15° and 44.08 (42.66–45.48) mm in men ad 39.95 (39.34–40.46) mm in women when inserted at 90°. The length of the needle is very important to reach the muscle and if it is too shallow then relaxation will not occur in the muscle and the desired therapeutic effect will not be achieved. Furthermore, if the needling is done in this way, the maxillary artery, and the buccal nerve which both pass between the two heads of the LPM cannot be damaged. In addition, since the diameter of the needle is small, it is very unlikely to damage arteries, nerves, or veins. Although the entry points and needle angles described in previous studies differ from those proposed in the present study, the reported length values are largely consistent with the literature. However, compared with studies recommending 35–40 mm needle lengths, our findings indicate that longer needles are required to safely reach the LPM. In this context, the identified anthropometric reference provides extraoral approach that can be applied without the need for advanced imaging or ultrasound guidance, thereby complementing previous findings. However, although reproducible in cadaveric evaluation, maintaining these insertion angles in clinical practice may be technically challenging due to factors such as anatomical variations, mouth opening capacity, or operator experience. Therefore, future clinical studies are needed to validate its practical feasibility.

Another finding related to the LPM is the head variation of this muscle. Although the LPM is generally accepted as two-headed, variations have been described in which the muscle consists of one [52–55], two [56–58] or three heads [59–61]. In a systematic review, especially focusing on variations of the LPM, the incidence of single-headedness varies between 7.7 and 26.7%, the incidence of two-headedness varies between 61.4 and 91.1%, and the incidence of three-headedness varies between 4 and 35% [62]. Perhaps unsurprisingly, given the relatively low incidence of non-two-headedness in the literature and the small number of individuals involved in the present study, no variation was found in either dissections or on CT imaging.

This study has several limitations. The small sample size limits generalizability. In addition, cadaveric tissues differ from living tissues in terms of vascularity and muscle tone, which may affect the applicability of the findings in clinical settings. Individual anatomical variations also cannot be excluded. The limited sample size and the inability to evaluate the cadavers in terms of masticatory function, oral, and dental health may have caused the side-to-side differences observed in females during 90° needle insertion ($p = 0.041$). Future clinical studies with larger samples and imaging-based validation are required to confirm and extend these findings.

## 5 Conclusion

The deep location of the LPM, frequently involved in temporomandibular disorders, necessitates accurate and safe invasive approaches. In this cadaveric study, we identified an insertion point: descending 17 mm perpendicularly from 3/5 of the CTL provided access to a safe region between the condylar and coronoid processes, corresponding to the mandibular notch. From this standardized entry site, the needle length required to reach the LPM with a 50 mm needle was measured. At 15° anterior–posterior insertion, the median length was 43.45 (41.24–46.03) mm in males and 40.93 (40.25–42.38) mm in females, whereas at 90° perpendicular insertion it was 44.08 (42.66–45.48) mm in males and 39.95 (39.34–40.46) mm in females. Clinically, these parameters (entry point, angle, needle length) offer a practical guide that may reduce the risk of injury to adjacent neurovascular structures. Nevertheless, given the limited number of anatomical studies, further imaging-based and clinical investigations are required to validate the accuracy, safety,

and therapeutic effectiveness of this technique in patients with temporomandibular disorders.

**Acknowledgements** The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude.

**Author Contributions** The concept and design of the study were developed by Ş.H. and A.T. Ş.H., A.T. and Ö.Ç. were involved in the design and literature search. Intellectual content was defined by A.T. and Ö.Ç. All authors participated in clinical and experimental studies, as well as data analysis. Data acquisition was performed by Ş.H. and A.T., and statistical analysis was carried out by A.T. The manuscript was drafted by Ş.H. and edited by Ş.H. and A.T. Final review was conducted by A.T. Ş.H. and A.T. also served as the guarantors of the study.

**Funding** No funding was received for this study.

**Data Availability** The data supporting the findings of this study are available from the corresponding author upon reasonable request.

## Declarations

**Conflict of Interest** The authors declare no competing interests.

**Ethical Approval and Consent to Participate** This study was approved by the Non-Interventional Clinical Research Ethics Committee of Kocaeli University (Decision Number: KÜ GOKAEK 2020/11.01; Project Number: 2020/134). The research was conducted in accordance with institutional ethical standards and the Declaration of Helsinki.

**Consent to Participate** Not applicable.

**Human Ethics and Consent to Participate declarations** Not applicable.

**Clinical Trial Registration** Not applicable.

## References

1. Leeuw R. American academy of orofacial pain: guidelines for assessment, diagnosis and management, 4th ed. Chicago, pp; 2008;129–75.
2. Scrivani SJ, Keith DA, Kaban LB. Temporomandibular disorders. N Engl J Med. 2008;359:2693–705.
3. Alvarez DJ, Rockwell PG. Trigger points: diagnosis and management. Am Fam Physician. 2002;65:653–60.
4. Wright EF. Referred craniofacial pain patterns in patients with temporomandibular disorders. J Am Dent Assoc. 2000;131:1307–15.
5. Kietrys DM, Palombaro KM, Azzaretto E, Hubler R, Schaller B, Schlussel JM, et al. Effectiveness of dry needling for upper-quarter myofascial pain: a systematic review and meta-analysis. J Orthop Sports Phys Ther. 2013. https://doi.org/10.2519/jospt.2013.4668.
6. McNeill C, Danzig WM, Farrar WB, Gelb H, Lerman MD, Moffett BC, et al. Positionpaper of the American academy of craniomandibular disorders: Craniomandibular (TMJ) disorders the state of the art. J Prosthet Dent. 1980;44:434–7.
7. Murray GM, Phanachet I, Uchida S, Whittle T. The human lateral pterygoid muscle: a review of some experimental aspects and possible clinical relevance. Aust Dent J. 2004;49(1):2–8.
8. D'Ippolito SM, Borri Wolosker AM, D'Ippolito G, Herbert de Souza B, Fenyo-Pereira M. Evaluation of the lateral pterygoid muscle using magnetic resonance imaging. Dento Maxillo Facial Radiol. 2010;39(8):494–500.
9. Vier C, Almeida MB, Neves ML, Santos ARSD, Bracht MA. The effectiveness of dry needling for patients with orofacial pain associated with temporo-mandibular dysfunction: a systematic review and meta-analysis. Braz J Phys Ther. 2019;23(1):3–11.
10. Stratmann U, Mokrys K, Meyer U, Kleinheinz J, Joos U, Dirksen D, et al. Clinical anatomy and palpability of the inferior lateral pterygoid muscle. J Prosthet Dent. 2000;83(5):548–54.
11. Gezer İA, Levendoğlu F. Classification, diagnosis and treatment of temporomandibular joint disorders. J Gen Med. 2016;26(1):34–40.
12. Öz Z, Ciğer S. Chewing functions and malocclusion. J Ataturk Univ Fac Dent. 2013;23(3):436–40.
13. Mesa-Jiménez JA, Sánchez-Gutiérrez J, de-la-Hoz-Aizpurua JL, Fernández-de-las-Peñas C. Cadaveric validation of dry needle placement in the lateral pterygoid muscle. J Manipulative Physiol Ther. 2015;38(2):145–50.
14. Gonzalez-Perez LM, Infante-Cossio P, Granados-Nuñez M, Urresti-Lopez FJ, Lopez-Martos R, Ruiz-Canela-Mendez P. Deep dry needling of trigger points located in the lateral pterygoid muscle: efficacy and safety of treatment for management of myofascial pain and temporomandibular dysfunction. Med Oral Patol Oral Cir Bucal. 2015;20(3):e326–33.
15. Gozalo-Marcilla M, Garrido-Ardila EM, Lara-Palomo IC. Effectiveness of dry needling for temporomandibular disorders: a systematic review and meta-analysis. Pain Res Manag. 2019;2019:1–11.
16. Fernández-de-Las-Peñas C, Mesa-Jiménez J, de-la-Llave-Rincón AI, et al. Is dry needling effective for the management of temporomandibular disorders? A systematic review and meta-analysis. Clin J Pain. 2021;37(7):558–71.
17. Menéndez-Torre Á, Gil-Martínez A, López-de-Uralde-Villanueva I, et al. Effectiveness of deep dry needling versus manual therapy in patients with myofascial temporomandibular disorders: a systematic review and network meta-analysis. Pain Med. 2023;24(2):187–99.
18. García-de-la Banda-García R, Rodríguez-Sanz J, Pecos-Martín D, et al. Effectiveness of dry needling compared to manual therapy in temporomandibular disorders: a randomized clinical trial and systematic synthesis. J Oral Rehabil. 2023;50(7):661–72.
19. Kuźdzal A, Majchrzycki M, Szkutnik J, et al. Dry needling for orofacial pain: a systematic review and meta-analysis of randomized clinical trials. Pain Rep. 2024;9(2):e1134.
20. Al-Shenqiti AM, Oldham JA. Test-retest reliability of myofascial trigger point detection in patients with rotator cuff tendonitis. Clin Rehabil. 2005;19:482–7.
21. Yoshida K. How do I inject botulinum toxin into the lateral and medial pterygoid muscles? Mov Disord Clin Pract. 2016;4:285.
22. Yoshida K. 2018 Involuntary movements of the stomatognathic region. Oromandibular dystoni. Jan. Available from: https://sites.google.com/site/oromandibulardystoniaenglish
23. Yoshida K. Effects of botulinum toxin type A on pain among trigeminal neuralgia, myofascial temporomandibular disorders, and oromandibular dystonia. Toxins. 2021;13:605.
24. Pons M, Meyer C, Euvrard E, Weber E, Sigaux N, Louvrier A. MR-guided navigation for botulinum toxin injection in the lateral pterygoid muscle. First results in the treatment of temporomandibular joint disorders. J Stomatol Oral Maxillofac Surg. 2019;120(3):188–95.
25. Nowak Z, Chęciński M, Nitecka-Buchta A, Bulanda S, Ilczuk-Rypuła D, Postek-Stefańska L, et al. Intramuscular injections and dry needling within masticatory muscles in management of myofascial

pain. Systematic review of clinical trials. Int J Environ Res Public Health. 2021;18(18):9552.
26. Arıncı K, Elhan A. Anatomy. 2020 7th ed. Ankara: Güneş Tıp Kitabevi;.
27. Reyes FI, et al. 2022 *Ultrasound-Guided OnabotulinumtoxinA Injections to Treat Lateral Pterygoid in Oromandibular Dystonia (Cerebral Palsy)*. Toxins
28. Rodríguez-Gimillo P, Valverde-Navarro A, Margaix-Muñoz M, et al. 2023 Lateral pterygoid muscle ultrasound-guided injection: a technical note. J Stomatol Oral Maxillofac Surg. 2024;125(5):101547.
29. Rusu MC. Debate on the morphological variability of the lateral pterygoid muscle. Medicina (B Aires). 2024;60(12):1913.
30. Coskun Akar G, Govsa F, Ozgur Z. Examination of the heads of the lateral pterygoid muscle on the temporomandibular joint. J Craniofac Surg. 2009;20(1):219–23.
31. Gonzalez-Perez LM, Infante-Cossio P, Granados-Nuñez M, Urresti-Lopez FJ. Treatment of temporomandibular myofascial pain with deep dry needling. Med Oral Patol Oral Cir Bucal. 2012;17(5):781–5.
32. Villanueva EA, Garmendia AM, Torres G, Sánchez-Mejorada G, Gómez-Valdés JA. Gender assessment using the mandible in the Mexican population. Rev Esp Med Legal. 2017;43(4):146–54.
33. Dommerholt J, Fernández-de-las-Peñas C, editors. 2018 Trigger Point Dry Needling: An Evidence and Clinical-Based Approach. 2nd ed. China
34. Menéndez Torre E, Fernández-Carnero J, López-de-Uralde-Villanueva I, La Touche R. Comparative effectiveness of dry needling versus manual therapy on orofacial myofascial pain: a randomized clinical trial. J Oral Facial Pain Headache. 2023;37(1):45–54.
35. Dib Zakkour A, Alshammari F, Alazzawi S, Alnajrani M. Effectiveness of dry needling of the masseter muscle in patients with myofascial temporomandibular disorders: a randomized controlled trial. J Oral Rehab. 2022;49(12):1143–50.
36. Kuzdzal A, Ernst E, Posadzki P, Wronski Z. Dry needling for orofacial pain: a systematic review and meta-analysis of randomized clinical trials. Pain Rep. 2024;9(6):e1208.
37. Direk F. Morphometric Examination of Human Mandible and Its Channels by Multidetector Computed Tomography (Master Thesis). Konya: Selcuk University; 2014.
38. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an ındicator for sex in fragmentary mandible. J Forensic Sci. 2011;56(1):13–6.
39. Dong H, Deng M, Wang W, Zhang J, Mu J, Zhu G. Sexual dimorphism of the mandible in a contemporary Chinese Han population. Forensic Sci Int. 2015;255:9–15.
40. Abofakher MGA, Owayda A, Al-assaf M, Hamadah O, Abdulhak M, Nofal H. Mandibular sexual dimorphism analysis in CBCT scans in a Syrian sample. Cumhur Dent J. 2020;23(2):124–8.
41. Cappella A, Gibelli D, Vitale A, Zago M, Dolci C, Sforza C, et al. Preliminary study on sexual dimorphism of metric traits of cranium and mandible in a modern Italian skeletal population and review of population literature. Legal Med. 2020. https://doi.org/10.1016/j.legalmed.2020.101695.
42. Talaat WM, McGraw TA, Klitzman B. Relationship between the canthal-tragus distance and the puncture point in temporomandibular joint arthroscopy. Int J Oral Maxillofac Surg. 2010;39(1):57–60.
43. Ganapathy A, Kumar V, Prathapamchandra V, Jessy JP, Rani N, Kaler S, et al. Topographic localization of nerve to masseter muscle to determine the primary nerve- muscle relation, an aid to facial sculpting techniques. Muscles Ligaments Tendons J. 2020;10(1):124–9.
44. Kucukguven A, Demiryurek MD, Kucukguven MB, Vargel I. A novel injection technique to the lateral pterygoid muscle for temporomandibular disorders: a cadaveric study. Plast Reconstr Surg. 2021;148(5):785–90.
45. Rodríguez-Gimillo P, Valverde-Navarro A, Margaix-Muñoz M, Poveda-Roda R, Delgado-Navarro C, Puig-Bernabeu J. Lateral pterygoid muscle ultrasound-guided injection: a technical note. J Stomatol Oral Maxillofac Surg. 2023;125(5):10154.
46. Lopez-Martos R, Gonzalez-Perez LM, Ruiz-Canela-Mendez P, Urresti-Lopez FJ, Gutierrez-Perez JL, Infante-Cossio P. Randomized, double-blind study comparing percutaneous electrolysis and dry needling for the management of temporomandibular myofascial pain. Med Oral Patol Oral Cir Bucal. 2018;23(4):454–62.
47. Nakazawa T, Motoyoshi M, Sasamoto S, Shimizu N. Ultrasonographic approach for the lateral pterygoid muscle: a cadaver study. Cranio. 2009;27(3):159–65.
48. Vas L, Pai R, Pattnaik M. Ultrasound-guided injection into the lateral pterygoid muscle: a new technique. Pain Med. 2014;15(9):1649–54.
49. Borghol A, Granados-Nuñez M, Infante-Cossio P, et al. An ultrasound-guided extraoral approach to the lateral pterygoid muscle: anatomical study and clinical application. J Oral Maxillofac Surg. 2018;76(5):1046.e1-1046.e8.
50. Al-Tairi A, Miyamoto J, Katayama I, et al. Anatomical and computed tomography study on safe needling of the lateral pterygoid muscle. Cranio. 2014;32(3):178–83.
51. Kearns G, Gilbert KK, Allen B, Sizer PS, Brismée JM, Pendergrass T, et al. Accuracy and safety of dry needle placement in the piriformis muscle in cadavers. J Man Manip Ther. 2017;26(2):89–96.
52. Abe S, Takasaki I, Ichikawa K, Ide Y. Investigations of the run and the attachment of the lateral pterygoid muscle in Japanese. Bull Tokyo Dent Coll. 1993;34(3):135–9.
53. Antonopoulou M, Iatrou I, Paraschos A, Anagnostopoulou S. Variations of the attachment of the superior head of human lateral pterygoid muscle. J Craniomaxillofac Surg. 2013;41(6):91–7.
54. Foucart JM, Girin JP, Carpentier P. Innervation of the human lateral pterygoid muscle. Surg Radiol Anat. 1998;20(3):185–9.
55. Naohara H. The macroscopic and microscopic study of the human lateral pterygoid muscle. Tsurumi Shigaku. 1989;15(1):1–26.
56. Choukas NC, Sicher H. The structure of the temporomandibular joint. Oral Surg Oral Med Oral Pathol. 1960;13:1203–13.
57. Moritz T, Ewers R. Der Ansatz des Musculus pterygoideus lateralis am Kiefergelenkdes Menschen. Deutsche Zahnarztliche Zeitschrift. 1987;42(7):680–5.
58. Sümnig W, Bartolain G, Fanghänel J. Histologische Untersuchungen über die morphologischen Beziehungen des Musculus pterygoideus lateralis zum Discus articularis am menschlichen Kiefergelenk. Anat Anz. 1991;173:279–86.
59. Birou G, Garcier JM, Guillot M, Vanneuville G, Chazal J. A study of the lateral pterygoid muscle: anatomic sections and CT appearances. Surg Radiol Anat. 1991;13(4):307–11.
60. Fujita S, Iizuka T, Dauber W. Variation of heads of lateral pterygoid muscle and morphology of articular disc of human temporomandibular joint anatomical and histological analysis. J Oral Rehabil. 2001;28(6):560–71.
61. Troiano MF. New concept of the insertion of the lateral pterygoid muscle. J Oral Surg. 1967;25(4):337–40.
62. Stöckle M, Fanghänel J, Knüttel H, Alamanos C, Behr M. The morphological variations of the lateral pterygoid muscle: a systematic review. Ann Anat. 2019;222:79–87.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.