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Optimising needle depth in temporomandibular joint arthrocentesis: a magnetic resonance-based study for safety and efficacy

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Abstract

The aim of this paper was to determine the optimal needle depth for temporomandibular joint (TMJ) arthrocentesis using magnetic resonance imaging (MRI), with the aim of improving procedural safety and efficacy in clinical practice. A retrospective analysis of 264 TMJ MRIs from 132 patients at Istanbul Medipol Mega University Hospital was conducted. T2-weighted MRI sequences were utilised to measure distances from skin to joint capsules at varying needle entry points, applying the double puncture technique. The study adhered to ethical standards with appropriate approvals. The analysis revealed significant gender-related variations in needle depths (females showing shorter distances than males, $p < 0.05$). No significant gender differences were found in condylar angles. An inverse correlation between age and condylar angle suggested age-related anatomical changes. Crucially, a 20 mm needle depth was identified as safer and more effective than the previously recommended 25 mm. This study underscores the necessity of revising needle depth to 20 mm in TMJ arthrocentesis. These findings hold significant implications for improving procedural safety and catering to demographic variations.

Keywords: TMJ Arthrocentesis; MRI; Needle Depth

Introduction

The temporomandibular joint (TMJ), a critical component in our ability to speak, chew, and yawn, is a specialised synovial joint comprising the mandibular condyle and the glenoid fossa of the temporal bone.[1] It is rather troubling that temporomandibular disorders, which substantially impair these essential functions, are rampant, presenting with symptoms such as pain, restricted jaw movements, and masticatory difficulties.[2]

The complexity of temporomandibular disorders and their profound impact on patients' quality of life necessitate a re-evaluation and refinement of TMJ arthrocentesis techniques, with an acute focus on needle depth to improve both safety and efficacy. The diagnosis and treatment of these disorders are critical in the formulation of medical intervention and treatment strategies. TMJ arthrocentesis, often trivialised, is actually a straightforward, cost-effective, and efficient minimally-invasive procedure for conditions such as arthralgia, internal derangement, and degenerative joint disease.[3,4] However, the efficacy and safety of this procedure hinge on the precise determination of the safe needle penetration depth within the joint capsule, which is a detail often overlooked.

Magnetic resonance imaging (MRI) is the gold standard technique for radiological diagnosis of TMJ diseases.[5]

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MRI is a non-invasive and high-resolution imaging that plays a pivotal role in revealing the detailed anatomical structure of the TMJ and evaluating associated pathologies.

The aim of this study is to determine the optimal needle depth for TMJ arthrocentesis using MRI. Given that the depth can vary significantly among patients due to anatomical differences, this study seeks to provide insights that can help tailor needle depth more accurately to individual patient profiles, improving safety and efficacy in treating temporomandibular disorders, a point that should not be understated.

Material and methods

Ethical approval for this retrospective study was duly obtained from the Ethics Committee of Istanbul Medipol University. The study included 264 TMJ MRIs from 132 white patients, aged between 16 and 68 years, all of whom were scanned at our university hospital. Patients with TMJ ankylosis and pathologies were excluded from the study.

Individuals were segmented into age cohorts as follows: patients of 15–24 years were classified as youths, 25–44 years as young adults, 45–60 years as middle-aged, and those 60 years and older were categorised as elderly.

The MRI methodology employed the Holmlund Helsing line (HHL) to establish needle insertion points. The posterior needle entrance was marked 10 mm anterior to the tragus and 2 mm below the HHL, while the anterior entrance was set 20 mm anterior to the tragus and 10 mm under the HHL (Fig. 1). Measurements were conducted using high-resolution T2-weighted STIR images in the axial plane. This imaging protocol was chosen for its enhanced ability to delineate the hypointense joint capsule and its borders clearly, and to allow for the precise evaluation of joint effusion. On these T2-weighted axial slices, the distance from the skin to both the medial and lateral joint capsules at the specified needle entry points were calculated. This approach yielded four distinct data points: anterior lateral (AL), anterior medial (AM), posterior lateral (PL), and posterior medial (PM), as shown in Figure 2. Additionally, the condylar angle was assessed to provide a more comprehensive understanding of TMJ structure (Fig. 3). For the measurement of condylar angles, MRI images were carefully reoriented and resliced according to the Frankfurt horizontal plane to ensure consistent sagittal plane orientation. Furthermore, for each patient, images were aligned to maintain an equal distance from the tragus to the mid-sagittal plane on each side, facilitating accurate and consistent measurements within individual assessments.

The MRI measurements were conducted by a radiologist specialising in the field. To ensure reliability, a subset of 40 patients was randomly selected for repeat measurements by the same radiologist at a different time. Intra-examiner reliability was confirmed with kappa values for AL ($\kappa = 0.88$), AM ($\kappa = 0.85$), PL ($\kappa = 0.90$), PM ($\kappa = 0.87$), and condylar angle ($\kappa = 0.92$).

IBM SPSS Statistics 22 software (IBM SPSS Inc) was used for statistical analysis. The Student's t test was used to compare data between genders and different anatomical sides. ANOVA was carried out to analyse differences between age groups and a correlation analysis was conducted to explore the relationship between the condylar angle and age groups.

Results

The participant pool comprised 91 females and 41 males, ranging in age from 16 to 68 years, with a mean (SD) age of 32.89 (12.64) years. The study identified gender-based differences in measurements, with females demonstrating significantly shorter distances than males across all metrics

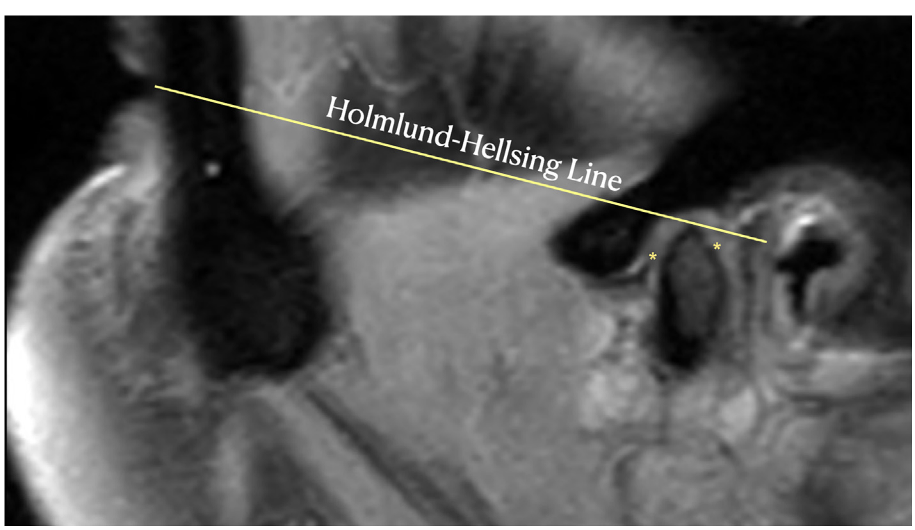

Fig. 1. Sagittal magnetic resonance image slice illustrating the Holmlund-Helsing line and the anterior and posterior entry points (marked with asterisks) for temporomandibular joint arthrocentesis.

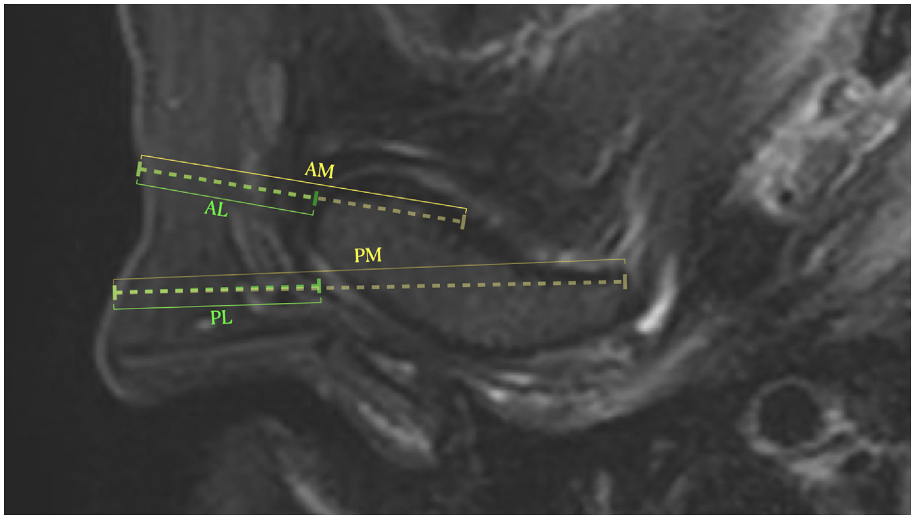

Fig. 2. Axial magnetice resonance image section showing the anterior-medial (AM), anterior-lateral (AL), posterior-medial (PM), and posterior-lateral (PL) distances for temporomandibular joint arthrocentesis needle placement.

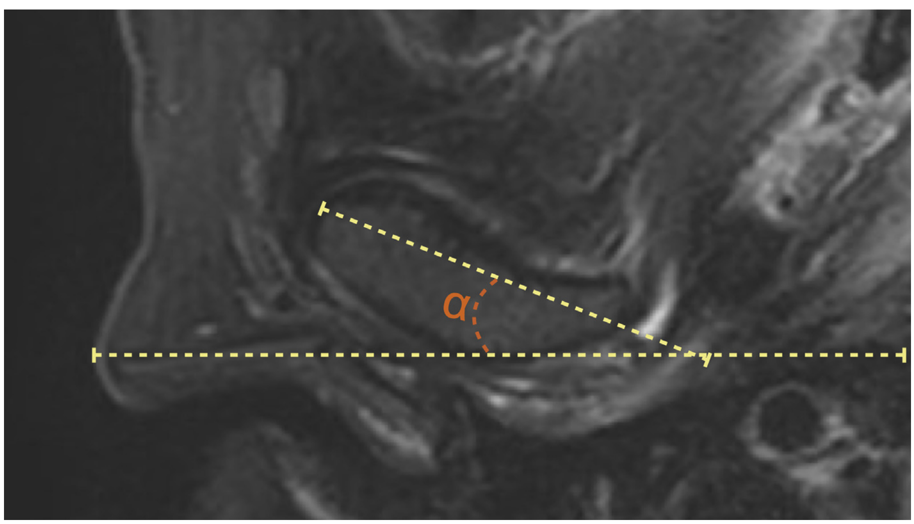

Fig. 3. Measurement of the condylar angle on an axial magnetice resonance image slice, demonstrating the methodology for assessing temporomandibular joint structure.

Table 1
Gender-based comparison of needle penetration measurements and condylar angles. Data are mean (SD) and mm unless otherwise stated.

Variable	Female	Male	p value
AL	13.9 (3.1)	15.2 (3.3)	0.005*
AM	25.6 (4.5)	27.2 (5.0)	0.01*
PL	14.8 (2.9)	16.5 (3.3)	0.000*
PM	26.6 (4.2)	29 (5.3	0.000*
Condylar angle	22.12 (9.3°	22.97 9.5°	0.502

AL = anterior lateral; AM = anterior medial; PL posterior lateral = ; PM = posterior medial.
* Statistically significant ($p < 0.05$).

($p < 0.05$). No significant gender difference was noted in the condylar angle ($p > 0.05$), with details provided in Table 1.

In our data, 79 out of 264 PM measurements (29.9%) and 99 out of 264 AM measurements (37.5%) were below 25 mm. However, the mean (SD) PM measurement for females was 26.6 mm (4.2) mm, and for males, it was 29 mm (5.3) mm. Additionally, the mean (SD) AM measurement for females was 25.6 mm (4.5) mm, and for males, it was 27.2 mm (5.0) mm.

Regarding age-related variations, no statistically significant differences were observed in the measurements or condylar angle across age groups ($p > 0.05$). A weak inverse correlation between age and condylar angle was noted ($p = 0.038$, $r = -0.128$), indicating a tendency for the condylar angle to diminish with age. All measurements positively correlated with one another, as detailed in Table 2.

The analysis of the condylar angles revealed an inverse relationship with both the medial measurements (PM and AM) and PL, with statistical significance. The correlation coefficient of this inverse relationship was particularly higher in the medial measurements ($p < 0.001$ for PM, $r = -0.323$;

Table 2
Pearson correlation coefficients between temporomandibular joint measurements and condylar angle.

	Posterior lateral	Posterior medial	Anterior lateral	Anterior medial	Condylar angle
Posterior lateral:					
Pearson correlation	1	0.543**	0.515**	0.465**	-0.159**
p value		0.000*	0.000*	0.000*	0.010*
Posterior medial:					
Pearson correlation	0.543**	1	0.306**	0.382**	-0.323**
p value	0.000*		0.000*	0.000*	0.000*
Anterior lateral:					
Pearson correlation	0.515**	0.306**	1	0.415**	-0.068
p value	0.000*	0.000*		0.000*	0.269
Anterior medial:					
Pearson correlation	0.465**	0.382**	0.415**	1	-0.313
p value	0.000*	0.000*	0.000*		0.000*
Condylar angle:					
Pearson correlation	-0.159**	-0.323**	-0.068	-0.313**	1
p value	0.010*	0.000*	0.269	0.000*	

* Statistically significant ($p < 0.05$).
** Correlation is significant at the 0.01 level (2-tailed).

$p < 0.001$ for AM, $r = -0.313$; $p = 0.010$ for PL $r = -0.159$). The AL distances did not exhibit a statistically significant change in relation to the condylar angle. Additionally, a direct proportional relationship was observed among all measured distances, suggesting consistent anatomical scaling within the TMJ dimensions. Crucially, the data indicate that higher condylar angles are associated with a need for shallower needle depths. Specifically, as the condylar angle increases - reflecting a more pronounced tilt of the mandibular condyle in the axial plane - the required needle depth correspondingly decreases.

Finally, the comparison of measurements between the right and left sides showed no statistically significant differences ($p > 0.05$), suggesting symmetrical TMJ measurements on both sides.

Discussion

Optimising needle depth in TMJ arthrocentesis is paramount to circumvent iatrogenic complications, such as nerve paralysis due to canula perforation or mechanical damage, a risk highlighted in a case report by Aliyev et al.[6] A comprehensive understanding of the optimal needle depth is therefore not just recommended, but essential.

In this study, we used MRI to determine needle depth for TMJ arthrocentesis due to its non-invasive nature and superior soft tissue imaging capabilities, crucial for accurate anatomical assessments.[7] While MRI avoids the ionising radiation risks associated with CT scans and provides more detailed structural visualisation than ultrasound, it lacks the real-time procedural feedback available in intraoperative techniques. Nevertheless, MRI was selected for its ability to safely and precisely map TMJ anatomy in a pre-procedural setting, which is vital for minimising risks in clinical applications.[8]

Şentürk et al proposed a needle insertion depth of approximately 20 mm for TMJ arthrocentesis in their literature review, without considering variations based on entry point or gender.[9] Our study identified statistically significant gender differences in measurements but supports the conclusion that a 20 mm depth is generally suitable. Despite identifying these gender differences, the absence of significant age-related changes in our measurements further reinforces the applicability of a 20 mm needle depth across a wide range of patients. This supports the practicality and safety of adopting a 20 mm approach, which simplifies clinical procedures and potentially minimises the risk of iatrogenic complications. Although we observed a weak inverse correlation between age and the condylar angle, it did not alter our previous recommendation concerning the depth of the needle, which demonstrates the efficacy of a uniform approach. In contrast to the deeper insertion depth of about 25 mm suggested by Nitzan and Soni for accessing the upper joint space,[10,11] a depth of 20 millimetres may be a safer alternative to ensure that the needle remains within the joint capsule, based on the findings of our study.

Incorporating our findings into clinical practice, the pronounced inverse relationship between condylar angles and required needle depths suggests the need for a tailored approach in TMJ arthrocentesis. Individuals with higher condylar angles may benefit from shallower needle insertion to avoid complications associated with deeper penetration. This supports the idea of adapting needle depth guidelines to better match patient-specific anatomical variations, while further research is encouraged to confirm these findings across diverse populations.

The selective request for MRI in patients with clinical symptoms of temporomandibular disorders led to an intriguing gender disparity in our study, with a significant preponderance of female participants (91 females to 41 males). This gender distribution aligns with the findings of Alrizqi and Aleissa, who reported a higher incidence of temporomandibular disorders in females,[12] and is echoed in Shimshak and DeFuria's research, which also showed a female-to-male ratio of 3:1 in temporomandibular disorders, a ratio similar to our study.[13]

In this study, the analysis did not incorporate the body mass index of the included patients, nor did it account for age-related changes in collagen and connective tissue among elderly individuals. Considering body mass index is particularly important as it can significantly affect anatomical landmarks and, consequently, the needle depth required for safe and effective TMJ arthrocentesis. These factors were not systematically considered in the assessment of variations in the 20 mm depth measurement.

Another limitation of this study is the absence of patient classification based on specific complaints, which has hindered more detailed analysis. Future research should address this by including larger cohorts with diverse complaints to enable broader generalisation of the results. This study offers valuable insights for novice surgeons and trainees, who can benefit from tailored depth guidelines for procedural safety and effectiveness. Experienced practitioners typically rely on palpation and tactile feedback, underscoring the study's relevance for those still mastering the technique.

Conclusion

This study offers vital insights into the anatomical landmarks that are crucial for safely and effectively implementing the double-puncture technique in TMJ arthrocentesis, establishing the practicality of a 20 mm needle depth as a safe and reliable guideline for both needle entry points.

Conflict of interest

We have no conflicts of interest.

Funding

No funding was obtained for this study.

Ethics statement/confirmation of patient permission

This study as a retrospective analysis, was conducted in line with the ethical norms set by both institutional and national research committees, aligning with the 1964 Helsinki declaration and its subsequent amendments or equivalent ethical standards. Ethics approval was procured from the Ethics Committee of Istanbul Medipol University, stamped with approval number E-10840098-772.02-7788.

Written informed consent was duly collected from all individual participants included into this study.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT 4.0 in order to enhance readability and check grammar for British English. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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