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Retrospective analysis of ideal needle puncture angles and depths for temporomandibular joint arthrocentesis using CBCT data

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Abstract

Background This study aimed to investigate the range of angles and depths necessary for effective entry into the TMJ using CBCT images, focusing on classical Holmlund Hellsing points and a two-needle approach.

Methods A retrospective cohort of CBCT images from January 2020 to November 2023 was analysed using 3D analysis to determine the variance in the required angles and depths.

Results The average age of the 68 participants included in the study was 29.5 ± 11.1, 58.8% of the participants were female and 41.2% were male. The anterior needle measurements showed a relatively low standard deviation(SD) in depth(SD:3.6) with a low variance coefficient(12.5%), whereas the axial and coronal angles exhibited greater variability(SD:9.1 and 7.6, respectively). For the posterior needles, moderate SDs in depth(SD:3.5) and greater variabilities in axial and coronal angles(SD:9.6 and 5.3, respectively) were observed. A weak negative correlation was observed between the axial angle of the posterior needle and age(p: 0.028, Pearson r: -0.29) Anterior needle depth (p:0.037) and posterior needle axial angle(p:0.014) were greater in males than females. The anterior needle depth in patients with temporamandibular disease was greater than in those without(p:0,03).

Conclusion There were significant differences in the angle measurements for both anterior and posterior needles, but lower variance in depth. The depths and angles of the needles did not correlate with age.

Keywords Arthrocentesis, Internal derangement, Temporomandibular joint, Three-dimensional imaging, Virtual planning

Background

Temporomandibular disorders (TMD) are a range of pathologies characterized by symptoms such as pain, limited movement, and joint sounds, stemming from functional disorders of the jaw joint and surrounding muscles [1]. TMD encompass a wide spectrum of conditions, being either arthrogenic or myogenic. Despite this heterogeneity, traditional treatment approaches are generally applied in a similar pattern [2]. Conservative treatments or minimally invasive methods often constitute the first step in this process [3]. Minimally invasive methods, including temporomandibular joint (TMJ)

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arthrocentesis, were first described by Nitzan et al. in 1991 [4] and have since been widely used in the management of TMD. Postarthrocentesis improvements in joint sounds, pain, and mandibular mobility have been reported, with overall success rates varying between 70 and 95% [5–12].

Arthrocentesis treatment involves lavage, decompression, and irrigation of the upper joint space, aiming to remove unhealthy synovial fluid and other inflammatory components from the joint [13, 14]. To date, skin puncture marks have been derived from cadaver dissections and dry skulls, mostly through the discussion of anatomical points without mentioning entry angles [15, 16]. The literature on 3D analysis of arthrocentesis points and angles is limited [17]. The traditional method involves placing two needles along the line known as the cantal-tragal line, which runs from the lateral canthus to the tip of the tragus; the first needle is placed 10 mm anterior to the midtragus and 2 mm below the cantal-tragal line; and the second needle is placed anterior to the first [4, 16, 18]. This procedure is a blind technique, and some anatomical landmarks for surface anatomy have been suggested [19]. The success of the procedure depends on the correct placement of the needles in the joint space and the ability to perform effective irrigation.

Arthrocentesis is a fundamental skill in TMJ surgery [20], yet it remains a minimal invasive procedure associated with complications [21]. Avoiding complications and achieving better lavage largely depend on accurate positioning of the needles [22]. Moreover, a procedure that is safer, more reliable, and easier to perform will also enhance patients' quality of life [20]. Therefore, proposing more reliable anatomical points or entry angles is highly important.

The objective of this study was to determine the range of angles and depths required for entry into the TMJ space using classical Holmlund Hellsing points and the two-needle method. The study hypothesizes that the ideal needle penetration angles and depths for temporomandibular joint arthrocentesis are different between genders or age groups.

Methods

This study was conducted under the ethical approval granted by institutional review board (08.12.2023.1703) and in accordance with the principles of the Helsinki Declaration. Participants were selected among individuals who visited the Marmara University Faculty of Dentistry between January 2020 and November 2023. Patients' demographic information and clinical data related to TMD were obtained from the university's dental faculty patient registration system(Uni-dis, Turkey). The inclusion criteria were patients between the ages of 18 and 65, who had CBCT images including the head and neck region, and who had complete demographic and clinical information. The exclusion criteria included pathological conditions in the condyle, nonexistent or insufficient imaging quality, being in in stages IV, and V according to the Wilkes classification of TMJ internal derangement, prior TMJ surgery, systemic diseases that could affect the structure or function of the TMJ, a history of trauma in the maxillofacial region, or other serious disorders or deformities affecting the maxillofacial area. All patients signed an informed consent form for the CBCT scans and the use of these scans for scientific purposes.

All CBCT scans were performed using the Planmeca Promax 3D Mid device (Planmeca, Helsinki, Finland) under a fixed protocol (90 kVp, 9 mA, 18.2 s, 0.20 mm voxel size, 160×184 mm field of view) with the mouth closed. The images were exported using Planmeca Romexis Viewer 4.6.2. R software(Planmeca, Helsinki, Finland) and processed on a computer equipped with Slicer 5.4.0 software [23] in DICOM format. Appropriate threshold values were used for soft tissue and mandibular bone segmentation and CBCT data were converted from DICOM to stereolithography(STL) format. Since opening the mouth as wide as possible during needle insertion provides easy access to the TMJ [4, 13], to mimic this clinical scenario, the mandible segment was rotated clockwise around the axis passing through the right and left condylar heads to simulate mandibular rotational movement. The extent of this movement was determined by the downwards movement of 20 mm in the sagittal plane from the cutting edges of the incisor teeth. The right temporamandibular joint was selected for arthrocentesis in all CBCTs. Classical Holmlund Hellsing points were used to identify skin puncture points for two-needle TMJ arthrocentesis method. The skin puncture points for the posterior needle(R1) and anterior needle(R3) were positioned along the lateral canthus-tragus line with reference to 10 mm anterior, 2 mm inferior, and 20 mm anterior, 10 mm inferior to the tragus, respectively. R1 and R3 were marked on the soft tissue segment. Two sylinders with a 21-gauge(0,8×38 mm) needle size were placed at these points. The needle tips were targeted to insert in the upper joint space. For this purpose, the needles were directed towards the midpoint (C point) of the line connecting the most superior point of the glenoid fossa (A point) to the most inferior point of the articular eminence (B point) in the sagittal section corresponding to the middle of the condylar head. When the needle tips were placed at point C, the relationship of the needles to the mandibular condyle, the zygomatic bone, and the temporal bone was evaluated in axial, coronal, and sagittal sections. In the event of any penetration into the bone structures, the angle and/or depth of the needles were changed. The ideal position of the needles was determined as the position of the needle tips closest to point C, without any penetration into the bone structures.(Figs. 1 and 2) The end points of the posterior needle(R2) and anterior needle(R4) were marked. This procedure was repeated for both needles with the mouth open(when the mandible was rotated 20 mm) and closed (when the mandible was not rotated). The depth of the posterior and anterior needles was calculated by measuring the distance between R1 and R2 and between R3 and R4, respectively.(Figs. 3 and 4).

The axial, coronal, and sagittal planes of each patient were redetermined according to anatomical points to prevent position differences during scanning from causing errors in angle measurement. First, the sagittal plane was defined as the plane passing through the anterior nasal spine (ANS), sella (S) and nasion (N). The

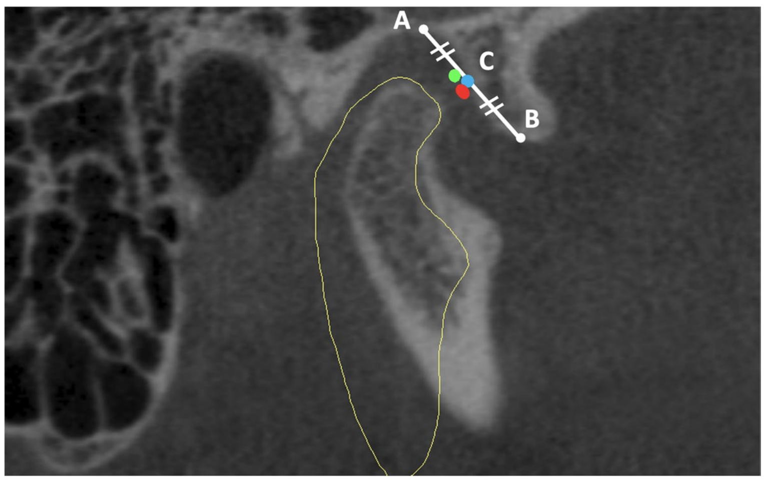

Fig. 1 Positioning the needles with the mouth open in the sagittal section on CBCT. Yellow lines marked the borders of the mandibular segment. Point A defined the glenoid fossa's most superior point, and point B defined the articular eminence's most inferior point. The middle of the line connecting **A** and **B** points (**C** point) was defined by the blue point where the needle tips are directed. The green point showed the posterior needle tip (R2), and the red point showed the anterior needle tip (R4)

Fig. 2 Positioning the needles with the mouth open in the coronal section on CBCT. Yellow lines marked the borders of the mandibular segment. The blue point (C point) defined where the needle tips are directed. The green point showed the posterior needle tip (R2), and the red point showed the anterior needle tip (R4)

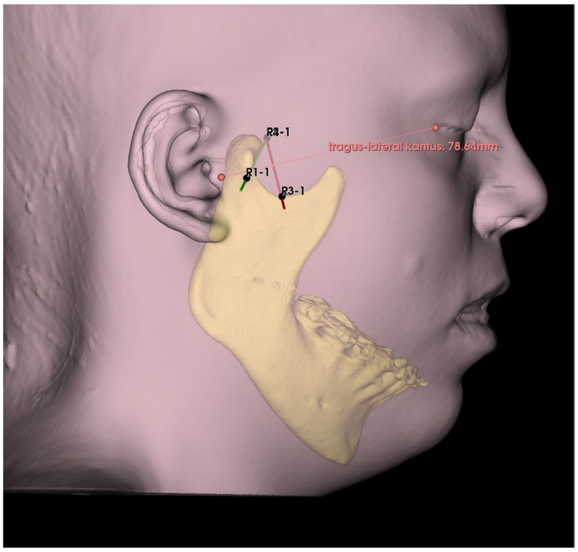

Fig. 3 Positioning of the needles with the mouth open

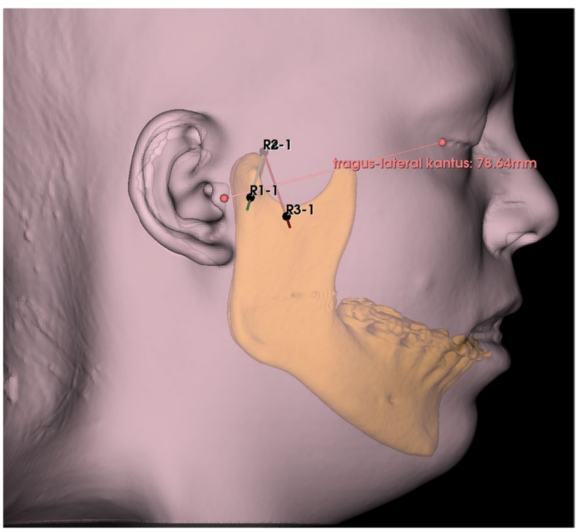

Fig. 4 Positioning of the needles with the mouth close

axial plane was defined the plane that passes through the bilateral porion (Po) and orbitale inferior (Or) points and intersects the sagittal plane perpendicularly. The coronal plane was determined as the plane passing through bilateral porion (Po) points and perpendicularly intersecting the sagittal and axial planes. The determined planes were moved to the skin penetration points to calculate needle angles. The angles of the needles with the coronal and axial planes were calculated at the R1 for the posterior needle and R3 for the anterior needle.(Figs. 5 and 6) The analyses were conducted by an oral and maxillofacial surgeon experienced in 3D planning but inexperienced in arthrocentesis, and calibrated by another surgeon with over ten years of experience in both fields.

Measurements of the depths and axial and coronal angles of both the anterior and posterior needles were taken with the mouth open and closed. The reliability of these measurements taken while the mouth was open or closed was analysed. The measurements taken while the mouth was open were used for analyzes regarding age, gender, and TMD. Patients were classified as > 45 and < 46 years old. The depths and axial and coronal angles of the needles were analyzed in relation to age and gender. Patients were divided into two groups: those with TMD and those without TMD, based on clinical data related to TMD. The depths and axial and coronal angles of the needles were compared between the two groups.

Consistency among measurements was evaluated using SPSS 29.0 for MAC(Chicago, IL, USA), while other statistical analyses were conducted using Prism 10 software(GraphPad, Boston, MA, USA). Five randomly selected images were reassessed after a two-week interval to evaluate intraobserver agreement. The reliability of the measurements taken while the mouth was open or closed was analysed using intraclass correlation coefficient(ICC) values. For each measurement parameter, the mean or median, standard deviation(SD), and variance coefficient were calculated to assess the distribution and consistency of the data. The variance coefficient, which represents the ratio of the standard deviation to the mean, indicates the relative variability of the data set. Pearson or Spearman correlation analysis was performed to evaluate the correlation of depth and angle with age. An unpaired t-test or Mann–Whitney test was performed to assess differences between male and female, with and without TMD.

Results

CBCTs of 68 patients met the inclusion criteria. 15 of the participants were > 45 years old (22.1%), and 53 were < 46 years old (77.9%). The average age of these participants was 29.5 years(SD:11.1). Forty of the participants were women (58.8%), and 28 were men (41.2%). Sixteen patients were included in the with TMD group (23.5%), while 52 patients had no TMD (76.5%). ICC analysis indicated high reliability across all variables, with values ranging between 0.85–0.97. Comparisons between open and closed mouth measurements showed consistent anterior needle measurements(range:0.91 to 0.93) and more variable posterior needle measurements(ICC range:0.79 to 0.96), resulting in high ICC values indicating that these measurements are consistent with each other.

The results obtained from the anterior needle measurements were as follows: depth measurements revealed

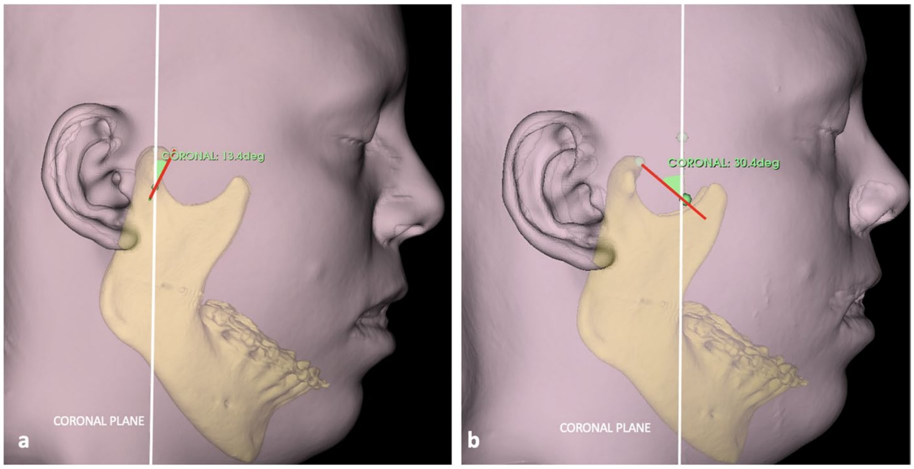

Fig. 5 Angle of the needle with the coronal plane. The white line showed the coronal plane; the red line showed the needle; and the green area showed the needle's angle with the coronal plane. **a** Coronal angle of the posterior needle. **b** Coronal angle of the anterior needle

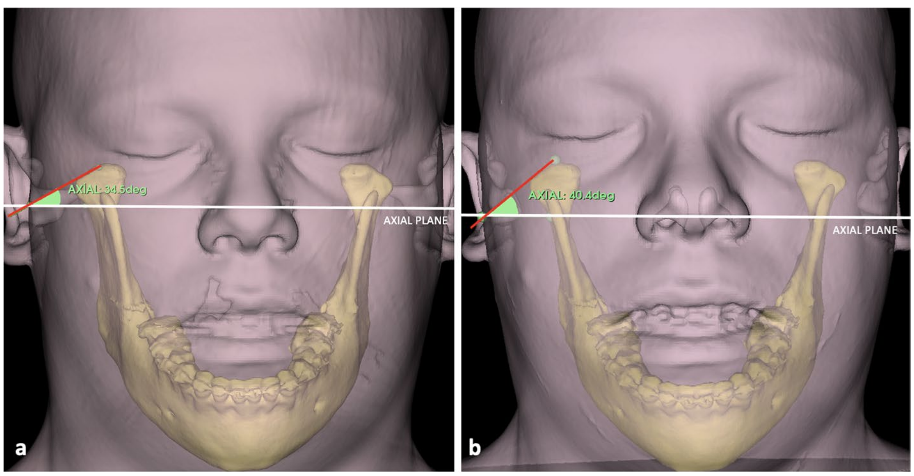

Fig. 6 Angle of the needle with the axial plane. The white line showed the axial plane; the red line showed the needle; and the green area showed the needle's angle with the axial plane. **a** Axial angle of the posterior needle. **b** Axial angle of the anterior needle

a relatively low standard deviation(SD:3.6) and a low variance coefficient(12.5%), indicating consistency in the measurements. Axial measurements exhibited a greater standard deviation(SD:9.1) and variance coefficient(27.2%), suggesting greater variability in these measurements. In the coronal images, a high standard deviation(SD:7.6) and the highest variance coefficient(31.3%) were observed, indicating that these measurements varied more significantly than did the other measurements(Table 1).

In the measurements made with the posterior needle, the depth measurements exhibited a moderate standard deviation(SD:3.5) and variance coefficient(13.8%). Axial measurements showed a high standard deviation(SD:9.6) and variance coefficient(31.6%), while coronal measurements revealed a high standard deviation(SD:5.3) and the highest variance coefficient(71.4%). These findings indicate that depth measurements have less variability than the other two measurements but still possess a moderate level of variance(Table 1).

A significant weak negative correlation was observed between age and the axial angle of the posterior needle. (p: 0.028, Pearson r: -0.29) Age did not significantly correlate with the depth, axial, and coronal angles of the anterior needle or the depth and coronal angles of the posterior needle. (p:0.384, p:0.229, p:0.374, p:0.675, and p:0.306, respectively) (Fig. 7).

The anterior needle depth and axial angle of the posterior needle were significantly higher in males than females (p:0.037 and 0.014, respectively). The axial and

Table 1 Summary of needle parameters for temporomandibular joint arthrocentesis using CBCT data

	Mean	Median	SD	95% CI		Min	Max	Range	Coefficient of variation
Anterior needle				Lower	Upper				
Length	28.7	28.5	3.6	27.8	29.5	22.4	36.4	14.0	12.5%
Axial	33.3	32.3	9.1	31.1	35.5	12.0	54.6	42.6	27.2%
Coronal	24.1	24.5	7.6	22.3	26.0	7.5	42.4	34.9	31.3%
Posterior needle									
Length	25.5	25.1	3.5	24.7	26.4	19.6	34.2	14.6	13.8%
Axial	30.5	29.5	9.6	28.1	32.8	14.2	59.2	45.0	31.6%
Coronal	7.4	6.7	5.3	6.1	8.6	0.0	24.2	24.2	71.4%

SD Standard deviation, *CI* Confidence interval, *Min* Minimum, *Max* Maximum

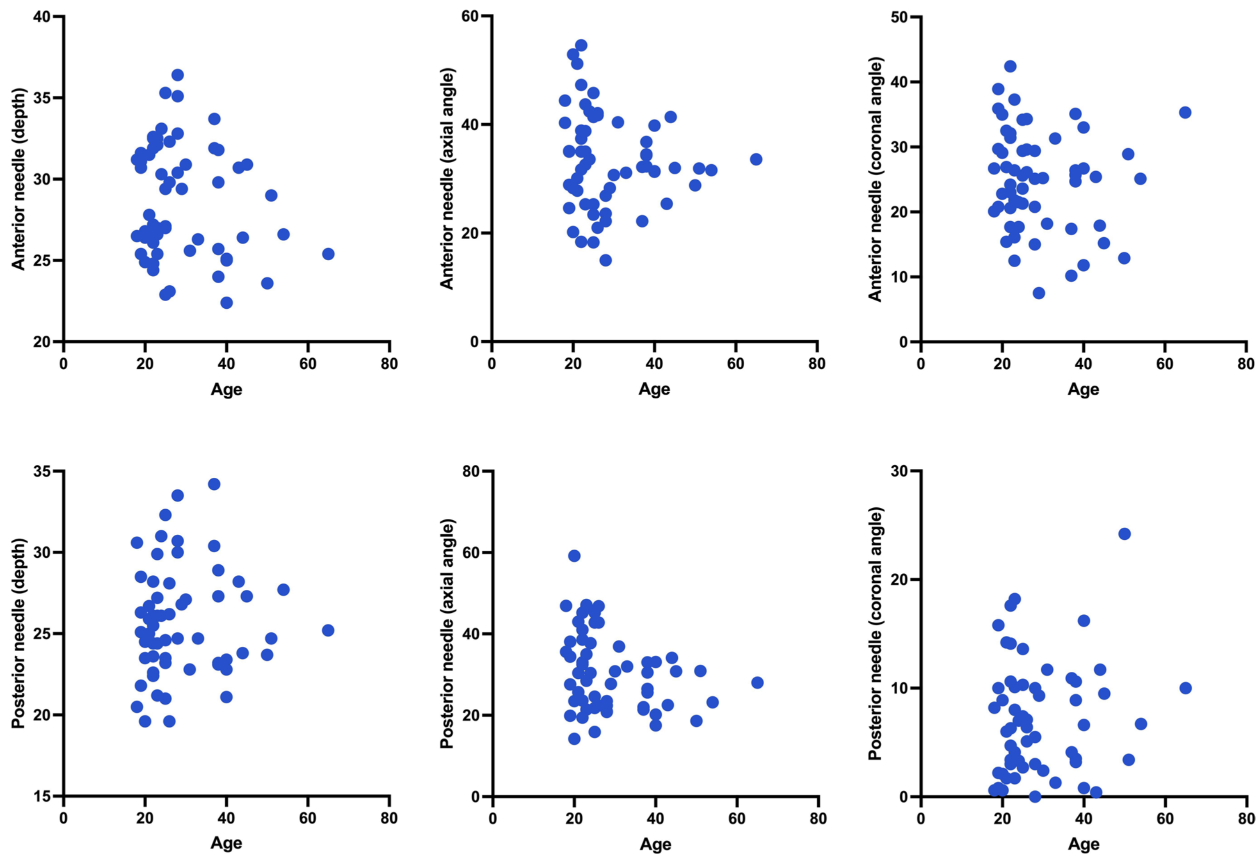

Fig. 7 The correlation analyses of depth and angles with age

coronal angles of the anterior needle or the depth and coronal angle of the posterior needle were not different between genders. (p:0.515, p:0.849, p:0.194, p:0.867, respectively).

In patients with TMD, the depth of the anterior needle was statistically significantly greater than in those without TMD (p:0,03). There was no statistical difference between the axial and coronal angles of the anterior needle or the depth, axial, and coronal angles of the posterior needle between those with and without TMD. (p:0.584, p:0.229, p:0.221, p:0.416, and p:0.436, respectively).

Discussion

The primary aim of this study was to determine the angle and depth range most likely to facilitate entry into the TMJ cavity, a topic that has not been adequately addressed in the literature. This determination was made using 3D analysis in conjunction with the classical Holmlund Hellsing line and a two-needle approach. Particularly for blind procedures, a standardized puncture technique can significantly help the operator. However, the findings of this research indicate that there is considerable variance in the angle measurements for both anterior and posterior needles, making it challenging to propose a standard range, even though the variance is lower in depth.

Arthrocentesis is considered a minimally invasive procedure, but care must still be taken to avoid vascular and nerve injuries and to carefully assess the roof of the glenoid fossa, which separates the upper joint space from the neurocranial structures above. Fracture of these structures can lead to some significant complications that may require immediate hospitalization of the patient for monitoring and appropriate treatment [21]. It is therefore of great importance to identify approximately safe points and depths to access the upper joint space [24].

Arthrocentesis requires needle insertion into the upper space of the TMJ. Traditionally, this point is estimated using the surface anatomy of the head. The most commonly used references for entering the TMJ are the Holmlund-Hellsing line and its associated specific points [16, 25]. Many authors have used these points to perform TMJ arthrocentesis [4, 26]. However, failures during entry attempts due to anatomical variations among different patients have also been reported with this method [20]. Palma et al. reported very low success rates, varying between 0 and 37.5%, in cadaver studies on fresh or formalin-treated cadavers. [27] To facilitate access to the joint cavity, the researchers offered various reference points and entry techniques [28, 29]. However, the entry angle was rarely reported in these studies. Our study revealed that when a standard entry point is used, there is significant variation in the angles.

This study's age-related analyses revealed a weak correlation between the axial angle of the posterior needle and age. No correlation was found between other angles, depth measurements and age. Additionally, it was observed that there was a difference in needle depth between genders, with males exhibiting a higher anterior needle depth. Münevveroğlu et al. examined the classical Holmlund Hellsing points and two-needle method on MRI images. [30] Their findings indicated that there is no significant correlation between age and needle depth. Needle depths were higher in males than females, similar to our study.

One crucial aspect of arthrocentesis is mouth opening, which assists in expanding the joint space and facilitates easy access to the TMJ [2, 4]. Various studies recommend that the mouth be opened as wide as possible during needle placement [4, 13, 28]. Considering that some patients indicated for arthrocentesis have limited mouth opening, this should be taken into account in three-dimensional planning for the entry position. The reliability of the conventional point in the closed mouth position has been supported by Palma and colleagues. They concluded that the conventional point is not a correct reference for needle placement when maximum mouth opening is not achieved [27]. Virtual access to the joint space with the mouth open and closed was achieved in this study based on 3D images. However, no significant difference in entry angle or depth was observed between the closed- and open-mouth positions. A possible reason for this difference could be that the assessment was based solely on hard tissues. Therefore, extrapolating this result to a clinical scenario may not be entirely accurate.

It is well recognized that accessing the superior joint space with minimal trauma is necessary for effective irrigation [22]. For blind procedures such as arthrocentesis, physicians are encouraged to practice the procedure on cadavers or simulate it on plastic models before applying it to patients [31]. Training on cadavers provides good precision [16]. However, due to feasibility challenges, this is not always possible. An unforeseen benefit of this study is that the researcher(SAE), who was experienced in planning but inexperienced in the clinical application of arthrocentesis, reported feeling more comfortable performing arthrocentesis on subsequent patients after planning with CBCT. However, this statement is based only on personal experience with few patients. High-quality clinical studies are needed to evaluate the accuracy of these findings.

Strengths of this study include the use of verifiable 3D data assessed for reliability using intra-observer reliability tests and the absence of postmortem effects commonly found in cadaveric studies. Compared to manual measurements, 3D program not only precisely measures distance and angle but also allows for simultaneous investigation of various aspects of facial patterns. However, the main limitations of this study stem from its retrospective cross-sectional design and the nature of the imaging modalities used. This study is based on CBCT images from a single hospital, which limits the generalizability of the results. Additionally, the ability of CBCT to evaluate only hard tissues, creating a gap in the assessment of soft tissue structures that could be crucial in TMJ arthrocentesis.

The study's findings indicated that there were differences between the participants, particularly in the angles. Despite the fact that arthrocentesis is basically a method applied based on clinical examination and needle angles are personalized for each patient, planning and implementation based on CBCT data can make the procedure safer. Although CBCT does not offer as accurate information about soft tissues as MRI, it can provide useful information on needle depth and angles prior to arthrocentesis by estimating skin thickness at the appropriate threshold value. CBCT can serve as an auxiliary imaging tool before an arthrocentesis procedure.

Conclusion

3D analysis of CBCT images revealed considerable variance in the angle measurements for both anterior and posterior needles, but lower variance in depth. The depths and angles of the needles showed no correlation with age.

Abbreviations

TMD Temporomandibular disorders
TMJ Temporomandibular joint
ICC Intraclass correlation coefficient
SD Standard deviation

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Not applicable.

Authors' contributions

SAE contributed to data collection, data analysis/interpretation, statistics analysis, drafting article, and approval of article. FB contributed to concept/design, data collection, drafting article, critical revision of article, and approval of article. GG concept/design, data collection, drafting article, critical revision of article and approval of article. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The present study was performed according to the guidelines of the 2013 revision of the Helsinki Declaration and complied with the STROBE guidelines. Ethical approval was obtained from Marmara University Faculty of Medicine Clinical Research Ethical Commitee (08.12.2023.1703). Every patient signed a written informed consent form.

Consent for publication

Consent for publication was obtained from the person to whom the CBCT images were used in the figures.

Competing interests

The authors declare that they have no competing interests.

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References

1. Magnusson T, Egermark I, Carlsson GE. A longitudinal epidemiologic study of signs and symptoms of temporomandibular disorders from 15 to 35 years of age. J Orofac Pain. 2000;14:310–9.
2. Guarda-Nardini L, De Almeida AM, Manfredini D. Arthrocentesis of the Temporomandibular Joint: Systematic Review and Clinical Implications of Research Findings. J Oral Facial Pain Headache. 2021;35:17–29. https://doi.org/10.11607/ofph.2606.
3. Hu Y, Liu S, Fang F. Arthrocentesis vs conservative therapy for the management of TMJ disorders: a systematic review and meta-analysis. J Stomatol Oral Maxillofac Surg. 2023;124:101283. https://doi.org/10.1016/j.jormas.2022.09.004.
4. Nitzan DW, Dolwick MF, Martinez GA. Temporomandibular joint arthrocentesis: a simplified treatment for severe, limited mouth opening. J Oral Maxillofac Surg. 1991;49:1163–7. https://doi.org/10.1016/0278-2391(91)90409-f. discussion 8-70.
5. Grossmann EP, Poluha RlDdS M, Iwaki LCVP, Iwaki Filho LP. Arthrocentesis with different irrigation volumes in patients with disc displacement without reduction: One-year follow-up. Cranio. 2020;38:122–7. https://doi.org/10.1080/08869634.2018.1491930.
6. Murakami K, Hosaka H, Moriya Y, Segami N, Iizuka T. Short-term treatment outcome study for the management of temporomandibular joint closed lock. A comparison of arthrocentesis to nonsurgical therapy and arthroscopic lysis and lavage. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995;80:253–7. https://doi.org/10.1016/S1079-2104(05)80379-8.
7. Hosaka H, Murakami K, Goto K, Iizuka T. Outcome of arthrocentesis for temporomandibular joint with closed lock at 3 years follow-up. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1996;82:501–4. https://doi.org/10.1016/s1079-2104(96)80193-4.
8. Nitzan DW, Samson B, Better H. Long-term outcome of arthrocentesis for sudden-onset, persistent, severe closed lock of the temporomandibular joint. J Oral Maxillofac Surg. 1997;55:151–7. https://doi.org/10.1016/s0278-2391(97)90233-0.
9. Murakami K, Segami N, Okamoto M, Yamamura I, Takahashi K, Tsuboi Y. Outcome of Arthroscopic Surgery for Internal Derangement of the Temperomandibular Joint: Long-term results covering 10 years. J Craniomaxillofac Surg. 2000;28(5):264–71. https://doi.org/10.1054/jcms.2000.0162.
10. Carvajal WA, Laskin DM. Long-term evaluation of arthrocentesis for the treatment of internal derangements of the temporomandibular joint. J Oral Maxillofac Surg. 2000;58:852–5. https://doi.org/10.1053/joms.2000.8201.
11. Al-Belasy FA, Dolwick MF. Arthrocentesis for the treatment of temporomandibular joint closed lock: a review article. Int J Oral Maxillofac Surg. 2007;36:773–82. https://doi.org/10.1016/j.ijom.2007.04.005.
12. Kim YH, Jeong TM, Pang KM, Song SI. Influencing factor on the prognosis of arthrocentesis. J Korean Assoc Oral Maxillofac Surg. 2014;40:155–9. https://doi.org/10.5125/jkaoms.2014.40.4.155.
13. Guarda-Nardini L, Manfredini D, Ferronato G. Arthrocentesis of the temporomandibular joint: a proposal for a single-needle technique. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;106:483–6. https://doi.org/10.1016/j.tripleo.2007.12.006.
14. Nitzan DW, Etsion I. Adhesive force: the underlying cause of the disc anchorage to the fossa and/or eminence in the temporomandibular joint–a new concept. Int J Oral Maxillofac Surg. 2002;31:94–9. https://doi.org/10.1054/ijom.2001.0153.
15. 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;39:57–60. https://doi.org/10.1016/j.ijom.2009.11.016.
16 Holmlund A, Hellsing G. Arthroscopy of the temporomandibular joint. An autopsy study. Int J Oral Surg. 1985;14:169–75. https://doi.org/10.1016/s0300-9785(85)80089-2.
17. Yongvikul A, Kim JY, Ku JK, Jung JH, Huh JK. Needle orientation for temporomandibular joint arthrocentesis in Koreans. Cranio. 2022:1–7. https://doi.org/10.1080/08869634.2022.2047509.
18. McCain JP, de la Rua H, LeBlanc WG. Puncture technique and portals of entry for diagnostic and operative arthroscopy of the temporomandibular joint. Arthroscopy. 1991;7:221–32. https://doi.org/10.1016/0749-8063(91)90111-a.
19. Nagori SA, Roy Chowdhury SK, Thukral H, Jose A, Roychoudhury A. Single puncture versus standard double needle arthrocentesis for the management of temporomandibular joint disorders: a systematic review. J Oral Rehabil. 2018;45:810–8. https://doi.org/10.1111/joor.12665.
20. Matsumoto K, Bjornland T, Kai Y, Honda M, Yonehara Y, Honda K. An image-guided technique for puncture of the superior

temporomandibular joint cavity: clinical comparison with the conventional puncture technique. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;111:641–8. https://doi.org/10.1016/j.tripleo.2011.01.019.
21. Vaira LA, Raho MT, Soma D, Salzano G, Dell'aversana Orabona G, Piombino P, et al. Complications and post-operative sequelae of temporomandibular joint arthrocentesis. Cranio. 2018;36:264–7. https://doi.org/10.1080/08869634.2017.1341138.
22 Zardeneta G, Milam SB, Schmitz JP. Elution of proteins by continuous temporomandibular joint arthrocentesis. J Oral Maxillofac Surg. 1997;55:709–16. https://doi.org/10.1016/s0278-2391(97)90583-8. discussion 16-7.
23. Fedorov A, Beichel R, Kalpathy-Cramer J, Finet J, Fillion-Robin JC, Pujol S, et al. 3D Slicer as an image computing platform for the Quantitative Imaging Network. Magn Reson Imaging. 2012;30:1323–41. https://doi.org/10.1016/j.mri.2012.05.001.
24. Nitzan DW. Arthrocentesis–incentives for using this minimally invasive approach for temporomandibular disorders. Oral Maxillofac Surg Clin North Am. 2006;18(311–28):vi. https://doi.org/10.1016/j.coms.2006.03.005.
25. Gudova R, Voog-Oras U, Ivask O. Arthrocentesis techniques used in the treatment of temporomandibular disorders: Literature review. Stomatologija. 2021;23:95–100.
26. McCain JP. Arthroscopy of the human temporomandibular joint. J Oral Maxillofac Surg. 1988;46:648–55. https://doi.org/10.1016/0278-2391(88)90107-3.
27. Palma LF, de Godoy FG, Pereira A, Tateno RY, Campos L, de Moraes LOC. Puncture points related to the tragal-lateral canthus line in conventional temporomandibular joint arthrocentesis: are they accurate? A cadaver study Oral Maxillofac Surg. 2021;25:247–51. https://doi.org/10.1007/s10006-020-00911-1.
28. Laskin DM. Needle placement for arthrocentesis. J Oral Maxillofac Surg. 1998;56:907. https://doi.org/10.1016/s0278-2391(98)90043-x.
29. Alkan A, Etoz OA. A new anatomical landmark to simplify temporomandibular joint arthrocentesis. Br J Oral Maxillofac Surg. 2010;48:310–1. https://doi.org/10.1016/j.bjoms.2009.06.020.
30. Münevveroğlu S, Söylemez EE, Karaalioğlu B, Güzel C. Optimising needle depth in temporomandibular joint arthrocentesis: a magnetic resonance-based study for safety and efficacy. Br J Oral Maxillofac Surg. 2024;4:S0266-4356(24)00139-6. https://doi.org/10.1016/j.bjoms.2024.05.009.
31. Dooley P, Martin R. Corticosteroid injections and arthrocentesis. Can Fam Physician. 2002;48:285–92.

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