

# Advantages of ultrasound guidance for TMJ arthrocentesis and intra-articular injection: A narrative review

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## Abstract

Ultrasound (US) is a widely available, low-cost, non-invasive, and safe medical imaging method that enables real-time observation. Ultrasound offers several advantages for dentomaxillofacial images, such as portability, the possibility of dynamic and repeated examinations, patient comfort, and availability. It is a useful tool for recognizing the temporomandibular joint (TMJ) structures and their involvement during the course of different pathological processes, such as articular disk displacement, joint effusion and cortical erosion. In addition to its diagnostic use, US has been proposed as an auxiliary tool in minimally invasive procedures for arthrogenic temporomandibular disorders (TMD) to achieve an accurate puncture, recognize joint spaces and reduce surgical trauma. While US is widely used for large joints to visualize internal structures and guide the injection, this technique has only recently gained popularity for the TMJ procedures. Hence, the literature on this topic is scarce.

The present review describes the potential advantages and the clinical technique of US guidance for TMJ arthrocentesis and intra-articular injection (IAI).

**Keywords:** ultrasonography, temporomandibular joint disorders, arthrocentesis, interventional ultrasonography

## Cite as

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## Introduction

Temporomandibular disorders (TMD) encompass a group of musculoskeletal and neuromuscular conditions that involve the temporomandibular joints (TMJs), masticatory muscles and associated tissues.<sup>1</sup> Temporomandibular disorders have been categorized into myogenous (masticatory muscular problems) and arthrogenous (problems with the TMJ components), the latter including internal derangements, arthralgia, osteoarthritis, and osteoarthrosis, which can be manifested by TMJ pain, TMJ noises during jaw function, jaw deviation, and functional limitation.<sup>2</sup>

Temporomandibular disorders are a significant public health problem affecting approx. 5–12% of the general population, and they are the second most common musculoskeletal condition (after lower back pain).<sup>3</sup> Temporomandibular disorders have been identified as the main cause of non-dental orofacial pain, with the most common symptoms being pain aggravated by mandibular function, limited mouth opening and joint sounds (described as “clicking”, “popping” and “crepitus”).<sup>1</sup> Orofacial pain affects patients’ social functioning, and physical and psychological well-being. Likewise, the chronic nature of the pain substantially reduces quality of life,<sup>4</sup> probably due to the anxiety, stress, depression, physical and social disability, impaired work capacity, decreased productivity, social costs, and reduced economic income, which underscores the need for medical attention.<sup>5</sup>

General therapeutic goals for TMD involve restoring function, reducing pain, improving quality of life, and reducing the need for future treatment. However, since pain is an individual experience and each patient is exposed to different risk factors, each case should receive a customized therapeutic approach. Additionally, the structural damage may present different degrees of progression, and therefore a therapeutic goal may be different for each patient.<sup>6</sup> The management of TMD consists of a combination of medical-behavioral strategies, including non-invasive ones (i.e., patient education, relaxation techniques, coping strategies, home self-care programs, biobehavioral therapy, physical therapy, pharmacotherapy, and orthopedic therapy with occlusal appliances), and minimally invasive and open surgical procedures. In the majority of cases (75–90%), which are either joint or muscular TMD, positive results can be obtained from conservative and reversible interventions,<sup>7</sup> but in patients refractory to conservative treatment and/or where anatomical-structural disorders are a substantial source of pain and limitation, minimally invasive procedures can be considered.<sup>8</sup> Recent literature suggests that arthrocentesis, followed by the intra-articular injection (IAI) of different therapeutic agents, may be effectively used to treat arthrogenous TMD.<sup>2</sup> During these procedures, needle insertion is tradition-

ally performed based on anatomical landmarks (the blind technique), with a potential risk of damage to the surrounding structures. To improve the precision of the procedure and reduce potential surgical damage, US has recently been suggested as an aid to guide punctures during arthrocentesis and IAIs.

The aim of the present review is to describe the potential advantages and the clinical technique of US guidance for TMJ arthrocentesis and IAIs.

## Methodology

An electronic search of the medical literature was performed on July 30, 2021 and revised on January 25, 2022. The search was carried out in the PubMed, Scopus and Google Scholar databases, using controlled vocabulary. The authors used both MeSh (Medical Subject Headings) terms and free-text keywords for searching relevant articles. The keywords used were: “temporomandibular joint disorders”; “arthrocentesis”; “injection”; “ultrasound”; and “ultrasonography”. The search strategy was adapted for each database. The search was limited to articles in peer-reviewed journals that were written in the English language. The process was repeated across all databases to ensure that no relevant articles were lost during the identification phase.

Studies conducted on patients (or cadavers) that received TMJ injections and/or arthrocentesis guided by US were considered for inclusion. Studies on humans of both genders without age limitation were taken into consideration. Studies included clinical trials (randomized and non-randomized), prospective and retrospective observational studies, case reports, case series, cadaveric studies, and technical notes, without restriction on the publication date. Only articles available as full texts that presented the descriptors in their title, abstract or main text were included. Narrative reviews, in vitro studies, duplicates between databases, and studies not reporting relevant data were excluded. No limits were applied with regard to the publication status. After verifying the availability of articles, the titles and abstracts of all the records obtained through the literature search were screened, and the full texts of the records meeting the inclusion criteria were retrieved for examination. After screening, the bibliography of the included studies and review articles on the subject were hand-searched for any missed references. All the reported outcomes and methods were identified, and they were recorded in a standardized data extraction sheet formulated in Microsoft Excel with information about: authors; the year of publication; the study design; the condition to be treated (a TMD diagnosis); the number of case subjects; the technique; the joint space (upper or lower); the US transducer; the drug injected; the number of control subjects; the route of US scanning; and the main results.

## Results

### Search results

The flowchart for article selection is shown in Fig. 1. After the removal of duplicate articles, a total of 141 records were identified, and then screened based on title and abstract. After the inclusion/exclusion criteria were applied, 13 articles were full-text reviewed and 3 additional records were identified through the manual search of the reference lists from the retrieved articles, and were added for a total of 16 articles. Among the selected articles, 4 were randomized clinical trials (RCTs),<sup>9–12</sup> 1 was a non-controlled clinical trial (CT),<sup>13</sup> 3 were retrospective studies (RSs),<sup>14–16</sup> 1 was a case report (CR),<sup>17</sup> 2 were technical notes (TNs),<sup>18,19</sup> 3 were cadaveric studies (Cad),<sup>20–22</sup> and 2 were systematic reviews.<sup>23,24</sup> The details of the included primary studies are presented in Table 1.

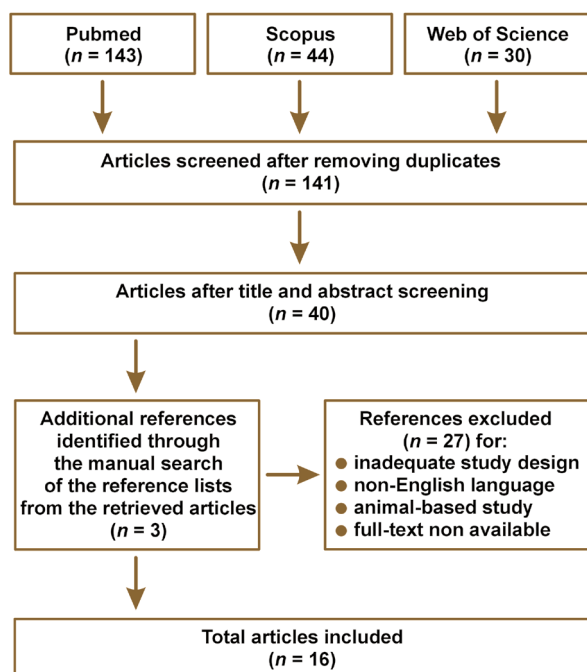


Fig. 1. Flowchart of the literature selection process

### Minimally invasive procedures for TMJ pain

The literature describing TMJ pain management suggests that non-invasive strategies should precede invasive procedures<sup>25</sup>; this conservative approach proposes to perform all non-interventional procedures before executing minimally invasive procedures, such as IAI and arthrocentesis to restore jaw function and relieve pain.<sup>2</sup> The IAI of hyaluronic acid (HA) alleviates pain and the functional symptoms of TMD.<sup>25–27</sup> However, other drugs, such as corticosteroids (CSs) and non-steroidal anti-inflammatory drugs (NSAIDs), can be used with satisfactory results.<sup>25</sup> In a systematic review, Ferreira et al. reported that HA appeared to be more effective for pain resolution as compared to placebo or other therapies in arthrogenous TMD.<sup>26</sup>

Temporomandibular joint arthrocentesis (first described in 1991 by Nitzan et al.) is a simple, minimally invasive, inexpensive, and highly effective procedure that involves the irrigation of the upper joint space to remove the synovial fluid and inflammatory elements.<sup>28</sup> Its main purpose is to clean the joint space, remove inflammatory products, release disk adhesions, reduce pain, and mobilize the joint, for which several techniques have been described in the literature.<sup>29</sup> Şentürk and Cambazoglu classified these techniques based on the number of punctures – either double-puncture arthrocentesis (DPA) or single-puncture arthrocentesis (SPA).<sup>30</sup> Single-puncture arthrocentesis is subclassified by the number of needles into 2 categories: type 1 (single-needle cannula method); and type 2 (double- or dual-needle cannula method).<sup>29</sup> Recent evidence suggests that SPA is as efficacious as DPA for pain reduction and mandibular range improvement; moreover, there is no superiority of SPA over DPA with regard to the secondary operator-related factors (e.g., the ease of operation, the operating time) and patient-related outcomes (e.g., the range of motion improvement, patient satisfaction).<sup>31,32</sup> In general, arthrocentesis can improve jaw function and reduce pain in patients with disk displacement without reduction and osteoarthritis. However, there are inconsistent findings about its possible superiority over other kinds of treatment for TMJ pain, with the exception of its superiority over splints.<sup>33</sup> Furthermore, a meta-analysis by Al-Moraissi et al. showed that non-invasive procedures had significantly lower therapeutic quality in terms of pain reduction and improvement of mouth opening, which supports a paradigm shift in the treatment of arthrogenous TMDs.<sup>2</sup> This recent evidence, although based on primary studies of very low to moderate quality, indicates that minimally invasive procedures (particularly in combination with the IAI of platelet-rich plasma (PRP), HA or CSs) are significantly more effective than the conservative treatment in reducing pain and improving mouth opening in the short and medium term in arthrogenous TMD cases. Therefore, minimally invasive procedures should be considered as first-line treatment.<sup>2</sup> Nonetheless, a systematic review by Li et al. suggests that when conservative treatment fails, early arthrocentesis may result in the greatest improvement in mouth opening and pain relief; however, when it is applied as initial treatment, without attempting the conservative treatment at first, the outcome may be less satisfactory.<sup>34</sup>

Temporomandibular joint arthrocentesis seems to be very safe given that a minimal number of major complications have been reported, and the ones reported are generally transitory, mostly due to the effect of anesthetic drugs or the extravasation of fluids to the surrounding soft tissues.<sup>35</sup> While the permanent complication rate is 0%, some short-term complications have been reported, such as facial nerve injury, preauricular hematoma, superficial temporal artery injury, the development of an arteriovenous fistula, joint bleeding, intracranial perforation, severe bradycardia, needle breakage inside the joint, failed needle insertion, the leakage of the washing liquid into the extra-articular

**Table 1.** Primary studies on the ultrasound(US)-guided temporomandibular joint (TMJ) interventional procedures

Study	Study design	Condition to be treated	US-guided procedure				Drug injected	Control (blind technique) <i>n</i>	Route of scanning	Main results
			case subjects (TMJs) <i>n</i>	technique	joint space	US transducer				
Parra et al. 2010 <sup>14</sup>	RS	JIA	83 (180)	IAI	U or L	15 MHz linear or 8 MHz curvilinear	CSs	–	CP	with US guidance, the needle tip was located intra-articularly in 91%
Habibi et al. 2012 <sup>15</sup>	RS	JIA	34 (63)	IAI	NR	NR	CSs	–	NR	efficacy of 92.06%; in 100% – pain resolution, in 71.4% – chewing dysfunction diminished, in 92.8% – jaw deviation diminished with US guidance
Dayisoylu et al. 2013 <sup>18</sup>	TN	NR	9 (NR)	DPA	U	7 MHz linear	HA	–	CP	technique description
Levorova et al. 2015 <sup>19</sup>	TN	NR	NR (NR)	IAI	L	7.5–14 MHz linear	NR	–	CP	technique description
Sivri et al. 2016 <sup>9</sup>	RCT	DD	10 (NR)	DPA	U	NR	HA	DPA	CP	US-guided arthrocentesis was not more successful than the conventional technique and it took more time
Chakraborty et al. 2016 <sup>17</sup>	CR	structural abnormality	1 (1)	IAI	NR	high-frequency linear	CSs	–	CP	US guidance increased the efficacy of IAI, especially in the presence of TMJ structural abnormality
Ayoub Al-Delayme et al. 2017 <sup>13</sup>	CT	DD	34 (NR)	IAI	U	NR	PRP	–	NR	US-guided IAI to the upper joint space brought the alleviation of signs and symptoms
Resnick et al. 2017 <sup>16</sup>	RS	JIA	23 (35)	IAI	NR	high-frequency	CSs	type II SPA	NR	no statistical differences in short-term outcomes, but the procedure times were longer for the image-guided group
Antony et al. 2019 <sup>10</sup>	RCT	DD	40 (NR)	DPA	U	NR	–	DPA	CP	the US-guided group showed a significant reduction of pain in the immediate postoperative period; however, it showed no significant alleviation of the overall symptoms as compared to the blind technique
Bhargava et al. 2019 <sup>11</sup>	RCT	DD	10 (NR)	type II SPA	U	12 MHz linear	CSs	type II SPA	CP	no significant difference in pain between the groups, US-guided SPA minimized the number of attempts of needle manipulation
Şentürk et al. 2019 <sup>12</sup>	RCT	DD	12 (12)	type II SPA	U	NR	–	type II SPA	CP	US guidance was effective in type II SPA in the long term; however, it did not improve the outcome results as compared to the blind technique
Cha et al. 2019 <sup>20</sup>	Cad	NR	10 (10)	IAI	U and L	5–20 MHz linear	coloured agents	IAI	CP	the accuracy of US-guided IAI was significantly greater as compared to the blind technique (95% vs. 55%), the success rate for IAI into the upper joint space was similar for both techniques, US-guided IAI into the lower joint space had a much higher success rate than the blind technique (90% vs. 30%, $p = 0.020$ )
Champs et al. 2019 <sup>21</sup>	Cad	NR	13 (25)	IAI	U and L	NR	NR	–	CP	IAI was successful in all cases, the median time period between the skin puncture and IAI was 23 s
Torres-Gaya et al. 2021 <sup>22</sup>	Cad	NR	NR (NR)	DPA	U	13–6 MHz linear	NR	–	OP	high-frequency US linear probe (7.5–20 MHz) and US preset in the MSK mode helped to reach the optimal image definition, the US probe placed oblique relative to the zygomatic arch facilitated orientation and puncture, introducing the needle parallel to the probe major axis allowed greater precision and safety

RS – retrospective study; TN – technical note; RCT – randomized clinical trial; CR – case report; CT – clinical trial; Cad – cadaveric study; JIA – juvenile idiopathic arthritis; DD – disk displacement; IAI – intra-articular injection; DPA – double-puncture arthrocentesis; SPA – single-puncture arthrocentesis; U – upper; L – lower; CS – corticosteroids; HA – hyaluronic acid; PRP – platelet-rich plasma; CP – coronal plane; OP – oblique plane; MSK – musculoskeletal; NR – not reported.

space, damage to the joint surface, and allergic reactions.<sup>29</sup> One promising strategy proposed to prevent some of these drawbacks is US guidance for needle insertion.

## Ultrasound fundamentals

Ultrasound is a widely available, low-cost, non-invasive, and safe medical imaging method that enables real-time observation.<sup>19,23</sup> In this method, images are obtained based on the propagation and reflection of high-frequency sound waves in tissues. Ultrasounds are oscillating sounds with frequencies from 2 MHz to 20 MHz, which are beyond the upper limit that humans can hear.<sup>36</sup> These sound waves are emitted by a transducer placed on the patient's skin, combined with a water-soluble gel as a coupling agent.<sup>37</sup> The transducer acts as a transmitter and a receiver of acoustic energy, and then transforms it into images.<sup>38</sup> The emitted US waves are partly reflected when they pass through tissues, with a reflection coefficient that depends on the characteristics of different anatomical structures.

Ultrasound offers several advantages for dentomaxillofacial images, such as portability, the possibility of dynamic and repeated examinations, patient comfort, and availability.<sup>39</sup> Sonograms (US images) are sections of the region of interest, of a particular thickness, generated along the face of the transducer, which are composed of different shades of gray, where the brightness/darkness depends on the frequency of the reflected echoes, which in turn depends on the ability of a tissue/structure to reflect or absorb sounds; this concept is known as echogenicity. In sonograms, tissues are classified according to their echogenicity: hyperechoic or echogenic (very bright) – highly reflective tissues, such as bone or cartilage; moderately echogenic (bright), such as glands; hypoechoic (fairly dark), such as blood vessels and muscles; and anechoic (very dark), such as liquids and air.<sup>36</sup>

A US examination is a procedure that is highly dependent on the skill and experience of the operator. Differences of opinion between researchers/clinicians may be due to the lack of standardization in the performance of the examina-

tion,<sup>40</sup> probe selection and the configuration of equipment, all of which may generate differences in the interpretation of the results.<sup>41</sup> Nevertheless, researchers have proposed the use of US as a promising screening tool for the evaluation of maxillofacial structures, such as TMJs.<sup>11,36,37,39,41</sup>

## Ultrasonographic features of TMJ

The TMJ area has some particularities, including a small examination area, limited access to deep structures and a high risk of sound reflecting from the bone tissue, which can make image interpretation very complex.<sup>38</sup> Soft tissue visualization is severely limited by bone, as sound energy is almost completely absorbed by soft-tissue interfaces and the bone tissue. Thus, the external placement of the transducer enables only the acquisition of the lateral third of the joint, and only in the axial and coronal planes.<sup>37</sup> Therefore, the main disadvantage of US in the TMJ area is the limited imaging of the upper and medial parts of the condyle and the disk; these structures are hidden by the acoustic shadowing caused by the rebounding and absorption of US waves by the zygomatic bone.<sup>12,19,20,42</sup> The TMJ images produced by US depend on the echogenicity of tissues as follows: the condylar head and the articular eminence are hypoechoic and appear black<sup>39</sup>; the bone margins are hyperechoic and appear white<sup>39</sup>; the connective and muscular tissues are isoechoic (an intermediate reflection of sound waves) and appear heterogeneously gray<sup>23,39</sup>; the joint capsule surface is highly reflective of sound waves, creating a hyperechoic line (white)<sup>11,23,39,42</sup>; the articular disk appears as a thin, hypo-to-isoechoic, homogeneous band<sup>11,23,42</sup>; articular fluid-filled spaces are hypoechoic and appear black,<sup>11,23,42</sup> although these are virtual cavities that are generally not detectable unless joint effusion is present<sup>38</sup>; bone marrow is usually hypoechoic and appears black.<sup>38</sup>

In most publications, TMJ US monitoring is based on the standardized protocol of Emshoff et al.<sup>43</sup> Most studies have adopted similar protocols, which include transversal and longitudinal scans to evaluate the joint compartments in the coronal, axial and oblique planes (Fig. 2).<sup>41</sup>

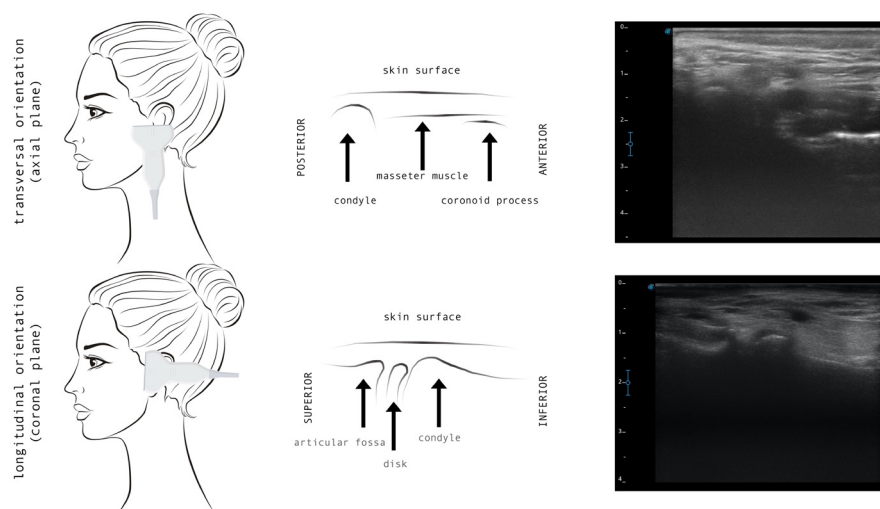


Fig. 2. Ultrasound (US) probe orientation for the observation of the temporomandibular joint (TMJ) in the axial and coronal planes



During the longitudinal scanning, the probe is placed over TMJ, perpendicular to the zygomatic arch and parallel to the mandibular ramus, and inclined until the best view is achieved; then static and dynamic evaluations are performed (Fig. 3).<sup>38</sup> The performance of the US diagnostics is outside the scope of the present review and has been extensively described for 3 main diagnostic domains: disk displacement; joint effusion; and cortical erosion.<sup>38,40–42,44</sup> It has been suggested that US can complement a clinical examination as an initial evaluation tool.<sup>40</sup>

### Ultrasound-guided minimally invasive procedures for TMJ pain

In addition to its diagnostic use, US has been proposed as a useful tool in interventional procedures, such as US-guided peripheral venous access, central venous access, abscess drainage, the aspiration of hip and shoulder joints, pleural effusions, paracentesis, and TMJ arthrocentesis.<sup>11</sup> It has been suggested that US may allow more precise execution with real-time observation.<sup>45</sup> The lysis and lavage of the upper joint space is an effective method for controlling TMJ pain, so identifying this space is important for a satisfactory procedure.<sup>11</sup> However, the traditional blind technique (based on anatomical landmarks) requires experience to reach the upper joint space and carries a potential risk of damage to the collateral disk ligaments and the adjacent soft tissue, especially if multiple attempts are made.<sup>18,20</sup> Furthermore, the confirmation of the correct needle placement can sometimes be ambiguous in clinical practice.<sup>20</sup> Given the complex TMJ anatomy, clinicians have used image-guided techniques to aid the verification of the needle position, and reduce potential damage to joint tissues and neurovascular structures, or needle penetration in the middle cranial fossa during minimally invasive procedures.<sup>12,21,23</sup> Some image-guided techniques using magnetic resonance imaging (MRI) or cone-beam computed tomography (CBCT) have shown promising

results; however, their routine use is not feasible in The MJ procedures due to cost and the need for a hospital environment.<sup>23</sup> On the other hand, it has been postulated that US-guidance minimizes trauma to the joint, and improves the accuracy and efficiency of the procedure. Furthermore, real-time images, the lack of ionizing radiation and easy access make US a promising aid for minimally invasive TMJ procedures, such as arthrocentesis and IAI.<sup>23</sup> While US is widely used for large joints to visualize internal structures and guide IAI, this technique has only recently gained popularity for the TMJ procedures. Hence, the literature on this topic is scarce. The articles regarding US-guided TMJ arthrocentesis or IAI available in PubMed, Scopus and Web of Science, published since 2010 are listed in Table 1 (the main characteristics are provided to facilitate the comparison of the studies). The uncontrolled RT by Parra et al. from 2010 was the first to report the accuracy of US-guided TMJ IAI; they observed that the needle was located intra-articularly in 91% of cases.<sup>14</sup> Dayisoğlu et al. (2013) were the first to describe a reliable technique for US-guided TMJ arthrocentesis, which was suggested to be “better than arthroscopy” with regard to cost-benefits.<sup>18</sup>

Ultrasound-guided punctures may approach the target (joints, vessels or nerves) from a position perpendicular or parallel to the US beam, referred to as ‘out-of-plane’ and ‘in-plane’, respectively (Fig. 4). The in-plane approach enables the operator to visualize the needle shaft and tip, as it is directed toward the target, but it requires skill and may result in a false sense of security, despite having been demonstrated to result in faster and more accurate performance. On the other hand, the out-of-plane technique is more difficult and relies on tissue movement or fluid localization rather than strict needle visibility to confirm its position.<sup>46</sup> In the TMJ US-guided injections using the out-of-plane approach, the correct position of the needle is achieved by extending and narrowing the joint space by the infiltration and aspiration of fluid, respectively.<sup>19</sup>

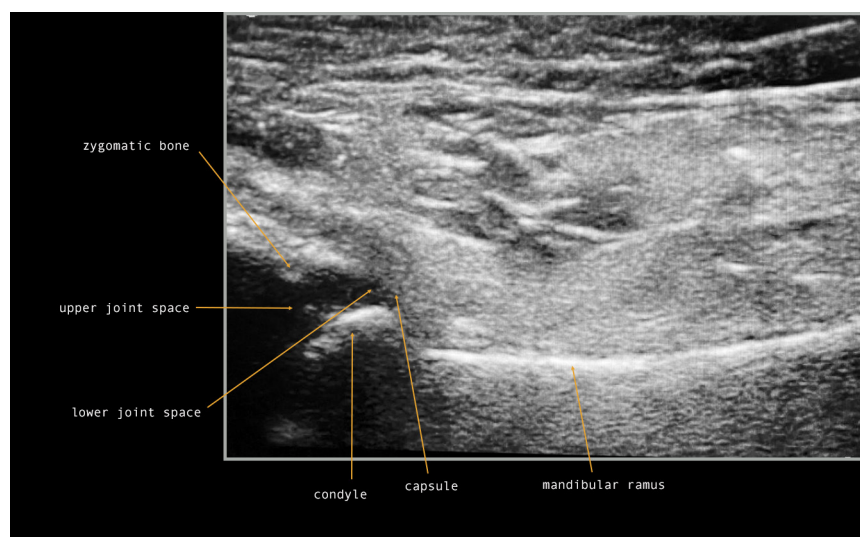


Fig. 3. Ultrasound (US) anatomy of the temporomandibular joint (TMJ) in the coronal plane

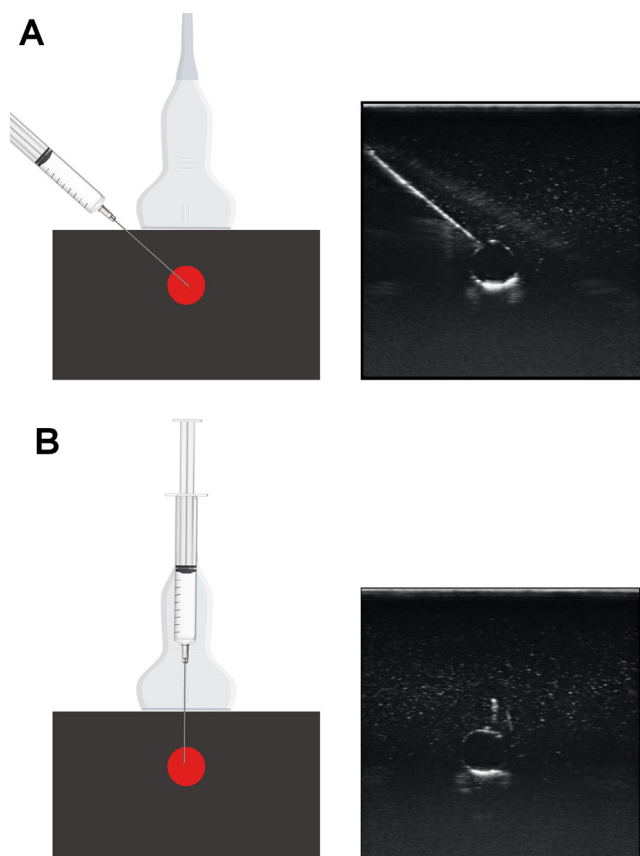


Fig. 4. Needle and probe orientation in ultrasound (US)-guided procedures A – in-plane (long axis) approach; B – out-of-plane (short axis) approach.

Champs et al. validated a longitudinal US-guided in-plane approach for TMJ IAI, in which the needle is inserted at an angle of 30°, with the US probe in the preauricular region, approx. 1 cm in front of the tragus, parallel to the mandibular ramus and perpendicular to the zygomatic arch.<sup>21</sup> This technique proposes a direct visualization of the needle all the way to the joint with great precision and provides noticeably higher accuracy during puncture.<sup>21</sup> Most clinical and cadaveric studies use the coronal route of scanning and in-plane needle insertion (Fig. 5),<sup>9–12,14,17–21</sup> whereas other reports did not report these technical details.<sup>13,15,16</sup>

Most articles describing TMJ minimally invasive procedures (and daily clinical practice) are based on washing-out the upper joint space in both the US-guided and blind techniques. Nevertheless, some evidence has demonstrated that IAI directed to the lower or both TMJ spaces has a better effect than IAI into the upper space alone.<sup>47</sup> Lower joint space injection is believed to be a difficult procedure because of a narrow space, a small volume and the ‘hidden’ location. The blind technique for lower joint space injection was described by Li et al.<sup>47</sup> Clinical information on US-guided IAI into the lower joint space appears to be very limited.<sup>20</sup> Levorova et al. reported a technique for US-guided TMJ intra-articular infiltration directed toward the lower joint space (Fig. 6).<sup>19</sup> Cha et al., in a cadaver-based study, observed that upper joint space injection showed

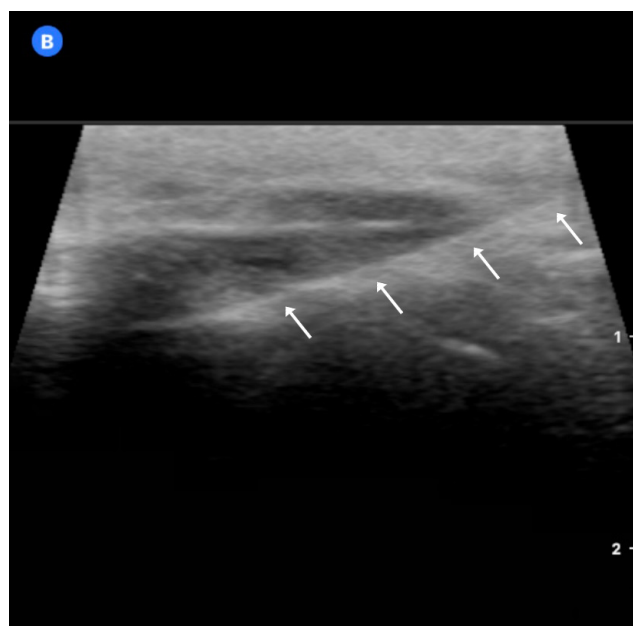


Fig. 5. In-plane needle insertion for upper joint space injection under ultrasound (US) guidance (the needle is marked with white arrows for academic reasons)

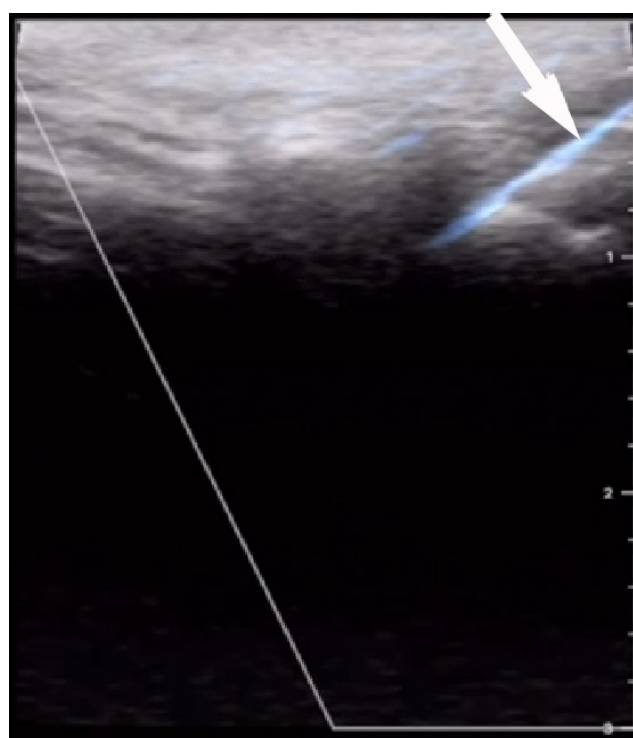


Fig. 6. In-plane needle insertion for lower joint space injection under ultrasound (US) guidance (the needle can be seen in light blue and is marked with a white arrow for academic reasons)

a similar level of success for the blind and US-guided techniques.<sup>20</sup> However, for the lower joint space, the US-guided technique had a significantly higher success rate (90% vs. 30%) and the blind technique was associated with a considerable proportion of unsuccessful/inappropriate injections to the lower joint space.<sup>20</sup> To date, only 4 controlled CTs that compare the blind and US-guided techniques for TMJ arthrocentesis have been published.<sup>9–12</sup> Two of them used

DPA<sup>9,10</sup> and the others used type II SPA<sup>11,12</sup> (the comparison of these studies is presented in Table 1). Şentürk et al., in a CT, reported the longest follow-up (1 year) in a comparison between the blind and US-guided techniques for TMJ arthrocentesis.<sup>12</sup> The results show that US guidance is effective in type 2 SPA, as it aids the visualization of the needle during puncture; however, it did not resolve pain or improve the range of motion as compared to the blind technique.<sup>12</sup> The clinical effectiveness of US guidance for TMJ arthrocentesis and IAI is mostly analyzed based on 4 aspects: pain reduction; the range of movement; needle positioning (or repositioning) attempts; and the total procedure time. The literature comparing US-guided arthrocentesis vs. the blind technique is scarce. Two systematic reviews have been published recently,<sup>23,24</sup> in which very similar conclusions were reached, since they both selected the same articles for the final analysis.<sup>9–12</sup> Both reviews found no significant differences in pain reduction and the maximum mouth opening, no conclusive results were observed in reducing needle repositioning, and also data on the potential to reduce the procedure time was inconclusive.<sup>23,24</sup> Although achieving access to the joint space occupies most of the surgical time, studies show that the total time is longer in the US-guided procedures, since a US examination itself requires additional time.<sup>9</sup> These conclusions are shared by all studies, as some publications suggest that US guidance would improve the precision of needle placement, especially when the lavage of the lower joint space is performed.<sup>20</sup> Cadaver-based studies observed that US-guided IAI and arthrocentesis techniques had a higher accuracy when the needle was located inside the joint spaces,<sup>20,21</sup> as they provide the image verification of having punctured the joint space and the real-time screen visualization of the distension of the space after infiltrating fluid.<sup>22</sup> Antony et al. observed that the US-guided technique resulted in a significantly greater pain reduction in the immediate postoperative period.<sup>10</sup> Bhargava et al. found that in type 2 SPA, US guidance minimized the number of attempts of needle manipulation as well as possible complications, and provided easier access to the upper joint space.<sup>11</sup> Additionally, Anthony et al. suggested that in patients with obesity, US-guided arthrocentesis could be more precise in locating the joint spaces, whereas the blind technique arthrocentesis required multiple punctures to achieve successful lavage.<sup>10</sup>

Finally, from a clinical point of view, some technical suggestions can be made for the execution of US-guided TMJ intra-articular procedures<sup>12,18,19,48</sup>: 1) always perform an initial US TMJ evaluation to observe anatomy in the coronal and axial views; 2) use high-resolution (over 12 MHz) linear probes<sup>22,38</sup>; 3) administer a local anesthetic solution (lidocaine or mepivacaine, without a vasoconstrictor) with a 27-gauge needle into the TMJ capsule,<sup>48</sup> otherwise, the auriculotemporal nerve blockage may be needed; 4) it is not necessary to use anatomical reference landmarks when puncture is guided by US imaging<sup>22</sup>,

5) after reaching the upper or lower joint spaces, HA, CSs or platelet concentrates should be injected slowly; 6) washing the articular space with saline or Ringer's lactate solution if arthrocentesis is intended; 7) close the injection area using a sticking plaster with light pressure to avoid the formation of hematoma; and 8) use ice or cold-pack applications and NSAIDs after the procedure.<sup>48</sup>

## Conclusions

This review summarizes the recent evidence regarding the use of US as an auxiliary tool in minimally invasive procedures for arthrogenic TMD. Ultrasound guidance has shown promising advantages; it reduces the number of needle placement attempts, minimizes trauma to TMJ, improves the accuracy and efficiency of joint injections, results in a significantly greater pain reduction in the immediate postoperative period, provides easier access to both joint spaces, and has a significantly higher success rate when lower joint space injection is attempted. Future research is required to confirm the impact US may have on the clinician's performance, and the consequent benefit to the patient.

## Ethics approval and consent to participate

Not applicable.

## Data availability


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

## Consent for publication

Not applicable.

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## References

1. De Leeuw R, Klasser GD, eds. *Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management*. 5<sup>th</sup> ed. Chicago, IL: Quintessence Publishing; 2013:129–130.
2. Al-Moraissi EA, Wolford LM, Ellis E 3<sup>rd</sup>, Neff A. The hierarchy of different treatments for arthrogenous temporomandibular disorders: A network meta-analysis of randomized clinical trials. *J Craniomaxillofac Surg*. 2020;48(1):9–23. doi:10.1016/j.jcms.2019.10.004
3. Schiffman E, Ohrbach R, Truelove E, et al.; International RDC/TMD Consortium Network, International Association for Dental Research – Orofacial Pain Special Interest Group, International Association for the Study of Pain. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: Recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. *J Oral Facial Pain Headache*. 2014;28(1):6–27. doi:10.11607/jop.1151



4. Shueb SS, Nixdorf DR, John MT, Fonseca Alonso B, Durham J. What is the impact of acute and chronic orofacial pain on quality of life? *J Dent*. 2015;43(10):1203–1210. doi:10.1016/j.jdent.2015.06.001
5. Mena-Iturriaga MJ, Mauri-Stecca MV, Sizer PS, Leppe J. Quality of life in chronic musculoskeletal symptomatic Chilean population: Secondary analysis of National Health Survey 2009–2010. *BMC Musculoskelet Disord*. 2020;21(1):262. doi:10.1186/s12891-020-03261-x
6. Friction J. Temporomandibular disorders: A human systems approach. *J Calif Dent Assoc*. 2014;42(8):523–535. PMID:25174211.
7. Bastos Machado de Resende CM, Lemos de Oliveira Medeiros FG, de Figueiredo Rêgo CR, de Sousa Leite Bispo A, Seabra Barbosa GA, de Almeida EO. Short-term effectiveness of conservative therapies in pain, quality of life, and sleep in patients with temporomandibular disorders: A randomized clinical trial. *Cranio*. 2021;39(4):335–343. doi:10.1080/08869634.2019.1627068
8. Scrivani SJ, Khawaja SN, Bavia PF. Nonsurgical management of pediatric temporomandibular joint dysfunction. *Oral Maxillofac Surg Clin North Am*. 2018;30(1):35–45. doi:10.1016/j.coms.2017.08.001
9. Sivri MB, Ozkan Y, Pekiner FN, Gocmen G. Comparison of ultrasound-guided and conventional arthrocentesis of the temporomandibular joint. *Br J Oral Maxillofac Surg*. 2016;54(6):677–681. doi:10.1016/j.bjoms.2016.04.004
10. Antony PG, Sebastian A, D A, et al. Comparison of clinical outcomes of treatment of dysfunction of the temporomandibular joint between conventional and ultrasound-guided arthrocentesis. *Br J Oral Maxillofac Surg*. 2019;57(1):62–66. doi:10.1016/j.bjoms.2018.11.007
11. Bhargava D, Thomas S, Pawar P, Jain M, Pathak P. Ultrasound-guided arthrocentesis using single-puncture, double-lumen, single-barrel needle for patients with temporomandibular joint acute closed lock internal derangement. *Oral Maxillofac Surg*. 2019;23(2):159–165. doi:10.1007/s10006-019-00753-6
12. Şentürk MF, Yıldırım D, Bilgir E. Evaluation of ultrasonography guidance for single-puncture temporomandibular joint arthrocentesis: A randomized clinical study. *Cranio*. 2019;37(3):181–187. doi:10.1080/08869634.2017.1407095
13. Ayoub Al-Delayme RM, Alnuamy SH, Hamid FT, et al. The efficacy of platelets rich plasma injection in the superior joint space of the temporomandibular joint guided by ultra sound in patients with non-reducing disk displacement. *J Maxillofac Oral Surg*. 2017;16(1):43–47. doi:10.1007/s12663-016-0911-9
14. Parra DA, Chan M, Krishnamurthy G, et al. Use and accuracy of US guidance for image-guided injections of the temporomandibular joints in children with arthritis. *Pediatr Radiol*. 2010;40(9):1498–1504. doi:10.1007/s00247-010-1581-2
15. Habibi S, Ellis J, Strike H, Ramanan AV. Safety and efficacy of US-guided CS injection into temporomandibular joints in children with active JIA. *Rheumatology (Oxford)*. 2012;51(5):874–877. doi:10.1093/rheumatology/ker441
16. Resnick CM, Vakilian PM, Kaban LB, Peacock ZS. Is intra-articular steroid injection to the temporomandibular joint for juvenile idiopathic arthritis more effective and efficient when performed with image guidance? *J Oral Maxillofac Surg*. 2017;75(4):694–700. doi:10.1016/j.joms.2016.09.045
17. Chakraborty A, Datta T, Lingegowda D, Khemka R. Ultrasound-guided temporomandibular joint injection for chronic posthemimandibulectomy jaw pain. *A A Case Rep*. 2016;7(10):203–206. doi:10.1213/XAA.0000000000000384
18. Dayisoğlu EH, Cifci E, Uckan S. Ultrasound-guided arthrocentesis of the temporomandibular joint. *Br J Oral Maxillofac Surg*. 2013;51(7):667–668. doi:10.1016/j.bjoms.2013.05.144
19. Levorova J, Machon V, Hirjak D, Foltan R. Ultrasound-guided injection into the lower joint space of the temporomandibular joint. *Int J Oral Maxillofac Surg*. 2015;44(4):491–492. doi:10.1016/j.ijom.2014.12.013
20. Cha YH, O J, Park JK, Yang HM, Kim SH. Ultrasound-guided versus blind temporomandibular joint injections: A pilot cadaveric evaluation. *Int J Oral Maxillofac Surg*. 2019;48(4):540–545. doi:10.1016/j.ijom.2018.09.002
21. Champs B, Corre P, Hamel A, Laffite CD, Le Goff B. US-guided temporomandibular joint injection: Validation of an in-plane longitudinal approach. *J Stomatol Oral Maxillofac Surg*. 2019;120(1):67–70. doi:10.1016/j.jormas.2018.10.008
22. Torres-Gaya J, Bosca-Ramón A, Marqués-Mateo M, Valverde-Navarro A, García-San Segundo MM, Puche-Torres M. Temporomandibular joint arthrocentesis guided by ultrasonography: An anatomical study. *J Stomatol Oral Maxillofac Surg*. 2021;122(4):e27–e31. doi:10.1016/j.jormas.2021.03.002
23. Hu Y, Zhang X, Liu S, Xu F. Ultrasound-guided vs conventional arthrocentesis for management of temporomandibular joint disorders: A systematic review and meta-analysis. *Cranio*. 2020;1–10. doi:10.1080/08869634.2020.1829870
24. Leung YY, Wu FHW, Chan HH. Ultrasonography-guided arthrocentesis versus conventional arthrocentesis in treating internal derangement of temporomandibular joint: A systematic review. *Clin Oral Investig*. 2020;24(11):3771–3780. doi:10.1007/s00784-020-03408-z
25. Goiato MC, da Silva EV, de Medeiros RA, Túrcio KH, Dos Santos DM. Are intra-articular injections of hyaluronic acid effective for the treatment of temporomandibular disorders? A systematic review. *Int J Oral Maxillofac Surg*. 2016;45(12):1531–1537. doi:10.1016/j.ijom.2016.06.004
26. Ferreira N, Masterson D, de Lima RL, et al. Efficacy of viscosupplementation with hyaluronic acid in temporomandibular disorders: A systematic review. *J Craniomaxillofac Surg*. 2018;46(11):1943–1952. doi:10.1016/j.jcms.2018.08.007
27. Iturriaga V, Bornhardt T, Manterola C, Brebi P. Effect of hyaluronic acid on the regulation of inflammatory mediators in osteoarthritis of the temporomandibular joint: A systematic review. *Int J Oral Maxillofac Surg*. 2017;46(5):590–595. doi:10.1016/j.ijom.2017.01.014
28. Nitzan DW, Dolwick MF, Martinez GA. Temporomandibular joint arthrocentesis: A simplified treatment for severe, limited mouth opening. *J Oral Maxillofac Surg*. 1991;49(11):1163–1177. doi:10.1016/0278-2391(91)90409-f
29. Şentürk MF, Yazıcı T, Gülşen U. Techniques and modifications for TMJ arthrocentesis: A literature review. *Cranio*. 2018;36(5):332–340. doi:10.1080/08869634.2017.1340226
30. Şentürk MF, Cambazoğlu M. A new classification for temporomandibular joint arthrocentesis techniques. *Int J Oral Maxillofac Surg*. 2015;44(3):417–418. doi:10.1016/j.ijom.2014.11.014
31. Gomes Carneiro Monteiro JL, Almeida de Arruda JA, de Oliveira E Silva ED, do Egito Vasconcelos BC. Is single-puncture TMJ arthrocentesis superior to the double-puncture technique for the improvement of outcomes in patients with TMDs? *J Oral Maxillofac Surg*. 2020;78(8):1319.e1–1319.e15. doi:10.1016/j.joms.2020.03.020
32. 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(10):810–818. doi:10.1111/joor.12665
33. 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(1):17–29. doi:10.11607/ofph.2606
34. Li DTS, Wong NSM, Li SKY, McGrath CP, Leung YY. Timing of arthrocentesis in the management of temporomandibular disorders: Aan integrative review and meta-analysis. *Int J Oral Maxillofac Surg*. 2021;50(8):1078–1088. doi:10.1016/j.ijom.2021.01.011
35. Vaira LA, Raho MT, Soma D, et al. Complications and post-operative sequelae of temporomandibular joint arthrocentesis. *Cranio*. 2018;36(4):264–267. doi:10.1080/08869634.2017.1341138
36. Kocasarac HD, Angelopoulos C. Ultrasound in dentistry: Toward a future of radiation-free imaging. *Dent Clin North Am*. 2018;62(3):481–489. doi:10.1016/j.cden.2018.03.007
37. Katzberg RW. Is ultrasonography of the temporomandibular joint ready for prime time? Is there a “window” of opportunity? *J Oral Maxillofac Surg*. 2012;70(6):1310–1314. doi:10.1016/j.joms.2012.02.034
38. Manfredini D, Guarda-Nardini L. Ultrasonography of the temporomandibular joint: A literature review. *Int J Oral Maxillofac Surg*. 2009;38(12):1229–1236. doi:10.1016/j.ijom.2009.07.014
39. Evirgen Ş, Kamburoğlu K. Review on the applications of ultrasonography in dentomaxillofacial region. *World J Radiol*. 2016;8(1):50–58. doi:10.4329/wjr.v8.i1.50
40. Almeida FT, Pacheco-Pereira C, Flores-Mir C, Le LH, Jaremko JL, Major PW. Diagnostic ultrasound assessment of temporomandibular joints: A systematic review and meta-analysis. *Dentomaxillofac Radiol*. 2019;48(2):20180144. doi:10.1259/dmfr.20180144

41. Klatkiewicz T, Gawriołek K, Pobudek Radzikowska M, Czajka-Jakubowska A. Ultrasonography in the diagnosis of temporomandibular disorders: A meta-analysis. *Med Sci Monit.* 2018;24:812–817. doi:10.12659/msm.908810
42. Bas B, Yılmaz N, Gökçe E, Akan H. Diagnostic value of ultrasonography in temporomandibular disorders. *J Oral Maxillofac Surg.* 2011;69(5):1304–1310. doi:10.1016/j.joms.2010.07.012
43. Emshoff R, Jank S, Bertram S, Rudisch A, Bodner G. Disk displacement of the temporomandibular joint: Sonography versus MR imaging. *AJR Am J Roentgenol.* 2002;178(6):1557–1562. doi:10.2214/ajr.178.6.1781557
44. Su N, van Wijk AJ, Visscher CM, Lobbezoo F, van der Heijden GJ. Diagnostic value of ultrasonography for the detection of disc displacements in the temporomandibular joint: A systematic review and meta-analysis. *Clin Oral Investig.* 2018;22(7):2599–2614. doi:10.1007/s00784-018-2359-4
45. Davidson J, Jayaraman S. Guided interventions in musculoskeletal ultrasound: What's the evidence? *Clin Radiol.* 2011;66(2):140–152. doi:10.1016/j.crad.2010.09.006
46. Speer M, McLennan N, Nixon C. Novice learner in-plane ultrasound imaging: Which visualization technique? *Reg Anesth Pain Med.* 2013;38(4):350–352. doi:10.1097/AAP.0b013e3182926d6b
47. Li C, Zhang Y, Lv J, Shi Z. Inferior or double joint spaces injection versus superior joint space injection for temporomandibular disorders: A systematic review and meta-analysis. *J Oral Maxillofac Surg.* 2012;70(1):37–44. doi:10.1016/j.joms.2011.04.009
48. Orhan K, Rozyło-Kalinowska I. Ultrasonography-guided invasive procedures of the temporomandibular joint. *Clin Dent Rev.* 2021;5:3. doi:10.1007/s41894-020-00091-x