Int. J. Oral Maxillofac. Surg. 2019; 48: 540–545
https://doi.org/10.1016/j.ijom.2018.09.002, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Research Paper
TMJ Disorders

Ultrasound-guided versus blind temporomandibular joint injections: a pilot cadaveric evaluation

Y. H. Cha[1], J. O[2], J.-K. Park[3], H.-M. Yang[2a], S. H. Kim[3a]
[1]Department of Oral and Maxillofacial Surgery, Yonsei University College of Dentistry, Seoul, Republic of Korea; [2]Department of Anatomy, Yonsei University College of Medicine, Seoul, Republic of Korea; [3]Department of Anesthesiology and Pain Medicine, Anesthesia and Pain Research Institute, Yonsei University College of Medicine, Seoul, Republic of Korea

Y. H. Cha, J. O, J. -K. Park, H. -M. Yang, S. H. Kim: Ultrasound-guided versus blind temporomandibular joint injections: a pilot cadaveric evaluation. Int. J. Oral Maxillofac. Surg. 2019; 48: 540–545.

Abstract. Temporomandibular disorders are painful conditions that require precise injection therapy in selected patients. This pilot cadaveric study was undertaken to compare the accuracy of temporomandibular joint (TMJ) injection between the anatomical landmark-based (blind) technique and an ultrasound-guided technique. TMJ injections using the blind technique or the ultrasound-guided technique were performed in 10 non-embalmed cadavers. After dissection, the accuracy of the TMJ injections was found to be significantly greater for the ultrasound-guided injections than for the blind technique (blind 55% vs. ultrasound 95%, $P = 0.008$). For injections into the upper joint space of the TMJ, the success rate of the injection was comparable for the two techniques (blind 80% vs. ultrasound 100%, $P = 0.474$). However, ultrasound-guided injections into the lower joint space had a much higher success rate than the blind technique (blind 30% vs. ultrasound 90%, $P = 0.020$). The blind technique was associated with a considerable proportion of failed or inappropriate injections, especially for lower joint space injections. Ultrasound-guided TMJ injections were accomplished with a higher accuracy than the conventional blind technique, especially in the case of injections targeting the lower joint space of the TMJ.

Key words: cadaver; cartilage; articular; chronic pain; injections; intra-articular; temporomandibular joint; ultrasonography.

Accepted for publication 5 September 2018
Available online 2 October 2018

Temporomandibular disorders are painful conditions characterized by intra-articular positional and/or structural abnormalities[1,2]. The temporomandibular joint (TMJ) can be affected by various pathological conditions such as abnormal dynamics of the disc–condyle complex, degenerative osteoarthritis, inflammatory arthritis, and crystal arthropathy[3]. TMJ injections using steroids or hyaluronic acid are commonly used to treat patients with TMJ disorders[4].

The TMJ is a synovial joint surrounded by a fibrous capsule that is divided into

[a] Hun-Mu Yang and Shin Hyung Kim contributed equally to this work as corresponding authors.

0901-5027/040540 + 06

upper and lower spaces by a fibrocartilaginous articular disc[5]. Thus, the exact determination of upper and lower joint spaces is important for the treatment outcome if an intra-articular injection is necessary. Although TMJ injection is usually performed using anatomical landmarks, there is the potential risk of damage to the collateral ligaments of the disc or the adjacent soft tissue, especially if multiple attempts are made[6,7]. Extra-articular injections can also result in poor clinical outcomes and unintended complications[8]. Moreover, confirmation of the correct needle placement can sometimes be ambiguous in real clinical practice.

Ultrasound is used widely for larger joints of the body to visualize the articular structures and guide intra-articular injections. However, it has only recently gained popularity for TMJ injections[9]. Although several studies have demonstrated that the ultrasound-guided approach is safe and highly efficacious for the treatment of painful TMJ disorders[10,11], the accuracy of this technique has not been compared with a conventional blind technique. In particular, clinical information regarding ultrasound-guided injections targeting the lower joint space of the TMJ seems to be very limited[12]. Currently, there is no well-established approach for performing injections in the upper and lower joint spaces of the TMJ using ultrasound, and furthermore, targeted injection into each joint space has never been performed under controlled conditions.

This study was performed to determine whether ultrasound-guided injection targeting the upper and lower joint spaces of the TMJ using a low volume of dye solution was possible and to compare this technique with a conventional blind technique in an established cadaver model by anatomical dissection.

Methods

The institutional review board exempted this study from formal review. All cadavers (six male and four female, mean age 79.2 years) utilized in the present study were legally donated to the Surgical Anatomy Education Centre at Yonsei University College of Medicine (YSAEC). The injection procedures for targeting the upper and lower joint spaces of the TMJ were conducted on 10 fresh cadavers that were independently chosen by the scientific staff of YSAEC.

The cadavers were randomized to receive either ultrasound-guided injections or injections using the blind technique to the TMJ on the right or left side. Hence one side was allocated to ultrasound-guided injection and the other side was allocated to the blind (anatomical landmark-based) injection. On each side, the upper and lower joint spaces of the TMJ were individually approached using two different coloured agents. Thus, four injections were done in a single cadaver and 40 injections were done in the 10 cadavers (10 sides for the ultrasound-guided technique and 10 sides for the blind technique; two spaces – upper and lower joint spaces – for a single side).

Ultrasound-guided technique

All cadavers were placed in the supine position with appropriate head rotation to access the injection site. All injections were performed by a single experienced anaesthesiologist specialized in regional anaesthesia and pain medicine (SHK). A TE7 ultrasound unit (Mindray Bio-Medical Electronics, Shenzhen, China) and an L20–5 s high frequency (5–20 MHz) linear probe with 3.2-cm aperture (Mindray Bio-Medical Electronics, Shenzhen, China) were used, and all injections were performed with a 50-mm, 22-gauge needle. Pre-scanning using both the transverse and longitudinal views was done to sonographically identify the TMJ space between the articular tubercle of the temporal bone and mandibular condyle in the pre-auricular region. For each cadaver, possible passive jaw movement was also used to confirm the targeted TMJ location during real-time ultrasound imaging. The injection procedure was performed in the closed-mouth position. For each injection, the probe was positioned longitudinally on the targeted TMJ and the structures were imaged in the coronal plane. For the injection targeting the upper joint space, an in-plane technique under real-time ultrasound guidance was used to advance the needle towards the glenoid fossa in a caudal-to-cephalic direction until contact was made with the bone (Fig. 1A). Similarly, for the injection targeting the lower joint space, an in-plane technique was used to advance the needle towards the expected top of the mandibular condyle in a caudal-to-cephalic direction until contact was made with the bone (Fig. 1B). A schematic diagram of the injections using the ultrasound-guided approach is given in Fig. 1C. In both joint injections, the needle was retracted slightly after confirming bony contact. Correct needle placement was verified by injecting 0.5 ml of normal saline: the spread of the injectate into the targeted joint space, without resistance being encountered, could be seen on the real-time ultrasound image. Sonographic images were recorded digitally for all cadavers.

Anatomical landmark-based technique (blind technique)

The anatomical landmark-based (blind) technique in this study was performed according to a method described previously in the literature[13,14]. All injections were performed by a single experienced oral and maxillofacial surgeon (YHC). The expected needle entry point was approximately 10 mm anterior to the tragus. For each cadaver, anatomical landmarks were identified using careful palpation and passive jaw movement. Then, anatomical structures surrounding the TMJ were briefly marked using a marking pen on

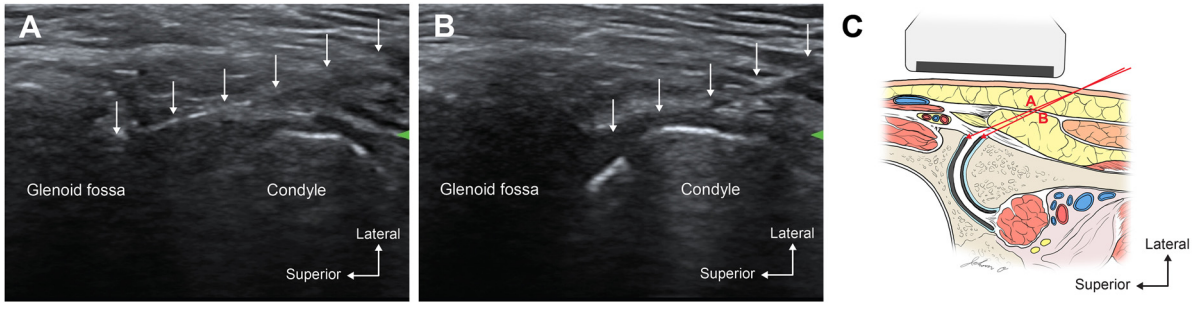

Fig. 1. Ultrasound images demonstrating needle placement during (A) upper joint and (B) lower joint injections in the temporomandibular joint. (C) Schematic diagram.

the skin. A 50-mm, 22-gauge needle was used for all injections and the injection was performed in the closed-mouth position. For injection into the upper joint space, the tip of the needle was directed towards the glenoid fossa anteriorly, superiorly, and medially. For injection into the lower joint space, the needle was directed towards the lateral pole of the condylar head, and the tip of the needle was moved to the posterior slope of the condylar head. When expected bony contact was made, the needle was retracted slightly. Normal saline (0.5 ml) was injected and aspirated to confirm the intracapsular position of the needle without difficulty.

Dye solution composition and injection

The dye solution used to confirm the localization of the injection consisted of a 0.2-ml mixture of 0.1 ml latex solution and 0.1 ml acrylic dye. This mixture was used in every injection regardless of the technique used and the space injected (upper and lower, right and left). Red dye was used for the upper joint space and blue dye was used for the lower joint space to distinguish the targeted location of the injected dye solution. After confirming the correct needle tip placement for all injections, 0.2 ml of dye was injected into each upper and lower joint space of the TMJ. During the whole procedure, any difficulty identifying the sonographic or surface anatomy and any injection-related technical problems were recorded.

Anatomical dissection procedure

Anatomists (HMY and JO) were blinded to the injection techniques. The exact same dissection protocol was followed for all cadavers, and dissection was initiated no longer than 1 hour after injection. For the purpose of this study, an injection was considered successful when the two dyes were separately situated in the upper and lower joint spaces of the TMJ with no mixing. In the pre-auricular area including the TMJ region, the skin was stripped off. The subcutaneous tissue including the superficial musculoaponeurotic system (SMAS) and the parotid gland overlaying the TMJ was removed. After the lateral ligament and fibrous capsule had been revealed, extracapsular spread of the dye was evaluated. The capsule was partially removed to investigate the upper and lower joint spaces. Intracapsular spread of the dye was determined within both joint spaces. Additionally, any spread of the dye into the infratemporal fossa including the lateral pterygoid muscle was also evaluated. Photographs were taken to record the spread of the dye, and the localization of the dye was meticulously noted.

Statistical analysis

The primary endpoint of this study was the accuracy of the locations of the TMJ injections in the upper and lower joint spaces with each technique. A χ^2 test was used to compare the success rate of injections between the blind and ultrasound-guided injection techniques. Data were analyzed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). A P-value of <0.05 was considered statistically significant.

Results

The key sonographic landmarks were readily identified in the bony and articular structures of the TMJ in the pre-auricular region of all cadavers. The anatomical landmarks for the blind technique were mostly identified using careful palpation and passive jaw movement; however the expected TMJ locations on both sides of two of the cadavers were somewhat ambiguous.

The comparison of the accuracy of the two techniques is summarized in Table 1. For the upper joint space injections, the ultrasound-guided injections were more accurate than the blind technique injections, but the success rate was statistically similar (blind 80% vs. ultrasound 100%, $P = 0.474$). For the lower joint space injections, however, ultrasound-guided injections resulted in a much higher success rate (blind 30% vs. ultrasound 90%, $P = 0.020$). Overall, the accuracy of TMJ injections, including both upper and lower joint injections, was significantly greater with the ultrasound-guided technique than with the blind technique (blind 55% vs. ultrasound 95%, $P = 0.008$).

In one ultrasound-guided injection, blue dye from the lower joint space injection was situated in the upper joint space. In this case, the lower joint space of the TMJ was atypically small in size. With the exception of this joint, all other injections using ultrasound showed clearly separated dye locations that targeted the upper or lower space of the TMJ (Fig. 2).

In contrast, there were many failed or inappropriate injections in the blind technique cases, especially with regard to the lower joint space. In the two failed cases of upper joint space injection, the red dye was situated within the lower joint space, contrary to the target. There were seven failed cases with the blind technique when targeting the lower joint space, where there was no intracapsular spread of the injected dye. In two cases, the dye targeted at the lower joint space was situated anterior to the condylar neck, superficial to the lateral pterygoid muscle (blue dye in Fig. 3A). Mostly, the dye was observed lateral and posterior to the condylar process and posterior ramus (Fig. 3B, C). The dye was located between the posterior border of the mandible and parotid gland. Even intramuscular spread of the dye was observed in one lower joint injection. A schematic diagram of the locations is shown in Fig. 3D.

Discussion

In this cadaveric study, ultrasound-guided TMJ injection showed higher accuracy than the conventional blind technique for targeting injections at the joint spaces. Also, ultrasound-guided injection targeting the lower joint space of the TMJ showed consistently reliable results, while the lower joint space injections using the blind technique were less reliable.

Although ultrasound has some potential advantages over other imaging modalities for evaluating TMJ disorders[15–18], the reliability of ultrasound is not yet fully established[3,9]. This limited use of ultrasound in TMJ disorders may result from technical difficulties identifying detailed pathological changes in small structures and the operator-dependent nature of ultrasound. Indeed, the main weakness of ultrasound is the limited imaging capacity in the superior and medial part of the condyle and disc in the TMJ[9]. These

Table 1. Comparison of the accuracy of temporomandibular joint injections using the blind technique and the ultrasound-guided technique, as confirmed by anatomical dissection.

	Success/total (%, 95% CI)		*P*-value
	Blind technique	US-guided technique	
Upper joint space	8/10 (80%, 0.442–0.964)	10/10 (100%, 0.655–1.000)	0.474
Lower joint space	3/10 (30%, 0.080–0.646)	9/10 (90%, 0.541–0.994)	0.020
Total	11/20 (55%, 0.320–0.761)	19/20 (95%, 0.730–0.997)	0.008

CI, confidence interval; US, ultrasound.

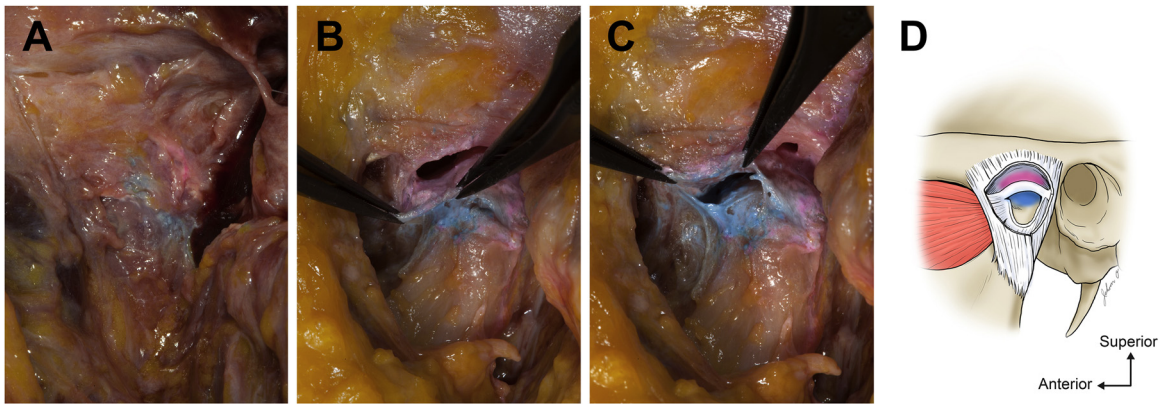

Fig. 2. Successful injections when using the ultrasound-guided approach. The two dyes could be identified after removal of (A) the lateral ligament. (B) The red dye was identified in the upper joint space above the disc; (C) the blue dye was identified in the lower joint space below the disc. (D) Schematic diagram.

structures are hidden by acoustic shadowing in the zygomatic bone[12]. However, for the purpose of intra-articular injection of the TMJ, the application of ultrasound was found to be quite easy and reliable in this study. Needle advancement under ultrasound guidance towards the glenoid fossa and the tip of the condyle head was achieved easily in all cases. This approach targets the lateral recess of each joint space of the TMJ, and their expected locations could be readily identified on the ultrasound images. Considering that the two joint spaces are clearly demarcated by a disc and its collateral ligaments, the real-time ultrasound image of the injectate filling the targeted joint space could also clearly verify injectate administration within the space (**Supplementary Material**). In living subjects, dynamic movement of the condylar head with real-time ultrasound imaging could help easily identify the exact location of the TMJ and visualize the vascular structures around the TMJ before the procedure.

In the present study, the blind technique for TMJ injection was associated with failed identification of the exact location of the targeted joint space. The lateral ligament is an intrinsic ligament continuous with the fibrous capsule of the TMJ and it attaches tightly to the condyle and neck of the mandible[19]. Hence, extracapsular spread of the injected agent does not seem to be effective for administration. A recent case report showed successful ultrasound-guided TMJ injection after an initial failed blind technique in a patient with lateral displacement of the mandibular condyle[20]. Other authors reported lipoatrophy and depigmentation at the injection site following steroid injection into the TMJ, indicating a suspected extracapsular injection in an elderly patient[21]. In this study, as expected, multiple needle manipulations were frequently required for correct needle placement using the blind technique. Meanwhile, the ultrasound approach resulted in the most successful TMJ injections without multiple attempts. Previous studies by the present authors' group have reported the detailed anatomical location of facial nerves and superficial temporal arteries in close proximity to the TMJ, which could potentially be damaged during an inaccurately placed injection[22,23]. Therefore, ultrasound-guided injections should be considered in order to achieve high accuracy and efficacy and to minimize complications, especially in patients whose TMJs are expected to be difficult to approach.

Of note, a high success rate of lower joint space injection using ultrasound over the blind technique was consistently observed in this study. The TMJ cavity actually consists of two separate joint capsules: tight fibres attach to the disc surrounding the lower part of the joint, and loose fibres attach to the temporal bone surrounding the upper part of the joint[19]. The lower joint space has a narrow cavity with a smaller amount of synovial fluid than the upper space. In addition, the lower lamina of the disc is

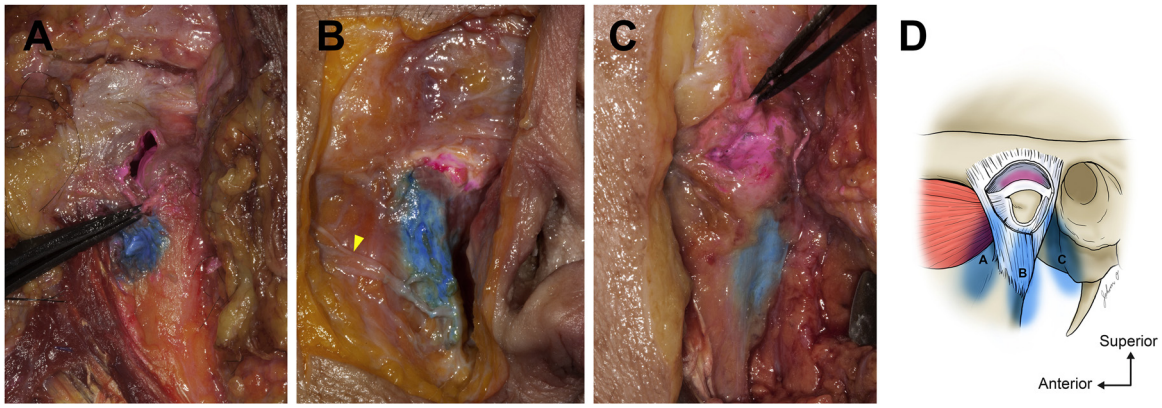

Fig. 3. Failed injections when using anatomical landmarks based on the blind approach. The dyes injected into the lower joint space were situated (A) anterior, (B) lateral, or (C) posterior to the condylar head. (D) Schematic diagram. The arrowhead in image B indicates the facial nerve trunk.

composed of stiff fibrous tissue lacking elastic fibres[19]. As the capsular fibres enclosing the lower joint space are very tight, only rotation can be allowed within the lower joint space, whereas sliding can be done within the upper space[19]. Also, despite different morphologies of the condyle, the condylar head is mostly convex or round in shape in contrast to the concave shape of the glenoid fossa. Given these anatomical features of the lower joint space, the proper needle trajectory and depth in the targeted lower joint space may be difficult to predict when using the blind technique. Indeed, we could not be fully sure when the needle was in the correct place in the lower joint space using the blind technique, even though we followed the recommended method with careful anatomical consideration.

Despite the technical difficulty of lower joint space injections, some studies have reported promising results. Lower joint space injections or both upper and lower joint injections using steroids or hyaluronic acid have shown better clinical efficacy than upper joint injection alone in TMJ disorders[14]. Also, the injection of hyaluronic acid into the lower joint space has been shown to promote condylar reparative remodelling and improve jaw function in patients with TMJ osteoarthritis with anterior disc displacement without reduction[13]. The condylar cartilage is a viscoelastic tissue; histologically, it consists of different functional zones including the proliferative zone[24]. Abnormal remodelling of the subchondral bone, inflammation, and chondrocyte apoptosis at the condylar head seem to be the main mechanisms that contribute to the degeneration of osteoarthritic cartilage[25]. This means that the administration of therapeutic agent into the lower joint space would be beneficial in patients with mandibular condylar pathologies[26]. Therefore, based on the present study results, the clinical efficacy of lower or double joint space injection for TMJ disorders should be evaluated using an ultrasound-guided approach in controlled studies.

This study has several limitations. The sample size was relatively small. Considering the cadaveric nature of this study, tissue integrity and joint movement would inevitably differ from those of living subjects. Thus, the technique used for blind injection in the present cadaveric study may not represent the one used in patients. The success rate of the blind technique may therefore have been somewhat underrated in this study. However, it is believed that these differences were unlikely to affect the accuracy of the ultrasound-guided injections. The interventional procedures using ultrasound may be significantly related to the physician's experience and skill. As a single experienced physician performed all ultrasound-guided injections in this study, further study is needed to determine the generalizability of the results.

In conclusion, this study demonstrated that the ultrasound-guided approach has the potential to enhance accuracy and safety over the blind technique for TMJ injection in a cadaveric model, especially when targeting the lower joint space. Further studies with a larger number of cadavers should be performed to confirm the results of this investigation. Also, evidence of improved clinical outcomes of the ultrasound-guided approach for TMJ injection should be investigated using controlled trials in patients with TMJ disorders.

Acknowledgements. We are deeply appreciative to Dae Won Kim and Jun Ho Kim for technical support. We are also grateful to the staff of the Surgical Anatomy Education Centre, Yonsei University College of Medicine. All of the schematic diagrams included in the figures in this article were drawn by Jehoon O, one of the authors. This study was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number HI17C1719).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ijom.2018.09.002.

References

1. Chantaracherd P, John MT, Hodges JS, Schiffman EL. Temporomandibular joint disorders' impact on pain, function, and disability. *J Dent Res* 2015;**94**:79S–86S.
2. Slade GD, Ohrbach R, Greenspan JD, Fillingim RB, Bair E, Sanders AE, Dubner R, Diatchenko L, Meloto CB, Smith S, Maixner W. Painful temporomandibular disorder: decade of discovery from OPPERA studies. *J Dent Res* 2016;**95**:1084–92.
3. Petscavage-Thomas JM, Walker EA. Unlocking the jaw: advanced imaging of the temporomandibular joint. *AJR Am J Roentgenol* 2014;**203**:1047–58.
4. Romero-Reyes M, Uyanik JM. Orofacial pain management: current perspectives. *J Pain Res* 2014;**7**:99–115.
5. Tanaka E, Koolstra JH. Biomechanics of the temporomandibular joint. *J Dent Res* 2008;**87**:989–91.
6. Dayisoylu EH, Cifci E, Uckan S. Ultrasound-guided arthrocentesis of the temporomandibular joint. *Br J Oral Maxillofac Surg* 2013;**51**:667–8.
7. Greene MW, Hackney FL, Van Sickels JE. Arthroscopy of the temporomandibular joint: an anatomic perspective. *J Oral Maxillofac Surg* 1989;**47**:386–9.
8. Fritz J, Pereira PL, Lewin JS. Temporomandibular joint injections: interventional MR imaging demonstrates anatomical landmark approach to be inaccurate when compared to direct visualization of the injectant. *Pediatr Radiol* 2010;**40**:1964–5.
9. Manfredini D, Guarda-Nardini L. Ultrasonography of the temporomandibular joint: a literature review. *Int J Oral Maxillofac Surg* 2009;**38**:1229–36.
10. 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**:874–7.
11. Parra DA, Chan M, Krishnamurthy G, Spiegel L, Amaral JG, Temple MJ, John PR, Connolly BL. Use and accuracy of US guidance for image-guided injections of the temporomandibular joints in children with arthritis. *Pediatr Radiol* 2010;**40**:1498–504.
12. 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**:491–2.
13. Li C, Long X, Deng M, Li J, Cai H, Meng Q. Osteoarthritic changes after superior and inferior joint space injection of hyaluronic acid for the treatment of temporomandibular joint osteoarthritis with anterior disc displacement without reduction: a cone-beam computed tomographic evaluation. *J Oral Maxillofac Surg* 2015;**73**:232–44.
14. Long X, Chen G, Cheng AH, Cheng Y, Deng M, Cai H, Meng Q. A randomized controlled trial of superior and inferior temporomandibular joint space injection with hyaluronic acid in treatment of anterior disc displacement without reduction. *J Oral Maxillofac Surg* 2009;**67**:357–61.
15. Emshoff R, Jank S, Rudisch A, Walch C, Bodner G. Error patterns and observer variations in the high-resolution ultrasonography imaging evaluation of the disk position of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002;**93**:369–75.
16. 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**:1557–62.

17. Jank S, Emshoff R, Norer B, Missmann M, Nicasi A, Strobl H, Gassner R, Rudisch A, Bodner G. Diagnostic quality of dynamic high-resolution ultrasonography of the TMJ—a pilot study. *Int J Oral Maxillofac Surg* 2005;**34**:132–7.
18. Jank S, Zangerl A, Kloss FR, Laimer K, Missmann M, Schroeder D, Mur E. High resolution ultrasound investigation of the temporomandibular joint in patients with chronic polyarthritis. *Int J Oral Maxillofac Surg* 2011;**40**:45–9.
19. Standring S. *Gray's anatomy: the anatomical basis of clinical practice*. Forty-first edition. Edinburgh: Churchill Livingstone; 2015: 542–6.
20. Chakraborty A, Datta T, Lingegowda D, Khemka R. Ultrasound-guided temporomandibular joint injection for chronic posthemimandibulectomy jaw pain. *A A Case Rep* 2016;**7**:203–6.
21. Skármeta NP, Hormazábal FA, Alvarado J, Rodriguez AM. Subcutaneous lipoatrophy and skin depigmentation secondary to TMJ intra-articular corticosteroid injection. *J Oral Maxillofac Surg* 2017;**75**:2540. e1–e5.
22. Yang HM, Won SY, Kim HJ, Hu KS. Neurovascular structures of the mandibular angle and condyle: a comprehensive anatomical review. *Surg Radiol Anat* 2015;**37**:1109–18.
23. Yang HM, Yoo YB. Anatomy of the facial nerve at the condylar area: measurement study and clinical implications. *Sci World J* 2014;**2014**:473568.
24. Singh M, Detamore MS. Biomechanical properties of the mandibular condylar cartilage and their relevance to the TMJ disc. *J Biomech* 2009;**42**:405–17.
25. Wang XD, Zhang JN, Gan YH, Zhou YH. Current understanding of pathogenesis and treatment of TMJ osteoarthritis. *J Dent Res* 2015;**94**:666–73.
26. 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**:37–44.

Address:
Shin Hyung Kim
Department of Anesthesiology and Pain Medicine
Anesthesia and Pain Research Institute
Yonsei University College of Medicine
50 Yonsei-ro
Seodaemun-gu
Seoul 03722
Republic of Korea
Tel: +82 2 2228 7500
E-mail: tessar@yuhs.ac

Address:
Hun-Mu Yang
Department of Anatomy
Yonsei University College of Medicine
50 Yonsei-ro
Seodaemun-gu
Seoul 03722
Republic of Korea
Tel: +82 2 2228 1649
Fax: +82 2 365 0700.
E-mail: yanghm@yuhs.ac