Description of Ultrasound-guided Injection of the Discomandibular Joint in Equids

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Abstract

The equine temporomandibular joint (TMJ) has been recently identified as a cause of poor performance in horses. There is an increasing need to accurately inject the TMJ to allow diagnosis and clinical management in horses. The TMJ consists of two non-communicating compartments: the discomandibular joint (DMJ) and the discotemporal joint (DTJ). While a methodology exists for injecting the DTJ, no approach for the DMJ has been described. To accurately diagnose TMJ related issues, both compartments should be injected. The purpose of this study was to describe an ultrasound-guided approach for injecting the DMJ, and to report its success, and the frequency of communication between the DMJ and DTJ. Seven cadaver heads, giving fourteen respective TMJ joints, were procured for injection. Each DMJ was injected with radiographic contrast using a timed ultrasound-guided technique. The heads underwent a CT scan and representative ultrasound images during injection were saved, allowing evaluation of both. There was a 100% success rate of DMJ injection, but in 29% joints a communication was demonstrated between the DMJ and DTJ. Based on the location of half of the communicating joints, there was a probability this was iatrogenic via a needle tract. The described technique was highly successful for injection of the DMJ. The sample size, experience, and use of only cadavers are limiting factors of this study.

Abbreviations: CT, Computed Tomography; DMJ, Discomandibular joint; DTJ, Discotemporal Joint; OA, osteoarthritis; TMJ, temporomandibular joint; RVC, Royal Veterinary College; USG, ultrasound-guided

KEYWORDS

Horse, equine, injection, TMJ, DMJ, ultrasound, jaw

1 | INTRODUCTION

The temporomandibular joint (TMJ) in equids is a commonly overlooked joint with lack of research into its anatomy and corresponding clinical relevance.[1] The TMJ, known as the 'jaw joint', is comprised of the zygomatic process of the temporal bone dorsally and the condylar process of the mandible ventrally. Case reports document a variety of TMJ pathology including neoplasia, [12] septic arthritis,[4,5,19] osteoarthritis (OA), [7] and traumatic injury. [5] Reported cases are uncommon, but this could be due to the lack of non-specific clinical signs rather than prevalence. [1,9] With the TMJ becoming increasingly imaged with CT and its possible role in impacting performance for a range of equine athletes, the need for a technique to accurately inject the entire joint is critical for clinical management and diagnosis.[2,4,5,8,9,10,20] Rodríguez et al. (2006) and Pimentel and Carmalt (2021) describe the TMJ as being composed of two noncommunicating articular capsules, the discomandibular joint (DMJ) and discotemporal joint (DTJ), separated by a fibrocartilaginous disk.[14,15,21] Intraarticular injection of the DTJ has been described, but, to the author's knowledge, no methodology to inject the DMJ has been reported. By injecting both compartments, diagnostic analgesia will be more sensitive and medications more efficacious. In the stifle, a common multi-compartment injection site, there is a significant decrease in lameness when diagnostic analgesia of all three compartments was performed, compared to just one.[19] From this, we can deduce that the ability to inject both the DMJ and DTJ, of the TMJ would result in a better clinical outcome. In the case of antibiotics, an intra-articular injection could have benefits compared to systemic routes by increasing local concentrations.[13] Having the ability to inject both capsules of the TMJ would increase the efficacy of intra-articular medications.

This study aims to describe how to perform ultrasound-guided injection of the discomandibular joint (DMJ). The objectives of this study are as follows:

1. Describe how to perform ultrasound-guided injection of the discomandibular joint, DMJ, in equids.
2. Describe the success rate of injection.
3. Describe the frequency of communication between the DMJ and DTJ.

The ultrasound-guided technique can help avoid vital surrounding structures.[15]

We hypothesize that:

1. Ultrasound-guided technique leads to penetration of the DMJ.
1. No communication between the DMJ and DTJ exists.

2 | METHODS

Seven equine cadaver heads, that were euthanized for unrelated reasons to this study, were sourced from a local abattoir. This provided 14 joints for injection. An RVC, year 4 undergraduate student, and an RCVS and EBVS European specialist in Equine Surgery were the principal investigators of this study. The Injections were performed by the RCVS and EBVS European specialist in Equine Surgery using ultrasound guidance.[11,17,22] All cadaver heads were removed from the freezer to thaw 6 days prior to injection. Two millilitres of contrast material (omnipaque: iohexol) diluted in tap water at a ratio of 1:1 in a 5mL syringe (total volume 4mls) was injected with a 1.5-inch 20G needle into the DMJ. Confirmation of penetration of the DMJ and communication between DMJ and DTJ was verified via a CT scan performed within 15 minutes. The scans were assessed by the two investigators.

2.1.1 | ULTRASOUND-GUIDED INJECTION OF CADAVERS

All heads were placed in ventral recumbency and prepared according to the technique described by Norvall et al. (2020) The area around the TMJ was clipped from the lateral canthus of the eye to the external ear base.[11] The clipped area was then cleaned with 4% chlorohexidine surgical scrub and isopropyl alcohol to simulate a live-horse procedure. Ultrasound coupling gel was then applied to the skin surface as well as the ultrasound probe. A Logiq E9 ultrasound machine (GE Healthcare) with a 10-15 MHz linear transducer (GE Healthcare) was used. The external landmarks of the TMJ the mandibular condyle and zygomatic process of the temporal bone were visualized and palpated. The probe was positioned transversely across the soft depression (i.e. perpendicular to the sagittal plane of the TMJ, similar to the technique by Norvall et al. (2020)) between the external landmarks.[11,18] The mandibular condyle and temporal bone were visualized via ultrasound. When these two structures were identified, the probe was slowly moved caudally until the DMJ was visualized. This was identified via a triangular echogenic structure (discus), the mandibular condyle ventrally and temporal bone dorsally (figure 1). When the investigator reached this position, the needle was inserted ventrally at approximately 30° - 40° to the probe (figure 2) and adjusted based on ultrasound image. The aim was to visualise the needle ultrasonographically entering the DMJ immediately dorsal to the mandibular condyle (figure 3).

FIGURE 2: This figure shows the investigator inserting the needle in the DMJ. Rostral is to the right, and the base of cadaver's head is behind the investigator's hands. This depicts the approximate angle (30° - 40°) between the 1.5-inch needle and the probe positioned above the TMJ.

The length of time to perform the injection was recorded. Once the needle was in the desired position, 4mL contrast solution was injected into the DMJ. The needle and syringe were withdrawn and the head set aside for CT. During injection, ultrasound images and videos were saved to review post-scan. After CT, the saved ultrasound images and videos were assessed by the investigators and graded for quality on a scale from 1 - 3: 1 - neither needle nor gas could be clearly visualized, 2 – either needle **or** gas could be clearly visualized, 3 – both needle and gas were clearly visualized.

2.1.2 | CT TECHNIQUE

Each head was CT scanned within 15 minutes of injection to prevent dissipation of the contrast solution.[6] The head was placed in ventral recumbency on the CT gantry for scanning. A 16-detector 160-slice helical scanner with a 90 cm gantry (Canon Aquilion Exceed LB) was used. The images were reconstructed with Eunity (Mach7, US) to allow review by both investigators (Figure 5).[2,16]

2.1.3 | STATISTICAL METHODS

Statistical analysis was performed using commercial software Excel by Microsoft, based in the United States. The percentage for successful penetration was found; The percentage of injection with communicating joints was found. The mean time for injecting was calculated and then further differentiated into mean time for injections with no

FIGURE 1: Ultrasound image of the TMJ in preparation to inject the DMJ. T stands for Temporal bone and M stands for Mandibular condyle

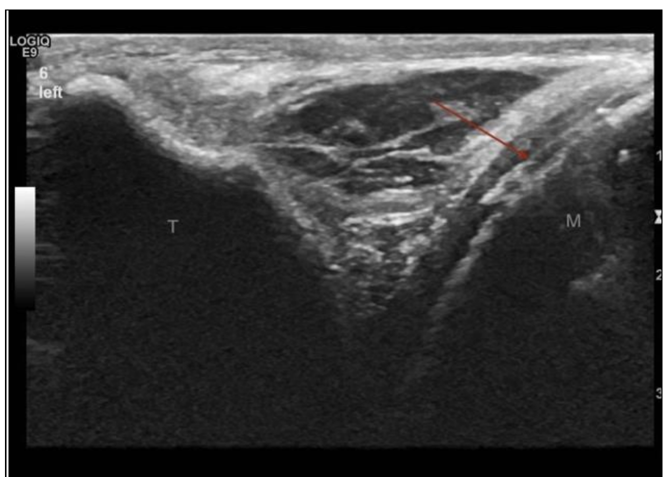

FIGURE 3: Ultrasound image of the needle in the DMJ. Red arrow pointing to the needle in the intraarticular space of the DMJ. T stands for Temporal bone and M stands for Mandibular condyle.

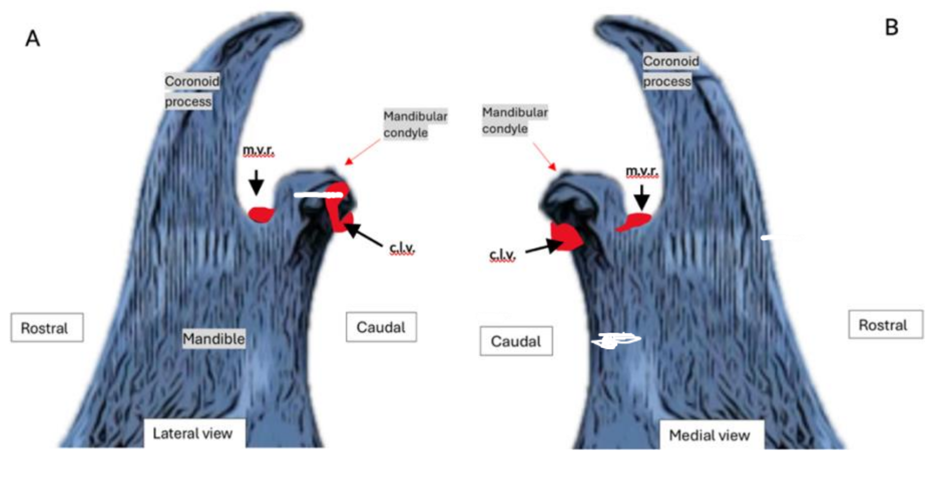

FIGURE 4: Shows the mandible at the level of the TMJ in lateral (A) and medial (B) view. The image depicts the location of two pockets in the discomandibular joint. The red illustrations around the mandibular condyle is representative of the pockets which the contrast settled. This figure was made with reference to the CT images that were collected in this study. The two pockets are represented as **m.v.r.** (medial, ventral, rostral pocket) and **c.l.v.** (caudal, lateral, ventral pocket).

communication and mean time for injections with communication. A two-tail, T-distribution test of the data set for time taken between communicating and non-communicating joints was done to find the P value for significance.

3 | RESULTS

The described method to injecting the DMJ was successful across all 7 heads and 14 joints. Values for each head - the corresponding joint, time of injection, ultrasound grade, communication and success of DMJ penetration - are shown in Figure 6. All CT images showed contrast within the DMJ (Figure 5 A, B, C, D). There were two main pockets within the DMJ where the contrast accumulated: a pocket in the rostromedioventral aspect of the mandibular condyle that extended across the mandibular incisure, and the caudolateralventral aspect of the mandibular condyle extending up laterally and dorsally (figure 4). There was communication between the DMJ and DTJ in 4 joints, in 3 different heads demonstrating a rate of communication of 28.6%. Two of the communicating joints were on the same head, and of these two, the communication was along the lateral aspect of the joint in a lateral to medial, ventral to dorsal angle. In the other two joints, in separate heads, the communication was on the medial, dorsal aspect of the articular disk.

Additionally, the time it took to inject each joint ranged from 28.41 seconds to 2.24.38 minutes. The mean time for injection was 1.19.35 minutes. The time was affected by the image quality the investigator was able to achieve during ultrasound and the ease of positioning the needle into the joint. The left DMJ on head 1 was not timed.

The ultrasound image quality was all scored at a 2 or 3, apart from one, which scored a 1. The investigator had a clear image of the needle and/or gas at time of injection for all the joints which scored 2 or 3. The investigator did not get a clear image of needle and gas on the joint scored 1.

For the injection, 4mLs of contrast were prepared. During 3 of the procedures, the investigator experienced back pressure and was not able to inject the total 4mL contrast solution. In two additional joints, back pressure was experienced but 4 mLs was still injected. All CT scans showed extravasation of the contrast into the subcutaneous space.

4 | DISCUSSION

Based on injection of the 14 TMJs, the methodology was successful. We had a 100% success rate in penetration of the DMJ thereby accepting our first hypothesis. However, a 28.6% rate of communication into the DTJ was seen, so our second hypothesis was rejected. In the two communicating joints on the same head, the lateral to medial, ventral to dorsal angle is comparable to a needle track; in the investigator's opinion, this could be the cause of communication in head 5 right and left joints. This conclusion was reached by comparing the angle at which we inserted the needle into the DMJ and the path of communication through the articular disk. Head 1, right joint and head 3, left joint communicated on the medial, dorsal aspect of the articular disk. There are certain diseases that can cause communication, but this study did not investigate pathology or conformation of the joint, so we cannot draw conclusions as to why communication occurred here. [10] In all other joints, we concluded that no communication occurred with reference to WELLER et al. (2002) and Rodríguez et al. (2006). [15,21]

We used 4mL concentration of contrast solution to saturate the entire DMJ joint capsule, but due to the extravasation, we believe this volume is excessive. It is hard to determine a set concentration with backpressure occurring at varying amounts of volume, but going forward, we believe 1mL, used by WELLER et al. (2002), is a more appropriate volume. [21]

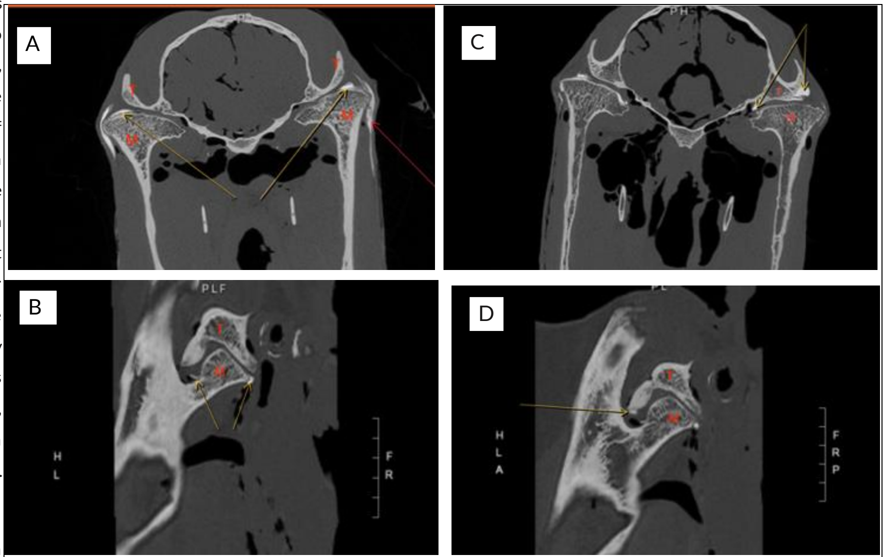

FIGURE 5: Four CT scans: (A) a coronal view of the right and left TMJ with contrast in the DMJ, (B) a sagittal view of the left TMJ with contrast in the DMJ, (C) a coronal view of the right and left TMJ with contrast that communicates into the DTJ, (D) a sagittal view of the left TMJ with contrast that communicates into the DTJ. (A, B) Yellow arrows point to contrast in the DMJ. Red arrow points to extraarticular contrast that is subcutaneous. (C, D) Yellow arrows point to contrast in the DTJ). M - Mandibular condyle, T - Temporal bone.

Head #	Joint	Time (min)	Contrast volume (mL)	Within the DMJ	Communication between DMJ and DTJ	Ultrasound grade 1-3
1	R	0.40.28	4	yes	yes	3
	L	n/a	4	yes	no	2
2	R	1.04.01	3	yes	no	2
	L	1.05.63	4	yes	no	2
3	R	1.25.59	4	yes	no	3
	L	0.32.95	4	yes	yes	3
4	R	2.24.38	4	yes	no	1
	L	1.09. 56	4	yes	no	3
5	R	2.00.23	4	yes	yes	3
	L	2.20.84	4	yes	yes	3
6	R	1.16.76	4	yes	no	3
	L	0.28.41	4	yes	no	3
7	R	1.13.17	2.5	yes	no	2
	L	1.29.72	3	yes	no	3

FIGURE 6: Shows the Head number, the corresponding joints, and how long it took for the investigator to inject the volume of contrast solution. It shows whether the contrast solution was visualized in the DMJ on CT, and if it communicated with the DTJ.

Time was recorded for each injection to discover if there was a correlation between time taken and success of penetration or communication. The time ranged 28.41 seconds to 2.24.38 minutes with a 1.19.35-minute average. With 100% success rate, time does not seem to influence penetration. The times, in minutes, we had for our communicating joints were: .40.28, .32.95, 2.00.23, 2.20.84. The average time for communicating joints was 1.23.58 minutes. The average time for the non-communicating joints was 1.17.47 minutes. The P-value from a two-tail, T-distribution of the data set is .7983 indicating this is not significant. The variable time is suspected to be due to the differing levels of difficulty to acquire the representative image of the DMJ for injection.

Ultrasound images and videos were taken to discover if there was a link between visualization of the needle and/or gas and success of penetration or communication. Since we had a 100% success rate of penetration into the DMJ, and grade 2 or 3 on all but one joint, we can infer ultrasound image quality does affect success of injection penetration. We cannot draw conclusions between image quality and communication; we had high image quality associated with communicating joints and our one low image quality associated with a noncommunicating joint. It is assumed accuracy of injection corresponds with good visualization and experience of the investigator.[11] Head 4, right joint with poor image quality, was injected halfway through the injection process, and it is of the investigators opinion the experience gained through the previous 6 joints aided in successful intraarticular injection without communication despite poor image quality.

We believe this approach could be used if good ultrasound visualization is achieved, but care should be taken to not extend the needle too far into the joint as to not penetrate the fibrocartilaginous disk. We believe that the approach could be altered to avoid iatrogenic communication due to the assumed needle track caused in head 5. There

should be a note of head 1 and 3 having communication on the dorsomedial aspect, but we are unable to determine a cause of this. Iatrogenic communication seems unlikely based on the location. Consequentially, if a practitioner is interested in using this technique, previous experience in ultrasound-guided injections would be advisable to limit side effects.

Limitations of this study are comprised of lack of history on the cadavers, use of only cadavers, lack of investigator's practice prior to, and the number of samples. There is potential for pathology of the TMJ that can cause communication of the joint,[10,14] but more research needs to be done on frequency and cause of communication in the TMJ with the DTJ[14]. Use of only cadaver heads limits potential issues that may arise in the live horse, particularly with the surrounding structures. In the live horse, the positioning and movement of the subject would be a consideration when attributing it to the increased risk of penetrating structures including, but not limited to, hypoglossal nerve, parotid gland, mandibular nerve, caudal ligament, rostral auricular artery.[15] In our study, we could have potentially eliminated iatrogenic changes depicted by needle tracks if the practice was done previously, still, our work was done with the idea inexperienced vets may use this technique. New graduates, or vets without previous ultrasound-guided injection experience attempting to inject the DMJ may find achieving an appropriate ultrasound image, and positioning the needle correctly, to be difficult. We believe the described method to be the most useful for veterinarians with experience in ultrasound-guided injections. It was useful to learn this is not an easily accomplished skill. Finally, if we had a larger sample size, then we would have more cadavers to hone our injection technique, a more significant rate of success, and determine if communication is a common side effect of the injection.

5 | CONCLUSION

This ultrasound guided injection technique had a 100% success rate of penetrating the DMJ. There is a risk of causing communication between the DMJ and DTJ, so care should be taken during injection.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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