Temporomandibular joint injections in dogs with temporomandibular joint pain: 11 cases (2015-2019)

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ABSTRACT

Objectives: To describe and evaluate the clinical application of temporomandibular joint injections using betamethasone and ropivacaine in German Shepherd dogs suffering from non-odontogenic orofacial pain due to temporomandibular dysplasia and/or osteoarthritis.

Materials and Methods: Outcomes in dogs presented with clinical signs of non-odontogenic orofacial pain associated to temporomandibular joint dysplasia and/or arthritis and treated with a temporomandibular joint injection were retrospectively-prospectively evaluated.

Results: The overall clinical signs free period ranged between 25 to 1579 days, with an average of 461 days. The clinical signs free period for temporomandibular joint osteoarthritis scores 1, 2 and 3 were on average 659 days (180-1579 days), 134 days (42-355 days) and 723 days (25-1377 days), respectively. Similarly the temporomandibular dysplasia scores 1, 2 and 3 were on average 306 days (26-1579 days), 1377 days and 669 days (25-1429 days) respectively. Those dogs in which only one side was injected the clinical signs free period average was 639 days (25-1578 days), compared with dogs in which both temporomandibular joints were injected showing a clinical signs free period average of 378 days (42-1377 days).

Clinical Significance: The temporomandibular joint injection technique proved to be feasible with a decent outcome in dogs suffering from non-odontogenic orofacial pain associated with temporomandibular joint osteoarthritis and/or dysplasia. Further randomised studies are required to confirm the effectiveness of this intervention.

INTRODUCTION

Arthrogenous conditions of the temporomandibular joint (TMJ) are a major cause of non-dental orofacial pain (Jerjes et al. 2008, Mountziaris et al. 2009, Arzi et al. 2013, Laskin 2020). These disorders in dogs are generally found in combination where more than one condition is present e.g., dysplasia and osteoarthritis (OA). OA of the TMJ is the most common disorder in dogs followed by fractures and TMJ dysplasia (Arzi et al. 2013). TMJ dysplasia is a congenital disease of unknown aetiology that affects young dogs and cats and it is the main differential diagnosis for open-mouth jaw locking (Arzi & Lantz 2020). The clinical signs of degenerative joint disease in the human TMJ include pain, joint clicking, crepitation on manipulation of the mandible and decreased range of motion of the mandible

(Hegab et al. 2015, Gracis & Zini 2016). Similar clinical signs have been reported in the veterinary literature (Arzi et al. 2013, Lerer et al. 2014), with the variable severity of TMJ dysplasia influencing the age of onset, frequency and duration of open-mouth jaw locking, as well as the variety of radiological signs (Lantz & Cantwell 1986). Several non-surgical approaches have been proposed to treat disorders affecting the TMJ in humans. These include occlusal splint therapy, physiotherapy, pharmacotherapy, joint injection and arthrocentesis (Dionne 1997, Nikolakis et al. 2002, Yura et al. 2003, Turp et al. 2004, Mountziaris et al. 2009, Hegab et al. 2015, Zhang et al. 2016), with no such treatments been described in dogs so far. Condylectomy has historically been described (Bennett & Prymak 1986) but it is not advisable due to the high probability of further mandibular instability (Arzi & Lantz 2020).

Intra-articular corticosteroid injections are commonly used for the treatment of symptomatic OA in human medicine due to their anti-inflammatory and immunosuppressive effect (Yaftali & Weber 2019). Corticosteroids are commonly combined with a local anaesthetic agent such as ropivacaine to help ameliorate the pain related to the injection process (Yaftali & Weber 2019). This local anaesthetic agent works by inhibiting nerve excitation through specific Na^+ channels on the neural cell membranes thus causing local analgesia (MacMahon et al. 2009). In animals, the use of corticosteroids have been well described in equine medicine, where they have been used for the past half century to treat joint diseases (Caron 2005). Its value in dogs have been reported in experimental studies where a canine OA-induced model was used to evaluate corticosteroids in vivo effects with very good outcomes (Vandeweerd et al. 2015). Other substances including sodium hyaluronate and platelet-rich plasma have been used for the diagnosis and treatment of arthralgia in dogs with varying results (Hellstrom et al. 2003, Van Vynckt et al. 2010, Cabon et al. 2019, Venator et al. 2020)

The aims of this manuscript were: (1) to describe the technique for TMJ injection in the dog and (2) a retrospective-prospective case series was done to describe the response and progression of 11 clients owned dogs that underwent TMJ injection with betamethasone and ropivacaine for the treatment of TMJ related pain.

MATERIAL AND METHODS

Using the key words TMJ, injection, dysplasia and OA a search of the dentistry and maxillofacial referral service at the Onderstepoort Veterinary Academic Hospital of the Faculty of Veterinary Science of the University of Pretoria case logs between January 2015 and December 2019 was performed. The medical records and CT images of the heads of client-owned dogs were reviewed for those dogs identified. These dogs were evaluated because of pain the TMJ represented by a combination of the following signs: unwillingness to open the mouth, reduced mandibular vertical range of motion, reduced or absent vocalisation, crying when opening the mouth, not eating hard food, not playing with toys, cries and/or moves head away when the TMJ area was palpated, withdrawn behaviour, not socialising with other pets. Dogs were included in this study if they showed CT signs of TMJ dysplasia and/or TMJ OA, were not under any analgesic treatment, and had no history of trauma to the craniofacial region. The age, sex, breed, skull conformation, bodyweight, history and clinical signs were recorded and analysed for each dog enrolled in the study. Follow-up visit records were also retrieved.

Image acquisition and evaluation

An oral examination and dental charting was performed followed by a CT scan. Ten of the dogs underwent an institutional head helical CT examination in sternal recumbency using a dual slice scanner (Siemens Emotion Duo with sliding gantry; Siemens Medical Systems, Forchheim, Germany). The CT images were reconstructed into the appropriate multiplanar soft tissue and bone windows with transverse slice thickness of 1 mm, but in two cases, the slices were 1.5 and 3 mm thick, respectively. Case 6 was referred with already obtained CT images using a 32-slice scanner (GE Medical Systems Optima CT660, Pollards Wood, Chalfont St Giles Buckinghamshire, United Kingdom) with 2.5-mm slice thickness. Digital Imaging and Communication in Medicine (DICOM) images were evaluated individually on personal computers utilising varying DICOM interpretative programs. Window levels, window widths and magnification were adjusted as needed in order to optimise visualisation of pathology. The whole head was examined by board certified veterinary radiologist (RMK) to ensure there was no non-TMJ-related pathology potentially causing orofacial pain such as root fractures, tooth resorption, periapical radiolucencies, foreign bodies, infection or neoplasia. The presence of minor other pathology was noted but not reported on if deemed not to influence the current study.

The CTs were then reviewed in a bone algorithm by a board certified veterinary radiologist (RMK), a recognised specialist in veterinary dentistry (GS) and a board eligible resident in veterinary dentistry (JCAR) to evaluate TMJ dysplasia and OA and a consensus opinion obtained. The OA evaluation was based on a previously described a 4-point semi-quantitative system giving an overall subjective grading of 0-3 (absent, mild, moderate or severe) for each joint by each evaluator (Arzi et al. 2013). The presence of TMJ dysplasia, irrespective of breed predisposition, was given an overall subjective grading of 0-3 as above. The diagnosis was based on the presence of any or a combination of the following abnormalities: A flattened mandibular head of the condylar process and mandibular fossa, mandibular head of the condylar process subluxation and minimal or no retroarticular process was evaluated on sagittal reconstructed slices made over medial 25% of the joint; and an undulating mandibular head of the condylar process, medial, central or lateral widening of the joint space and obliquity of the joint relative to the base of the skull was evaluated on transverse slices.

Institutional ethics approval was granted (V116-17) for the use of a cadaver for descriptive purposes, as well as the prospective section of the study (the last five patients included in this study).

Technique description

In order to access the TMJ for injection, an imaginary line was drawn from the lateral canthus of the eye to the palpable wing of the atlas (Fig 1A, B). The ventral border of the zygomatic process of the temporal bone was followed caudally and where it intersected with the described line, the index finger was placed over the surgically prepared skin. At the same time, an assistant opened and closed the mandible in order to feel the most central point of the lateral aspect of the condylar process. A depleted elastoplast roll was used as a fulcrum and placed between the maxillary and mandibular premolar and molar teeth, and the mouth closed over it, which allowed gentle widening the joint space. A 22 g × 1 1/4″ hypodermic needle (Terumo needle, Terumo (Philippines) Corp, Binan, Laguna, Philippines) was inserted carefully into the TMJ to a depth of 10-15 mm depending on the size of the patient. For demonstration purposes, the positioning of the needle was confirmed with a CT scan in an

adult mesocephalic dog cadaver (Fig 2A). Thereafter 1 mL of contrast medium (Omnipaque™ (iohexol) 300 mg/mL, GE Healthcare) was injected in the joint space and the CT scan repeated to visualise the distribution of the fluid within the TMJ (Fig 2B).

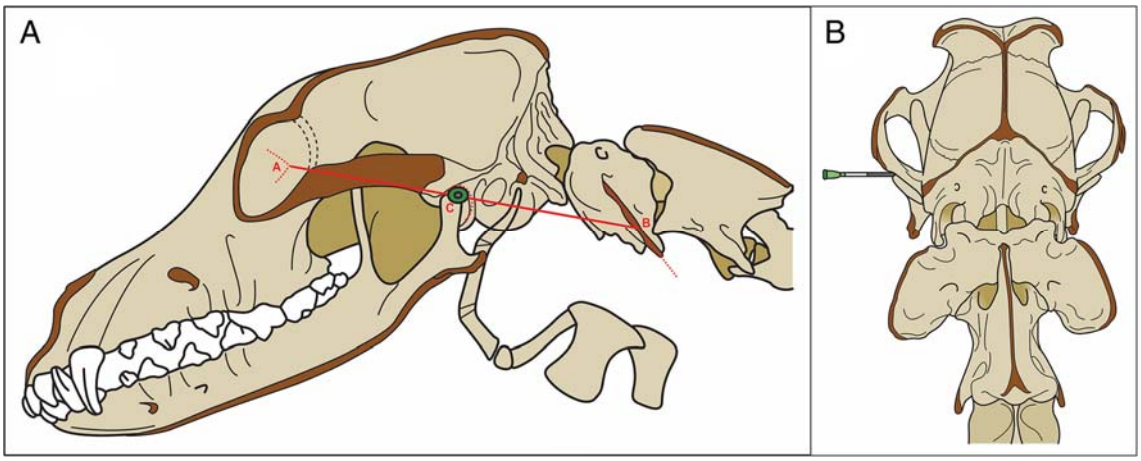

FIG 1. (A) The temporomandibular joint (TMJ) is located by drawing an imaginary line from the lateral canthus of the eye (A) to the palpable wing of the atlas (B) with the neck in a neutral position; the temporomandibular joint (C) is located just dorsal to the midpoint between A and B. (B) Caudodorsal view of the location for the insertion of the needle into the TMJ space

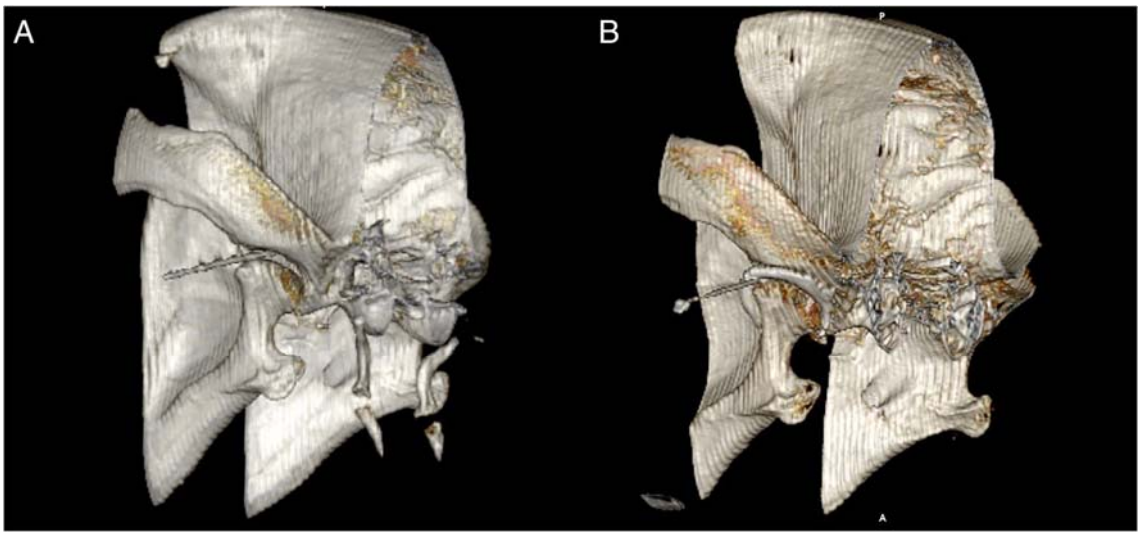

FIG 2. Volume-rendered CT image of a cadaver demonstrating (A) the presence of the needle in the left temporomandibular joint space, (B) and after injection the horseshoe shaped distribution of the contrast media in the peripheral aspect of the left temporomandibular joint space. Needle still present

Study design

In the clinical cases with both TMJs showing signs of dysplasia and/or OA, the client was informed that only one side was going to be treated, in order to confirm the problematic joint. The joint to be injected was selected based either on the clinical examination, or on the relative severity of OA or dysplasia on CT. If the patient did not respond to treatment within 72 hours, the contralateral joint was injected. If, after this second procedure, the patient still did not respond, a third procedure was performed at least 2 weeks after the last injection,

when both joints were injected. In three of the dogs, the clients on initial presentation requested both joints to be injected due to the long distance they needed to travel for treatment.

Dogs were premedicated with morphine hydrochloride (0.3 mg/kg [10 mg/mL], subcutaneously, sc. Morphine Hydrochloride 10 mg/mL, Pharma-Q holdings) 20 minutes before induction. General anaesthesia was co-induced according to a standard protocol with propofol (6 mg/kg, [10 mg/mL], intravenously, iv. Fresenius Propoven 1%, Fresenius Kabi AB) and diazepam (0.2 mg/kg [15 mg/3 mL], iv. Diazepam inj 10 mg/2 mL, Pharma Q holdings) given to effect. Orotracheal intubation was performed and anaesthesia maintained by administration of isoflurane (Isofor, Safeline Pharmaceuticals) carried in oxygen, delivered through a semi-closed circle system. Dogs were positioned in lateral recumbency with the affected TMJ uppermost. The skin surrounding the TMJ was clipped free of hair. The surgical site was aseptically prepared by washing with a chlorhexidine gluconate soap (Accu-Dil™ 0.05%, Accu-Sol) (three times) followed by spraying the area with a chlorhexidine gluconate and alcohol solution (Biotane™ in alcohol, B-Braun Medical). The solution was applied three times, wiped off the first two times and then left on the skin during routine draping. After inserting the needle a 3-mL Luer lock syringe (Avacare™, Avacare Health) preloaded with ropivacaine (2 mg/kg Naropin 10 mg/mL Polyamp®AstraZeneca Pharmaceuticals) and betamethasone (0.1 mg/kg [4 mg/mL]. Celestone® Soluspan® injection, MSD) was locked to the inserted needle. The function of the ropivacaine was to provide acute pain relief of the joint, either from the pre-existing condition or from the injection itself. Careful aspiration before and during injection was performed to prevent intravascular injection. Swelling around the injection area or resistance to injection was indicative of extra-articular injection. Similarly, no resistance to injection was taken as a successful injection and if any latent backpressure was felt the injection was stopped as it was presumed the joint was adequately distended with the medication.

Outcome evaluation

Due to the distance many of the dogs travelled to seek treatment a follow-up physical examination was not feasible. Clients were thus contacted telephonically 72 hours after the procedure and a subjective evaluation based on a numerical rating scale (NRS) questionnaire was performed (Table 1). All clients were instructed to contact the clinic if any of the clinical signs returned after treatment. Further telephonic follow-ups were performed before composing this manuscript to evaluate the long-term outcome of the treatment. All clients were advised to prevent any tug of war play, sleeve work, chewing on rawhides or hard toys for a period of 7 days.

Table 1. Numerical rating scale (NRS) questionnaire used to evaluate success of dogs subjected to TMJ injections minimum score = 0, maximum score = 16

1) Has the type of food you feed your dog changed compared to the past? (0-3)
- No, it's the same type (0) -Gone from dry to mixed (1) -Gone from mixed to wet (2) -Gone from dry to wet (3) 2) Has the feeding behaviour of your dog changed compared to the past? (0-2) - Nothing has changed (0) -Eats slower (1) -Eats less (2) 3) How do you rate the level of willingness to play/interact with people and/or other pets compared to the past? (0–2) - The same as before (0) -Plays less (1) -Does not play at all (2) 4) Does your pet shows any of the following behaviours? (0-9) • Absent or reduced vocalisation (1) • Withdrawn (1) • Cries when trying to yawn (1) • Cannot open the mouth as before (1) • Increased aggressiveness (1) • Paws at the face (1) • Does not want to play with toys (Used to) (1) • Cries and/or Moves head away when the TMJ area is touched (1) • Avoids face to be touched (1) • None of the above (0)

RESULTS

Thirty-seven cases were identified using the keywords TMJ, injection, OA and dysplasia. Sixteen cases were excluded because of the presence of a fracture affecting the mandibular head of the condylar process (n = 2), signs of craniomandibular osteopathy (n = 4), TMJ subluxation (n = 2), temporomandibular ankylosis (n = 7) and the presence of a foreign body in the joint space (n = 1). Between January 2015 and December 2019, 11 dogs were presented that fitted the inclusion criteria (Table 2). Eight different dog breeds were seen, five with mesocephalic, five brachycephalic and one with dolichocephalic skull conformation.

Table 2. The signalment of dogs injected and their outcome

PN	BREED	AGE	SEX	WEIGHT (KG)	DIAGNOSIS	OA SCORE (R/L)	TMJ AFFECTED	SIDE INJECTED (FIRST TREATMENT)	CSFP (DAYS)	SIDE INJECTED (SECOND TREATMENT)	CSFP (DAYS) (SECOND TIME)	CONDYLECTOMY
1	English Bulldog	1 year 4 months	NF	22	Dysplasia/OA	1/1	B	R	1579			No
2	cocker spaniel	2 years	F	10.6	Dysplasia/OA	3/3	B	L	708	L	785	No
3	golden retriever	1 year 9 months	NF	26	Dysplasia/OA	1/2	B	L	61			Yes (L)
4	Maltese	8 years 1 months	NF	4	Dysplasia/OA	1/1	B	L	1429			No
5	boxer	5 years 6 m	M	43	Dysplasia/OA	3/3	B	B	1377			No
6	dachshund	6 years	NF	6.6	Dysplasia/OA	2/1	B	L	317			No
7	boxer	4 years	NM	38.4	Dysplasia/OA	2/3	B	B	42	L	25	Yes (L)
8	Scottish terrier	1 year 6 months	NM	11.4	Dysplasia/OA	1/1	B	L	26	B	240	No
9	GSD	4 years 11 months	M	42.5	Dysplasia/OA	2/2	B	B	76	B	355	No
10	English Bulldog	1 year 3 months	M	25.6	Dysplasia/OA	1/1	B	L	30	B	180	No
11	English Bulldog	10 years 7 months	NM	21.2	Dysplasia/OA	2/1	B	L	210			No

CSFP Clinical signs free period, F Intact female, L Left, M, Intact male, NF Neutered female, NM Neutered male, OA Osteoarthritis, PN Patient number, R Right, TMJ Temporomandibular joint

Ages ranged from 1 year 3 months to 10 years 7 months, with a median of 4 years. The weight ranged from 4 kg to 43 kg, with mean weight of 22.8 kg. Two of the dogs were security dogs, the rest were pets. The clinical signs included decreased vertical mandibular range of motion (n = 11), reduced vocalisation (n = 4), difficulty in yawning (n = 7), pain when the mouth was opened by the owner or veterinarian (n = 11), pawing at the side of the face (n = 3), withdrawn (n = 5), not wanting to play with other pets (n = 8), not willing to eat dry food (n = 8) and eats slower (n = 10).

On CT examination all dogs had varying grades of OA bilaterally, four had bilateral mild signs and three bilateral severe signs (Table 3). Ten dogs had bilateral TMJ dysplasia and one had only one joint involved. Five dogs had severe dysplasia with two of these having moderate dysplasia of one joint. The remaining six dogs only had mild dysplasia (Table 4). Only three dogs had concomitant bilateral moderate to severe OA and TMJ dysplasia. Examples of TMJ pathology are given in Figure 3.

Table 3. Comparison of the TMJ OA scores using a semi-quantitative method described by Arzi et al. of dogs treated for TMJ pain; OA score (0-3)

PATIENT NUMBER	EVALUATOR 1 SCORE (R/L)	EVALUATOR 2 SCORE (R/L)	EVALUATOR 3 SCORE (R/L)	CONSENSUS OA SCORE (R/L)
1	1/1	1/1	2/1	1/1
2	2/2	3/3	3/3	3/3
3	1/2	1/2	1/2	1/2
4	1/1	1/1	1/1	1/1
5	2/2	3/3	3/3	3/3
6	2/1	2/1	2/1	2/1
7	2/3	2/3	2/3	2/3
8	1/1	1/1	1/1	1/1
9	2/2	3/2	2/1	2/2
10	1/1	1/1	1/1	1/1
11	2/1	2/1	2/1	2/1

L Left, OA Osteoarthritis, R Right, TMJ Temporomandibular joint

Table 4. Comparison of the TMJ dysplasia scores using a semi-quantitative method of dogs treated for TMJ pain; TMJ dysplasia score (0-3)

PATIENT NUMBER	EVALUATOR 1 SCORE (R/L)	EVALUATOR 2 SCORE (R/L)	EVALUATOR 3 SCORE (R/L)	CONSENSUS TMJ DYSPLASIA SCORE (R/L)
1	1/1	1/1	1/1	1/1
2	2/1	2/3	3/3	2/3
3	2/1	1/2	1/1	1/1
4	3/3	3/3	3/2	3/3
5	3/2	1/2	3/3	3/2
6	3/3	3/3	3/3	3/3
7	3/2	3/3	2/3	3/3
8	1/1	2/1	1/1	1/1
9	1/1	1/1	1/1	1/1
10	1/1	1/1	2/2	1/1
11	1/1	0/0	0/1	0/1

L Left, OA Osteoarthritis, R Right, TMJ Temporomandibular joint

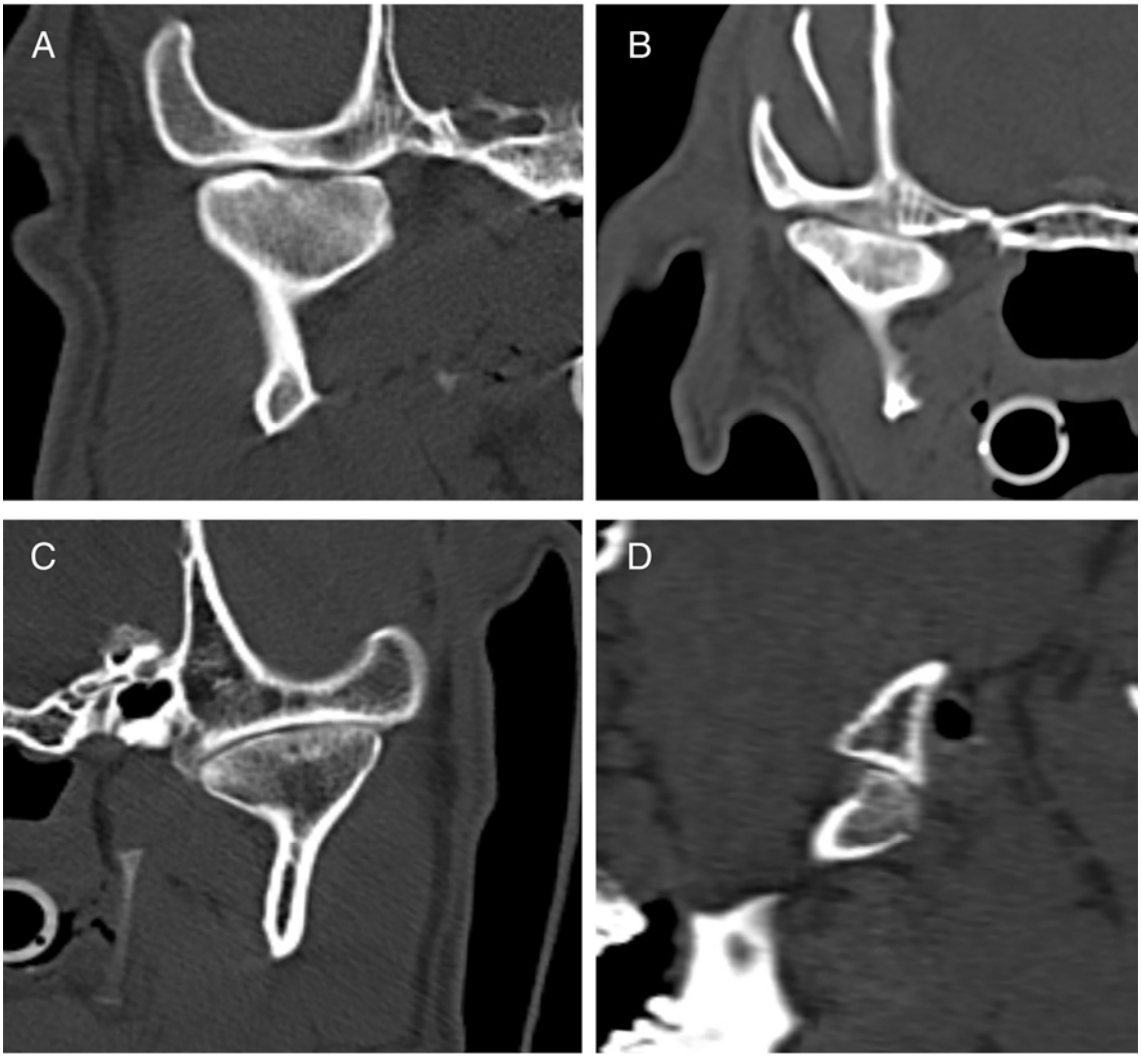

FIG 3. Transverse CT images in a bone window. (A) The left temporomandibular joint (TMJ) of dog 5 with grade 3 OA and grade 2 dysplasia. Note the undulating condylar process with marked subchondral sclerosis laterally and narrowed joint space medially. Osteophyte on medial aspect of the mandibular condyle. (B) The left TMJ of dog 2 with grade 3 OA and grade 3 dysplasia. Note with markedly narrow joint space, undulating mandibular fossa with associated widened joint space laterally. Osteophyte on medial aspect of the mandibular condyle. Mild angulation of the joint to the horizontal plane. (C) The right TMJ of dog 7 with grade 2 OA and grade 3 dysplasia. Note narrowed curved joint space with mandibular fossa subchondral sclerosis and marked angulation of the joint to the horizontal plane (D) Sagittal reconstruction CT of dog 7 right TMJ in C above. Note shallow mandibular fossa with lack of a retroarticular process and subluxation of the mandibular head of the condylar process

Of the 11 dogs, three (27.27%) had both TMJs injected, seven (63.63%) had the left and one (9.1%) had the right TMJ injected. While injecting the TMJs no aspiration of synovial fluid was possible in any of the joints injected.

The overall owner-observed clinical signs free period (CSFP, time elapsed since resolution of clinical signs) based on a NRS improvement ranged between 25 to 1579 days, with an average of 461 days. The NRS before treatment ranged between 5 and 11 points, with an average of 8 points. The NRS after injection ranged between 0 and 4 points, with an average of 1 point. The NRS of all dogs are represented in Table 5.

Table 5. Representation of the numerical rating scale (NRS) scores before and after treatment of dogs treated for TMJ-related pain with TMJ injection

PATIENT	PRE-TREATMENT NRS	POST-TREATMENT NRS
1	10	0
2	7	0
3	6	0
4	7	0
5	8	0
6	8	2
7	10	2
8	9	0
9	8	3
10	11	4
11	5	0

The CSFP for TMJ OA score 1, 2 and 3 was on average 659 days (180-1579 days), 134 days (42-355 days) and 723 days (25-1377 days), respectively. Similarly the temporomandibular dysplasia scores 1, 2 and 3 were on average 306 days (26-1579 days), 1377 days, and 669 days (25-1429 days), respectively. Those dogs in which only one side was injected, the CSFP average was 639 days (25-1578 days), compared with dogs in which both TMJs were injected showing a CSFP average of 378 days (42-1377 days). The comparison of OA and dysplasia scores with their correspondence CSFP is represented in Table 6.

Table 6. Comparison of the TMJ OA and TMJ dysplasia scores with their CSFP in dogs treated with TMJ pain; OA score (0-3) TMJ dysplasia score (0-3)

PATIENT NUMBER	CONSENSUS OA SCORE (R/L)	CONSENSUS TMJ DYSPLASIA SCORE (R/L)	CSFP FIRST INJECTION R/L/B	CSFP SECOND INJECTION R/L/B
1	1/1	1/1	1579 (R)	
2	3/3	2/3	708 (L)	785 (L)
3	1/2	1/1	61 (L)	
4	1/1	3/3	1429 (L)	
5	3/3	3/2	1377 (B)	
6	2/1	3/3	317 (L)	
7	2/3	3/3	42 (B)	25 (L)
8	1/1	1/1	26 (L)	240 (B)
9	2/2	1/1	76 (B)	355 (B)
10	1/1	1/1	30 (L)	180 (B)
11	2/1	0/1	210 (L)	

B Both, L Left, OA Osteoarthritis, R Right, TMJ Temporomandibular joint

In six dogs (dogs 2, 3, 7, 8, 9 and 10), the injection procedure worked initially and the dogs became asymptomatic (Table 2). On return of the clinical signs, dog 3 received a condylectomy, dogs 2, 7 and 9 received a second treatment in the same joint; dogs 8 and 10 had both joints treated. The repeat treatment in dog 7 lasted 25 days; a condylectomy was performed. At the time of submission, patient 3 (1380 days) and patient 7 (630 days) remains asymptomatic. The repeated injection in dogs 8, 9 and 10 lasted 240, 355 and 180 days respectively; these dogs remain asymptomatic at the time of submission of this manuscript (Fig. 4).

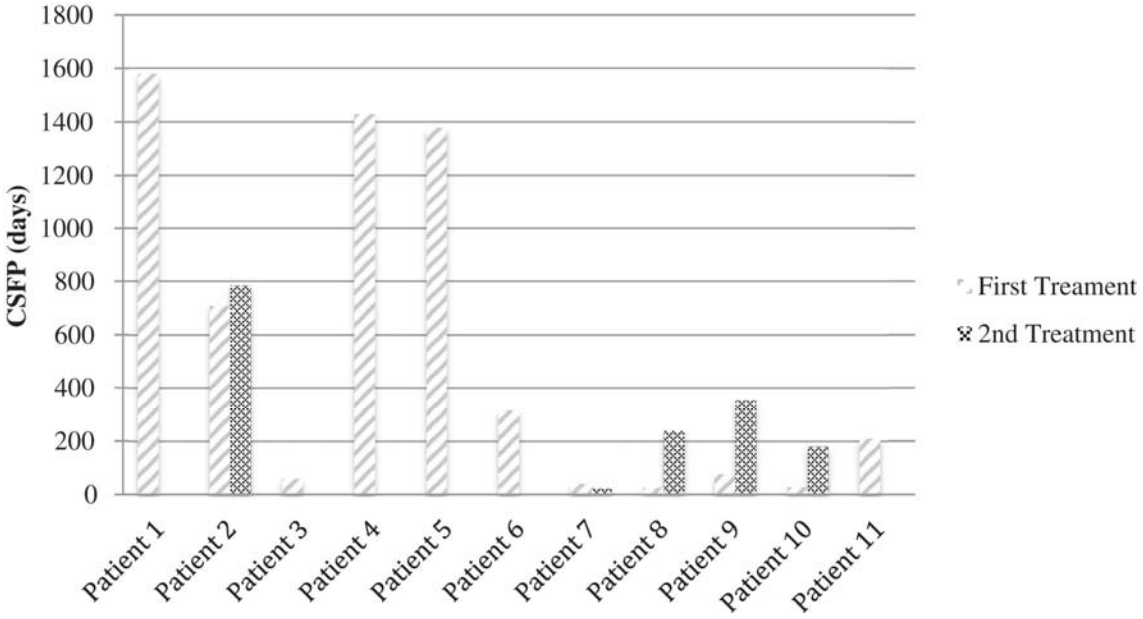

FIG 4. Representation of the clinical signs free period (CSFP) after the first and second temporomandibular joint (TMJ) injection in 11 dogs suffering from TMJ OA/dysplasia

No major complications were encountered during or after completion of the injections. A minor complication was recorded in patient 8, where a haematoma formed in the area where the skin was punctured. This hematoma resolved uneventfully with no apparent discomfort to the patient.

DISCUSSION

TMJ OA is the most common TMJ disorder with a prevalence of 78% in a case series of dogs, which is similar to that for human patients (Arzi et al. 2013). In the above study, all dogs with TMJ dysplasia also had OA, which also was the case in our study.

Other conditions that can present with similar clinical signs to TMJ pain are soft tissue lesions in the mouth, tooth fractures, tooth resorption, masticatory muscle myositis, osteomyelitis, neoplasia, retrobulbar abscesses, cellulitis due to foreign bodies, middle and inner ear pathology, cranio-maxillomandibular fractures, tetanus, craniomandibular osteopathy and TMJ ankylosis or pseudoankylosis. All of these can potentially be ruled out based on clinical and CT examination. The final diagnosis of TMJ OA was solely based on clinical and CT findings as well as response to intra-articular treatment. The authors were not able to aspirate synovial fluid in any of the dogs. We believe the reason for this may be twofold; firstly there is a small volume of synovial fluid present and secondly the fact that they were lying in lateral recumbency with the small amount of synovial fluid accumulating at the most medial aspect of the joint due to gravity. Exfoliative cytology of the synovial fluid would have been able to reinforce the CT diagnosis of TMJ OA (MacWilliams & Friedrichs 2003).

All dogs included in this study showed clinical signs of reduced range of motion and pain when opening and closing the mouth which is in agreement with the clinical signs reported by Arzi et al. (2013). Of interest from our case series was that all dogs had CT evidence of degenerative changes, with 54.54% (6/11) of the dogs treated having grade 1 OA in the joint

treated. Furthermore, it is known that 26.66% of dogs showing signs of TMJ OA are symptomatic (Arzi et al. 2013). Hence, there is a marked variability in pain sensation among individuals with TMJ OA, with poor correlation between severity and clinical signs (Arzi et al. 2013). It is important to remark that the CT of the heads image acquisition was performed with 1-3 mm slice thickness, which could have potentially under diagnosed the OA/Dysplasia severity of some of the TMJs evaluated, a slice thickness of ≤1 mm when possible is recommended to evaluate pathology in the TMJ (Arzi et al. 2013). The reduced range of motion and pain in humans are a consequence of a protective spasm reflex of the masticatory muscles and soft tissues around the joint (Hilton 2009); this is in accordance to Hilton's law, which states that the joint and the muscles that move that joint share the same neural innervation (Hilton 2009). This explains why the maximal vertical mandibular range of motion in dogs increases as the pain in the joint is controlled (Gracis & Zini 2016). Due to the nature of some of the dogs (aggressive towards the veterinarian), a pre-treatment inter-incisival distance to evaluate the vertical mandibular range of motion was not recorded objectively. Additionally, the majority of dogs did not come back for a follow-up examination; hence no follow-up measurement was recorded as an objective evaluation of the outcome. Thus, the evaluation of the clinical outcome of this study relied entirely on the answers given in the NRS questionnaire. This is a limitation of this study, as the primary care giver is the one evaluating the outcome of the therapeutic treatment, and could have resulted in a placebo effect biasing the answers from the owners to the NRS questionnaire. The fact that all of the dogs were treated unsuccessfully with oral analgesics and anti-inflammatories before referral shows that the resolution of the most common clinical symptom (pain when the mouth was opened by the veterinarian or owner) although subjective, is a positive outcome of the therapy described here. In order to avoid this placebo effect, a case-control double-blinded clinical trial should be done next together with the measurement of the vertical mandibular range of motion pre- and post-treatment. Unfortunately, because of the main retrospective nature and small number of cases treated this was not possible.

Some of the dogs received more than one injection as a poor response to the first injection implied the wrong joint was treated; this was to be expected, as there is no correlation between the CT findings and the presence or intensity of clinical signs as described earlier. This was further reinforced by the fact that there were three dogs showing bilateral signs of moderate to severe OA and TMJ dysplasia, with two of them showing a CSFP ranging between 708 and 1377 days which was well above the overall average of 461 days; the remaining dog showed a poor response to treatment with CSFP of 42 days initially and 25 days after second injection. A total of six dogs (54.54%) showed a good agreement between TMJ OA and dysplasia scores; which was associated with a longer CSFP. This finding can potentially be used as a prognostic indicator for treatment success.

There is scant information available regarding treatment of canine TMJ OA and dysplasia. All reports address open mouth jaw locking, a condition that often presents secondary to TMJ dysplasia (Hoppe & Svalastoga 1980, Lantz & Cantwell 1986).

The main movement in human TMJs is translation. This is in contrast to dogs, where translational movement is minimal, although it is possible that varying skull morphology may have different levels of congruency and translation (Lin et al. 2018). Due to this functional difference, the therapeutics applied in humans to improve TMJ OA may not have the same efficacy in dogs. Furthermore, as the dog's TMJ intra-articular space is very narrow and cannot be increased through translation, the introduction of very viscous substances, especially in small dog may be difficult. Indiscriminately inserting large bore needles into

this narrow space may cause mechanical damage to the joint cartilage and should be avoided, hence the importance of using a fulcrum between the maxillary and mandibular premolar and molar teeth to widen the joint space before needle insertion. The aspiration of synovial fluid from the TMJ would confirm needle location in the joint space but no fluid could be aspirated in any of our dogs; however, using our described landmarks, and with practice, joint entry was found reasonably easy. Although the confirmation of needle location using CT is advisable, it is not a readily available modality in veterinary practices and the lack thereof should not prevent patients being treated. The use of standard digital radiographs or ultrasound should also be considered to help with needle positioning.

Several corticosteroids have been used intra-articularly in human TMJs (Kopp et al. 1987, Wenneberg et al. 1991, Tanaka et al. 2008), with betamethasone, a particulate steroid that is non-soluble with poor systemic absorption, being the preferred intra-articular drug for the treatment of arthrogenous conditions (Kopp et al. 1987, Wenneberg et al. 1991, Gencer et al. 2014). Corticosteroids are anti-inflammatory drugs that interrupt inflammatory and immune pathways. They act on synovial tissue and reduce effusion, decrease pain and cause and increase in range of motion of synovial joints. Its use is well documented in the human TMJ (Kopp et al. 1987, Wenneberg et al. 1991, Bellamy et al. 2006, Bjornland et al. 2007, Tanaka et al. 2008, Araujo et al. 2016, Kiliç 2016, Favero et al. 2017, Sun et al. 2017) but not in the canine TMJ. Our results using betamethasone in dog's TMJ are in agreement with human studies that showed a significant reduction of TMJ pain and improved function with intra-articular corticosteroid therapy. (Kopp et al. 1987, Wenneberg et al. 1991, Gencer et al. 2014).

Caution should be exercised when using betamethasone preparations that contain benzalkonium chloride, as it increases the chondrotoxicity (Hegab et al. 2015). Total dosages of benzalkonium chloride lower than 2.1 mg caused no significant cartilage damage or cell death, while higher dosages were associated with significant chondrotoxicity (Ozcamdalli et al. 2017). We used betamethasone containing 0.2 mg/mL of benzalkonium chloride, which is 10 times lower than the human chondrotoxicity threshold in humans.

During injection of the TMJ, the volume of fluid within the joint is increased, which stimulates the nociceptive and proprioceptive receptors resulting in pain and discomfort. A local anaesthetic will thus help block these stimuli. Three different local anaesthetics are routinely injected into synovial joints, lidocaine, bupivacaine and ropivacaine (Jayaram et al. 2019). The toxicity of ropivacaine is dose dependent, showing toxicity in concentrations above 0.75%. Diluting the ropivacaine with betamethasone in our study reduced the concentration to below the toxic level. Furthermore, lidocaine and bupivacaine are chondrotoxic independently of their concentrations (Jayaram et al. 2019).

The drugs were injected indiscriminately in the dorsal or ventral compartment of our dogs TMJs as the CT images could not distinguish the compartments; however, it is more likely to have been the dorsal compartment as it has a bigger volume (Evans & Lahunta 2013). Furthermore, the medication can potentially distribute from the dorsal to the ventral compartment and vice versa in dogs suffering from disc perforation, a very rare finding in dogs (Lin et al. 2018). Disc perforation can only be diagnosed in dogs on MRI or double contrast radiography (Lin et al. 2018). In dogs with an intact disc, the medication will stay in the injected compartment, potentially resulting in partial resolution of the clinical signs and being recorded as a failed treatment. The volume of fluid injected in the TMJ may also help

release any adhesions within the joint space resulting in better mobility and increased range of motion.

The current case series showed that grade 3 OA TMJs had on average the longest CSFP compare to those of grades 1 and 2; this is in agreement with previously published data in human medicine (Weitoft & Uddenfeldt 2000) where radiological scores were not a prediction of outcome to corticosteroid injection. If immediate (within 24 hours) or incomplete pain relief is not achieved, then either the injection was not placed intra-articularly or the source of pain was only in part intra-articular or not at all. This could be the reason why 46% some of the dogs may have needed a second injection although 63.63% of cases responded to the first injection. In these dogs, the first injection procedure also confirmed the problematic joint. The wide range of CSFP reported here (25-1579 days), is similar to what is reported in human medicine (14-2920 days) (Wenneberg et al. 1991).

In exceptionally painful non-responsive, condylectomy may be considered if joint injections are not effective. There are several postoperative complications associated with the procedure including mandible retrusion, drifting, malocclusion and degeneration of the opposite condyle (Lantz & Verstraete 2012). In humans it has also lead to further deterioration and pseudo-joint degeneration on the operated joint (Tanaka et al. 2008).

TMJ injection using betamethasone and ropivacaine is a feasible method to treat dogs suffering from non-odontogenic orofacial pain associated with TMJ OA and dysplasia. The long-term results are promising with an overall average of 461 days of CSFP achieved.

Conflict of interest

This study received no financial support from any source. The authors declare no conflict of interest.

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