

## Analgesic effect of intra-articular ropivacaine injection after arthroscopic surgery on the shoulder joint in dogs

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**ABSTRACT:** Shoulder joint disorders are a major cause of forelimb lameness in dogs, and osteochondrosis, degenerative joint disease, and bicipital tenosynovitis are common joint disorders that have been reported in dogs. Many studies have investigated pain management after arthroscopy in human medicine, but reports from veterinary medicine are rare. Ropivacaine is a new amide local anaesthetic drug and a single isomer drug that is used more widely than bupivacaine in human medicine because it has fewer side effects. The present study was conducted to evaluate the analgesic effect of intra-articular injection of ropivacaine after arthroscopic surgery in dog shoulder joints. To accomplish this, ten dogs were randomly divided into two groups of five who underwent the same anaesthesia protocol and shoulder arthroscopic examination. After shoulder arthroscopy, ropivacaine or 0.9% NaCl was injected into the shoulder joint cavity and the dogs were evaluated at one hour, two hours, four hours, six hours, 12 hours and 24 hours after surgery. The evaluated parameters were heart rate, respiratory rate, lameness score, visual analogue scale and the short form of the Glasgow composite measure pain scale. Ropivacaine showed a higher analgesic effect than 0.9% NaCl, indicating that it may be useful for pain management following arthroscopic surgery in dogs.

**Keywords:** forelimb; lameness; VAS; CMPS-SF

In veterinary surgery, relief of postoperative pain has recently become an essential procedure to reduce the physical effects of postoperative pain and to address ethical issues in veterinary practice (Crane 1987; Mathews et al. 1996). Various studies have been conducted to investigate the relief of postoperative pain using parenteral opioids, local anaesthetics and epidural anaesthetics (Hoelzler et al. 2005; Aarnes et al. 2014; Abimussi et al. 2014; Lewis et al. 2014; Albuquerque et al. 2015). Opioids such as tramadol, butorphanol and morphine, are well-known and effective analgesics, but they can cause sedation, dysphoria and respiratory and cardiovascular depression (Soto et al. 2014).

Intra-articular injection of local anaesthetics with adjuvants has been introduced as an alternative to post-operative analgesia (Rauser et al. 2005; Vintar et al. 2005), and most studies con-

ducted to date have reported that intra-articular injection of a drug is sufficiently effective for diagnostic procedures (Boden et al. 1994; Convery et al. 1998; Moiniche et al. 1999; Rauser et al. 2005). Ropivacaine (s-(–)-1-propyl-2',6'-pipecoloxylidide hydrochloride monohydrate) is a new amide local anaesthetic single isomer drug (McCrae et al. 1995). Ropivacaine is similar in chemical structure to bupivacaine but has a propyl group instead of a butyl group on the piperidine nitrogen atom (McCrae et al. 1995; Morton 1997). Bupivacaine has been employed in clinical use for more than 30 years, especially as extradural analgesia for labour (McCrae et al. 1995; Morton 1997). However, bupivacaine may cause motor block and can potentially elicit cardiotoxicity and central nervous system (CNS) toxicity (Albright 1979; Yarnell et al. 1990; Morton 1997; Merson 2001). In previous

studies, ropivacaine showed less cardiotoxicity and less pronounced arrhythmic effects than bupivacaine in laboratory animals and human volunteers (Feldman et al. 1989; Reiz et al. 1989; Scott et al. 1989; Pitkanen et al. 1992). According to a study by Hennig et al. (2010), intra-articular injection of a 0.5% solution of bupivacaine could cause the death of chondrocytes in the canine joint cavity.

We hypothesised that intra-articular administration of ropivacaine would result in a better analgesic than normal saline. Thus, this study was conducted to evaluate the analgesic effects of intra-articular ropivacaine injection following arthroscopic surgery on the shoulder joint in dogs.

## MATERIAL AND METHODS

**Animal preparation.** Ten adult mixed breed dogs with no other diseases were used in this study. The ages of the experimental dogs were unknown, but their body weights ranged from 4.5 to 10.5 kg (mean 6.63).

Each dog underwent a complete physical examination as well as left shoulder joint and thoracic radiography. In addition, preoperative complete blood cell counts and serum biochemical profiles were obtained from all dogs. All dogs judged to be in an optimal condition were included in the experiments.

The dogs were randomly divided into a ropivacaine (ROPIVA) group (five dogs; body weight 5.1–10.2 kg) and a normal saline (NOS) group (five dogs; body weight 4.5–10.5 kg).

This study was approved by the Animal Care and Use Committee of Gyeongsang National University (approval number: GNU-161004-D0054), and all dogs were treated humanely in accordance with its guidelines.

**Anaesthesia.** All dogs were subjected to the same anaesthetic protocol. Animals were fasted for 12 hours before anaesthesia. Intravenous catheters were inserted into the cephalic veins of dogs before the injections and the animals were premedicated with intramuscular injection of medetomidine (Sedator, Eurovet Animal Health B.V., The Netherlands, 0.02 mg/kg, *i.m.*) and subcutaneous injection of butorphanol (Butophan, Myungmoon Pharm., Republic of Korea, 0.4 mg/kg, *s.c.*). Thirty minutes after premedication, the dogs were administered propofol (Provive, Myungmoon Pharm., Republic of Korea, 4–6 mg/kg, *i.v.*) and intubated

with a single lumen endotracheal tube in a circle rebreathing system including a mechanical ventilator. General anaesthesia was maintained with isoflurane (Ifran, Hana Pharm., Republic of Korea) in 100% oxygen, and the end-tidal concentration of isoflurane was approximately 1.5–2%. A mechanical ventilator was used when there was no spontaneous breathing. Patient monitoring including electrocardiography, capnography, pulse oximetry, respiratory rate and body temperature (AS3, Datex-ohmeda Dicsion Instrumentarium Corp., Finland) was performed continuously during the anaesthesia. Electrocardiography was measured using limb electrodes. Capnography and respiratory rate were measured through an ET tube sensor. Pulse oximetry was measured by an ear clip sensor. Additionally, body temperature was kept at 38–39 °C using a circulating water blanket (Medi-Therm, Gaymer, USA). Lactated Ringer's solution (10 ml/kg/h) was administered via intravenous injection throughout the experiment.

**Application of arthroscopy.** All arthroscopic surgeries were performed by the same experienced surgeon. Shoulder arthroscopy was conducted using a 2.7-mm 30° fore-oblique arthroscope (Panoview telescope 98672422, Richard Wolf GmbH, Germany) (Figure 1A) with a trocar sleeve (8862.02, Richard Wolf GmbH) (Figure 1B) and a conical obturator (8862.11, Richard Wolf GmbH)

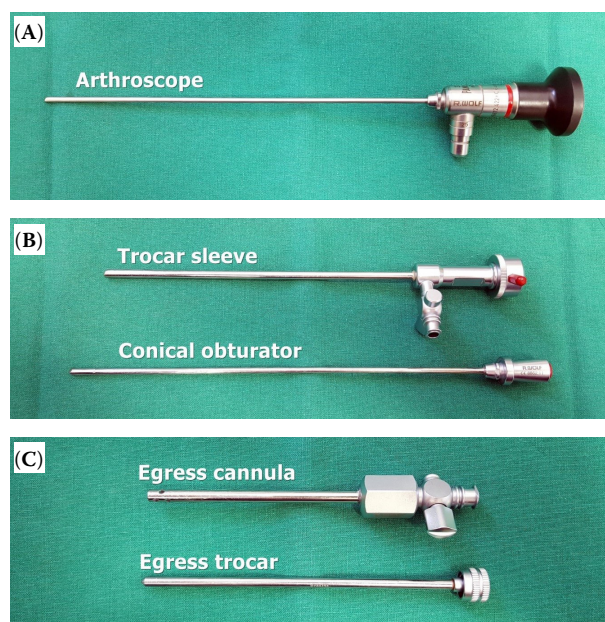


Figure 1. Surgical instruments used in arthroscopic surgery; (A) 2.7 mm 30° fore-oblique arthroscope; (B) trocar sleeve and conical obturator; (C) egress cannula and egress trocar



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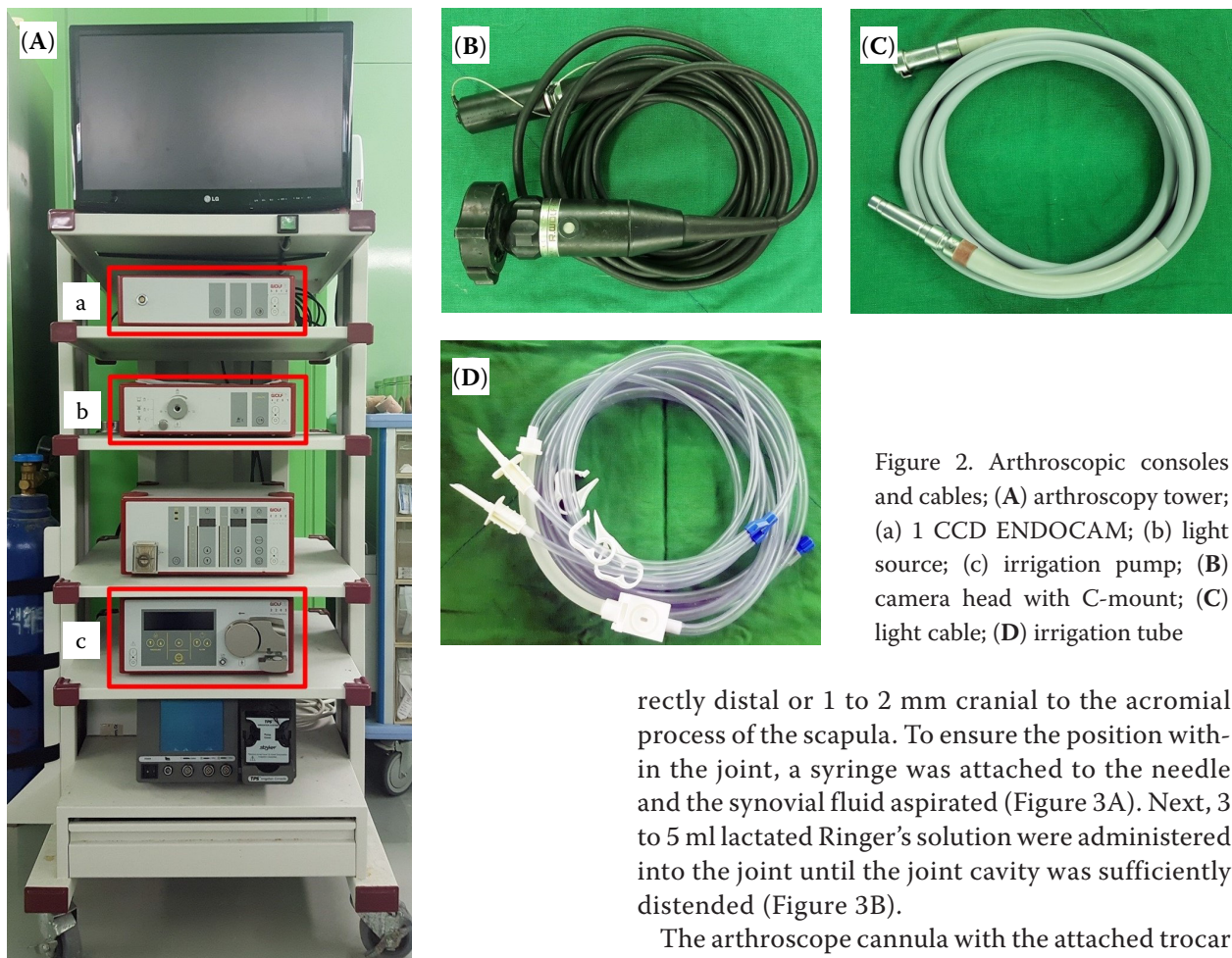


Figure 2. Arthroscopic consoles and cables; (A) arthroscopy tower; (a) 1 CCD ENDOCAM; (b) light source; (c) irrigation pump; (B) camera head with C-mount; (C) light cable; (D) irrigation tube

(Figure 1B). A 1 CCD Endocam (5512, Richard Wolf GmbH) (Figure 2A) and camera head with a C-mount (NTSC 5512.961, Richard Wolf GmbH) (Figure 2B) and light source (LP 4251, Richard Wolf GmbH) (Figure 2A) were connected to the arthroscope. Irrigation of the joint during arthroscopy was achieved by ingress of lactated Ringer's solution via egress cannula (8303.09, Richard Wolf GmbH) (Figure 1C) with an irrigation pump (Fluid Control, 2203, Richard Wolf GmbH) (Figure 2A) at a flow rate of 0.1 l/min and an intra-articular pressure of 90 mm Hg. All dogs were positioned in right lateral recumbency on an operating table and a lateral approach method was applied as previously described (Beale et al. 2003).

Two or three portal sites were used for shoulder arthroscopy depending on the purpose of arthroscopic intervention. If only visual exploration of the shoulder joint was required, an egress portal and an arthroscope portal were necessary.

The arthroscope portal was established first. The proper position for the arthroscope portal was di-

rectly distal or 1 to 2 mm cranial to the acromial process of the scapula. To ensure the position within the joint, a syringe was attached to the needle and the synovial fluid aspirated (Figure 3A). Next, 3 to 5 ml lactated Ringer's solution were administered into the joint until the joint cavity was sufficiently distended (Figure 3B).

The arthroscope cannula with the attached trocar and conical obturator was inserted first. To accomplish this, a No. 11 Bard-Parker blade was used to make a small entry wound through the skin and the superficial soft tissues adjacent to the needle (Figure 3C). It is not advisable to enter the joint with the scalpel blade because this makes extra vacation of fluid outside the joint cavity more likely. Next, the arthroscope cannula with the attached conical obturator was inserted (Figure 3D). Finally, the conical obturator was removed and the arthroscope was inserted through the cannula (Figure 3E).

The egress portal was subsequently established using either a hypodermic needle (18-gauge, 1.5-inch) or an egress cannula (2.7 mm). The shoulder was then palpated to locate the superior ridge of the greater tubercle, after which the egress cannula was inserted at the craniocaudal midpoint of the ridge. Finally, the egress cannula was directed caudally and medially at a 70° angle from the perpendicular (Figure 3F).

After portal establishment, joint lavage was performed prior to exploration for 20 to 30 seconds to clear synovial fluid and blood. Next, the structures

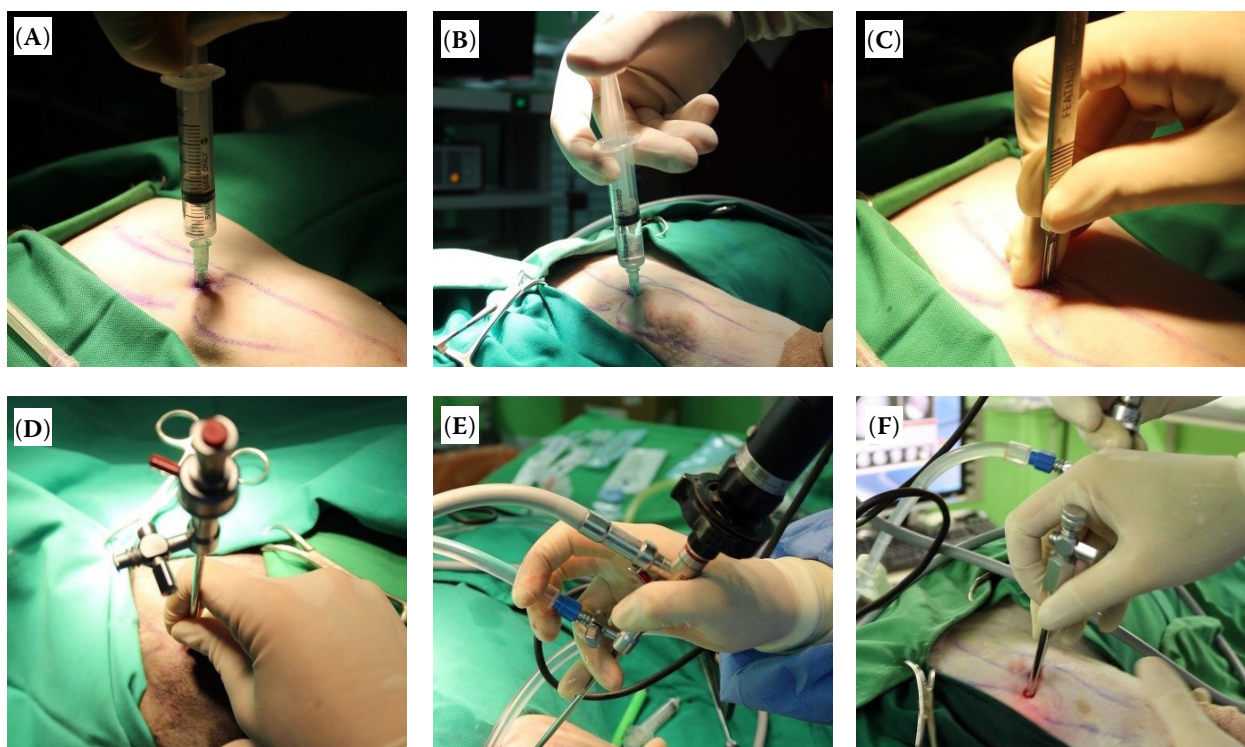


Figure 3. Arthroscopic surgery procedure on the shoulder joint in a dog. (A) The synovial fluid was aspirated using a syringe attached to a needle. (B) Lactated Ringer's solution was instilled into the joint to distend the joint cavity. (C) A No. 11 Bard-Parker blade was used to make a small entry wound through the skin to insert the arthroscope. (D) The arthroscope was inserted through the cannula after the conical obturator was removed. (E) The arthroscope portal installation was completed. (F) The egress cannula was inserted at the craniocaudal midpoint of the ridge

of the shoulder joint, including medial collateral ligament, subscapularis tendon and biceps tendon were investigated arthroscopically. Following joint exploration, the portal sites were sutured with 3-0 nylon.

**Intra-articular analgesic injection.** Drugs were injected into the intra-articular space of the left shoulder joint after arthroscopic examination. A needle with a syringe was inserted immediately distal to the acromion process. Next, 0.5 ml/kg of 0.75% ropivacaine or the same volume of normal saline were administered to each dog in the ROPIVA group and the NOS group. Finally, the volume of the intra-articular injection was determined as previously reported by Sammarco (Sammarco et al. 1996).

**Post-op evaluation.** An examiner who was blinded to the experiment performed postoperative examination for all dogs. Heart rate, respiratory rate, lameness score, visual analogue scale (VAS) and the short form of the Glasgow composite measure pain scale (CMPS-SF) were determined at baseline and at one, two, four, six, 12 and 24 hours after intra-articular injection of each dog. The baseline denoted

the time point immediately before commencement of surgery. The VAS utilises a 100-mm line, and the examiner places a mark on this line to denote the intensity of the pain (Reid et al. 1991; Holton et al. 1998; Hansen 2003). The lameness score was measured using the method described by (Cook et al. 1999). The CMPS-SF is a questionnaire based on five behavioural categories developed to assess acute pain for canine patients (Reid et al. 2007).

VAS is used in clinical trials and other studies as a means of producing primary or secondary outcomes or health indices (Bjordal et al. 2004; Sengupta et al. 2004; Elden et al. 2005; Brouwer et al. 2006; Ender et al. 2013; Richmond et al. 2013). The VAS is a straight line with a length of 10 cm with a label indicating the end of the scale on both ends (Huskisson 1974). Vertical and horizontal straight lines have been developed and used, but horizontal forms are most common (Scott et al. 1979). In the VAS line, the left end mark indicates no pain and the right end indicates the presence of severe pain. In veterinary medicine, it is impossible for an animal to directly assess its own pain, so the



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observer determines the degree of pain through observation. The distance from the left end to the indicated point is measured and used as an index of pain intensity. In 1999, Thornton and Waterman Pearson (1999) assessed pain responses in castrated lambs using the VAS based on a scheme described by Morton and Griffiths (1985).

The Glasgow Composite Measure Pain Scale (CMPS) was developed and used before the CMPS-SF. The CMPS is a behaviour-based composite scale for the assessment of acute pain in dogs (Holton et al. 2001). Since its initial development, the CMPS has been further developed, and the so-called CMPS-SF has now been introduced. The CMPS-SF consists of six categories of behaviour, as well as a description of the relevant behaviour: vocalisation, attention to wound, mobility, response to touch, demeanour and posture/activity (Reid et al. 2007). The items in each category are placed in increasing order of degree of pain and are numbered accordingly (Reid et al. 2007). The observer selects the single item that best matches the patient's condition within each category, and the pain score is the sum of the items selected. The maximum pain score is 24 points, or 20 points if it is impossible to evaluate mobility (Reid et al. 2007).

**Statistical analysis.** Body weight and body condition score were compared between groups using the Mann-Whitney test. Body condition score was evaluated according to a study by Laflamme (Laflamme 1997). To examine the differences in time-dependent post-operative changes in patterns of heart rate, respiratory rate, lameness score (walk and trot), VAS and CMPS-SF between groups, the interaction effects of group and time for each variable were evaluated using repeated-measures analysis of variance (ANOVA). Statistical significance was based on a *P*-value of 0.05 or less. All statistical analyses were performed using the IBM statistical software SPSS Statistics 22® (IBM Corp., USA).

## RESULTS

### Arthroscopic examination

The dogs in both groups were shown to have normal structures according to the arthroscopic findings (Figure 4). There were no specific lesions in the stifle joint, including articular cartilage, synovium, cruciate ligament and meniscus. All dogs recovered from anaesthesia uneventfully.

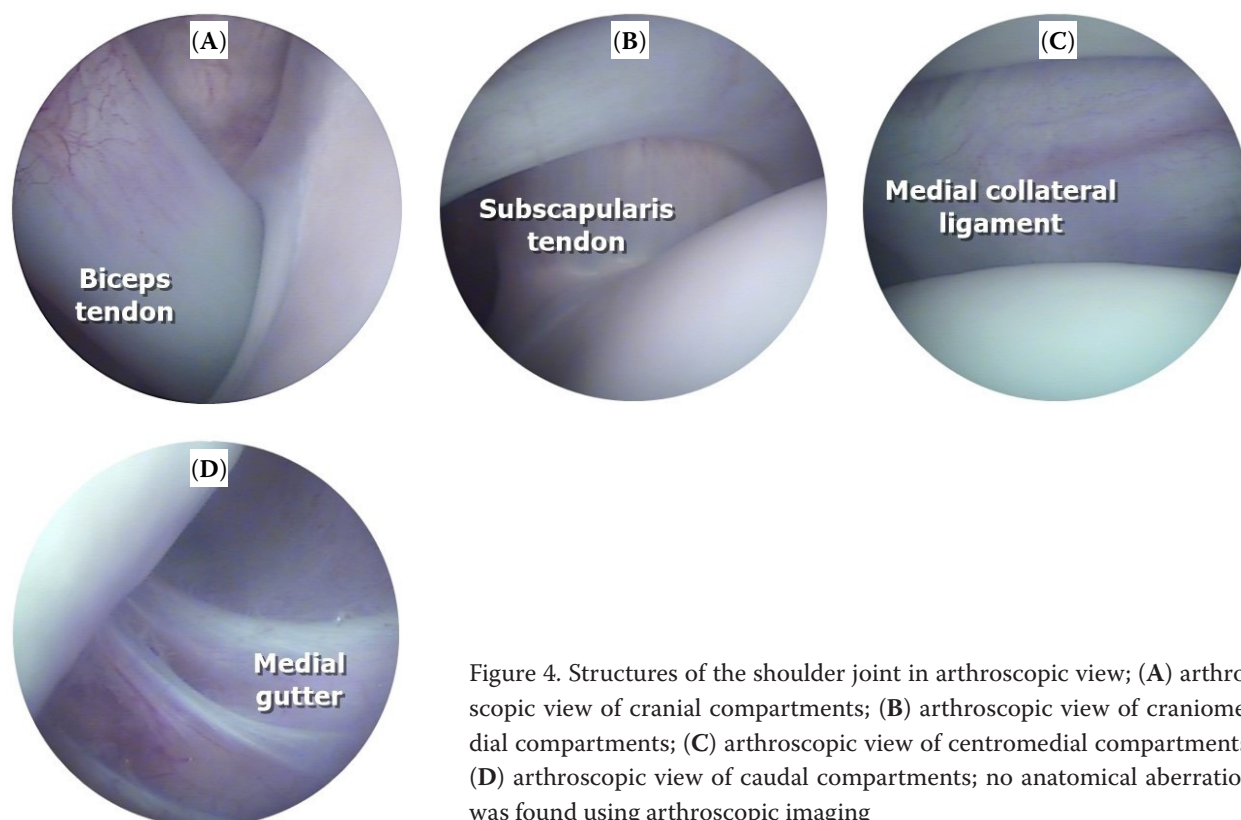


Figure 4. Structures of the shoulder joint in arthroscopic view; (A) arthroscopic view of cranial compartments; (B) arthroscopic view of craniomedial compartments; (C) arthroscopic view of centromedial compartments; (D) arthroscopic view of caudal compartments; no anatomical aberration was found using arthroscopic imaging

## Post-operative evaluation

Based on the repeated-measures ANOVA, post-operative evaluation of the heart rate and respiratory rate revealed no significant differences between groups (Tables 1 and 2). Lameness scores also showed the same results (Table 3). However, VAS and CMPS-SF showed a significant interaction effect between time and groups (Tables 4 and 5). The ROPIVA group showed lower scores than the NOS group. Finally, there were significant dif-

ferences over time after injection. In summary, the dogs in the ROPIVA group felt less pain than those in the NOS group.

## DISCUSSION

The present study investigated the efficacy of intra-articular injection of ropivacaine as an analgesic after arthroscopic surgery. Following injection of ropivacaine, the heart rate, respiratory rate,

Table 1. Changes in heart rate (beats per minute) after surgery (means  $\pm$  SD)

	Baseline	1 h	2 h	4 h	6 h	12 h	24 h
ROP	101.00 $\pm$ 23.10	124.40 $\pm$ 24.01	121.20 $\pm$ 21.99	123.40 $\pm$ 19.13	109.80 $\pm$ 14.99	109.00 $\pm$ 14.40	109.00 $\pm$ 17.13
NOS	109.20 $\pm$ 12.01	117.40 $\pm$ 5.98	117.80 $\pm$ 21.50	121.80 $\pm$ 26.46	111.20 $\pm$ 13.24	112.20 $\pm$ 16.19	100.40 $\pm$ 13.09

NOS = normal saline group (five dogs; body weight 4.5–10.5 kg), ROP = ropivacaine group (five dogs; body weight 5.1–10.2 kg)

Table 2. Changes in respiratory rate (breaths per minute) after surgery (means  $\pm$  SD)

	Baseline	1 h	2 h	4 h	6 h	12 h	24 h
ROP	28.00 $\pm$ 9.70	31.20 $\pm$ 10.18	32.40 $\pm$ 11.70	34.20 $\pm$ 8.38	36.00 $\pm$ 10.93	33.20 $\pm$ 9.98	36.40 $\pm$ 12.03
NOS	26.40 $\pm$ 4.39	33.60 $\pm$ 6.19	28.80 $\pm$ 5.02	30.00 $\pm$ 12.00	32.00 $\pm$ 5.70	28.80 $\pm$ 5.54	29.60 $\pm$ 9.66

NOS = normal saline group (five dogs; body weight 4.5–10.5 kg), ROP = ropivacaine group (five dogs; body weight 5.1–10.2 kg)

Table 3. Changes in lameness score after surgery (means  $\pm$  SD)

		Baseline	1 h	2 h	4 h	6 h	12 h	24 h
Walk	ROP	0.00 $\pm$ 0.00	2.40 $\pm$ 0.55	2.00 $\pm$ 0.71	1.60 $\pm$ 0.89	1.00 $\pm$ 1.22	0.40 $\pm$ 0.89	0.00 $\pm$ 0.00
	NOS	0.00 $\pm$ 0.00	2.80 $\pm$ 0.45	2.60 $\pm$ 0.55	2.20 $\pm$ 1.10	2.00 $\pm$ 0.71	1.40 $\pm$ 0.55	0.00 $\pm$ 0.00
Trot	ROP	0.00 $\pm$ 0.00	2.00 $\pm$ 1.00	1.60 $\pm$ 1.34	0.80 $\pm$ 0.84	0.80 $\pm$ 1.30	0.40 $\pm$ 0.89	0.20 $\pm$ 0.45
	NOS	0.00 $\pm$ 0.00	2.40 $\pm$ 0.55	2.80 $\pm$ 0.45	2.00 $\pm$ 1.22	1.60 $\pm$ 0.89	0.80 $\pm$ 0.84	0.20 $\pm$ 0.45

NOS = normal saline group (five dogs; body weight 4.5–10.5 kg), ROP = ropivacaine group (five dogs; body weight 5.1–10.2 kg)

Table 4. Changes in VAS after surgery (means  $\pm$  SD)

	Baseline	1 h*	2 h	4 h*	6 h*	12 h	24 h
ROP	0.00 $\pm$ 0.00	3.36 $\pm$ 1.10	2.36 $\pm$ 0.74	1.32 $\pm$ 0.38	0.64 $\pm$ 0.61	0.52 $\pm$ 0.83	0.38 $\pm$ 0.68
NOS	0.00 $\pm$ 0.00	4.78 $\pm$ 0.82	3.70 $\pm$ 1.15	3.56 $\pm$ 1.59	2.24 $\pm$ 1.37	1.52 $\pm$ 1.29	0.62 $\pm$ 0.29

NOS = normal saline group (five dogs; body weight 4.5–10.5 kg), ROP = ropivacaine group (five dogs; body weight 5.1–10.2 kg)

\*Statistically significant differences between groups ( $P < 0.05$ )

Table 5. Changes in CMPS-SF after surgery (means  $\pm$  SD)

	Baseline	1 h*	2 h	4 h	6 h*	12 h	24 h
ROP*	0.00 $\pm$ 0.00	5.00 $\pm$ 1.41	4.20 $\pm$ 1.79	3.00 $\pm$ 1.73	1.40 $\pm$ 1.52	0.80 $\pm$ 1.79	0.40 $\pm$ 0.89
NOS	0.00 $\pm$ 0.00	9.00 $\pm$ 2.12	6.80 $\pm$ 2.39	5.60 $\pm$ 2.19	4.20 $\pm$ 1.30	2.80 $\pm$ 1.30	1.00 $\pm$ 0.71

NOS = normal saline group (five dogs; body weight 4.5–10.5 kg), ROP = ropivacaine group (five dogs; body weight 5.1–10.2 kg)

\*Statistically significant differences between groups ( $P < 0.05$ )

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lameness scores (walk, trot), visual analogue scale and CMPS-SF were recorded at the specified times. Significant differences were only observed in the VAS and CMPS-SF.

An analgesic study using intra-articular injection was first reported by Stein et al. (1991), who investigated the analgesic effects of injection of morphine into the knee joint, and by Khoury et al. (1992), who published a study showing that the combination of morphine and bupivacaine is more effective than either alone. Allen et al. (1993) also found that a combination of morphine, bupivacaine (0.125%) and epinephrine was the best choice for analgesia after surgical arthroscopy. De Andres et al. (1993) compared intra-articular bupivacaine or morphine with femoral nerve block after surgery and found that intra-articular injections had similar analgesic effects to femoral nerve block. According to these previous studies, intra-articular local anaesthetic injection seems to be effective for relief of post-operative pain.

When inflammatory conditions are induced in the joint capsule, receptor activity increases by 400–500% (Hanesch et al. 1992). These receptors, called nociceptors, activate predominantly unmyelinated, small-diameter sensory nerves, which mediate nociceptive information to higher-order neurons in the dorsal horn of the spinal medulla. We interpret the results of this study to mean that the area within the joint space is multi-modal and can be reached by chemical mediators of injury (i.e., prostaglandins or substance P) or when exposed to tissue damage. The influence of local anaesthetics on the intra-articular space may suggest an ability to prevent intracellular calcium movement in response to nociceptive signals and to inhibit substance P binding (Li et al. 1995).

The advantages of arthroscopy compared to arthrotomy are the convenience of exploring the joint completely and the excellent visualisation of most parts in the joint (Munroe et al. 1994; Van Bree et al. 1998; Olivieri et al. 2007). In addition, arthroscopy offers a rapid recovery of function and short periods of hospitalisation (Van Bree et al. 1998; Wright et al. 1999). Conversely, arthroscopy requires special instruments that have a relatively high cost, as well as a trained surgeon for clinical application and may lead to some complications (infection, iatrogenic damage to the articular cartilage, extravasation of fluid in the surrounding soft tissue, haemorrhage in the joint space, etc.)

(McIlwraith 1984; Van Bree et al. 1998). Therefore, it is important to choose either arthrotomy or arthroscopy prior to diagnosis and treatment of joint disorder in small animals.

There are two limitations of this study that should be noted. First, this study was conducted in healthy dogs. Although the dogs used in this experiment were normal, significant differences were revealed in the pain assessment; accordingly, further studies using live dogs with shoulder disorders are needed. Additionally, intra-articular injection of ropivacaine was not compared with other local acting anaesthetics or systemic analgesics. Therefore, future research is needed to identify the usefulness of ropivacaine relative to other drugs.

In conclusion, this study was conducted to investigate the analgesic effects of ropivacaine after arthroscopic surgery on the shoulder joint in dogs. The ROPIVA group showed significantly lower pain scores than the NS group without any complications. Overall, the results indicate that ropivacaine may be useful for pain management following arthroscopic surgery in dogs.

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