Anatomical and safety considerations in establishing portals used for canine elbow arthroscopy

N. Jardel1; N. Crevier-Denoix2; P. Moissonnier3; V. Viateau1
1Surgery Department, Ecole Nationale Vétérinaire d’Alfort, Maisons-Alfort, France; 2Department of Anatomy, Ecole Nationale Vétérinaire d’Alfort, Maisons-Alfort, France

Keywords
Elbow, arthroscopy, anatomy, canine

Introduction
Arthroscopy has become the gold standard for the investigation and the treatment of elbow developmental diseases such as fragmented medial coronoid process (FMCP) and osteochondritis dissecans (OCD) of the medial humeral condyle in dogs. Arthroscopy has many advantages over arthrotomy, specifically: (i) tissue trauma is significantly reduced (1–6); (ii) more complete joint exploration is possible and a precise diagnosis of lesions is achieved (1–4, 7–11); and (iii) more rapid and superior postoperative functional recovery is anticipated (3, 12, 13).

Superficial iatrogenic cartilage lesions were observed in three joints. The arthroscopic portal was 23.1 mm (range: 16 to 28.5 mm) caudal to the brachial artery, 21.0 mm (13–30.5 mm) caudal to the median nerve, and 4.0 mm (1–7 mm) cranial to the ulnar nerve. The instrumental portal was 16.3 (9–24 mm) caudal to the brachial artery, 13.5 mm (7–24.5 mm) caudal to the median nerve, and 11.8 (8–18 mm) cranial to the ulnar nerve. The egress portal was 21.4 mm (12–37 mm) caudal to the ulnar nerve.

Conclusions and clinical relevance: The study confirmed the safety of elbow medial arthroscopic portals. Care must be taken when placing the camera portal so as to avoid injury of the ulnar nerve. Should extensive intra-articular procedures be needed, manipulation of instruments should be done cautiously in the cranio-medial compartment of the joint due to the proximity of the median nerve to the capsule.

Cranialateral and medial elbow portals have been described in the dog (5, 8, 10). The medial elbow portals that were originally described by Van Ryssen et al. have been routinely used at our institution since 1998 because they are adequate for elbow exploration and the treatment of the most commonly occurring elbow degenerative diseases (10). These portals consist from caudal to cranial of: (i) a caudal portal, which corresponds to the egress cannula, that can be used as an instrumental portal (1); (ii) a caudomedial portal which corresponds to the arthroscopic portal; (iii) a cranialateral portal through which instruments are inserted for palpation, removal of FMCP and curetage of OCD lesions (1–4, 10, 12).

Since important neurovascular structures run in the close vicinity of the medial aspect of the elbow joint, accurate positioning of these portals, as well as precautions in the intra-articular manipulation of instruments, are essential to avoid neurovascular complications. With the exception of one study that documented transient median nerve palsy in two out of 138 cases, clinical trials in dogs have not reported any neurovascular injury with medial portals (3, 12, 15, 16). In these studies arthroscopic procedures were performed for the diagnosis and the treatment of elbow dysplasia, and intra-articular procedures were mostly limited to the removal of FMCP and cartilaginous humeral flaps. Prevalence of neurological complications after elbow arthroscopy in humans can be as high as 14% (17). More extensive therapeutic procedures such as osteocapsular arthroplasty and synovectomy for the treatment of advanced osteoarthritis and rheumatoid arthritis are currently performed in humans.

Correspondence to:
Nicolas Jardel, DVM
Veterinary School of Alfort
Surgery Department
Av General de Gaulle
Maisons-Alfort, 94700
France
E-mail: Nicolas.jardel@wanadoo.fr

References
(17).
Portal establishment as well as technically demanding intra-articular procedures increase the risk of iatrogenic trauma under these circumstances (18). As elbow arthroscopy assumes a greater role in the diagnosis and management of elbow disease in dogs, more extensive surgical procedures such as video-assisted fracture repair, including lag screw insertion for the treatment of incomplete ossification of the humeral condyle may be performed, and new indications will continue to emerge. Treatment of pain and dysfunction associated with severe elbow osteoarthritis through the arthroscopic removal of osteophytes, and the release of a contracted capsule has given encouraging results in humans and may present future indications in dogs (18, 19).

Improved knowledge of the relationship of neurovascular structures with portals and articular capsules is critical to perform elbow arthroscopy safely. To our knowledge, there are not any reports of studies of the specific relationship of the neurovascular structures and the joint capsule of the canine elbow to the medial arthroscopic portals. The aim of our study was to determine the location of the standard medial elbow arthroscopic portals with respect to the periarticular muscular, ligamentous and neurovascular structures and to evaluate the risk of iatrogenic lesions.

Materials and methods

Specimens

Forelimbs were harvested by descapulation from eleven adult dogs that had died for reasons unrelated to this project at our institution between February and July 2004. Each dog selected weighed more than 20 kilograms and was free of joint pathology as determined by standard radiography and gross examination at the conclusion of the study. Specimens were stored frozen at –20 ºC. In order to avoid moisture loss and the effects of prolonged exposure to freezing conditions, evaluations were performed 12 hours after the specimens were thawed at room temperature.

Materials

The arthroscopic instrumentation used in the study included the following: (i) a 2.7 mm, 30 degree fore-oblique arthroscope in a 4mm arthroscopic sleeve; (ii) a cold light source and cable; and (iii) a digital single chip camera.

Arthroscopic procedures

The isolated limbs were fixed to an examination table using a vise with the medial aspect of the limb uppermost, and the elbow lying on the edge of the table. During establishment of the portals, the limbs were maintained with the elbow in 160º of extension with abduction and internal rotation of the paw as previously described (1, 10).

Anatomical landmarks such as the medial humeral epicondyle and the ulnar nerve were palpated through the skin and the three portals were established from caudal to cranial in the following order: egress cannula, and the arthroscopic and instrumental portals.

i: Egress cannula (caudal) portal placement

A 19-gauge needle was inserted in a craniodistal and slightly lateral direction between the medial humeral condyle and the most cranial part of the olecranon. To ensure placement within the joint, synovial fluid was aspirated with a syringe. Using this needle, the joint was filled with 3 ml of lactated Ringer’s solution until moderate pressure was felt against the plunger. The needle was left in situ to allow subsequent irrigation fluid drainage and was temporarily obturated with the syringe.

ii: Arthroscopic (caudomedial) portal placement

A 19-gauge needle was inserted into the joint 1 cm distally and 0.5 cm caudally to the medial humeral condyle; placement was ensured by fluid reflux. A short (2 to 3 mm) incision through the skin, soft tissues and articular capsule was made with a number-11 scalpel blade; care was taken to insert the blade parallel to the exact direction of the needle. The arthroscopic cannula with the blunt obturator were inserted first.

After entry into the joint was confirmed, the obturator was removed from the cannula. The fluid ingress line was attached to the cannula, and the arthrooscope was inserted. Difficulties associated with entering the joint were recorded. A short systematic arthroscopic joint exploration was performed under constant lactated Ringer’s solution irrigation through the arthroscopic portal. The following structures were assessed: anconeal process, trochlear notch, lateral and medial coronoid processes, medial and lateral humeral condyles, radial head and medial collateral ligament. Cartilage lesions resulting from trocar insertion were recorded and graded as either severe (lesions involving the whole cartilage thickness with exposure of subchondral bone), moderate (deep cartilage lesions not reaching subchondral bone) or mild (superficial cartilage abrasion). Lesions of the medial collateral ligament were graded as severe (total rupture), moderate (partial rupture of more than one-quarter of the width of the ligament), and mild (partial rupture less than one-quarter of the width of the ligament).

iii: Cranial instrumental (cranio lateral) portal placement

A 19-gauge needle was inserted into the joint 1 cm cranial to the arthroscope under arthroscopic control. A stab incision was performed with a number-11 scalpel blade parallel to the needle track and a blunt probe was inserted to check that both the medial coronoid process and medial humeral condyle could be reached through this portal.

Inspection and palpation of intra-articular structures

The following structures were observed through the camera portal and palpated...
through the instrumental portal: anconeal process, troclear notch, lateral and medial coronoid processes, medial and lateral humeral condyles, radial head and medial collateral ligament. The presence of iatrogenic cartilage damage was recorded in terms of anatomical location and graded as being severe (lesions involving the whole cartilage thickness with exposure of subchondral bone), moderate (deep cartilage lesions not reaching subchondral bone) or mild (superficial cartilage abrasion).

**Dissection, iatrogenic injury evaluation and measurements**

Three 4 mm diameter pins (equivalent to the width of the arthroscopic sleeves and instrumental cannulas) were introduced in the joint in place of the three portals. The soft tissues surrounding the elbow joint were sequentially removed with the pins in place. Limbs were dissected layer by layer allowing observations and measurements to be made as the dissection proceeded (Fig. 1 and 2). Muscles which were inspected for damage were: the pronator, flexor carpi radialis, deep digital flexor, superficial digital flexor, flexor carpi ulnaris, tensor fasciae antebrachii, and the long medial accessory head of the triceps muscles. Lesions were recorded, and any muscle that was penetrated by a pin was considered as damaged.

The ulnar nerve was dissected and exposed caudally to the medial humeral epicondyle. Its distal part was exposed by cranial retraction of the superficial digital flexor muscle. The median nerve was distally exposed by removing the pronator teres muscle. The brachial artery was exposed by removal of the median nerve. Care was taken throughout the dissections to minimise soft tissue disruption so that accurate measurements could be made. The distances from the arthroscope and instrumental portals to the brachial artery, as well as to the median and ulnar nerves were then measured with a calliper, with the elbow positioned as described in the arthroscopic procedures section (Fig. 3). Measurements were taken at the point of nearest approximation to the neurovascular structures. Distance (mm) between portals and neurovascular structures were reported as a mean value of experimental measurements and range.

All dissections, measurements and observations were performed by the same investigator (NJ).

**Results**

**Specimens**

Twenty specimens were collected from 11 dogs weighing from 25 to 45 kg (mean 37.7 kg). Amongst these dogs, there were four German Shepherds, four Rottweilers, one Labrador, one Golden Retriever, and one Bull Terrier. There were four females and seven males.

**Inspection and palpation of intra-articular structures**

Medial arthroscopic portals allowed adequate observation and palpation of all anatomical structures to be assessed in all specimens. Superficial lesions of the cartilage of the medial humeral condyle and the ulna were observed in three joints close to the arthroscopic portal and the caudal portal. No cartilage injury was associated with the insertion of the instrumental portal.

**Location of portals in relation to muscles and ligaments**

The caudomedial portal passed through the deep digital flexor muscle in four out of...
20 joints (20%), the superficial digital flexor muscle in 10 out of 20 joints (50%) and between the superficial digital flexor and the deep digital flexor in six out of 20 (30%).

The craniomedial portal passed through the flexor carpi radialis muscle in three out of 20 joints (15%), the deep digital flexor in five out of 20 joints (25%) and the superficial digital flexor in 11 out of 20 joints (55%).

In one joint, this portal passed between the flexor radialis muscle and the deep digital flexor muscle. The caudal portal passed through the tensor fasciae antebrachii muscle and the anconeal muscle in all joints and through the triceps muscle in 16 out of 20 joints (80%).

No ligament injury was found in any of the joints (Table 1).

### Location of portals in relation to the neurovascular structures

The arthroscopic portal was 23.1 mm caudal to the brachial artery (range: 16 to 28.5 mm), 21.0 mm caudal to the median nerve (range: 13 to 30.5 mm), and 4.0 mm cranial to the ulnar nerve (range: 1 to 7 mm). The instrumental portal was 16.3 mm caudal to the brachial artery (range: 9 to 24 mm), 13.5 mm caudal to the median nerve (range: 7 to 24.5 mm), and 11.8 mm cranial to the ulnar nerve (range: 8 to 18 mm). The egress portal was 21.4 mm caudal to the ulnar nerve (range: 12 to 37 mm) (Table 1).

### Location of the neurovascular structures in relation to the articular capsule

The radial nerve lay on the cranial aspect of the joint, but was separated from the articular capsule by the annular ligament. The median nerve and brachial artery were in close proximity to the capsule in the craniomedical aspect of the joint cranially to the medial collateral ligament. The ulnar nerve was found to not be in contact with the capsule. It was separated from the capsule by the medial head of the triceps brachii muscle proximally, and by the insertion tendon of the deep digital flexor muscle distally.

<table>
<thead>
<tr>
<th>Portals</th>
<th>Muscular lesions (n = 20 limbs)</th>
<th>Distances between portals and vasculo-nervous structures (mm)</th>
<th>Cartilage injury</th>
<th>Ligamentous injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egress portal</td>
<td>Tensor fasciae antebrachii and anconeus muscles: 20 Triceps muscle: 16</td>
<td>Ulnar nerve: 21.4 [12 - 37] Collateral ulnar artery and caudal cutaneous antebrachial nerve: 14.6 [7.5 - 22]</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 1

Summary of the iatrogenic lesions associated with the establishment of the instrumental, arthroscopic and egress portals. Cartilage and ligament injuries are graded as severe (+++); moderate (++), and mild (+).

Discussion

Elbow arthroscopy has been mainly utilised in dogs for the diagnosis and the treatment of elbow dysplasia. In the present study, specimens were harvested from Rottweiler, German Shepherd, Labrador and Golden Retriever dogs, all of which are breeds commonly affected by this disease (1, 3, 14, 21). It would have been interesting to investigate anatomical differences in the elbow amongst these breeds and correlate them to the outcome of arthroscopy. This approach, however, was not feasible because of the large number of animals required to reach definitive conclusions.

Portals were easily established in all limbs tested. Relevant anatomical landmarks can indeed be palpated in the canine elbow (1). Yet, it should be kept in mind that, in joints with altered anatomy or scarring, normal anatomical landmarks can be distorted, nerves can be adherent to the capsule and arthroscopic distension can be decreased. In these situations, portal establishment may be more challenging.

Muscular lesions resulting from portal establishment were minimal in all specimens evaluated in the present study. As previously observed and reported by Van Rysen, the camera portal passed either through or between the deep digital and the superficial digital flexors (10). Interestingly, the craniomedial instrumental portal consistently lay caudal to the medial collateral ligament; no ligament injury was observed in any of the limbs. These observations confirmed the minimally invasive character of the technique used in the press-
Elbow arthrotomy through muscular separation (which is the least invasive arthrotomy procedure in dogs) may require partial incision of the caudal part of the medial collateral ligament for better visualisation and access to the medial coronoid process (21).

Superficial iatrogenic cartilage lesions were observed in three specimens in the present study. This was similar to Van Rysen’s observations but contrasted with Tatarunas’s anatomic study in which cartilage lesions were systematically observed (10, 14, 20). In the present study, a stab incision of the skin, soft tissue, and joint capsule with a number 11 scalpel blade allowed establishment of the arthroscopic portal with a blunt trocar (which differed from Tartaruna’s study in which sharp trocars were used). Furthermore, all instrumental portals were established under arthroscopic control. This cautious procedure may explain the low incidence of cartilage damage and the absence of deep cartilage lesions observed in our study.

The present study thus confirmed the minimally invasive character of standard elbow medial arthroscopic portals, which was corroborated by the improved long-term functional recovery obtained in dogs treated with arthroscopy compared to arthrotomy for elbow disease (3,13).

Thorough knowledge of neurovascular anatomy is critical for performing elbow arthroscopy safely. As emphasised by Kelly, there are several reasons why the risk of nerve injury during elbow arthroscopy is of great concern: (i) major nerves rest close to the portals; (ii) nerves lie close to the joint capsule and, therefore, close to the sites where the instruments must operate; (iii) instruments may be withdrawn and inserted several times during the procedure; and (iv) the anatomy of the joint can be distorted by the pathology that necessitates arthroscopic treatment (17).

The brachial artery, the median nerve, and the ulnar nerve are potentially at risk when inserting the craniomedial instrumental and caudomedial arthroscopic portals, respectively. In accordance with two clinical trials involving 371 dogs, no neurovascular damage was recorded in the present study (3, 15). However, whereas the distances between the craniomedial instrumental portal and the brachial artery and the median nerve consistently remained in all specimens above 9 mm and 7 mm, respectively, the camera portal was as close as 1 mm to the ulnar nerve in four out of 20 joints. Because the ulnar nerve consistently lay caudal to this portal, we recommend puncturing the joint with the cutting edge of the blade oriented cranially when establishing this portal. Special care should also be taken in regards to the nerve should a more caudal portal placement be needed, as advocated by some authors for complete visualisation of a humeral osteochondritis dissecans lesion (1).

Aspects such as joint distension and degree of joint flexion or pronation can influence the anatomic relationship between elbow arthroscopic portals and neurovascular structures (22, 23). A study of human cadavers has shown that the distances between the median nerve and medial portals significantly decreased with full joint extension (22). In the present study, portals were established and measures were taken with the joint flexed at 160°. Furthermore, joint distension was not maintained while measures were taken as leakage consistently occurred around the entrance of the portals. The effect of joint distension and angle of elbow flexion on distances between portals and nerves in the dog requires further study as these distances might vary significantly with joint inflammation and elbow motion, as it has been shown in human subjects (22).

Attention should be paid to the proximity of neurovascular structures not only during portal placement but also during instrument manipulation. Forceful angulation of the scope in certain positions can cause nerve injury and should be avoided. Caution should also be exercised when utilising a radiofrequency device or a shaver in areas where the capsule comes in close contact with nerves. As observed during dissections of specimens in the present study, the median nerve is at risk in the craniomedial aspect of the elbow as it lies in close vicinity of the articular capsule in an area where there is no protection from the medial collateral ligament. Transient axillary nerve injuries have been reported in human subjects with thermal capsular shrinkage of the shoulder (24). These observations were further corroborated by a study conducted on cadaveric specimens which has shown that thermal capsular shrinkage caused an increase in the temperature of the axillary nerve and its branches (25). Cases in which capsular tissues have been caught in the Burr and drawn into it (thus bringing the nerve close to the Burr), have also been reported during elbow arthroscopic arthroplasty in humans (17). The risk for neurovascular damage increases in stiff elbows in which intra-articular instrument manipulation is challenging: in humans, the capacity of a stiff elbow averages 6 ml compared to 14 ml for normal elbows (17). Thus, should extensive procedures be needed in regions at risk for neurovascular damage, placement of instruments (such as small elevator or probes) in a separate portal to retract the capsule away from the working instruments is highly recommended. Motorised instruments should also be directed away from the nerves rather than towards them, and suction should be avoided when working near nerves.

In summary, this is the first anatomical study to document the safety of standard medial elbow arthroscopic portals pertinent to the relevant neurovascular structures at risk in dogs. Establishment of the craniomedical instrumental portal does not place the median nerve and the brachial artery at risk. However, we do stress that care must be taken during arthroscopic portal establishment because the ulnar nerve lies in close proximity at that site. Neurovascular lesions can be avoided by careful technique and constant vigilance. The following aspects should be considered: (i) special care should be taken when establishing the camera portal, making sure to palpate the ulnar nerve through the skin and maintain joint position while puncturing the joint during insertion of trocars; (ii) excessive extension of the joint while establishing the anterior instrumental portal should be avoided; and (iii) radiofrequency devices, shavers and suction should be handled with caution in the antero-medial compartment of the joint. One should also keep in mind that distorted anatomical landmarks, decreased arthroscopic distension, and adherence of nerves to the joint capsule can be encountered in elbows that exhibit altered...
anatomy or scarring. In such difficult situations, an open arthrotomy technique may be a wise alternative strategy.

References


