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Evaluation of traction stirrup distraction technique to increase the joint space of the shoulder joint in the dog: A cadaveric study

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ABSTRACT

The objective of this study was to evaluate technical feasibility and efficacy of a joint distraction technique by traction stirrup to facilitate shoulder arthroscopy and assess potential soft tissue damage.

Twenty shoulders were evaluated radiographically before distraction. Distraction was applied with loads from 40 N up to 200 N, in 40 N increments, and the joint space was recorded at each step by radiographic images. The effects of joint flexion and intra-articular air injection at maximum load were evaluated. Radiographic evaluation was performed after distraction to evaluate ensuing joint laxity.

Joint distraction by traction stirrup technique produces a significant increase in the joint space; an increase in joint laxity could not be inferred by standard and stress radiographs. However, further clinical studies are required to evaluate potential neurovascular complications. A wider joint space may be useful to facilitate arthroscopy, reducing the likelihood for iatrogenic damage to intra-articular structures.

1. Introduction

The first reports concerning the use of arthroscopy in joint surgery date from the early 20th century (Beale et al., 2003). Since then, the use of arthroscopy in human joint surgery has been developed worldwide. Although in small animals arthroscopy has only been developed over the last few decades, it is now recognized as the standard method for examining the joint surface, intra-articular structures and for arthroscopy-assisted joint surgery (Ridge, 2011). Its increased clinical application is due to lower patient morbidity rate, enhanced visualization, the greater surgical precision achieved, reduced postoperative pain and improved recovery (Beale et al., 2003). Recently, postoperative sepsis following arthroscopy in small animals has been evaluated to be as high as 0.85%, similar to its occurrence in horses (0.9%) (Ridge, 2011).

Arthroscopy has been largely used as a diagnostic tool and as a treatment technique for shoulder diseases in small animals (Bardet, 1998; Cook and Cook, 2009; Wall and Taylor, 2002). Many arthroscopic findings in the dog shoulder have been described, whose diagnosis was extremely difficult before the use of arthroscopic examination (Bardet, 1998). In human medicine, shoulder arthroscopy can be performed with the patient in either lateral recumbency or a sitting position (Correa et al., 2008), while the standard position in the dog is lateral recumbency with the leg to be operated on in uppermost position and the humerus parallel to the ground or slightly adducted (Bardet, 1998; Beale et al., 2003; Riener et al., 2009; Schulz et al., 2004). Alternatively, however, a hanging limb technique with the dog in dorsal recumbency has also been described to allow for bilateral arthroscopy (Cook and Cook, 2009).

Joint distraction has been used in human medicine to enhance arthroscopic visualization in several joints; with studies reporting the use of distraction in the shoulder (Correa et al., 2008; Hoenecke et al., 2004; O'Brien et al., 1997), ankle (de Leeuw et al., 2010; Qin-wei et al., 2010; Theken et al., 1992; Yates and Grana, 2010), elbow (Takahashi et al., 2000), hip (Dienst et al., 2000; Flecher et al., 2011), wrist (Davies et al., 2008) and knee (Hagemeister et al., 2002; Harfe et al., 1998). The role of distraction during arthroscopy is aimed at improvement in the visualization and manipulation of joint structures. The increase in the joint space makes use of instruments in the joint easier and safer for the patient, reducing the likelihood of cartilage damage as a consequence of intra-articular surgical maneuvres. However, distraction does have potential complications, such as fractures, ligamentous injury or neurovascular damage (Dienst et al., 2000; Theken et al., 1992). In small animals, there are few reports concerning the development of distractors to help perform arthroscopy (Böttcher et al., 2009; Gemmill and Farrell, 2009; Schulz et al., 2004), and data on the amount of distraction that can be achieved, or concerning the evaluation of potential soft

The study was performed at the Veterinary Teaching Hospital of the Veterinary School, Complutense University of Madrid, Spain.

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tissue injuries due to the distraction, are completely missing. Recently, such data have been reported for hip (Devesa et al., 2014) and tarsus distraction (Rodriguez-Quiros et al., 2014).

The aim of the study was to experimentally evaluate the technical feasibility and efficacy of traction stirrup technique for shoulder distraction, and to assess the potential soft tissue injuries caused by this technique. The effects of ancillary procedures other than distraction, i.e. injection of air in the joint and joint flexion, were also evaluated.

2. Materials and methods

2.1. Study population

Twenty shoulder joints from eleven cadavers of medium–large breed dogs that died as a result of causes unrelated to the study were included. They had no clinical evidence of osteoarthritis or fractures. Within 24 hours after death, cadavers were collected and stored at −20 °C until further study (Gemmill and Farrell, 2009; Hidaka et al., 2009; Whatmough et al., 2008). Before the beginning of the study, cadavers were thawed for 48 hours at room temperature, weighed, and height and length measures were made. The body mass index of each dog included in the study was calculated as BMI = body $\text{weight}_{(kg)}$/(height at $\text{withers}_{(m)} \times$ length from occipital protuberance to base of $\text{tail}_{(m)}$), a modification of a previously reported method that used height at shoulders instead of height at withers (Mawby et al., 2004).

2.2. Radiographic study

Before the distraction study, medio-lateral and caudo-cranial radiographic projections (X-Ray Diagnost 93, Philips Electronics. Chassis CRMD4.0T 24 × 30, Agfa HealthCare) were made to confirm that cadavers were free of orthopedic diseases or fractures of the shoulder. To take the medio-lateral projection, animals were placed in lateral recumbency with the leg to be examined lowermost. The limb was extended cranially and ventrally and the opposite limb was drawn caudally to separate the limbs. The neck was extended dorsally to alleviate superimposition of the neck muscles, trachea, sternum and ribs (van Bree and Gielen, 2006). The medio-lateral (ML) scapulohumeral angle was calculated. The scapular axis was drawn following the scapular spine. In the humerus, two lines determining the diameter of the proximal bone were drawn, and the humeral axis was defined as the line passing through the middle points of both lines. The angle between these axes was measured. Animals were placed in this position so that the angle between the scapula and proximal humerus was from 138° to 148°.

To take the caudo-cranial projection in a consistent way, the distance from the greater tubercle of the humerus and the lateral epicondyle was measured and divided into three parts. A 5.5-mm hole was placed in the distal third of the humerus, a M5 threaded bar was passed through it, and stabilized to the bone by nuts and washers on both sides of the bone. Cadavers were positioned in a custom-made polymethyl methacrylate positioner in dorsal recumbency with the front legs extended cranially. The sagittal plane of the thorax was rotated 15–30° (Slatter, 1993; van Bree and Gielen, 2006) away from the shoulder under examination in order to avoid superimposition of the rib cage. The scapular spine was parallel to the cassette. The threaded bar was locked to the PMMA positioner with nuts and washers (Fig. 1). A radiographic reference was positioned at the same level of the joint in order to allow measuring of the anatomic structures, calculating the radiographic magnification ratio (Fig. 1). A standard caudo-cranial projection was taken. Varus and valgus stresses were applied to the joint translating the cadaver body medially and laterally with respect to the humeral axis until the joint reached the maximum varus and valgus joint angulation allowed by soft tissue constraints, respectively. Varus and valgus stress projections were obtained at the maximum achievable joint angulation.

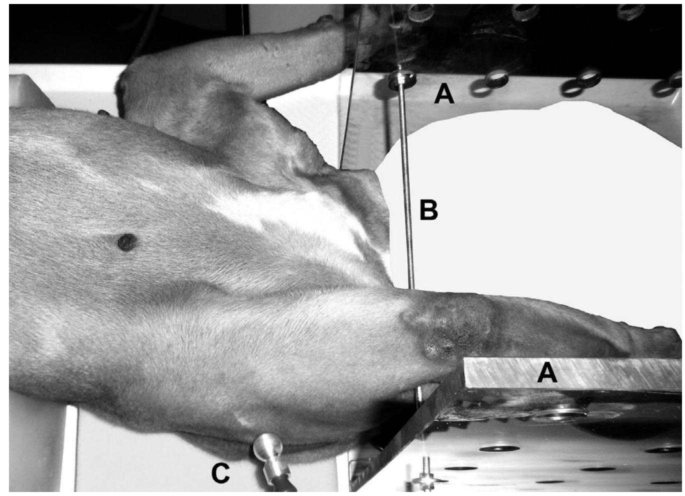

Fig. 1. Cadaver placed in PMMA positioner (A) in order to consistently perform caudo-cranial projections to evaluate joint laxity. Note the threaded bar (B) passed through a hole in the distal third of humerus, and locked to the humerus and positioner by means of nuts and washers. A radiographic reference (C) positioned at the same level of the joint was used to measure the anatomic structures, calculating the radiographic magnification ratio. The head of the cadaver was erased for cosmetic reasons.

2.3. Distraction study

Dogs were positioned in lateral recumbency with the shoulder to be examined uppermost. The limb was placed in a neutral position, with the humerus parallel to the ground, as described for performing shoulder arthroscopy (Beale et al., 2003). A 1.5 mm diameter K-wire was placed through the scapula neck in a caudolateral to cranio-medial direction and connected to a traction stirrup (Traction stirrup, Ad Maiora, Cavriago, Italy). A second K-wire was inserted in a caudo-lateral to cranio-medial direction in the area of the greater tubercle of the humerus, immediately cranial to the deltoid muscle belly, and connected to a traction stirrup. Then, the distractor (General distractor, Ad Maiora, Cavriago, Italy) was connected to the stirrups. The limb was aligned and stabilized so that the scapula and the humerus were on a horizontal plane (Fig. 2). Distraction was applied with loads of 40 N up to 200 N, in 40 N increments. A digital dynamometer (Digital dynamometer model HCB20K10, Kern & Sohn, Balingen, Germany) was used to measure the load applied. A 1% tolerance was accepted in determining the planned load for each step. Immediately after each load increase, a digital radiographic image was obtained. After the first set of sequential distractions was performed, and while the load of 200 N was maintained, the maximum joint flexion allowed by the distraction was applied while a further radiographic picture was taken. Then, after the shoulder was allowed to come back to its physiological position and while maintaining the 200 N load, a needle (18 G, 1.2 × 40 mm) was inserted into the joint space and 10 ml of air was injected. This procedure allowed venting of the joint for elimination of the vacuum phenomenon. A radiographic image was obtained after this procedure also.

2.4. Post-distraction radiographic evaluation

Shoulders underwent radiographic examination after the distraction procedure, following the same protocol as detailed for before traction was applied.