Brief Communication

Relationship of the biceps-brachialis complex to the medial coronoid process of the canine ulna

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Summary
Objective: To describe the anatomic relationship of the biceps brachii-brachialis muscle complex and the medial compartment of the canine elbow.

Study design: Anatomical cadaveric study.

Methods: Cadaveric forelimbs, and radius and ulna bones were examined to study the anatomy of the biceps brachii-brachialis complex and its relationship to the medial compartment of the elbow.

Results: The biceps brachii and brachialis muscles comprise a large muscular complex. The biceps brachii is a pennate fibred muscle which plays a major role in stabilising the elbow joint during the stance phase and facilitating limb acceleration during the swing phase. Additionally, the insertion of the muscular complex onto the ulnar tuberosity is such that a moment is generated which the authors hypothesise rotates the medial coronoid process against the radial head. The result is a compressive force which generates internal shear stress oblique to the long axis of the medial coronoid process. The authors further hypothesise that this may result in the microdamage or fragmentation of the medial coronoid process.

Conclusion: The authors conclude that contraction of the biceps brachii and brachialis complex may explain an aetiology pathogenesis for fragmented medial coronoid process not associated with elbow dysplasia.

Introduction

Canine elbow dysplasia is a commonly reported thoracic limb disorder (1–3). Elbow dysplasia denotes an abnormal development of the elbow joint, and includes conditions such as un-united anconeal process, fragmentation of the medial coronoid process, and cartilage erosion of the medial coronoid process secondary to incongruence (4). Cartilage lesions may also occur on the medial aspect of the humeral condyle, and are commonly caused by osteochondritis dissecans or erosion associated with ‘kissing lesions’ secondary to incongruence. Many hypotheses have been formulated about the aetiopathogenesis of elbow dysplasia; most prevalent among these are osteochondrosis and radio-ulnar incongruence (5–7). Radio-ulnar incongruence is believed to be secondary to asynchronous growth of the radius and ulna during maturation (8). The result is malalignment of the articular surfaces where the medial coronoid process is subject to high mechanical loads. Increased mechanical load can give rise to abnormal internal stress, which initiates microdamage or fragmentation of the medial coronoid process. The histological and ultra-structural appearance of fragmented coronoid process is consistent with mechanical failure and subsequent unsuccessful fibrous repair (6).

The authors believe that malalignment and incongruence occurs, and may give rise to fragmentation and cartilage abrasion of the medial coronoid process. However, fragmentation and incongruence secondary to radius and ulna growth abnormality would best explain abnormalities found in younger patients, or mature patients with chronic recurring clinical problems. Abnormal growth and incongruence may not explain the pathology of the medial coronoid process seen frequently in a population of mature dogs. The latter cases commonly exhibit an obvious lameness, but no other abnormal physical or radiographic findings (9). Arthroscopy or computed tomography examination confirm fragmentation of the medial coronoid process adjacent to the radial head without the presence of visible cartilage erosion. The authors hypothesised that fragmentation or microdamage of the medial coronoid process in the latter group of patients is secondary to mechanical overload associated with contraction of the biceps brachii-brachialis muscle complex. The objectives of this study were to describe the anatomical relationship of the biceps brachii-brachialis complex and the medial compartment of the elbow, and to propose an alternative mechanical explanation for the fragmentation or microdamage of the medial coronoid process.
Methods

Six cadaveric forelimbs were harvested from Coon Hound dogs weighing between 25 kg to 30 kg. Limbs were frozen at –20 degrees centigrade until being thawed for anatomical study. Prior to the study, each limb was thawed at room temperature and the skin and muscles were removed with the exception of the biceps brachii and brachialis muscles. The elbow joint capsule and collateral ligaments were also preserved. The biceps muscle and brachialis muscle were scanned by ultrasound to determine fibre pattern (pennate or parallel) and cross sectional area using a linear array 13 MZ probe *(Fig. 1)*. Limbs were then dissected to examine the gross relationship of the insertions of the biceps brachii and brachialis muscles to the medial compartment of the elbow joint. In addition four radius and ulna bones from dogs estimated to weigh between 25 kg to 30 kg were examined to document the location of the insertion sites of the biceps-brachialis complex. The location and length of the ulnar tuberosity and radial tuberosity were determined as well as the distance from the ulnar tuberosity to the cranial edge of the medial coronoid process *(Fig. 1)*.

Results

The biceps brachii originates from the supraglenoid tuberosity by means of a long tendon of origin. The tendon crosses the shoulder joint and enters the intertubercular groove to gain access to the cranial surface of the humerus. Distal to the intertubercular groove, the tendon becomes a strong, spindle shaped muscle. Ultrasoundographic examination determined the biceps brachii to be a pennate fibre muscle with a central tendon and an angle of pennation of approximately 20°. In these cadaveric specimens, the cross sectional area of the biceps at its midportion was in the order of 3.4 cm². At the elbow joint, the tendon of insertion splits into two parts. The larger of the two inserts onto the ulnar tuberosity and the smaller of the two onto the radial tuberosity. The radial tuberosity is located at the caudomedial surface of the radius *(Fig. 1)*. The ulnar tuberosity of the bone specimens began 2–3 mm distal to the articular margin, and extended distally for approximately 17 mm (range 15 – 20 mm) defining the size of the biceps-brachialis tendon of insertion. The location of the ulnar tuberosity was approximately 12 mm (range 10–13 mm) caudal to the most cranial edge of the medial coronoid process; this distance is the moment arm for the force exerted by the biceps-brachialis complex *(Fig. 1)*. The brachialis muscle arises from the caudo-proximal surface of the humerus. The muscle then courses through the musculospiral groove to the cranial surface of the humerus as it courses distally. Ultrasonographic examination determined the brachialis to be more similar to a parallel fibre muscle, although a small central tendon was present in some specimens. The cross sectional area of the brachialis muscle at its midpoint was in the order of 1.75 cm². At the elbow joint, part of the brachialis muscle inserts with the biceps brachii onto the radial tuberosity. The remainder inserts with the biceps brachii onto the ulnar tuberosity *(Fig. 2)*. The larger part of the biceps-brachialis complex crosses craniomedial to the elbow joint to insert onto the ulnar tuberosity. As the tendon crosses the craniomedial compartment of the elbow, it lies immediately superficial to the medial collateral liga-

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Fig. 1  Skeletal specimen showing position and length of ulnar tuberosity (black arrow heads) and radial tuberosity (white arrow heads). Contraction of the biceps-brachialis complex exerts a polar (rotational) moment compressing the cranialateral section of the medial coronoid process against the radial head (circular arrow).

Fig. 2  Cadaveric specimen showing large tendon of insertion of biceps-brachialis complex onto ulnar tuberosity and smaller tendon of insertion of the complex onto the radial tuberosity (*). MCL denoted medial collateral ligament.
Discussion

A number of conditions have been described which cause elbow lameness including osteochondrosis, ununited anconeal process, and fragmented medial coronoid process process. Of these, fragmented medial coronoid process occurs most frequently, and is commonly included as one of the conditions noted with elbow dysplasia. The prevailing theory is that malalignment within the elbow results in mechanical overload and microdamage or fragmentation of the cranialateral segment of the medial coronoid process. Additionally, varying degrees of cartilage erosion may be observed, and cartilage erosion appears to progress with age. In the authors’ experience, there is a population of patients which exhibit forelimb lameness, but do not fit within the category of cases diagnosed with elbow dysplasia. The majority of these are large breeds of dogs (Labrador Retriever), however smaller breeds of dogs (Shetland Sheep Dog, Border Collie) are also often identified. Frequently these cases present with long-standing forelimb lameness and no abnormal physical findings such as joint effusion and pain, or abnormal radiographic findings attributed to the elbow (9). Nuclear scintigraphy and computed tomography examination identify the elbow as the source of the lameness, and arthroscopy confirms the presence of microdamage or fragmentation of the medial coronoid process. There is often fragmentation of the medial coronoid process without any grossly observable cartilage erosion seen during arthroscopic examination. The fragmentation of the coronoid characteristically involves the cranialateral segment of medial coronoid process adjacent to the radial head (Fig. 4).

Although extension of the shoulder will often elicit discomfort in these cases, the authors believe the discomfort arises from the elbow. When the examiner extends the shoulder, one often extends the elbow at the same time. This maneuver tenses the biceps-brachialis complex overlying the craniomedial joint capsule and cranial segment of the medial coronoid process (Fig. 3). Pressure overlying the inflamed synovial lining and rotation of the cranial segment of the medial coronoid process into the radial head may give rise to pain. Additionally, if a fragment is present, movement of the fragment directly beneath the tendon complex is a potential cause of pain. The biceps-brachialis muscles constitute a large muscular complex. In the Greyhound, the muscular complex exerts a joint moment at the elbow of approximately 2000 Ncm (10). The muscular force exerted by the biceps muscle is continuous in that contraction stabilises the elbow and balances moments about the elbow during the weight bearing force phase. Additionally, biceps shortening allows for the rapid elbow flexion required for limb protraction at higher speed gaits (10). The fact that the force exerted by the biceps muscle is continuous is in concert with the fact that the biceps muscle is a pennate muscle with central tendon. More importantly, because the insertion of the biceps-brachialis complex is primarily at the ulnar tuberosity, a large (rotational) moment (in the order of 1000 Ncm in the greyhound [10]) is exerted at the cranial segment of the medial coronoid process (Fig. 1). The magnitude of the moment is a product of the moment arm (distance from the ulnar tuberosity to the tip of the coronoid) multiplied by the force created by the biceps-brachialis muscular complex. The force is dependent upon many factors including limb position, acceleration, velocity of contraction, fiber recruitment, and muscle temperature. Based on the anatomical findings in this study, which show the position of the insertion sites for the biceps-brachialis complex and joint moments, the authors hypothesise that the moment produced by the force of contraction rotates the cranialateral...
segment of the medial coronoid process against the radial head. With the radial head stabilised by the annular ligament and contraction of the radial insertion of the biceps-brachialis complex, the medial coronoid process is compressed against the radial head. As predicted by mechanical beam theory, the magnitude and direction of shear stress secondary to compression is highest at an oblique angle to the applied compressive force (11). As such, if this compression of the medial coronoid process against the radial head occurs clinically, this would generate internal shear stress within the medial coronoid process. Computer modelling would lend credence to this hypothesis and is a logical next step. With computer modelling one could determine if the shear stress produced by contraction of the biceps-brachialis complex exceeds the structural (catastrophic or plastic failure) material (cyclic failure) strength of the cancellous bone in the cranio-lateral segment of the medial coronoid process. If modelling agreed with the hypothesis, it would confirm that micro-damage or fragmentation would occur adjacent to the radial head at an oblique angle to the long axis of the medial coronoid process. This would coincide with the clinical finding that the plane of microdamage or fragmentation of the medial coronoid process as seen in clinical cases is in the same location and direction as the predicted maximum shear stress (Fig. 4).

References