Role of the tendons of the biceps brachii and infraspinatus muscles and the medial glenohumeral ligament in the maintenance of passive shoulder joint stability in dogs

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Objective—To objectively evaluate the effect of transecting the tendon of the biceps brachii muscle (BBT), tendon of the infraspinatus muscle (IFS), or medial glenohumeral ligament (MGHL) on shoulder joint stability in canine cadavers.

Sample Population—81 forelimbs from mature dogs.

Procedure—Cadaver forelimbs were placed in a testing frame and axially preloaded with 4 kg of weight. Shoulder joint stability was tested in neutral joint position, flexion, and extension before and after transection of the BBT (n = 37), IFS (37), or MGHL (7). Humeral translation relative to the glenoid was induced by applying a 3-kg load in each of 3 directions (cranial, lateral, and medial) and quantitatively measured by use of an electromagnetic motion tracking system. Peak translational data were compared in each joint position before and after transection of the BBT, IFS, or MGHL.

Results—When tested in neutral position, the cranial, lateral, and medial translation of the humerus was significantly increased after BBT transection. In the extended position, the medial translation of the humerus was significantly increased after BBT transection. Complete medial luxation of all humeral heads occurred following transection of the MGHL.

Conclusions and Clinical Relevance—The BBT contributes to passive shoulder joint stability in dogs, particularly in the neutral and flexed positions. It also provides medial stability during shoulder joint extension. Complete luxation of the joint occurs when the MGHL is transected. (Am J Vet Res 2004;65:1216–1222)

Stability in the functionally normal shoulder joint is dependent on a complex interaction between the active and passive stabilizers of the joint.1,3 Both active and passive mechanisms function in unison, with the active stabilizers being more important when humeral head displacement is small and the passive stabilizers having a more important role when humeral head displacement is greater.7 No single structure or stabilizing mechanism is responsible for stability during all joint positions or in all directions. In dogs, shoulder joint stability is primarily dependent on the joint capsule and glenohumeral ligaments.1,2,9 The periarticular musculature is also important, especially in the active state.5

Shoulder joint instability often causes forelimb lameness in dogs and is the most common shoulder joint disease diagnosed.1,2,4 It is defined as an abnormal translation of the humeral head on the glenoid, leading to discomfort or dysfunction of the shoulder joint, and results from incompetence or disruption of the shoulder joint stabilizing mechanisms.1,2,9 With shoulder joint instability, translation of the humeral head relative to the glenoid exceeds that found in the functionally normal joint. Although the clinical, radiographic, and arthroscopic findings of shoulder joint instability have been well described,1 little is known about the role of periarticular structures in maintaining shoulder joint stability in dogs. In a previous study, the effects of transecting various periarticular muscles on shoulder joint range of motion were evaluated. However, translation of the humeral head relative to the glenoid before and after transection of periarticular structures has not been described in dogs.

This study was designed to provide biomechanical information regarding the importance of the tendon of the biceps brachii muscle (BBT), the tendon of the infraspinatus muscle (IFS), and the medial glenohumeral ligament (MGHL) on shoulder joint stability. These structures were evaluated because of their clinical relevance. The BBT was tested to determine whether transection of the tendon as a treatment for bicipital tenosynovitis in clinically affected dogs could be detrimental to joint stability. The IFS was tested because it is often transected during surgical approaches to the shoulder joint or as the treatment for infraspinatus contracture. The MGHL was tested because of its association with medial shoulder joint luxation in dogs. Our hypotheses were 4-fold as follows: transection of the BBT will create an increase in cranial and medial shoulder joint translation, transection of the
IFS will create an increase in lateral shoulder joint translation, transsection of the MGHL will cause a medial shoulder joint luxation, and the amount of increase in shoulder joint translation after transsection of the BBT or IFS will be affected by shoulder joint position.

Materials and Methods

Testing frame—A custom-designed frame was built to accommodate canine forelimbs during biomechanical testing. The frame consisted of a foundation, a locking plate, a loading platform, and 3 horizontal loading bars (Figures 1 and 2). The foundation was constructed from a 1.25-cm-thick aluminum plate. Attached to the foundation was a locking plate for anchoring the antebraclium during mechanical testing. Four stainless steel vertical posts (height, 91.4 cm) were fixed to the corners of the foundation (25.4 cm apart). The loading platform was positioned on the 4 posts and weighed 4 kg. It was used to axially load the shoulder joints once they were positioned in the frame. A ball-bearing system was present in each corner of the loading platform, which allowed the platform to glide vertically along the posts. A braking device placed on one of the vertical posts prevented loading of the limbs during mounting of the specimens. The loading platform also contained a metal brace to which the scapula was rigidly fixed during testing. Two semicircular grooves cut into the scapular brace allowed for angular adjustment of the shoulder joints. Once mounted in the testing frame, the shoulder joint was easily flexed and extended with only minor adjustments made to the limb and testing frame, and rotation of the scapula and antebraclium were prevented. On 3 sides of the testing frame, adjustable loading bars were present and permitted loading of the proximal portion of the humerus in the cranial, lateral, and medial directions.

Data collection—An electromagnetic motion tracking system was used to measure 3-dimensional movement (in centimeters) of the humeral head after application of a horizontal load to the proximal portion of the humerus. The transmitter of the tracking system was permanently attached to the horizontal loading bar of the testing frame just cranial to the forelimb, and the sensor was secured to the proximal portion of the humerus of each limb.

Specimen preparation and mounting—Right and left forelimbs were harvested by amputation with removal of the scapula from skeletally mature dogs immediately following euthanasia. All dogs weighed between 15 and 26 kg. Dogs were obtained after use in a veterinary surgical teaching laboratory, but no surgical procedures had been performed on any of the limbs used in the study. At the time of collection, the skin and subcutaneous tissues of the limbs were removed. Forelimbs were wrapped in saline (0.9% NaCl) solution-soaked towels and stored at –10°C until the study removed. Forelimbs were wrapped in saline (0.9% NaCl) to maintain tissue hydration.

Each forelimb was prepared and mounted in the testing frame in a similar manner. Two holes were drilled in the scapula cranial to the scapular spine by use of a drill bit (diameter, 3/8 inches) with the aid of a custom-made drill guide. The drill guide ensured that the holes were consistently placed 8 cm apart. The distal hole was drilled at the level of the acromion process. The proximal hole was drilled 8 cm proximal to the first hole and just cranial to the scapular spine. The scapula was secured to the scapular brace of the loading platform with 2 stainless steel bolts, lock washers, and nuts. With the limb hanging from the loading platform, 2 smooth Steinmann pins (diameter, 7/64 inches) were drilled with the aid of a second custom-made drill guide in a craniocaudal direction through the radius and through preset holes in the locking plate. The drill guide ensured a consistent distance of 3 cm between these fixation pins. The pins immobilized the distal portion of the limb during testing. The sensor for the electromagnetic motion tracking system was then attached to the proximal portion of the humerus. The attachment site was consistently at a point just lateral to the tendon of insertion of the supraspinatus muscle on the greater tubercle. The joint capsule was then vented with a 20-gauge hypodermic needle. A mediolateral hole used for horizontal loading of the humerus was drilled with a drill bit (diameter, 3/64 inches) through the proximal portion of the humerus. The hole was drilled parallel to the testing frame foundation and centered in a craniocaudal direction on the humerus. The location of the hole was at the midpoint of the deltoit tuberosity. A strand of 60-lb tensile strength monofilament nylon leader material was threaded through the hole, and 1 toggle rod was tied to the nylon medial and lateral to the humerus. The toggle rods were tied 2 to 3 cm from the bone with approximately 10 to 15 cm of nylon remaining outside of the toggle rod. The free ends of the monofilament nylon on each side were tied, leaving a large loop that would accommodate the loading weights.

Shoulder joints were positioned in the desired testing angle before releasing the brake on the testing frame. The same observer (BKS) measured the shoulder joint angle twice by use of a goniometer to assure the correct joint position for biomechanical testing. Notice the loading platform with attached scapular brace (A), foundation (B), locking plate (C), electromagnetic transmitter and sensor (D), and adjustable bars used for horizontal loading of the proximal portion of the humerus (E).
Biomechanical testing—The 3-dimensional starting point of each shoulder joint was first established on the basis of coordinates supplied by the electromagnetic motion tracking system. Three consecutive X, Y, and Z coordinate readings were recorded with the electromagnetic motion tracking system and were averaged independently to establish the 3-dimensional humeral head starting point (referred to as starting coordinates). All translational measurements were calculated from the starting point of each limb.

In each limb, a 3-kg horizontal load was applied to the proximal portion of the humerus by use of a free weight to create translation of the humeral head in relation to the glenoid. This amount of load and similar loads have been used to create a horizontal translation of joints in human studies.12-14 The load was applied to each tested forelimb in the cranial, lateral, and medial directions separately, and the sequence of loading was randomized for each limb. Application of the horizontal load was similar in all limbs. Loading weights were placed within the loop of nylon on the appropriate side of the humerus, and the nylon was laid over the desired (cranial, lateral, or medial) loading bar on the testing frame. Before the loading weights were hung, the loading bars on the frame were positioned at the level of the hole previously drilled in the proximal portion of the humerus to ensure that loading occurred perpendicular to this point. During loading in the lateral and medial directions, engagement of the toggle rods with the cortex of the bone on the opposite side of the humerus created displacement of the humeral head. During loading in the cranial direction, both ends of the nylon were laid over the cranial loading bar and the nylon coursing through the humerus created displacement of the humeral head. The loading weights were gently hung over the loading bars and allowed to settle so that no movement occurred during collection of translational data.

Once humeral head translation ceased during the horizontal loading, a peak translation point consisting of X, Y, and Z coordinates was recorded by use of the electromagnetic motion tracking system and electromagnetic motion tracking software. Three consecutive loading trials were performed for each direction of loading. Humeral heads were unloaded between trials and allowed to return to a resting position. The peak translational data points were stored by use of commercial spreadsheet software for later analysis. The mean value of the 3 peak translational data points was used to determine the translation (in cm) of the humeral head after loading, compared with its starting position before loading as follows:

\[
\text{Peak coordinates (mean, intact) – starting coordinates} = \text{translation in each direction for the intact shoulder joint}
\]

After translational measurements in the medial, lateral, and cranial directions were determined for the intact joint, 1 structure (the BBT, IFS, or MGHL) was transected in each limb. Without removing the axial load from the limb and without interfering with the frame or the limb position, the structures were transected by use of 1 of 2 methods. The BBT and IFS were transected by use of a No. 11 scalpel blade. The BBT was transected just proximal to the transverse humeral ligament. The IFS was transected 0.5 cm from its insertion on the greater tubercle of the humerus. The MGHL (and a portion of the medial aspect of the joint capsule) was transected with a sheathed arthroscopic knife midway between the origin of the MGHL on the glenoid and its insertion on the humerus. After transection, limbs were subjected to the same testing protocol as already described. The sequence of horizontal loading was again randomized for each limb. Similar to before, the mean value of the 3 peak translational data points was used to determine the translation (in cm) of the humeral head after loading, compared with its starting position before loading, as follows:

\[
\text{Peak coordinates (mean, transected) – starting coordinates} = \text{translation after transection}
\]

The translation (mean of 3 measurements for each direction) in the lateral, medial, and cranial directions in the intact shoulder joints was subtracted from that of the shoulder joints after transection of each desired structure (mean of 3 measurements for each direction) to calculate the difference in translation as follows:

\[
\text{Translation (mean, transected) – translation (mean, intact)} = \text{difference in translation between transected (cut) and intact joint}
\]

Statistical analysis—For statistical analysis, the peak translation distance was compared between the intact and
transected groups. Shoulder joints in the MGHL group completely luxated (medially) after transection of the ligament; therefore, no comparison analysis was performed. Translation of the humerus in relation to the scapula was analyzed separately for each direction of loading (cranial, medial, and lateral) by use of an ANOVA for repeated-measures design with 2 between-limb factors and 1 within-limb factor in a factorial arrangement. The between-limb factors were type of structure (BBT or IFS) and shoulder joint position (neutral, flexed, or extended). The within-limb factor was tendon status (intact, or transected). The residuals from each ANOVA were examined by use of frequency histograms and normal probability plots; the normality assumption appeared to be adequately satisfied. An ANOVA was performed by use of a commercial software program. When significant effects were found, means were separated by use of the least significant difference test. The clinical importance of significant differences was assessed by use of 95% confidence intervals (CIs). All calculations were performed by use of commercial software; values of $P < 0.05$ were considered significant.

**Results**

No radiographic abnormalities were found in any of the shoulder joints. Therefore, all 81 forelimbs were tested. Thirty-seven forelimbs were assigned to the BBT group. Of these 37 forelimbs, 12 had shoulder joints tested in neutral position, 12 in flexion, and 13 in extension. Thirty-seven forelimbs were assigned to the IFS group. Of these 37 forelimbs, 14 had shoulder joints tested in neutral joint position, 12 in flexion, and 11 in extension. Seven forelimbs were assigned to the MGHL group; all had shoulder joints tested in neutral position only.

**BBT group**—With the shoulder joints in neutral position and a 3-kg load applied in a cranial direction to the proximal portion of the humerus, mean translation of the humerus increased significantly ($P < 0.001$) by 0.29 cm (CI, 0.21 to 0.37 cm) after transection of the BBT (Table 1). When the proximal portion of the humerus was loaded in the lateral direction, mean translation increased significantly ($P < 0.001$) by 0.34 cm (CI, 0.25 to 0.42 cm) after transection of the BBT. When the proximal portion of the humerus was loaded in the medial direction, mean translation increased significantly ($P < 0.001$) by 0.28 cm (CI, 0.13 to 0.43 cm) after transection of the BBT.

With shoulder joints in flexion and a 3-kg load applied in a cranial direction to the proximal portion of the humerus, mean translation of the humerus increased significantly ($P < 0.001$) by 0.15 cm (CI, 0.07 to 0.23 cm) after transection of the BBT. When the proximal portion of the humerus was loaded in the lateral direction, mean translation increased significantly ($P = 0.01$) by 0.11 cm (CI, 0.03 to 0.20 cm) after transection of the BBT. When the proximal portion of the humerus was loaded in the medial direction, mean translation increased by 0.15 cm (CI, 0.004 to 0.29 cm) after transection of the BBT, but this increase was not significant ($P = 0.06$).

With shoulder joints in extension and a 3-kg load applied in a cranial direction to the proximal portion of the humerus, mean translation of the humerus increased by 0.03 cm (CI, –0.05 to 0.10 cm) after transection of the BBT, but this increase was not significant ($P = 0.62$). When the proximal portion of the humerus was loaded in the medial direction, mean translation increased significantly ($P = 0.04$) by 0.15 cm (CI, 0.01 to 0.29 cm) after transection of the BBT.

**IFS group**—With shoulder joints in neutral position and a 3-kg load applied in a cranial direction to the proximal portion of the humerus, mean translation of the humerus increased by 0.03 cm (CI, –0.05 to 0.10 cm) after transection of the IFS, but this increase was not significant ($P = 0.47$; Table 2). When the proximal portion of the humerus was loaded in the lateral direction, mean translation increased by 0.04 cm (CI, –0.04 to 0.12 cm) after transection of the IFS, but this increase was not significant ($P = 0.28$). When the proximal portion of the humerus was loaded in the medial direction, mean translation increased by 0.02 cm (CI, –0.12 to 0.16 cm) after transection of the IFS, but this increase was not significant ($P = 0.76$).

With shoulder joints in flexion and a 3-kg load applied in a cranial direction to the proximal portion of the humerus, mean translation of the humerus increased by 0.02 cm (CI, –0.06 to 0.10 cm) after transection of the IFS, but this increase was not significant ($P = 0.65$). When the proximal portion of the humerus was loaded in the lateral direction, mean translation increased by 0.01 cm (CI, –0.07 to 0.09 cm) after transection of the IFS, but this increase was not significant ($P = 0.80$). When the proximal portion of the humerus was loaded in the medial direction, mean translation increased by 0.02 cm (CI, –0.14 to 0.16 cm) after transection of the IFS, but this increase was not significant ($P = 0.86$).

With shoulder joints in extension and a 3-kg load applied in a cranial direction to the proximal portion of the humerus, mean translation (0.00 cm) of the humerus did not change significantly ($P = 0.88$; CI, –0.08 to 0.09 cm) after transection of the IFS. When

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<th>Position and translation</th>
<th>Before and after BBT transection</th>
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<td>Neutral</td>
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<td>CT (cm)</td>
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<td>MT (cm)</td>
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<tr>
<td>Extended</td>
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<td>CT (cm)</td>
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<td>LT (cm)</td>
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<td>MT (cm)</td>
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*Standard error of the least squares mean as determined on the basis of a pooled estimate of variation from an ANOVA. †Values of $P < 0.05$ were considered significant. BBT = Tendon of the biceps brachii muscle. CT = Cranial translation. LT = Lateral translation. MT = Medial translation.
the proximal portion of the humerus was loaded in a lateral direction, mean translation (0.00 cm) did not change significantly ($P = 0.98$; CI, $-0.09$ to $0.09$ cm) after transection of the IFS. When the proximal portion of the humerus was loaded in the medial direction, mean translation increased by $0.01$ cm (CI, $-0.14$ to $0.17$ cm) after transection of the IFS, but this increase was not significant ($P = 0.89$).

MGHL group—Complete medial luxation of all humeral heads occurred following transection of the MGHL and medial aspect of the joint capsule. Therefore, translational data were not analyzed after transection of the MGHL.

### Discussion

In our study, selective cutting of periarticular structures with horizontally applied translational loads was used to evaluate the role of the BBT, IFS, and MGHL in maintaining shoulder joint stability in dogs. Loading the limbs during testing simulated the weight-bearing nature of the canine forelimb, and the scapula and antebrachium were immobilized to isolate movement to the shoulder joint. The selective cutting method involves the biomechanical testing of cadaveric specimens before and after creation of specific lesions. Although the use of selective cutting of periarticular structures for biomechanical testing has several potential disadvantages, researchers have relied heavily on this method to define functionally normal stabilizing mechanisms in the joints of humans. This method is more reliable and reproducible than the alternative testing technique (ie, injury simulation studies). 17

To our knowledge, this is the first study to use horizontally applied loads to measure translational motion of the shoulder joint of dogs. However, the use of horizontally applied translational loads to evaluate joint instability is not a new concept. Examination techniques such as cranial drawer motion for evaluation of cranial cruciate ligament injuries and Barden palpation16 for evaluation of coxofemoral joint laxity provide examples of horizontal loading tests that are used clinically. Barden12 has also described the craniocaudal or mediolateral drawer sign (translational movement) for the diagnosis of shoulder joint instability. Our study objectively documented the magnitude of shoulder joint translation in anatomically normal shoulder joints and in shoulder joints after selective cutting of the BBT, IFS, and MGHL. Translational loads have also been used to evaluate the shoulder joint stabilizing function of the BBT in humans. In these studies, a 1.5- to 3-kg horizontal load was typically applied to create translation movement, as was used in our study. Information regarding the translational stability of the shoulder joint before and after selective cutting of periarticular structures augments the information provided in a previous study evaluating range of motion of the shoulder joint.

An electromagnetic motion tracking system was used to quantitatively measure translation of the humeral head in our study. Electromagnetic motion tracking systems have been used in vitro and in vivo to measure simultaneous 3-dimensional rotational motion as well as translational displacement in the study of human shoulder joints. Recently, the same electromagnetic motion tracking system was used to kinematically evaluate the canine stifle joint. The systems are highly accurate and reliable. They provide dynamic real-time measurements with 6 degrees of freedom (3 linear coordinates [Cartesian: X, Y, and Z] and 3 angular coordinates [Eulerian: yaw, pitch, and roll]) to specify position and orientation in 3-dimensional analysis of rigid body motion. The electromagnetic motion tracking system that was used in our study has a static accuracy of 0.08 cm (0.03 inch) root mean squared for X, Y, and Z positions and 0.15° root mean squared for orientation. The resolution of the system is 0.0005 cm/cm (0.0002 inch/inch) of transmitter-receiver separation and 0.025° for orientation.

Venting of the joint capsule during biomechanical testing of the shoulder joint is controversial. In studies on human shoulder joints, the joint capsule has usually been vented to eliminate the potential influence of negative intra-articular pressure on shoulder joint stability. However, by venting the joint capsule, the normal synergy of the shoulder joint stabilizing mechanisms may be disrupted, and some studies indicate that venting the joint capsule increases shoulder joint instability. The effect of negative intra-articular pressure on shoulder joint stability in dogs has not been reported. However, it may be less important in dogs because of the weight-bearing nature of the forelimb. In our study, the joint capsule was vented prior to obtaining positional data on the intact joints and remained vented while data were collected after tendon transection. Subjectively, it did not appear that venting the joint had an effect on shoulder joint stability. However, venting the shoulder joints prior to testing provided consistency between the groups because the joint was instantly violated once the BBT and MGHL were transected.

The 81 forelimbs evaluated in our study were collected from dogs weighing 15 to 26 kg. Findings in a previous study indicate that dogs place approximately 30% of their body weight on each forelimb during ambulation. Thus, a 4-kg preload was applied to all the forelimbs to simulate their weight-bearing status.
tested limbs to simulate weight-bearing load on the shoulder joint. However, it is possible that this may have impacted the results because the preload was the same for all limbs, despite small variations in size and conformation. The magnitude of this impact is unknown because the effect of joint compression (or weight bearing) on shoulder joint stability in dogs has not been reported. Although a constant axial load was applied during testing of the forelimbs in our study, the specific effect of joint compression on shoulder joint stability was not measured. However, because the forelimb in dogs bears weight during standing and ambulation, it is feasible that axial loading plays an important role in shoulder joint stability.

Lesions of the BBT are frequently recognized as a cause of shoulder joint lameness in dogs. They are the third most common shoulder joint disorder after shoulder joint instability and osteochondrosis. Recently, a study classified BBT lesions into 1 of 6 subtypes. Historically, the preferred treatment for BBT lesions was bicipital tenodesis. However, with the increased availability and use of arthroscopy, arthroscopic bicipital tenotomy has become popular when it is available. It is unknown whether bicipital tenotomy in dogs causes long-term adverse effects. The importance of the BBT as a shoulder joint stabilizer in humans has been well documented, and researchers in human medicine have implied that sacrificing the intra-articular part of the BBT during surgical procedures could result in shoulder joint instability and dysfunction.

After transection of the BBT in our study, a significant increase in humeral translation occurred in the lateral, medial, and cranial directions when the shoulder joint was tested in neutral position. A significant increase in translation also occurred in the cranial and lateral directions when testing the shoulder joint in flexion and in the medial direction when testing the shoulder joint in extension. These findings indicate that the BBT does provide passive restraint to the shoulder joint in dogs. However, because the shoulder joint has many stabilizing mechanisms, it is quite possible that in the live dog, 1 or more of these mechanisms could compensate for the loss of BBT function and maintain joint stability once the BBT is transected. This is supported clinically by the favorable short-term outcomes reported for dogs following tenotomy for the treatment of bicipital tenosynovitis and BBT tears. These reports describe early weight bearing and improved comfort after tenotomy. However, the question as to whether any long-term adverse effects develop in the shoulder joint (such as osteoarthritis) that may be caused by a mild instability after tenotomy has not been answered.

Following tenotomy of the IFS, no significant increase in humeral translation was found in the lateral, medial, or cranial directions, compared with intact shoulder joints. The IFS functions primarily as an active stabilizer of the shoulder joint and appears to have a minimal role in passive restraint. The technique used in our study is a static biomechanical model because no muscle contraction was simulated in any of the cuff muscles (ie, the supraspinatus, infraspinatus, subscapularis, and teres minor muscles) during testing. In fact, once the shoulder joint was axially loaded in the testing frame, laxity was invariably observed in the IFS as well as other periarticular muscles. Thus, when the already lax IFS was transected, no significant change in humeral translation occurred. This finding is supported by the positive clinical results achieved after transection of the IFS for treatment of infraspinatus contracture.

In dogs, the joint capsule and glenohumeral ligaments have been regarded as vital structures in shoulder joint stability. In fact, shoulder joint luxation is not possible unless the glenohumeral ligaments are severed. The results of our study support these observations. Complete luxation of the humeral head occurred in all of the shoulder joints evaluated in our study after transection of the MGHL and medial aspect of the joint capsule.

The clinical relevance of the increased translation found in our study remains unclear. The magnitude of the humeral translation that occurred after tendon transection was significantly greater than that found in intact joints. As in humans, it is possible that an increase in shoulder joint laxity in dogs does not necessarily equate to clinically relevant shoulder joint instability. However, the fact that dogs use their forelimbs for weight bearing, unlike humans, may make smaller degrees of joint laxity more clinically important. Additionally, our study was conducted on cadavers and evaluated only passive stabilizing mechanisms of the shoulder joint. The role of the BBT and other joint structures in providing active joint stabilization was not evaluated.

Results of our study indicate that the BBT contributes significantly to passive shoulder joint stability in dogs, particularly in the neutral and flexed positions, and provides medial stability during shoulder joint extension. The IFS provides little passive restraint to the shoulder joint. The MGHL is an important stabilizer of the canine shoulder joint, and transection of the MGHL results in complete medial luxation of the joint.

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