Arthroscopic tenotomy for treatment of biceps tendon luxation in two apprehension police dogs

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CASE DESCRIPTION

A 7.5-year-old 37.8-kg (83.2-lb) sexually intact male German Shepherd Dog (dog 1) and a 2.6-year-old 28.2-kg (62.0-lb) sexually intact male Dutch Shepherd (dog 2), both apprehension police dogs, were admitted for evaluation of left and right thoracic limb lameness, respectively.

CLINICAL FINDINGS

In both dogs, signs of pain were elicited on palpation of the shoulder joint in the affected limb, and a distinct popping of the biceps brachii tendon (BT) was palpable on the craniomedial aspect of the affected joint on flexion and extension and was associated with moderate signs of pain. Biceps brachii tendon luxation (BTL) was diagnosed with dynamic musculoskeletal ultrasonography (both dogs) and MRI (dog 1).

TREATMENT AND OUTCOME

Arthroscopic BT release by tenotomy was performed in both dogs. Lameness appeared to have resolved by 8 weeks after surgery and had not recurred by the last follow-up communications at 36 and 9 months after surgery for dogs 1 and 2, respectively. Both dogs successfully returned to their level of work performed before their injury.

CLINICAL RELEVANCE

Our findings for the dogs of the present report suggested that arthroscopic BT release could be considered a viable treatment option for BTL in dogs, including police dogs or other high-performance athletic dogs. Although our findings provided encouraging results, further research, best conducted with a multicenter prospective randomized study, would be needed to establish the most reliable treatment of BTL in high-performance athletic or working dogs. (*J Am Vet Med Assoc* 2020;257:1157–1164)

Dog 1

A 7.5-year-old 37.8-kg (83.2-lb) sexually intact male German Shepherd Dog (dog 1), an apprehension police dog, was admitted for evaluation because of a 1-month history of weight-bearing lameness (grade 2 on a scale[1] from 0 [no lameness] to 5 [continuous non–weight-bearing lameness]) in the left thoracic limb. Results of a CBC and serum biochemical analyses were unremarkable. Conservative medical management with carprofen (2.2 mg/kg [1 mg/lb], PO, q 12 h) and gabapentin (10 mg/kg [4.5 mg/lb], PO, q 8 h) combined with limited activity (10-minute leash walks 3 times daily for 3.5 weeks) yielded slight improvement of the lameness, which then worsened with resumed police dog training.

ABBREVIATIONS

BT	Biceps brachii tendon
BTL	Biceps brachii tendon luxation
BTR	Biceps brachii tendon release by tenotomy
LOAD	Liverpool osteoarthritis in dogs
MSK US	Musculoskeletal ultrasonography
pROM	Passive range of motion
PSWA	Pressure-sensitive walkway analysis
TRH	Transverse retinaculum of the humerus
TPI	Total pressure index
UWTM	Underwater treadmill

On orthopedic examination, dog 1 had severe weight-bearing lameness (grade 3/5) in the left thoracic limb that progressed with episodes of non–weight-bearing lameness (grade 4/5) during exercise. When the pROM of the left shoulder joint was evaluated, a distinct popping of the BT was palpable on the craniomedial aspect of the joint during flexion and extension and was associated with moderate signs of pain. Because of the dog's aggressive and protective behavior, further examination without sedation was not practical. Therefore, the dog was sedated with hydromorphone (0.1 mg/kg [0.05 mg/lb], SC) and midazolam hydrochloride (0.5 mg/kg [0.23 mg/lb], SC). Results of a CBC and serum biochemical analyses were unremarkable, and dog 1 underwent general anesthesia for diagnostic imaging. Anesthesia was induced with propofol (3 mg/kg [1.4 mg/lb], IV) and maintained with 1.5% isoflurane (vaporizer setting) in oxygen (2.2 L/min). Radiography revealed no abnormalities; thus, MRI[a] of the left shoulder joint was performed. Multiplanar sagittal, transverse, and dorsal oblique image planes were obtained with gradient-echo, spin-echo, and STIR sequences. Abnormal findings on MRI included mild effusion along the biceps muscle and around the BT, displacement of the BT medial to the bicipital groove, and edema in the biceps muscle, suspected to have been related to disruption of the TRH **(Figure 1)**. Dog 1 recovered from anesthesia, and arthroscopic treatment was scheduled for the following week. No medical treatment was initiated at this point. Activity was limited to short leash walks for elimination purposes only, and the dog was otherwise kept in a large kennel while inside the house.

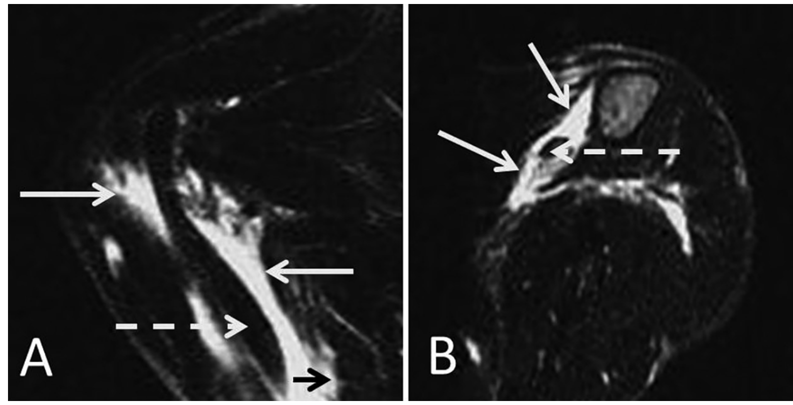

Figure 1—Sagittal oblique (A) and dorsal oblique (B) STIR sequence MRI images of the left shoulder joint of a 7.5-year-old 37.8-kg (83.2-lb) sexually intact male German Shepherd Dog (dog 1) with a 1-month history of weight-bearing lameness in the left thoracic limb. A—The BT (dotted arrow) has effusion (white solid arrows) around it and edema (black arrow) within it. B—There is effusion (white solid arrows) around the BT (dotted arrow). No abnormalities are evident in the biceps brachii muscle.

One week later, dog 1 was returned and underwent the same anesthetic protocol for general anesthesia. In addition, cefazolin (22 mg/kg [10 mg/lb], IV) was administered at induction. After the dog's hair was clipped from the craniomedial aspect of both shoulder joints, soft tissue swelling in the left shoulder joint region could be felt, compared with the right. With a 12-MHz linear probe,[b] MSK US was performed on the left thoracic limb and revealed that the BT was located medial to the intertubercular groove, which was filled with fluid, presumably synovial fluid. No abnormalities were identified in the supraspinatus muscle and tendon. For the right thoracic limb, results of MSK US were clinically normal. Additional hair from the left shoulder joint was clipped; the dog was positioned in right lateral recumbency, with its sternum close to the edge of the surgical table; and the left shoulder joint was aseptically prepared for surgery.

Arthroscopy with a 2.3-mm, 30° arthroscope[c] and 2.5-mm joint probe[d] was performed on the left shoulder joint and revealed evidence of severe synovitis surrounding the origin of the BT and affecting the entire cranial and craniomedial aspects of the joint capsule. The subscapular tendon and medial glenohumeral ligaments appeared clinically normal. Biceps tendon luxation could not be elicited intraoperatively while performing shoulder joint pROM; however, with the use of a joint probe through the cranial arthroscopic port, the BT could be pushed over the lesser tubercle of the humerus. Arthroscopic BTR was performed similarly as previously described[2]; however, a No. 11 scalpel blade was used instead of a radiofrequency probe, which has been associated with thermal damage to articular cartilage after shoulder joint arthroscopy.[3] The blade was inserted craniomedially under arthroscopic guidance, and transverse biceps tenotomy was performed immediately distal to the BT origin, ensuring not to damage any other joint structures. After completion of the procedure, dog 1 recovered from anesthesia without complications.

Later the same day, dog 1 was weight-bearing on the surgically treated limb and discharged with prescriptions of cephalexin (22 mg/kg, PO, q 12 h for 5 days), carprofen (2.2 mg/kg, PO, q 12 h for 10 days), and tramadol hydrochloride (3 mg/kg [1.4 mg/lb], PO, q 12 h for 7 days). For the first 2 weeks after surgery, activity was limited to short leash walks not lasting > 10 min/walk and only for elimination purposes. Thereafter, leash walks were allowed to increase by 5 min/wk, with 3 walks/d allowed. Activity was gradually increased without any signs of pain as seen before surgery, and at 6 weeks after surgery, the dog was allowed to engage in off-leash play for 5 to 10 min/d, which was tolerated well.

During the 8-week follow-up examination, dog 1 showed no signs of pain or lameness when walking. At a gallop, the dog had a subjectively short stride during the swing phase of the gait in the left thoracic limb, compared with the right. However, this did not limit the dog's function or ability to return to normal work as an apprehension police dog. One year after surgery, the dog subjectively appeared to have had complete recovery and was observed leading with its left thoracic limb (**Supplementary Video S1**, available at: avmajournals.avma.org/doi/suppl/10.2460/javma.257.11.1157).

The final follow-up on dog 1 was at 3 years after surgery and consisted of a telephone interview with the dog's handler and completion of a LOAD questionnaire.[4] No lameness was reported, and the dog was being used with full capacity as a police dog. The final aggregate LOAD score was 9 (on a LOAD lameness scale in which 0 to 10 = mild, 11 to 20 = moderate, 21 to 30 = severe, and 31 to 52 = extreme), which was in the lowest category (mild) of lameness of this validated[5] questionnaire. In addition, the dog subjectively had no signs of lameness or discomfort (**Supplementary Video S2**, available at: avmajournals.avma.org/doi/suppl/10.2460/javma.257.11.1157) and was reported by its handler to have had 100% functionality in its limbs and full ability to work.

Dog 2

A 2.6-year-old 28.2-kg (62.0-lb) sexually intact male Dutch Shepherd apprehension police dog (dog 2) was referred because of a 9-day history of right thoracic limb lameness. The referring veterinarian had performed bilateral radiography of the shoulder and elbow joints, and results were clinically normal. Although no diagnosis had been established, the referring veterinarian suspected a right shoulder joint injury and prescribed carprofen (2 mg/kg [0.9 mg/lb], PO, q 12 h for 10 days).

During the initial referral examination, dog 2 had weight-bearing lameness (grade 1 to 2/5) in the right thoracic limb when walking and did not apply the same weight to the affected limb, compared with the contralateral limb, when standing. Both elbow joints had clinically normal pROM, and the dog showed no resistance to flexion or signs of pain with palpation of the medial compartments. For each thoracic limb, with the shoulder joint in flexed position, the elbow joint was extended (biceps stretch test). During the biceps stretch test on the right thoracic limb, the typically distinguishable stop in flexion that occurs when a noninjured BT moves through the intertubercular groove and limits continued shoulder joint flexion was not noticed. In addition, during pROM evaluation of the shoulder joint, a distinct popping of the right BT was palpated on the medial aspect of the shoulder joint during flexion and extension. These findings were suggestive of BTL. No abnormalities were detected in the left shoulder joint on palpation. With the dog standing, a tape measure designed for measuring body dimensions[e] was used to measure the circumference of each thoracic limb at the level of the greater tubercle of the humerus, and the circumference was 30 cm bilaterally. The remainder of findings on orthopedic examination were within reference limits. The dog underwent PSWA,[f] and the TPI was 28% and 33% (reference range,[6] 28% to 32%) for the right and left thoracic limbs, respectively.

With an 18-MHz linear probe,[g] MSK US was performed and revealed a clinically normal left shoulder joint but abnormalities in the right **(Figure 2)**. In the right thoracic limb, the supraspinatus muscle (18.7 mm thick in the transverse plane at the level of the shoulder joint) had a generalized homogeneous fiber pattern, and the supraspinatus tendon (0.41-cm length, 0.42-cm width, and 0.47-cm^2 cross-sectional area) appeared clinically normal and had no contact with the BT, which was medial to the bicipital groove of the humerus. The thickness of the shoulder joint capsule appeared regular and was 0.10 to 0.12 cm (considered clinically normal). The BT had a disrupted fiber pattern with distinct hypoechoic foci centrally at the point of the origin at the supraglenoid tubercle. This finding was interpreted as a grade 2 tendon strain on a grading scale[7] of 1 (mild) to 3 (complete tendon rupture). Distally, the biceps muscle and tendon appeared to have had a good homogeneous fiber pattern. In addition, the BT appeared to have been out of the bicipital groove, with a hypoechoic area between the BT and bicipital groove just distal to the BT origin. In this hypoechoic area, an irregularly shaped hyperechoic substance was evident and suspected to have been related to disruption of the TRH. During dynamic ultrasonographic evaluation of the shoulder joint, the BT was observed to luxate medially during flexion, and the working diagnosis was a medial BTL secondary to a torn TRH.

Surgical treatment options discussed with the handler of dog 2 included an attempt to reconstruct the TRH with bone screws and suture or to perform a BTR. The handler elected to reassess progress after further conservative management.

Six months after MSK US, dog 2 was returned for a recheck examination because of continued lameness in the right thoracic limb. The handler reported that the dog was able to walk slowly without lameness; however, when training or working, the dog would intermittently show signs of pain, such as limping or

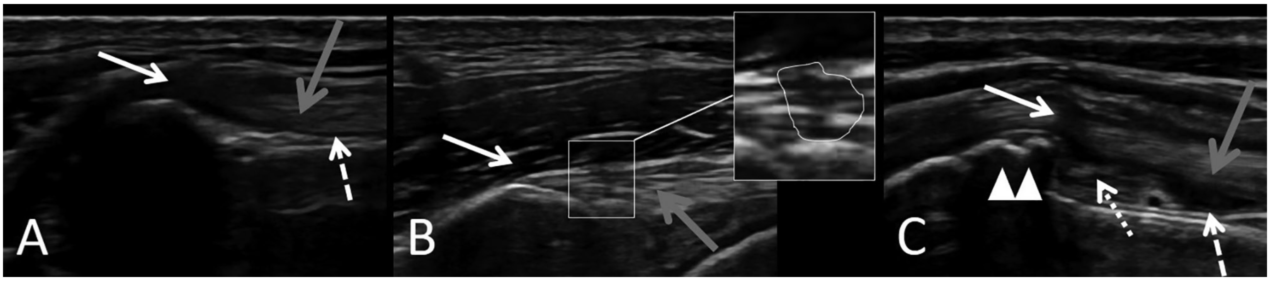

Figure 2—Representative ultrasonographic images of the left (A) and right (B and C) shoulder joints of a 2.6-year-old 28.2-kg (62.0-lb) sexually intact male Dutch Shepherd (dog 2) evaluated because of a 9-day history of right thoracic limb lameness. In all images, proximal is to the left and cranial is to the top. A—Craniocaudal sagittal ultrasonographic image showing a clinically normal left BT origin (white arrow) and a clinically normal BT (gray arrow) sitting within and having close contact with the bicipital groove (white dashed arrow) of the humerus. B—Craniocaudal sagittal ultrasonographic image showing that the right BT origin (white arrow) has abnormal hypoechoic foci (enlarged in inset image) and that the BT (gray arrow) appears intact. C—Craniolateral-caudomedial oblique sagittal ultrasonographic image showing the right BT origin (white arrow) from the supraglenoid tubercle (double triangle) of the scapula, which in this image has an irregular margin. The BT (gray arrow) is intact; however, there is a hypoechoic space between the BT and the bicipital groove (dashed arrow), consistent with a gap created by a medially displaced BT not having close contact with bicipital groove. In addition, there is a hyperechoic substance (dotted arrow) in the space between the BT and the bicipital groove, consistent with a torn TRH or fibrous tissue secondary to trauma.

appearing to have a stiff right thoracic limb when rising or after heavy activity. Results of physical examination were similar to those 6 months earlier; however, the dog's lameness had progressed to a grade 2/5, and asymmetry in muscle mass had developed in that the circumference of the dog's right versus left thoracic limb at the level of the greater tubercle of the humerus was 29 cm versus 30 cm, respectively, as measured by the same veterinary surgeon (DD) who had also obtained such measurements of the dog 6 months earlier.

Dog 2 underwent a recheck PSWA. Results of TPI were 27% (a 1% decrease from previous findings) for the right thoracic limb and 33% (unchanged from previous findings) for the left thoracic limb. A recheck MSK US was completed, and findings were similar to those 6 months earlier. Right shoulder joint arthroscopy with BTR was recommended, and the handler agreed. Results of a CBC and serum biochemical analyses were within reference limits, and the surgery was scheduled.

On the day of surgery, dog 2 was premedicated with hydromorphone (2.2 mg/kg, IV) and midazolam (0.5 mg/kg, IV). Anesthesia was induced with propofol (4 mg/kg [1.8 mg/lb], IV to effect) and maintained with 1.5% to 2% isoflurane (vaporizer setting) in oxygen (1.9 L/min). The dog was then prepared for arthroscopy as described earlier for dog 1, except that the right shoulder joint of dog 2 was prepared, and the dog was positioned in left lateral recumbency.

Right shoulder joint arthroscopy was performed on dog 2 with a 2.7-mm, 30° oblique arthroscope,[h] and the BT was observed to move medial to the subscapularis muscle with pROM of the joint **(Figure 3)**. Mild inflammatory changes to the origin of the BT (eg, loss of typical ivory appearance at the very origin of the tendon, thickening and bulging of the BT at the origin, and mild fraying of the outermost fibers) and moderate to severe synovitis (eg, synovial hyperemia, proliferation, and thickening) were evident. In addition, there was mild disruption and fraying of the subscapularis tendon. A second port, just caudal to the arthroscope port, was used for insertion of arthroscopic scissors,[d] and BTR was performed (**Figure 4**; **Supplementary Video S3**, available at: avmajournals.avma.org/doi/suppl/10.2460/javma.257.11.1157). After routine closure, dog 2 recovered from anesthesia without complication.

Postoperative analgesia overnight for dog 2 consisted of a fentanyl (2 to 3 µg/kg/h) constant rate infusion, and the arthroscopy incisions sites were iced for 20 minutes every 8 hours. The dog was discharged the following day with prescriptions of gabapentin (7 mg/kg [3.2 mg/lb], PO, q 8 h for 30 days), carprofen (1.7 mg/kg [0.8 mg/lb], PO, q 12 h for 14 days), codeine (1 mg/kg [0.45 mg/lb], PO, q 12 h for 5 days), and cefpodoxime (7.1 mg/kg [3.6 mg/lb], PO, q 24 h for 5 days). The handler was instructed to restrict the dog's exercise for the following 8 weeks, with slow, controlled leash walks only for elimination purposes during the first 2 weeks, then 5-minute leash walks 2 to 3 times daily for a week, and then a 5-minute increase in the walk duration for each week. While inside the house, the dog was to be kept in a crate or small room for the first 2 weeks. Physical therapy by the handler was initially limited to pROM and gentle stretching of the dog's treated limb, starting on postoperative day 5.

Two weeks after surgery, dog 2 was returned for a recheck examination. The arthroscopy incisions had healed, and the dog had a grade 2/5 lameness in the treated right thoracic limb.

In addition, the dog showed signs of mild resistance to flexion and extension of the right shoulder joint. A biceps stretch test was not performed to avoid irritating the surgical site and prevent the dog's reaction to aggressive manipulation of the treated joint. The dog's in-home confinement was expanded from

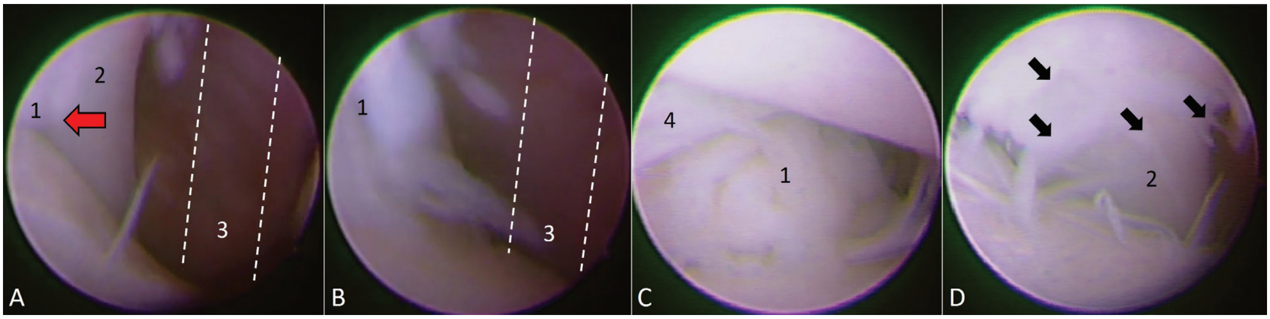

Figure 3—Arthroscopic images of the right shoulder joint region in dog 2. A—Arthroscopic image of the craniomedial compartment of the shoulder joint showing that the BT (2) is luxated medially (red arrow) from its normal position (3; between the dotted lines) and is partially covered by the subscapularis tendon (1). Distal is toward the bottom of the image. B—A more medial arthroscopic image of the craniomedial compartment of the shoulder joint showing that the subscapularis tendon (1) has mild fraying and the BT is not evident in its normal location (3; between the dotted lines). Medial is toward the left of the image, and distal is toward the bottom. C—Nearly medial arthroscopic image of the shoulder joint showing that the subscapularis tendon (1) is frayed and that the cranial portion of the medial glenohumeral ligament (4) appears intact. Distal is toward the bottom of the image. D—Fraying (arrows) of the BT (2) near its origin is visible. Medial is toward the left of the image, and distal is toward the bottom.

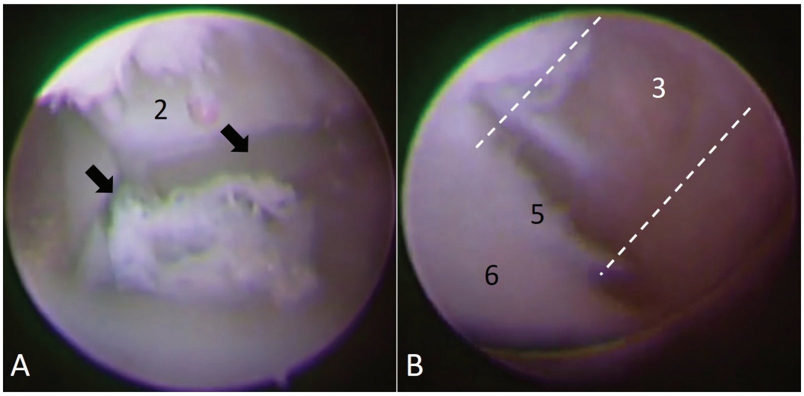

Figure 4—Arthroscopic images obtained immediately before (A) and after (B) BTR in the right shoulder joint of dog 2. A—The BT (2) is engaged by arthroscopic scissors (arrows). Medial is toward the left of the image, and distal is toward the bottom. B—The humeral head (6) and fraying of the subscapularis tendon (5) are visible, and the BT is absent from its normal path (3; between the dotted lines). Medial is toward the left of the image, and distal is toward the bottom.

a crate or small room to a larger room, and formal rehabilitation therapy was initiated. The first session of rehabilitation therapy consisted of manual therapies (ie, massage, pROM, stretching, and joint mobilization techniques) and isometric exercises (ie, standing on 3 limbs, weight shifting, and cookie stretching [ie, use of a treat to lure the dog to follow and move its head toward its shoulder joints, midsection of the body, and hip joints and down the lengths of its limbs to its paws]). Rehabilitation therapy was continued once weekly throughout the recovery period until 12 weeks after surgery and progressed from manual therapies to isometric therapeutic exercises and then to eventual concentric and eccentric exercises of the musculature surrounding the right shoulder joint. Lastly, muscle conditioning was performed. In addition, the handler followed a prescribed daily home-exercise plan that progressed alongside the dog's improvements in the formal sessions of rehabilitation therapy, and further recheck examinations were scheduled for 4, 8, and 12 weeks after surgery.

During the recheck examination 4 weeks after surgery, dog 2 had a grade 1 to 2/5 lameness in the right thoracic limb and mild resistance to deep shoulder joint flexion and a biceps stretch test. The dog's right shoulder joint had clinically normal extension; however, there was a 2-cm difference in the circumference of the right thoracic limb (28 cm [atrophied]), compared with the left (30 cm), measured (DD) at the level of the greater tubercle of the humerus. Therefore, the handler was given a progressive home-exercise plan for the dog, and the dog's in-home activity was expanded to free activity on 1 floor. The PSWA revealed TPIs of 28% and 30% for the right and left thoracic limbs, respectively. At this point, weekly UWTM[i] therapy was also started, with a steady increase in duration (initially 9 minutes) but with a static pace (0.8 mph) and water height (17.5 inches).

On recheck examination 8 weeks after surgery, dog 2 had no evidence of lameness (grade 0/5), clinically normal results for pROM of the right shoulder joint, and no sign of pain or discomfort on a biceps stretch test of the right thoracic limb. In addition, there was only a 1-cm difference in circumference measured (DD) at the level of the greater tubercle of the humerus for the right thoracic limb (29 cm [atrophied]), compared with the left (30 cm), and PSWA revealed TPIs of 29% and 32% for the right and left thoracic limbs, respectively. The dog's UWTM therapy was advanced to 20 minutes at 1.5 mph in 17.5 inches of water. In addition, eccentric and concentric strengthening exercises were begun, including modifying the progressive home-exercise plan to focus on strengthening muscle and building endurance.

At the recheck examination 12 weeks after surgery, dog 2 had no evidence of lameness, and the muscle mass was symmetric in both thoracic limbs, with a 30-cm circumference of each limb measured (DD) at the level of the greater tubercle of the humerus. The PSWA revealed TPIs of 30% and 31% for the right and left thoracic limbs, respectively. The handler was instructed to begin a slow return to normal companion activity (eg, unlimited in-home activity, 3 to 5 daily leash walks for 15 to 20 minutes each, and free running, including 5 to 10 minutes of fetching activity) over 2 weeks, followed by 4 to 6 weeks of work-specific conditioning before returning to training as an apprehension police dog.

At 9 months after arthroscopic right BTR, dog 2 was reported not to have been lame since 8 weeks after surgery and to have since returned to full work level. A LOAD questionnaire completed by the handler yielded a final score of 3, which was in the lowest category of lameness, and the handler relayed that the dog was considered to be 100% sound with full ability to work.

Discussion

Biceps brachii tendon luxation from the intertubercular groove of the humerus is a rare condition that has been reported only in a limited number of working dogs (14 racing Greyhounds[8–10] and 1 herding Border Collie[11]) and 2 pet dogs (1 German Shepherd Dog and 1 Afghan Hound[12]). Although a definitive cause typically cannot be proven, BTL has been associated with a rupture of the TRH[8,9,11,12] that, on the basis of limited reported postmortem findings, seemed to be more degenerative than sudden nature.[j] The most likely underlying cause is sudden trauma or long-term, repetitive strains during combined rapid deceleration, shoulder joint flexion, and elbow joint abduction, during which the BT rises up the medial aspect of the intertubercular groove, resulting in rupture of the TRH's center or from its origin on the lesser tubercle of the humerus.[8] Hypoplasia or agenesis of the lesser tubercle has been hypothesized as a possible, less likely cause.[9]

Biceps tendon luxation results in various degrees of lameness that are exacerbated with exercise. Examination findings include abduction and external rotation of the affected limb and signs of pain elicited on shoulder joint flexion and abduction.[8,9,11,12] Palpatory diagnosis can be made by medial luxation of the BT with shoulder joint flexion and subsequent tendon reduction with shoulder joint extension.[8,9,11,12]

In addition, as an objective way to compare and monitor muscle mass symmetry between the affected and unaffected thoracic limbs in dog 2 over the course of treatment, a tape measure designed to measure body dimensions was used to obtain serial measurements of the circumference of each thoracic limb at the level of the greater tubercle of the humerus, with the dog in standing position. Although, to our knowledge, this method has not been described previously in the literature, an author (DD) of the present report has consistently used the method in all patients examined for reasons involving the thoracic limbs. Furthermore, these measurements in dog 2 were performed by the same surgeon to minimize interobserver variability.

Diagnostic procedures for tendinopathies of the BT include radiography,[13] arthrography,[14] MSK US,[15] MRI,[16] and arthroscopy.[2,17,18] Radiographic findings for affected shoulder joints are typically clinically normal,[8,9,11,12] and of the imaging techniques listed, only MSK US can be used as a noninvasive dynamic diagnostic imaging modality.[15] Furthermore, to our knowledge, neither noninvasive (MRI or MSK US) nor minimally invasive (arthroscopy) procedures to diagnose BTL specifically in veterinary patients has been described in the peer-reviewed literature prior to this report.

During MSK US, flexion and extension of the shoulder joint combined with use of the ultrasound probe to push against the BT or with digital manipulation by the operator and simultaneous ultrasonographic examination were very helpful in identifying BTL in both dogs of the present report. To our knowledge, neither these steps nor arthroscopic assessment of BTL has been reported previously in dogs. In humans, intraoperative arthroscopic testing to assess BT subluxation with specific shoulder joint manipulation (ramp test) has been described.[19,20] In short, for the ramp test in people, a blunt joint probe is inserted arthroscopically and used as a lever to try to move the BT out of the bicipital groove.[20] If the BT can be moved out of the bicipital groove, the result is positive for the ramp test and indicates BT instability, requiring surgical removal of the BT from the shoulder joint.[19] In the 2 dogs of the present report, however, it was not possible to elicit or to record complete luxation of the BT during arthroscopy because when a joint probe was used to push the BT over the lesser tubercle of the humerus in each dog, the BT moved medial to the subscapularis muscle. In other words, the distinct popping sensation felt during the physical and ultrasonographic examinations was not felt intraoperatively and could not be visualized, possibly because of the joint distension and introduced instruments. Although the surgeons had previously performed arthroscopy in dogs on a regular basis over the previous 10 to 14 years, it was possible that their lack of experience with BTL and the ramp test contributed to their not being able to fully luxate the BT during arthroscopy. Nonetheless, in both dogs of the present report, BTL had been diagnosed with MSK US (dogs 1 and 2) and MRI (dog 1) before arthroscopy, and the main purpose of arthroscopy was to perform BTR as the surgical treatment for each dog.

Unlike descriptions of traditional open surgical techniques to treat BTL, the present report described a minimally invasive arthroscopic approach to treat BTL. Surgical placement of a single screw into the lesser tubercle to block medial BT translation has been suggested[j]; however, peer-reviewed case reports or case series are lacking, and the effectiveness of the treatment is controversial.[k] Most descriptions of BTL repair focus on reestablishing the BT's function and keeping the tendon positioned correctly by crossing the intertubercular groove from the lesser to the greater tubercle with braided polyethylene suture secured with a screw[12] or wire,[11] polypropylene suture,[9] or a small plate or a surgical staple[10] or by relocating the BT through a groove in the greater tubercle.[8] A general concern with implant placement or attempts to surgically repair a disrupted TRH is local irritation of the soft tissues.[8–10] Thus, other treatment options should be considered.[8,9,11,12]

In contrast to the rarity of BTL, multiple reports[2,17,18,21] have been published regarding partial or complete tears of BTs. Treatment options for tears of the BT include surgical (eg, tenodesis or tenotomy) and nonsurgical treatment.[2,17,18,21,22] The role of the BT to help stabilize the shoulder joint in dogs has been discussed controversially, with findings from 1 in vitro study[23] suggesting that the BT serves as a passive stabilizer. To maintain function of a torn BT, tenodesis has often been recommended.[17,21] However, on the basis of results of in vivo studies,[2,24] including a report[18] on 47 dogs that underwent BTR, the BT is suggested not to be a primary stabilizer of the shoulder joint, and BTR is considered to be a reliable and safe treatment option for a diseased BT. This was supported by a comparative study[l] between BTR and tenodesis, which did not detect a difference in clinical outcome. Following BTR, it appears that the brachialis muscle acts to maintain clinically normal flexion of the elbow joint, and it is theorized that reattachment of a surgically or traumatically released BT occurs, essentially producing a natural tenodesis.[18] This is supported by findings of excellent clinical outcome following BTR and the inability to hyperextend the elbow joint while the previously treated shoulder joint is in full flexion.[2,18,24] Considering such encouraging results, reports[8,9] that indicate BTL treatment by reconstruction of the TRH in racing Greyhounds is rarely successful, and previous negative clinical experience with TRH reconstruction by an author of the present report, the 2 dogs in the present report underwent BTR. In addition, dog 1 was an extremely aggressive dog, and as such, it was considered ideal to perform only 1 surgery, rather than to risk an attempted repair of the TRH, the failure of which would have required a revision surgery and likely resulted in eventual BTR. For dog 2, funding was available for only 1 procedure.

To our knowledge, although BTR is described as a successful treatment of BT tears,[2,18] its arthroscopic use as a minimally invasive treatment for BTL in dogs and subsequent postoperative long-term clinical outcome in such treated dogs have not been reported. However, the excellent outcomes for the 2 dogs of the present report were further supported with results for the LOAD questionnaire. This tool has been validated to be as objective as force-plate gait analysis in a direct comparative study[5] and has been verified in a recent independent clinical study,[25] in which results for data gathered by use of the LOAD questionnaire were similar to results for data obtained with actual force-plate gait analysis.

Contrary to reported excellent clinical outcomes of BTR in pet dogs,[2,18] anecdotally, there have been concerns regarding return to full function after BTR in working or athletic dogs.[m] Indeed, we are aware of anecdotal reports of BTR-treated racing Greyhounds that drift to the side of the treated limb when running in the straight line of the racecourse and that seem not to lean into the curve of the bends of the racecourse, but instead slow to counteract centrifugal forces because they are not able to resist pressure in extension and tend to tumble or go straight.[n] Additional injuries, for example to the medial glenohumeral ligament or the subscapularis tendon, could have an influence on competitive level outcome. Finally, it is possible that the loss of BT passive stabilization of the cranial portion of the shoulder joint and guiding of glenohumeral articulation during extension cannot be tolerated in the racing Greyhound. However, until the present report, peer-reviewed literature has been devoid of information on whether BTR in other high-level athletic dogs, such as the apprehension police dogs of the present report, would allow treated dogs to return to their preinjury performance level. Although our findings provided encouraging results, further research, best conducted with a multicenter prospective randomized study, would be needed to establish the most reliable treatment of BTL in high-performance athletic or working dogs.

For treatment of humans with pathological BT changes, there is no consensus on whether tenotomy or tenodesis is superior on the basis of functional and subjective outcomes.[26,27] Tenodesis in humans could be considered when cosmetic outcome is of concern; however, no differences were detected in subjective outcome results for patients treated with tenodesis versus tenotomy.[28]

Limitations of the present report include its retrospective character, small number of treated animals, differences in the type and duration of follow-up data for the treated dogs, and lack of a control group with different or conservative treatment for BTL. The LOAD questionnaire was not part of the initial examination for either dog in the present report because it was not a standard protocol to have the questionnaire completed for every patient seen for the first visit at our institutions; however, we decided to use the questionnaire as the most feasible form of objective data gathering for long-term follow-up gait analysis of the dogs because of the convenience for handlers and owners to complete it and because it has been validated and correlated with findings on force-plate gait analysis.[5] Our findings for the dogs of the present report suggested that arthroscopic BTR could be considered a viable treatment option for BTL in dogs, including police dogs or other high-performance athletic dogs.

Acknowledgments

The authors declare that there were no conflicts of interest.

Footnotes

a. Symphony Maestro Class 1.5T, Siemens Healthcare Diagnostics Inc, Tarrytown, NY.
b. GE logiq P5, GE Healthcare, Chicago, Ill.
c. Stryker Corp, Kalamazoo, Mich.
d. Arthrex Inc, Naples, Fla.
e. Gulik tape measure, 3B Scientific Corp, Tucker, Ga.
f. GAIT4Dog, CIR Systems Inc, Franklin, NJ.
g. Aloka Noblus, Hitachi Healthcare Americas, Twinsburg, Ohio.
h. Smith+Nephew Inc, Andover, Mass.
i. AquaPaws, Hudson Aquatic Systems LLC, Angola, Ind.
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