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The Canine Shoulder: Selected Disorders and Their Management with Physical Therapy

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The shoulder joint is the most mobile of all main limb joints. While its primary motion is in a sagittal plane, the shoulder has a significant amount of abduction and adduction, and internal and external rotation. Its stability is ensured by the joint capsule, by its specialized bands (medial and lateral glenohumeral ligaments), and by large tendons located inside (eg, tendon of origin of the biceps brachii muscle) or immediately outside the joint (eg, supraspinatus, infraspinatus, teres minor, and subscapularis). Sprains or strains of all supporting structures of the canine shoulder have now been reported and the shoulder pathology resembles the pathology of the human shoulder that includes strains and tears of the rotator cuff muscles, adhesive capsulitis, and calcific tendonitis.
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There are few reports discussing the effectiveness of physical rehabilitation strategies for shoulder lesions in dogs.[1-4] As a consequence, rehabilitation decisions are made by extrapolating information from the scientific evidence available in human clinical trials and by following universal rules of rehabilitation. Soon after injury or surgery, the goals of shoulder rehabilitation are to protect the joint, to alleviate pain, to maintain shoulder joint motion, and to avoid the onset of limb disuse. As tissue healing progresses over the next weeks, the goals are to stretch the joint when necessary and to maintain or recover limb strength. Rehabilitation of shoulder joint disorders consists of interventions such as cryotherapy (cold therapy), passive range of motion (PROM), massage, joint mobilization, therapeutic ultrasound, stretching, and therapeutic exercises.

Functional Anatomy

The shoulder joint is a highly mobile diarthrodial joint connecting the scapular glenoid and the humeral head. The shoulder is stabilized by concavity compression (the contact of the larger, convex humeral head and the small, concave glenoid) with restraining effects of the joint capsule and associated medial and lateral glenohumeral ligaments and cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis muscles).[5,6] The primary joint motion of the shoulder joint is flexion and extension (Fig. 1 A and B), which may be measured using a goniometer by comparing the orientation of the spine of the scapula to a line joining the insertion site of the infraspinatus tendon and the lateral epicondyle (Fig. 2).[7] Passive flexion was 57° in a group of normal Labrador Retrievers, 47° in a group of normal military German Shepherd dogs, and 32° in a group of cats.[7-9] Shoulder flexion in dogs and cats has a relatively soft end feel and may be limited by the tendon of origin of the biceps brachii muscle and the stretch in the joint capsule.[10] Passive extension was 165, 159, and 167° in the same groups. Shoulder extension in dogs and cats has a soft, capsular end feel and may be limited by the stretch of the long head of the triceps and deltoid muscles and by the joint capsule.[10] While the range of motion (ROM) of the shoulder joint does not differ statistically between Labradors and German Shepherd dogs, the Shepherds have more flexion and less extension than the Labradors.[8] The source of that difference is unknown but may be due to the difference in stance and gait between these two breeds. Mean active shoulder motion at a walk ranged from 89 to 125° in 10 normal Labrador Retrievers.[11] Mean active shoulder motion at a trot ranged from 109 to 137° in six normal Greyhounds.[12] While total ROM is slightly more than 100°, only 30 to 40° of that motion is used at a walk and trot. This is less than the elbow, which has approximately 45° of motion and the carpus, which has approximately 90° during these activities.[13]

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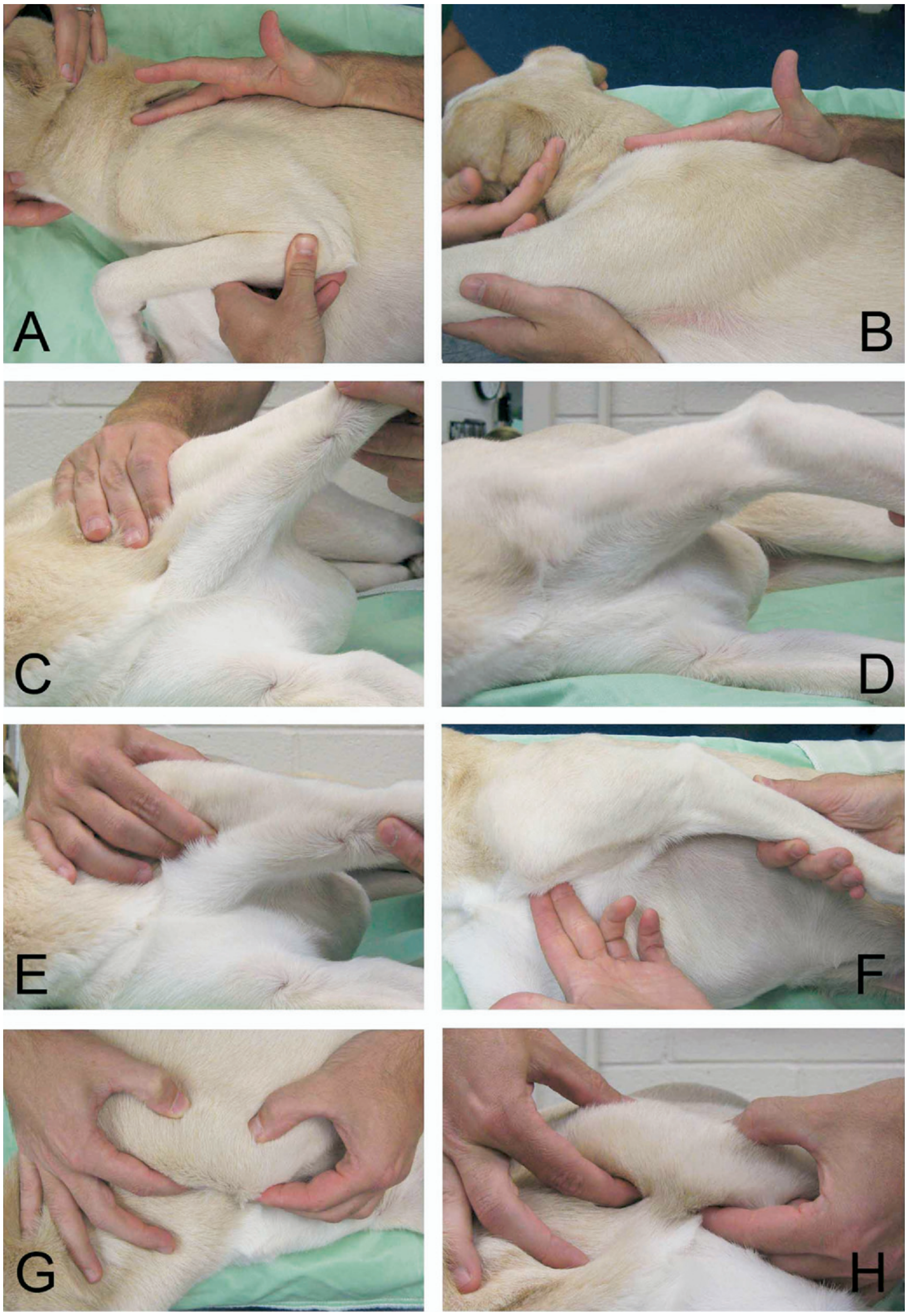

Figure 1 The palpation of the canine shoulder joint includes flexion (A), extension (B), abduction (C), internal rotation (D), bicipital tendon palpation (E), extension of the elbow joint with the shoulder joint flexed (F), cranio-caudal (G), and medio-lateral drawer palpation (H).

ROM may be measured without sedation in most dogs (Fig. 2). Measurements made awake and sedated in normal Labrador Retrievers did not differ statistically.[7] Awake cats, however, may be reluctant to extend their shoulder joint. Shoulder extension was the only joint position that differed statistically between measurements made awake and sedated in 20 cats, possibly because shoulder extension is one of the least natural motions to be elicited during ROM of patients.[9]

Little attention has been placed on other motions of the shoulder joint. These motions include abduction, adduction, internal and external rotation, cranial, caudal, medial, and lateral translation, and the motion of the scapula in relation to the body wall at the omothoracic junction. That junction is muscular and is named a synsarcosis. Shoulder abduction, however, has received recent attention because of its importance in the diagnosis of shoulder joint instability.[2,14] Dogs have approximately 30° of shoulder abduction (Figs. 1C and 2).[14]

Pathophysiology

Clinically, the shoulder joint is the most challenging and enigmatic of the six main joints in dogs. The four distal joints (carpus, elbow, tarsus, and stifle joints) have much less soft-tissue coverage than the proximal joints (shoulder and hip joints). The palpation of joints without large soft-tissue cov-

Figure 2 Goniometry of the shoulder joint includes the assessment of flexion (top), extension (center), and abduction (bottom). Shoulder flexion and extension are assessed by aligning the one arm of the goniometer with the spine of the scapula and the other with a line joining the insertion of the infraspinatus tendon and the lateral epicondyle. Shoulder abduction is assessed by aligning arms of the goniometer with the cranial aspect of the scapula and the central axis of the humerus, seen from the front of the patient.

erage is much easier than the palpation of joints with large soft-tissue coverage. The pathology of the shoulder joint is more complex and varied than other joints. Instability and effusion may be readily detectable in superficial joints but is more difficult to detect in joints with large soft-tissue coverage. Cranio-caudal and medio-lateral drawer motions of the proximal portion of the humerus in relation to the distal portion of the scapula appear often in unstable shoulder joints and should probably be included in the orthopedic evaluation of all dogs with forelimb lameness (Fig. 1G and H).[6] In a recent study of the canine shoulder joint, however, a clinical finding of instability did not correlate well with objective experimental measurements of instability, highlighting the challenges that the clinician faces when evaluating the shoulder.[15] The full, objective assessment of the shoulder joint often requires investigation and confirmation using more advanced imaging methods such as diagnostic ultrasound, magnetic resonance imaging, or arthroscopy.[6,16,17] The loss of joint negative pressure, which would be anticipated clinically after capsular tears, resulted in increased cranial drawer with the joint in neutral alignment and in medial drawer with the joint extended in two experimental studies.[15,18] Tears in the medial glenohumeral ligament or, to a lesser extent, of the tendon of origin of the biceps brachii muscle also led to significant shoulder instability.[19]

Developmental Shoulder Problems

Shoulder problems may result from an abnormal development of the glenoid or humeral head. The most common developmental shoulder problem is osteochondritis dissecans (OCD) of the caudal aspect of the humeral head. OCD is seen in growing dogs of large breeds, primarily male dogs. The disease is bilateral in 27 to 68% of the patients.[20] OCD creates pain originating from the subchondral region of the caudal aspect of the humeral head and from the secondary synovitis. The OCD flap often remains attached on its cranial aspect but may break free and migrate caudally into the cul-de-sac on the caudal aspect of the humeral head. It may grow over long periods of time, where it can grow over long periods of time, creating potential clinical problems such as pain during joint flexion. The OCD flap may also migrate cranially into the bicipital bursa and may trigger a tenosynovitis of the tendon of origin of the biceps brachii muscle. Even though some clinicians in the past have recommended conservative management, the conventional treatment of shoulder OCD has been surgical excision of the flap using an open arthrotomy or arthroscopy.[1] OCD may lead to osteoarthritis (OA).

Incomplete ossification of the caudal aspect of the glenoid is an unusual developmental anomaly of the glenoid with an osteochondral fragment that leads to chronic pain in some affected dogs.[21] This problem has been managed successfully by removing the glenoid osteochondral fragment.[21] Developmental shoulder subluxations and luxations have been reported, usually in small and miniature breeds.[22] Their management is challenging and may involve transposition of the tendon of origin of the biceps brachii muscle,[23] the placement of supporting sutures, or an arthrodesis of the shoulder joint.[22]

Repetitive Microtrauma

Shoulder problems may result from repetitive stress in working dogs, sporting dogs, and other dogs, particularly dogs of large and giant breeds and overweight dogs. Repetitive stress induces damage in tendons and ligaments, including partial tears, dystrophic mineralization, chronic tenosynovitis, peritendinous adhesions, and contractures. The tendons affected include the tendon of origin of the biceps brachii, the tendons of insertion of the supraspinatus, infraspinatus, and teres minor muscles. The clinical syndromes reported in the literature include bicipital tenosynovitis,[24,25] supraspinatus insertionopathy,[26,27] and contracture of the infraspinatus muscle.[28] Laxity of the medial and lateral glenohumeral ligaments, an emerging cause of chronic lameness, may also be caused by the overstretching of these ligaments that could result from repetitive trauma.[2,6,29]

Clinically, the most common of these repetitive injuries appears to be bicipital tenosynovitis. It includes tendon degeneration with or without an inflammatory component.[25] The problem is most often seen in middle-aged to old dogs of large breeds. The severity of resulting lameness varies widely from a mild weight-bearing lameness to a non-weight-bearing lameness with severe limb disuse. A severe pain response is present on digital palpation of the tendon on the craniomedial aspect of the proximal portion of the humerus and during extension of the elbow joint performed with the shoulder joint flexed (Fig. 1E and F). Predisposing factors to bicipital tenosynovitis include the presence of an OCD flap in the tendon sheath, elbow dysplasia with secondary loss of elbow joint flexion, obesity, or repetitive motion. The impact of other shoulder joint problems (ie, medial glenohumeral ligament instability, OA, supraspinatus insertionopathy) on the pathogenesis of bicipital tenosynovitis is unclear. Bicipital tenosynovitis is often managed conservatively, using rest and anti-inflammatory medications.[30] The use of depository corticosteroids (20 to 40 mg of methylprednisolone acetate injected intra-articularly) has been reported without conclusive evidence of its benefit.[30] Transection of the bicipital tendon and release or reattachment to the proximal portion of the humerus has also been reported. The benefits of these surgeries and their relative merit are only anecdotal, based on uncontrolled, nonrandomized patient cohorts.[24,30,31] Based on that limited evidence, surgical management should only be considered in patients responding poorly to 2 to 3 months of rest.[30] Bicipital tendon rupture and bicipital sheath tears have been reported but appear to be rare.[32,33]

Supraspinatus insertionopathy is an unusual lesion, most often seen in large-breed dogs.[26] Pain response to palpation of the large tendon of insertion of the supraspinatus may or may not be present.[26] Mineralization of the tendon may be present on radiographs, even in asymptomatic dogs, suggesting a low correlation of radiographic and clinical signs of supraspinatus insertionopathy.[26,27] The relationship of supraspinatus insertionopathy and bicipital tenosynovitis is unclear: supraspinatus lesion may lead to an impingement of the bicipital tendon with secondary tenosynovitis.[34] Supraspinatus insertionopathy is often managed conservatively but, like bicipital tenosynovitis cases with chronic lameness, may be operated.[27,35] The goal of surgery is to remove mineralized material from the tendon. Based on small, uncontrolled, nonrandomized studies, surgery does not appear to lead to a better outcome than conservative management.[27] Extracorporeal shockwave therapy has been used to manage supraspinatus insertionopathy in two dogs.[3] Its benefits, compared with conservative management, are not known.

Contracture of the tendon of insertion of the infraspinatus

Figure 3 A 12-year-old Golden Retriever has a mature contracture of the tendon of insertion of the supraspinatus muscle. The dog is unable to abduct and flex the shoulder joint.

muscle is a rare condition most often affecting large-breed dogs, particularly working dogs (ie, hunting dogs, herding dogs) and other very active dogs.[28] Repetitive microtrauma, blunt trauma, and osteo-fascial compartment syndrome have been reported to cause this problem.[36-38] Affected dogs most often present with mature contractures and adhesions of the tendon of insertion of the infraspinatus muscle to the adjacent joint capsule. As a consequence, most or all the internal rotation of the humerus in relation to the scapula is lost. This lack of rotation is a reliable clinical sign for diagnosis of the disorder. The humerus may also be held in slight abduction and external rotation (Fig. 3). Mature contractures are treated with a tenotomy of the tendon of insertion of the infraspinatus muscle and release of capsular adhesions of the tendon. Infraspinatus bursal ossification has been recently reported in Labrador Retrievers.[39] Teres minor myopathy has also be reported in a working Labrador Retriever.[40]

Instability of the medial compartment of the shoulder joint (also known as medial glenohumeral ligament instability or medial shoulder instability [MSI]) is a relatively common problem in dogs, seemingly more common than problems associated with the supraspinatus or infraspinatus muscles. The exact cause of MSI in dogs is unknown, although it is suspected to result from chronic repetitive activity or overuse, rather than trauma. Overuse of the shoulder support structures leads to degeneration of the tissues, lowering the tensile strength of the tissues, predisposing them to fraying, disruption, and eventually complete breakdown.[41,42] Sporting dogs that participate in activities such as agility place high stresses on their muscles, ligaments, and tendons. Repetitive activities such as jump–turn combinations and weave poles are performed regularly during practice and trials. These routine maneuvers place the shoulder near its end range of abduction, stressing the soft tissues of the medial aspect of the shoulder. Additionally, events such as slipping on wet surfaces, teeter, or A-frame may also contribute to the trauma inflicted on the shoulder while participating in agility. Over time, there may be a cumulative effect of the microtrauma occurring to the ligaments, tendons, and joint capsule, leading to a decrease in performance. Dogs with MSI may present with a medical history ranging from missing cues or refusing tight turns during performance to intermittent unilateral forelimb lameness. It is not uncommon to have a history from therapists (rehabilitation therapists, massage therapists, or chiropractors) that identify restrictions, spasm and trigger points, or mild atrophy in the affected shoulder during routine sessions. Chronic situations typically include a nonre-

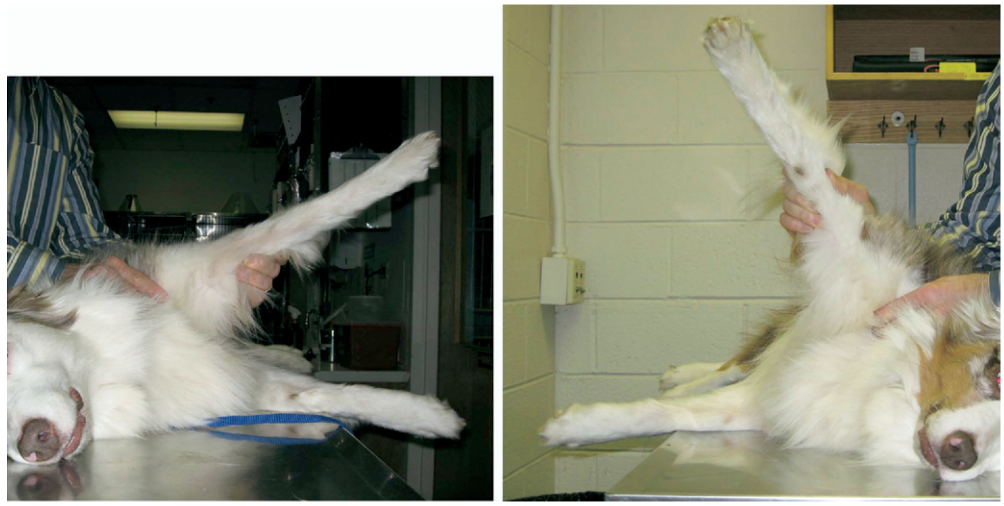

Figure 4 The right shoulder joint of this 4-year-old Australian Shepherd dog (right) has medial shoulder instability (60° of abduction, compared with 29° on the left side; left). The dog was engaged in herding activities before injury.

sponsive effect to rest and anti-inflammatory medications and dogs that are commonly worse after exercise and heavy activity. Gait evaluation ranges from a mildly shortened stride in the affected forelimb at a walk and a trot to a significant weight-bearing lameness. Depending on chronicity, atrophy may be noted in the affected shoulder on physical examination. Forelimb circumference may be decreased in the affected forelimb when compared with the contralateral unaffected forelimb. Dogs with MSI typically have a slightly decreased range of motion in extension of the shoulder joint. Spasm and discomfort are common during shoulder abduction and a slight subluxation may be felt during abduction of the severe cases. If a concurrent supraspinatus insertionopathy is present, a pain response may be present during shoulder flexion (direct stretch of the supraspinatus) or on palpation of its point of insertion. MSI may be diagnosed by measuring shoulder joint abduction during sedation.[14] Normal shoulder abduction angle is approximately 30°. The abduction angles in shoulders with MSI are most often larger, ranging up to 90°. Shoulder abduction is tested in lateral recumbency on an examination table. The forelimb is abducted to its physiologic limit with the elbow and shoulder held in extension (Fig. 4). Arthroscopic exploration with evaluation of intraarticular structures provides a definitive diagnosis of MSI.

Traumatic Injuries

Trauma of the shoulder region leads to fractures of the glenoid, the supraglenoid tubercle, the greater tubercle, and the humeral head. Salter 1 and 3 fractures of the humeral head may occur. Cranial, caudal, medial, and lateral traumatic luxations have been described.[43,44] Luxation of the scapula in relation to the body wall may result from a tear of the serratus ventralis muscle (Fig. 5).[45] The surgical repairs of shoulder joint trauma are mostly based on Kirschner wires, bone screws, and tension band wires and are therefore relatively weak.

Osteoarthritis

OA of the shoulder joint is common in dogs and cats. In a report comparing overweight and nonoverweight Labrador Retriever siblings, shoulder OA was present in 19 of 22 overweight dogs and 12 of 21 nonoverweight dogs.[46] Most dogs had mild OA. Shoulder OA may result from OCD, bicipital tenosynovitis, MSI, trauma, or other causes. Shoulder OA appears to be associated with few clinical signs, possibly because the shoulder joint is a loose joint (by comparison with the elbow joint, for example, that articulates more intricately) and because the joint is used in the middle of its ROM at a walk and trot (unlike the elbow joint, which is used in near-maximal extension at a trot). OA seemingly does not lead to large losses of shoulder motion in dogs and is often an incidental finding. Osteochondral fragments (joint mice) may be present in the joint, most often as the result of OCD, may become larger over long periods of time. Large fragments in the caudal joint recess may limit shoulder flexion and create significant limb disuse. With shoulder OA, osteophytes are visible on the caudal aspect of the glenoid and at the edge of the caudal portion of the humeral head.[46] It is not known if osteophytes develop in the bicipital groove as the result of shoulder OA. It is our impression that osteophytes in the bicipital groove are most likely the consequence of chronic bicipital tenosynovitis rather than shoulder OA.

Figure 5 A hunting Beagle has a luxation of the right scapula. The dog was treated by surgically reattaching the caudal border of the scapula to the dorsal aspect of a rib using a monofilament nylon line.

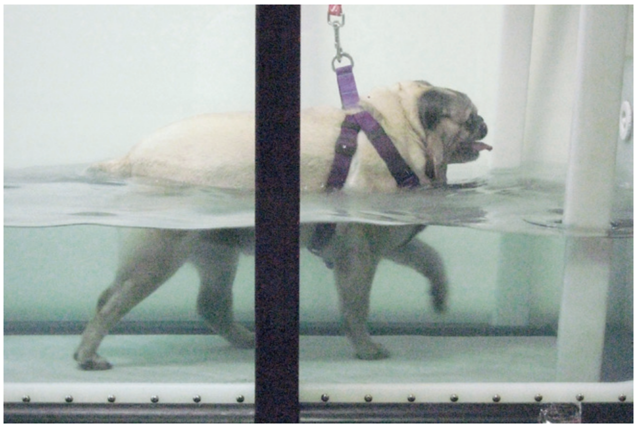

Figure 6 An overweight Pug is exercising in an underwater treadmill with the water level up to his greater trochanter. The dog is wearing a step-in harness that allows the operator to control the dog without placing stress on his shoulders and neck and without restricting the motion of his shoulder joints.

Rehabilitation Strategies and Goals

The successful physical rehabilitation of shoulder problems hinges on an accurate assessment of the patient. This assessment includes gait and posture anomalies, pain on palpation, joint motion, including flexion and extension, internal and external rotation, abduction, and adduction. The complete palpation of the shoulder joint also includes cranio-caudal and medio-lateral drawer palpation, bicipital tendon palpation, and extension of the elbow joint with the shoulder joint flexed (Fig. 1). The full assessment of potential shoulder problems also includes palpation of problems located above and below the elbow joint, including neck pain, excessive or decreased scapular mobility, axillary masses, elbow joint disease, etc.

In humans, physical therapists concentrate on four phases of rehabilitation after shoulder surgery. Phase 1 consists of rest, immobilization, and pain control using ice and anti-inflammatory medications, and PROM exercises. The goals of phase 1 are to control the pain and inflammation, promote tissue healing, gradually increase PROM, and delay muscle atrophy. Phase 2 focuses on active ROM and strengthening exercises for rotator cuffs and scapular stabilizers. Goals of phase 2 are to control pain and inflammation, continue to increase ROM, and initiate low-level muscle strengthening. Phase 3 includes muscle strengthening and endurance, and initiation of functional exercises for the affected muscles such as pushups in a person or controlled jogging in a dog. Goals include regaining full ROM and increasing strength and endurance. Phase 4 consists of increasing sports and job-related activities. The fundamental modalities used when treating shoulder conditions include ice, stretching, and therapeutic exercises.[47,48] Other modalities considered in patients with specific needs include joint mobilization, massage, electrical stimulation, therapeutic ultrasound, extracorporeal shock-wave therapy, pulsed electromagnetic field therapy, and low-level lasers.[49] In humans, rotator cuff disease, adhesive capsulitis, and calcific tendonitis are the primary problems treated using physical therapy.[50] Rotator cuff disease includes tears at the insertion sites of the supraspinatus, infraspinatus, teres minor, and subscapularis (listed in decreasing order of importance), compression of the subacromial space from impingement by the coraco-acromial ligament, scar tissue formation, and shoulder joint instability. These may be treated conservatively or surgically when weakness and functional impairment are severe.[51,52] The therapeutic strategies with proven benefits for the management of rotator cuff disease include therapeutic exercise (short-term recovery and long-term function enhanced), and joint mobilization combined with exercise.[50] Adhesive capsulitis (frozen shoulder) is commonly treated conservatively using physical therapy. If physical therapy alone is not sufficient, manipulation under anesthesia, arthroscopy, or open capsular release may be performed and followed by physical therapy.[51] Low-power laser has proven benefits for the management of adhesive capsulitis but physical therapy does not appear beneficial as sole treatment.[50] Treatments of calcific tendonitis with proven benefits include

Figure 7 A sling has been made to hold the forelimb of a Border Collie with MSI in suspension during the recovery after radiofrequency-induced capsulorrhaphy. The harness is fastened via three hooks and loop (Velcro®) bands which allow for easy removal for daily therapy. The sling is left in place for 2 to 4 weeks. Afterward, the dog will wear hobbles for approximately 8 weeks.

Figure 8 A Jack Russell terrier with severe instability of his shoulder joint has been placed in a spica splint. While the splint greatly limits the motion of the shoulder joint, it also limits the dog's mobility. The splint is changed weekly, under light sedation.

ultrasound, pulsed electromagnetic field therapy, and extracorporeal shockwave therapy.[50,53,54]

In dogs, physical rehabilitation of patients with shoulder problems is aimed at (1) protecting patients from further injury or protecting the potential repair from excessive stress and mechanical failure; (2) avoiding limb disuse; (3) maintaining or restoring normal joint motion; and (4) maintaining or restoring the strength of shoulder and other forelimb muscles. Joint protection is primarily achieved by limiting the activity of patients to walks and trots and avoiding gallop and jumps. Patients may wear step-in harnesses that enhance control and avoid pressure placed on the shoulder region (Fig. 6). In patients with weak surgical repairs (eg, glenoid fractures, radiofrequency-induced capsular shrinkage), the affected forelimb may be held in suspension using a velpeau sling or other sling (Fig. 7). Shoulder joint immobilization using a spica splint is sometimes used to protect weak shoulder joints (Fig. 8). Shoulder immobilization has been shown to lead to loss of shoulder motion and focal capsular adhesions, resembling adhesive capsulitis seen in humans.[55] The changes present in the joint after immobilization appear slowly reversible.[56] Shoulder joint immobilization should be kept to a minimum because of its negative impact on joint motion and muscle mass. Whenever possible, passive ROM and protected exercises with partial weight-bearing (ie, underwater treadmill walking) should be implemented between bandage changes. Joint immobilization should ideally be limited to situations where the joint has limited stability and should be avoided when the shoulder is structurally sound. Limb disuse is avoided by comprehensive pain management and by promoting early, protected activity through the use of therapeutic exercises (see below). Ice is used in the early postoperative or postinjury period to decrease the pain originating from the shoulder region and to decrease local inflammation and edema formation. A large rectangular gel pack or cooling pad may be placed directly on the skin and held for 10 to 15 minutes until the skin feels cold to the touch (Fig. 9).

Shoulder motion may be decreased or increased in dogs with shoulder problems. Loss of motion of the shoulder joint may be the result of OA, periarticular capsular tethers and contractures, trauma, and surgical procedures. Shoulder motion may also be decreased in dogs with upper motor neuron lesions associated with cervical disc herniation (Fig. 10). Stretching is used to improve joint motion. Joint mobilizations are specific rhythmic movements of the joints aimed at increasing joint ROM. Mobilizations aimed at treating capsular restrictions of joint motion are oscillated (Fig. 11).[49] Repetitive low intensity stretches are beneficial for stimulating

Figure 9 The shoulder joint may be cooled using a cooling pad attached to a unit circulating ice-cold water (Opti-Ice cold therapy pump, Chattanooga Group, Hixson, TN) or using a cold pack (inset).

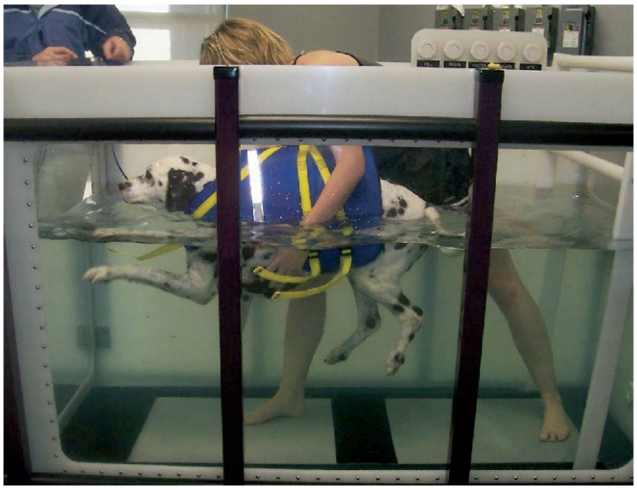

Figure 10 A 12-year-old Dalmatian with increased tone of the shoulder region secondary to a bilateral upper motor neuron lesion resulting from caudal cervical spondylomyelopathy is swimming under close supervision. The repetitive motion of his forelimbs decreases muscle tone in his shoulder region.

Figure 12 A dog walks across Cavaletti rails. The rails spacing and height is adjusted to have the dog make slow, controlled steps with exaggerated shoulder joint flexion, compared with normal locomotion.

articular or periarticular tissue elongation. By comparison, mobilizations for muscle, tendon, and skin restrictions are sustained.[49] Elongation of contractile tissues responds positively to sustained stretches, usually lasting 20 to 40 seconds. Stretching of the shoulder joint is also achieved through therapeutic exercises. Exercises promoting shoulder flexion include, in order of increasing intensity, swimming (Fig. 6), walking through horizontal obstacles (Cavaletti rails, Fig 12), therapeutic ball exercises (pelvic limbs on floor), and walking through an agility tunnel. Exercises promoting shoulder extension include, in order of increasing intensity, therapeutic ball exercises (forelimbs on floor), walking downhill, wheelbarrowing, jumping down graduated heights. Exercises promoting external rotation of the shoulder include walking in figure-of-eight, pole weaving, walking through trails, and playing. Shoulder motion ranged from 131 to 162° during wheelbarrowing compared with 120 to 148° at a walk in a report.[48] Shoulder motion may also be affected by scapulothoracic tightness. Scapular mobility should be assessed and compared with the nonaffected side.

Figure 11 A 3-year-old Dalmatian with OA secondary to OCD has limited shoulder flexion, extension, and abduction. Joint mobilization is performed by placing the mobilizing hand under the axilla and the stabilizing hand on the lateral aspect of the distal portion of the scapula and distracting repeatedly for two to three seconds at a time. After three sessions, the deficit in flexion, extension, and abduction, compared with the opposite unaffected shoulder joint, went from 18, 30, and 18° to 5, 10, and 6°, respectively.

Loss of strength is present in shoulder problems as a result of immobilization, disuse, or neurologic deficits. Unlike human beings where strengthening shoulder muscles involves specific exercises that vary for rotator cuff muscles, deltoid, biceps, and pectoral muscles, the strengthening exercises used for the canine shoulder are most often nonspecific exercises, including swimming (Fig. 10), walking in an underwater treadmill (Fig. 6), and pulling. Other exercises aimed at strengthening the shoulder include "shaking," walking through an agility tunnel, walking downhill, jumping down from graduated heights, and negotiating Cavaletti rails (Fig. 12) or A-frames. Exercise bands (eg, Therabands®; The Hygenic Corportion, Akron, OH) may be used to support weak muscles or to increase the workload of specific muscles. For example, a band placed above the carpal joint with a slight abaxial (lateral) force applied will increase the workload of weak pectoral muscles. By contrast, a band placed above the elbow joints as a hobble will decrease the workload of weak pectoral muscles. When dogs are exercising on a treadmill or underwater treadmill, suction cups with hooks placed on the inner vertical surfaces of the treadmill may be used to attach elastic bands and provide resistance or support throughout an exercise session. In patients unwilling or unable to exercise, neuromuscular electrical stimulation of the supraspinatus and the infraspinatus and triceps should be considered.

Physical Rehabilitation of Specific Shoulder Joint Problems

In the absence of controlled trials assessing physical rehabilitation of shoulder problems in dogs, the specific rehabilitation strategies are based on the general principles and on strategies used in human patients.

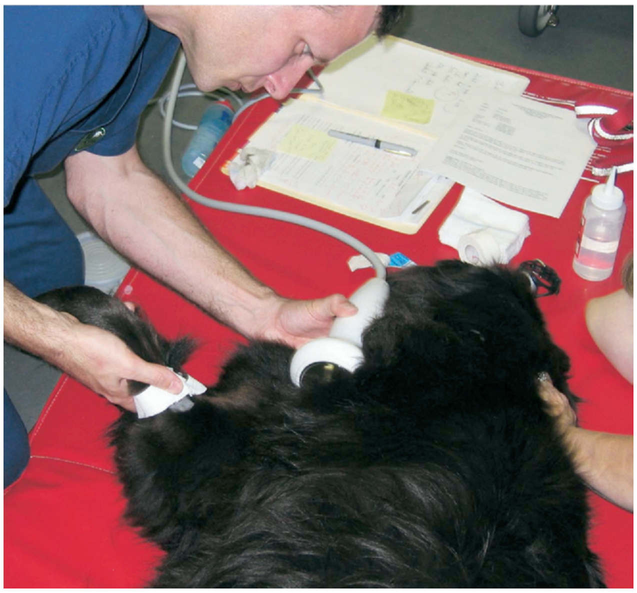

Figure 13 A Newfoundland with acute bicipital tenosynovitis is receiving extracorporeal shockwave therapy to decrease the inflammation of his biceps tendon. The procedure is performed under sedation. The leg is externally rotated to access the bicipital tendon. The probe is place in contact with skin and ultrasound gel is used as a coupling agent. Five hundred shocks are delivered to the tendon over a few minutes.

Osteochondritis Dissecans of the Humeral Head

The conservative management of OCD includes limitation of physical activities to leash walk and trot, cryotherapy, and PROM exercises. The postoperative rehabilitation of OCD patients includes pain management, cryotherapy, PROM exercises, and short controlled leash walks. Three weeks postoperatively, swimming may be initiated, as well as ground treadmill walking, gradually increasing the duration and intensity of walks. At approximately 6 weeks postoperatively, light jogging may be initiated and increased as tolerated. Stretching (Fig. 11) and strengthening programs may be implemented in dogs with chronic loss of joint motion.

Bicipital Tenosynovitis

The conservative management of bicipital tenosynovitis relies on the avoidance of strenuous exercise for long periods of time (3 months, possibly), cold therapy, and pulsed therapeutic ultrasound. Pulsed-mode (20% duty cycle) 3-MHz therapeutic ultrasound may be used over the tendon to decrease inflammation and promote tissue healing. Because of the close proximity to bone where ultrasound waves are reflected, the intensity must be carefully monitored for any signs of pain. The hair coat should be clipped over the area to be treated for safety and for maximal effectiveness.[47] Pulsed-mode ultrasound should not result in significant tissue temperature increase. The ultrasound treatment must extend down the tendon to the musculo-tendinous junction, because the inflammation commonly extends to this point.[47] Extracorporeal shock wave therapy has also been used to decrease inflammation (Fig. 13).[4] Deep transverse friction massage and stretching of the bicipital tendon may be also considered. The massage is performed to create acute inflammation in addition to the chronic inflammation already present in the tendon, with the presumption that treating acute inflammation (with rest, ice, and anti-inflammatory medications) is more rapid and predictable than treating chronic inflammation. The benefits of deep friction massage on tendon inflammation are equivocal in humans.[57] Anecdotally, gradual stretching of the biceps by combined shoulder flexion and elbow extension may lengthen the tissue, thus decreasing the forces placed on the tendon during daily activities.

The rehabilitation of patients after surgical release or transposition of the bicipital tendon includes cryotherapy, PROM, and short leash walks, preferably with a chest harness, and are used for the first 3 weeks. After this initial phase, treatment involves gradual strengthening exercises aimed at forelimb muscles (ie, brachialis muscle an elbow joint flexor). Neuromuscular electrical stimulation to the brachialis muscle, aquatic therapy, and treadmill activity may be used. Cryotherapy may be continued after exercise sessions to minimize postexercise soreness or inflammation.

Supraspinatus Tendon Insertionopathy

The conservative management of supraspinatus tendon insertionopathy involves rest, anti-inflammatory medications, cryotherapy, and PROM exercises. Pulsed therapeutic ultrasound should be considered, based on its effectiveness in humans (Fig. 14).[54] Extracorporeal shockwave therapy may also be considered and has been reported in two dogs.[3,53] Ascertaining the cause of the injury to help prevent future episodes is also indicated.

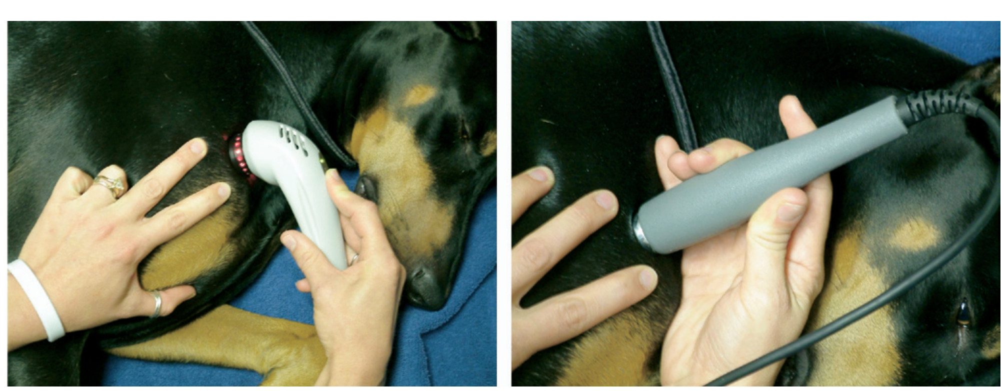

Figure 14 Laser therapy (left) and pulsed therapeutic ultrasound (right) may be used to decrease inflammation and pain associated with supraspinatus insertionopathy.

Fibrotic Contracture of the Infraspinatus Muscle

Physical rehabilitation of acute or subacute infraspinatus tenopathies could be used to maintain joint motion and prevent contracture. Continuous ultrasound and stretching exercises may help maintain the length and mobility of the affected tissues. There is no published report to our knowledge, however, of the successful nonsurgical treatment of this problem in dogs. Mature contractures most likely require surgical release. The postoperative management after adhesion release includes full weight-bearing, gentle, pain-free PROM exercises of the shoulder, elbow, and carpus two to three times daily to maintain ROM and to promote normal alignment of the healing tissues. Cryotherapy may be used after exercise. Excessive activity such as unrestricted running or playing should be avoided in the first several weeks to avoid tissue damage and recurrence of fibrous tissue. If the contracture has been present for more then a few weeks before the surgery is performed, atrophy of other forelimb muscles may be present. General conditioning exercises for the limb, such as progressive walking, wheelbarrowing, and aquatic therapy, should be used to gradually return these muscles to normal size and strength. The use of neuromuscular electrical stimulation may also be considered if the atrophy is severe and if the dog is having difficulty using the limb, because of weakness.

Medial Shoulder Instability

Based on the results of the orthopedic examination, abduction angle tests, and arthroscopy, patients may be placed into one of three treatment categories: mild, moderate, or severe. For patients with abduction angles of 35 to 45° and arthroscopic findings consisting of mild pathology (inflammation without fraying, disruption, or laxity of the MGL, subscapularis tendon, joint capsule), patients are placed in a shoulder support system/hobbles and entered into a physical rehabilitation program. Rehabilitation in conservatively managed MSI includes PROM in the sagittal plane and limited weight-bearing exercises in straight lines, on smooth surfaces. Dogs with moderate pathology typically have abduction angles ranging from 45 to 65°, and arthroscopic findings consisting of fraying, disruption, and laxity of the subscapularis tendon, medial glenohumeral ligament, focal synovial proliferation associated with the subscapularis tendon, and synovial hypertrophy or hyperplasia. Additional findings may occasionally include a bulge of the supraspinatus tendon with biceps impingement. Dogs in the moderate category are treated arthroscopically with imbrication and/or thermal capsulorrhaphy (radiofrequency shrinkage). Radiofrequency (RF) -induced capsular shrinkage has been used to decrease instability in humans with similar pathology.[41] In dogs, RF is used for treatment of the joint capsule, tendon, and ligament laxity; and ablation of pathologic intraarticular structures.[2] RF energy is used to modify tissues by employing the principle of ionic friction. RF energy causes oscillation of intracellular molecules, generating heat. Collagen protein cross-links are broken, causing denaturing. Disruption of the intramolecular bonds result in the "shrinkage" of collagen.[42] The intermolecular bonds are heat-stable and remain intact. The thermal insult produces a reparative response, leading to increased collagen deposition and thickened tissue. Following RF treatment, inflammation, repair, and remodeling occur. Inflammation is a crucial step in the healing process and therefore treatments that decrease inflammation (nonsteroidal anti-inflammatory drugs, laser therapy, acupuncture, etc) are not recommended during the initial postoperative period (approximately 6 weeks long). Treated tissue becomes weaker than pretreatment levels before it gets stronger and must be protected and insufficient immobilization results in stretching of the joint capsule and recurring laxity. Excessive immobilization, by comparison, results in joint stiffness and muscle contracture. After arthroscopic imbrication and/or RF treatment, postoperative care includes a custom shoulder support system/hobbles (Fig. 15), strict exercise restrictions, and rehabilitation. Postoperative physical rehabilitation following this repair consists of protection, cryotherapy, and PROM exercises for the first 3 weeks, followed by gradual resumption of weight-bearing exercises. Recovery for dogs in the moderate category range from 3 to 4 months with return to training occurring at 4 to 6 months.[2] Dogs with severe MSI typically have shoulder

Figure 15 Immediate postoperative image of a Border Collie with medial shoulder instability who was treated arthroscopically with radiofrequency treatment (top). Hobbles (DogLeggs, Reston, VA) have been applied to prevent abduction of the treated shoulder. The dog can stand and walk with the hobbles in place (bottom).

Figure 16 The shoulder joint of the dog in Figure 4 is managed conservatively using hobbles made by wrapping cast padding, rolled gauze, and then woven cotton tape around the antebrachia and by connecting the antebrachia with the cotton tape. Initial hobble length was chosen by placing the hobbles with one forelimb held with 20° of abduction. The hobbles were changed monthly and were worn for 5 months. Hobble length was increased by 1 to 2 cm at each bandage change. Right shoulder abduction was 39° (versus 38° on the left) at final assessment. The dog regained normal limb use afterward.

abduction angles greater than 65°. Arthroscopic findings usually include complete tears of the medial glenohumeral ligament and severe disruption and the supscapularis tendon and joint capsule. For this type of injury, reconstruction of the medial compartment by direct tissue reapposition and synthetic capsulorrhaphy by a medial approach may be indicated. Following surgical repair, dogs are placed in a custom non-weight-bearing velpeau sling (Fig. 7) for 2 to 4 weeks followed by the shoulder support system (hobbles) for 2 to 3 months. Rehabilitation therapy is required for a longer period of time as recovery following primary reconstruction ranges from 4 to 6 months. Fortunately, severe cases are less common and are usually due to trauma rather than repetitive activities. Patients with MSI have been conservatively managed successfully with long-term joint protection (Fig. 16).

Articular Fractures

The postoperative rehabilitation of articular fractures includes pain management, cryotherapy, PROM especially for the motions where a loss of ROM would be anticipated, and short leash walks for a few weeks after surgery. The goals of the early postoperative period are to maintain the ROM of the shoulder joint, limit periarticular fibrous tissue, and allow time for adequate bone healing to support more active weight-bearing exercises. When fracture healing is confirmed, continued ROM exercises, with stretching if needed, and active weight-bearing exercises such as progressive leash walking and aquatic therapy are implemented.

Scapular Fractures

Scapular fractures may be treated conservatively or with surgery. With conservative management, the limb may be held in suspension for 4 to 6 weeks. Intermittent PROM, massage, and low-level joint mobilization are recommended to maintain the motion of the shoulder joint and the scapula in relation to the body wall. As healing progresses, scapular PROM especially cranial to caudal motion and rotation is performed in increasing amounts in all planes to prevent fibrosis. Superficial heat applied with a moist heat pack may be used before exercise to allow increased tissue extensibility. Cross-fiber frictional massage may help to prevent or break down adhesions. Joint mobilization using scapular glides is also used for increasing ROM.[49] Aquatic therapy and gait activities such as treadmill walking may also be incorporated to regain muscle strength.

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