Treatment of medial shoulder joint instability in dogs by extracapsular stabilization with a prosthetic ligament: 39 cases (2008–2013)

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OBJECTIVE
To investigate clinical outcomes for dogs surgically treated for medial shoulder joint instability (MSI) by extracapsular stabilization with a prosthetic ligament.

DESIGN
Retrospective multicenter case series.

ANIMALS
39 client-owned dogs.

PROCEDURES
Medical records of 3 veterinary medical centers were searched to identify dogs with MSI diagnosed by clinical examination and arthroscopic assessment and treated by extracapsular stabilization with a prosthetic ligament. A minimum 6-month follow-up period was required for study inclusion. Signalment, function or use of the dog, duration of clinical signs, clinical and diagnostic imaging data, MSI grade (1 [mild] to 4 [complete luxation]), follow-up duration, complications, and outcome data were recorded.

RESULTS
All grades of MSI were represented. Implants were placed successfully in all dogs. Complications (4 major and 2 minor) were recorded for 6 of 39 (15%) dogs; all were treated successfully. Function at the time of last follow-up (6 to 68 months) was deemed full in 30 of 39 (77%) dogs and acceptable in 9 (23%).

CONCLUSIONS AND CLINICAL RELEVANCE
Surgical treatment of MSI in dogs by extracapsular stabilization with a prosthetic ligament was associated with a complication rate considered acceptable for orthopedic procedures. All patient outcomes were considered successful. (*J Am Vet Med Assoc* 2017;251:1042–1052)

The shoulder joint has the greatest range of motion of all canine joints. There are several soft tissue structures that contribute to stability of the shoulder joint; these are divided into active (biceps brachii, subscapularis, supraspinatus, infraspinatus, and teres minor muscles and the biceps brachii tendon) and passive (joint capsule, MGL, and LGL) stabilizers. Damage to ≥ 1 of these structures can result in MSI of various degrees, including shoulder joint luxation. When soft tissue pathological changes are severe enough to induce laxity that produces clinical signs, the condition is termed shoulder joint instability. Shoulder joint instability can occur in medial, lateral, and multiple directions, with MSI being the type most commonly reported in dogs.[1–8] The MGL is the stabilizing structure most commonly found to be damaged.[1,3,8–11]

ABBREVIATIONS

LGL	Lateral glenohumeral ligament
MGL	Medial glenohumeral ligament
MSI	Medial shoulder joint instability
SST	Subscapularis tendon

The spectrum of MSI abnormalities can include ligament tearing, laxity, or avulsion; tendinopathy; labral or capsular tears; and shoulder joint subluxation or luxation. A grading system for this spectrum of MSI has recently been described.[8,12] According to this system, grade 1 (mild MSI) = laxity without gross tearing of the MGL or SST; grade 2 (moderate MSI) = partial tear of the MGL, SST, or both; grade 3 (severe MSI) = complete tear of the MGL, SST, or both; and grade 4 (luxation) = complete displacement of the humeral head in relation to the glenoid cavity.[8,12]

Proposed causes for shoulder joint instability are categorized as acute traumatic or chronic overuse injuries. Traumatic instability results from a single event causing tearing or laxity in ≥ 1 of the joint stabilizers. A more common mechanism is thought to involve damage of joint stabilizers over time resulting from chronic repetitive microtrauma (or overuse) that leads to degeneration of tissues, decrease in tensile strength, and predisposition to fraying, disruption, and eventual breakdown.[1,2,8,13–16] The most severe form of shoulder joint instability is luxation, which is most often of traumatic origin.[17]

The most common clinical sign for dogs with MSI is unilateral lameness localized to the shoulder joint.

Presumptive diagnosis of MSI is made on the basis of results of palpation (cranial drawer sign and abnormal abduction angle) and diagnostic imaging (radiography, ultrasonography, CT, or MRI). Radiographic findings are often unremarkable. An increased shoulder joint abduction angle as measured with a goniometer is a finding consistent with MSI.[3] The mean ± SD abduction angle in dogs with a diagnosis of MSI (calculated by the authors on the basis of previous reports) is 49.4 ± 5.1°, compared with a mean abduction angle of 33.6 ± 2.7° for dogs without MSI.[1,3,4,11,18]

Advanced imaging is often used to aid diagnosis of shoulder joint disorders.[6,10,19–22] Definitive diagnosis of MSI is made by systematic arthroscopic assessment of the shoulder joint, including cranial, medial, caudal, and lateral compartments, with arthroscopic verification of damage to the MGL, SST, joint capsule, or a combination of these structures.[1–5,11,23–25]

Medial shoulder joint instability can be managed nonsurgically or surgically. Nonsurgical management consists of closed reduction of luxation if present, the use of hobbles to prevent abduction of the affected limb, administration of anti-inflammatory and analgesic medications, and physical rehabilitation. The goals of physical rehabilitation for dogs with MSI include joint protection, improvement in comfort, maintenance or improvement of joint range of motion, muscle building, and recovery of limb strength.[14]

In general, nonsurgical management of MSI is not as frequently associated with successful outcomes as is surgical treatment because of inherent laxity of the joint and continued stress on the associated soft tissues. In a study of 130 dogs with MSI, Franklin et al[7] found that those treated by surgical reconstruction were 3 times as likely to have a successful outcome (defined as assessment of function as full or acceptable by both the client and the clinician ≥ 1 year after treatment) as were dogs treated nonsurgically. However, it is important to recognize that nonsurgical management of MSI can vary substantially, and that its success is likely dependent on numerous factors including intended function of the dog, the severity of MSI, and the type, intensity, and duration of treatments, which to the authors' knowledge have not been critically examined to date. Placement of a prosthetic ligament has been attempted ex vivo and in vivo, although this method targeted repair of the MGL only.[26,27]

Surgical treatments for MSI in dogs include imbrication through an open approach, synthetic capsulorrhaphy through an open approach, or arthroscopically-assisted radio frequency–induced thermal capsulorrhaphy. Long-term success rates for reconstruction and radio frequency–induced thermal capsulorrhaphy in one study[7] were 38 of 44 (86%) and 4 of 5 (80%), respectively. Radio frequency–induced thermal capsulorrhaphy has been shown to be a safe, effective, and minimally invasive method for treating MSI or mild to moderate MSI.[4,7,28] Imbrication of the SST insertion has been shown to be a moderately effective procedure for management of MSI that is unresponsive to medical management.[18] Reconstruction of the medial compartment by means of synthetic capsulorrhaphy may be required for complete tears of the MGL.[23,26,27] None of these techniques have been proven efficacious against MSI involving > 1 structure.

Evidence and experience related to use of a prosthetic ligament system for extracapsular stabilization of the stifle joint in dogs with cranial cruciate ligament disease[29–32] and hip joint luxation[33–36] provided the impetus for the authors to develop a technique for use of this device for minimally invasive treatment of dogs with various degrees of MSI. Successful implementation of this technique in cadaveric shoulder joints and in a small number of canine patients led to surgeons from the participating institutions applying this method of treatment for routine clinical practice.

The objective of the study reported here was to evaluate clinical outcomes of dogs with MSI surgically treated by use of a prosthetic ligament system as a minimally invasive method for extracapsular shoulder joint stabilization.

Materials and Methods

Case selection criteria

Electronic medical records of Veterinary Orthopedic Sports Medicine Group, the Comparative Orthopedic Laboratory at the University of Missouri, and Veterinary Specialty Hospital San Diego were searched to identify dogs that underwent treatment for MSI between March 3, 2008, and April 2, 2013. Dogs were included in the study if preoperative radiographs and radiography reports were available for review, a diagnosis and grade of MSI were recorded or could be assigned retrospectively from data in the record, stabilization was performed with a prosthetic ligament system,[a] and follow-up data from ≥ 6 months after surgery were available. Dogs that had received previous nonsurgical treatment for MSI or required revision surgery were included.

Medical records review

Information obtained from the medical records included signalment (age, sex and neuter status, breed, and body weight), intended function of the dog, limb affected, duration of clinical signs before surgical intervention, and previous treatment for MSI and any concurrent injuries or orthopedic disease, if applicable. Abduction angle measurements for the affected and unaffected forelimbs, radiographic findings, arthroscopic findings, MSI grade, duration of follow-up, complications, and data required for determination of patient outcome (full, acceptable, or unacceptable function) were also recorded.

Diagnosis and grading of MSI

A diagnosis of MSI or shoulder joint luxation was determined, and grades were assigned for all dogs on the basis of abduction angle and radiographic and arthroscopic findings. The MSI was graded from 1 (mild) to 4 (complete luxation) according to a previously described system **(Appendix)**.[8,12] Subluxation was defined as partial displacement of the humeral head from the glenoid cavity and assigned a grade of 2 or 3 (moderate or severe MSI).

Diagnostic imaging

Preoperative radiographs of both shoulder joints were obtained. Views included mediolateral and craniocaudal. The images were reviewed at the time of diagnosis by the author responsible for the case for evidence of pathological changes including osteophytosis, soft tissue calcification, joint incongruity, and effusion. Preoperative ultrasonographic examination of the shoulder joint region, when performed, included assessment of bilateral supraspinatus, biceps brachii, infraspinatus, and subscapularis muscle origins, bodies, and insertions; joint fluid volume; the MGL; and the joint capsule.[1,11]

Surgical technique

The prosthetic ligament[a] used in the study was composed of 2 paired sutures (blue and white) consisting of multifilament braided strands of ultra-high molecular weight long chain polyethylene and polyester double-looped through a stainless-steel button and toggle.

After premedication, anesthesia, and preparation for aseptic surgery of the affected forelimb according to each center's standard of care, arthroscopic evaluation was performed with the dog in lateral or dorsal recumbency. Surgical preparation around the shoulder joint included a wide area to allow access to both medial and lateral aspects. One or more arthroscopy portals were created craniolaterally, craniomedially, or caudolaterally, according to surgeon preference. The shoulder joint was arthroscopically explored in a systematic manner that included assessment of the biceps brachii tendon, bicipital groove, SST, supraspinatus tendon, medial and caudal aspects of the labrum, MGL, LGL, synovium, articular cartilage, and laxity of the joint.

The stabilization technique used has been described elsewhere.[37] Steps of the procedure are illustrated **(Figure 1)**. Dogs were positioned in dorsal or lateral recumbency, with the affected limb positioned by a hanging limb technique. An approximately 2-cm-long incision was made just cranial to the superficial and deep pectoralis muscles on the medial aspect of the shoulder joint. Blunt dissection deep to the pectoralis muscle was performed, followed by caudal retraction of the muscles to allow access to the medial aspect of the shoulder joint.

A guidewire was inserted into the joint from the medial aspect in a manner that allowed it to be observed arthroscopically on the glenoid rim at the midpoint of the origin of the MGL **(Figure 2)**. The angle of insertion was adjusted so that the lateral exit point of the guidewire would be in the supraspinatus fossa just cranial to the spine of the scapula and just proximal to the neck of the scapula. The end of the guidewire was walked proximally to a distance of 4 to 5 mm off the glenoid rim. An assistant used a wire driver to drive the guidewire across the glenoid cavity to exit laterally. The locations of glenoid guidewire entrance and exit points were confirmed to be appropriate by arthroscopic assessment and palpation; fluoroscopic evaluation (available at 2 centers) was used in some patients.

Another guidewire was inserted into the joint from the medial aspect (Figure 1) in a manner that allowed it to be observed arthroscopically at the proximal aspect of the humerus; if the MGL was primarily affected, the point of the wire was placed at the insertion of the MGL, whereas if the SST was primarily affected, the point of the guidewire was placed at the insertion of the SST on the humerus. If both structures were considered to be contributing to the MSI, a midpoint between the 2 structures was chosen, or 2 guidewires (1/insertion site) were placed according to the surgeon's preference. The angle of insertion was adjusted so that the lateral exit point of the guidewire would be on the caudodistal aspect of the greater tubercle slightly cranial to the acromial head of the deltoid muscle. Each guidewire was then walked 4 to 5 mm distally along the proximal part of the humerus, to the estimated distal extent of the affected structure's insertion. An assistant used a wire driver to drive the guidewire across the proximal part of the bone to exit laterally. The entrance and exit points of humeral guidewires were confirmed to be appropriate in the same manner as described for the wire placed in the glenoid region.

Following guidewire placement, the arthroscope was removed, and a humeral tunnel was created with an appropriately sized (standard [diameter, 3.5 mm] or miniature [diameter, 2.7 mm]) cannulated drill bit placed over the guidewire and drilled across the humerus in the medial-to-lateral direction. A 2-cm-long incision was made over the lateral exit site of the drill bit, and dissection was performed to create an area large enough for the 2-hole button supplied for securing 1 end of the prosthetic ligament to be seated fully on the bone surface at the proximal aspect of the humerus. The guidewire was removed from the drill bit and the tip of the prosthetic ligament lead wire was pushed into the drill bit cannulation channel. The lead wire was pushed through the humeral tunnel laterally to medially, following the drill bit as it was withdrawn. The toggle attached to the leading edge of the prosthetic ligament was pulled through to the medial side of the bone and then pulled cranially to allow for drilling at the site of the glenoid guidewire. A 1- to 2-cm-long incision was made over the lateral point of the glenoid guidewire and the supraspinatus muscle was retracted to allow access to the bone in the supraspinatus fossa. A drill sleeve was placed over the wire and seated on the bone. A tunnel was drilled over the glenoid guidewire laterally to medially with an appropriately sized cannulated drill

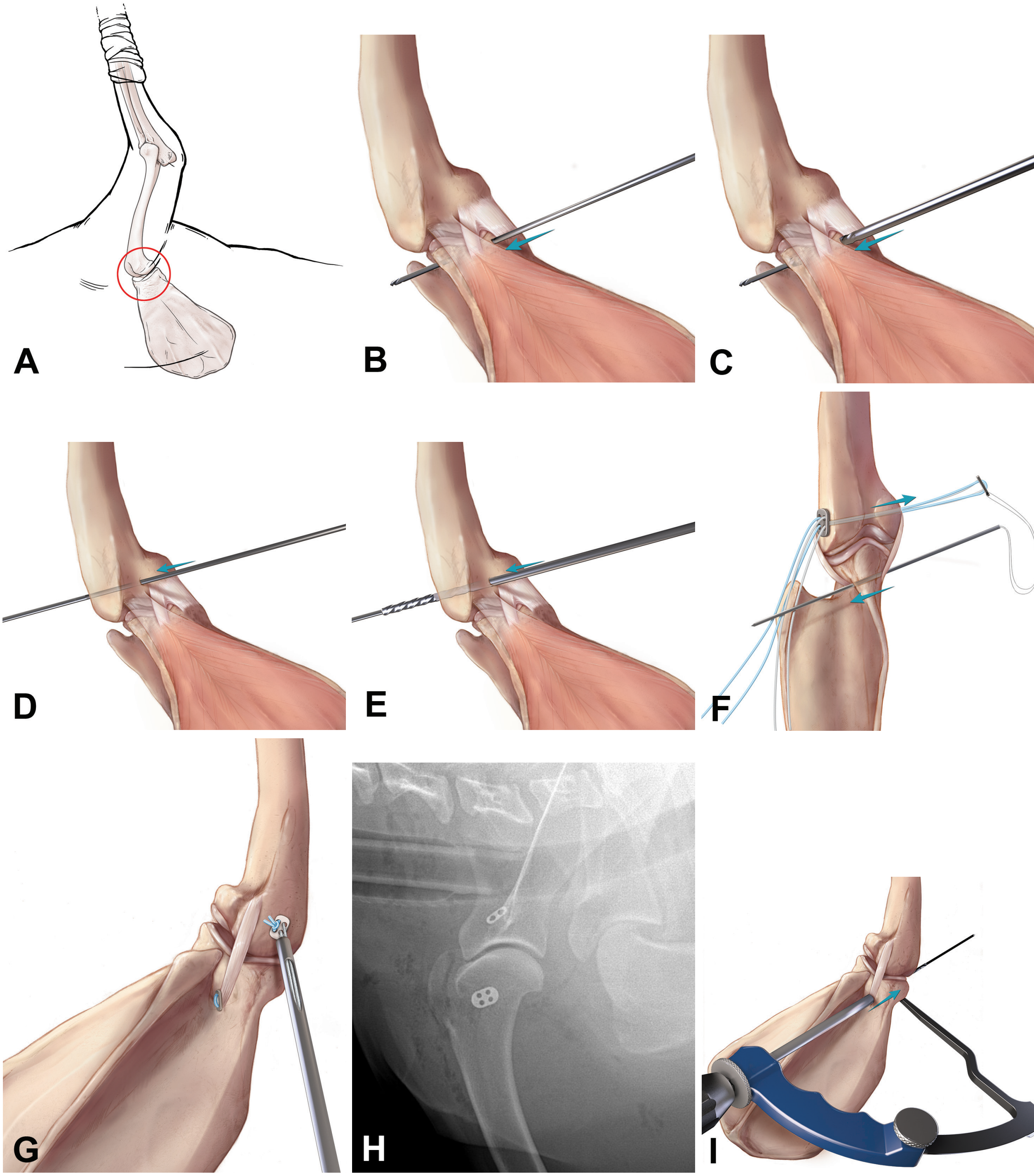

Figure 1—Images depicting a surgical technique (single humeral tunnel method) used for extracapsular stabilization of MSI in dogs with a commercially available prosthetic ligament. A—The affected forelimb is placed in a hanging position for creation of arthroscopic portals for shoulder joint evaluation and subsequent stabilization with the patient in dorsal recumbency (a laterally recumbent position can also be used). The scapulohumeral joint is indicated (circle). B and C—A guidewire is inserted into the joint from the medial aspect just cranial to the spine of the scapula and walked proximally to the glenoid rim. The images depict placement of the wire across the glenoid cavity (performed with a wire driver) and its subsequent overdrilling with a cannulated drill bit (performed at a later stage). D and E—A second guidewire is inserted into the joint from the medial aspect and directed from the proximal part of the humerus to the insertion of the affected soft tissue structure (SST or MGL) on the humerus. Overdrilling with a cannulated drill bit is performed after proper placement of all guidewires is confirmed. F—The supplied 2-hole button is fully seated on the bone surface, and the prosthetic ligament and toggle are passed through the humeral tunnel by use of a lead wire before overdrilling of the glenoid guidewire and completion of prosthetic ligament placement. G—The strands of tape or wire are pulled taut and adjusted with a tensioner. H—Representative postoperative radiograph depicting implant placement. I—A recent modification of the technique guide allows for guidewire placement from the lateral aspect of the joint (a technique not used in the present study). Images in panels A through G and I courtesy of Arthrex, Inc; reprinted with permission. Permission to use these figures must be obtained from the rights holder (Arthrex).

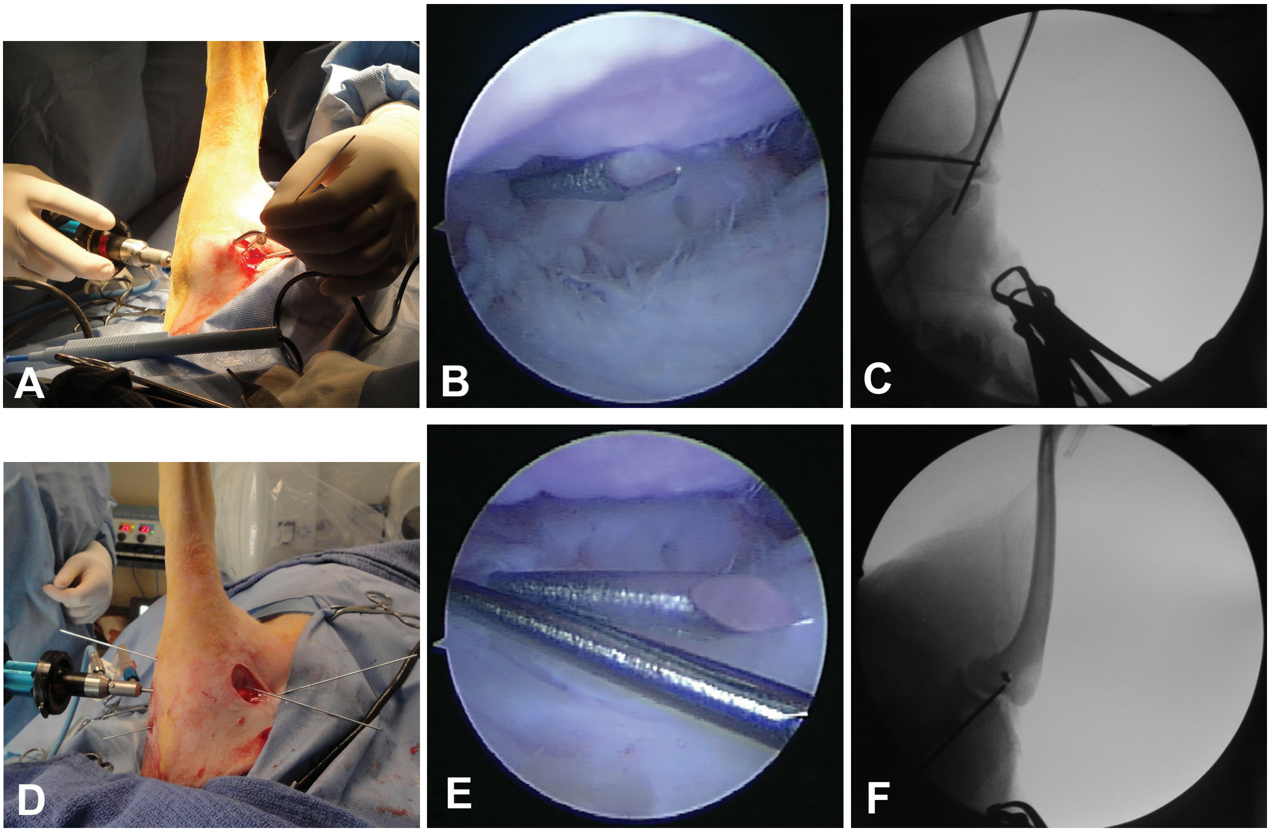

Figure 2—Images depicting arthroscopy-guided placement of guidewires to establish tunnel sites for placement of a prosthetic ligament for treatment of MSI in dogs. A through C—A guidewire is inserted into the joint from the medial aspect just cranial to the spine of the scapula and walked proximally 4 to 5 mm off of the glenoid rim. Placement is shown photographically (A), arthroscopically (B), and fluoroscopically (C). D through F—A second guidewire is similarly inserted medially and directed from the proximal aspect of the humerus to the insertion of the affected soft tissue structure (SST or MGL) on the humerus. Placement is shown photographically (D), arthroscopically (E), and fluoroscopically (F).

bit. The tip of the lead wire was pushed into the drill bit cannulation channel and through the glenoid tunnel in a medial to lateral direction, following the drill bit as it was removed. The prosthetic ligament toggle was pulled through to the lateral aspect, flipped, and pushed down until it was firmly seated on the bone surface. When 2 humeral tunnels were drilled, strands of white prosthetic ligament tape[b] or suture[c] (for tunnels created with standard and miniature drill bits, respectively) were pulled through the first humeral tunnel to the medial side. Then, the second humeral tunnel was drilled over the guidewire in a lateral to medial direction with an appropriately sized cannulated drill bit. The guidewire was removed from the drill bit, and a nitinol suture passer was inserted into the drill bit cannulation channel. The free ends of the tape or suture were inserted into the loop, and the suture passer was pushed through the humeral tunnel medially to laterally, following the drill bit as it was extracted. The tape or suture ends were then placed back through the prosthetic ligament button.

The tape or suture strands were pulled taut on the medial side, untwisted, and laid flat against the medial aspect of the joint capsule. The strands were pulled taut on the lateral side so that the prosthetic ligament button was pressed down to seat firmly on the humerus. The forelimb was then released from the hanging position and placed at a neutral abduction angle of approximately 0° to 10°. A suture tensioner[d] was placed over the blue strands of the tape or suture and used to tension the prosthetic ligament to 10 to 12 lbs of pressure with the button seated firmly and completely on the bone. With the tensioner in place, shoulder joint abduction, drawer, and range of motion were evaluated. Once the surgeon was satisfied with implant placement and tensioning on the basis of palpation, the white strands of the tape or wire were tied securely over the button. The tensioner was removed, and the blue strands of the tape or suture were tied securely over the button. Excess suture material was trimmed, and the lead wire suture was cut and removed. All incisions were closed routinely. Postoperative orthogonal view radiographs were obtained to subjectively assess implant placement.

Postoperative care

All dogs were hospitalized for 1 night after surgery and discharged with prescribed anti-inflammatory and analgesic medications according to surgeon preferences. Dogs with MSI grades < 4 had commercially available hobbles[e] applied immediately after surgery, and owners were advised to leave these in place for ≥ 4 weeks (duration at the surgeon's discretion with consideration of environmental factors including level of control of patient activity and environmental surface footing) or until adequate stability of the shoulder was reached as determined by palpation. Dogs that had shoulder joint luxations had a spica splint applied immediately after surgery; this was maintained until 4 to 8 weeks after surgery, and then replaced by hobbles for an additional 4 to 8 weeks. Rehabilitation therapy with a certified veterinary practitioner or therapist was recommended. Clients were also given directions regarding an at-home management program. Directions varied among centers, but in general, dogs were to remain in hobbles, once these were placed, at all times for ≥ 4 weeks; at-home activities were restricted to crate rest and leash walking for ≥ 8 weeks, and uncontrolled activities and training were gradually introduced beginning 12 weeks after surgery.

Outcome assessments

Assessment of patient progress was evaluated at recheck appointments. Postoperative radiographs were performed at long-term (≥ 4 months) follow-up appointments for some dogs, according to surgeon preference and owner agreement, to confirm continued appropriate implant position.

Complications and level of function were assessed by the attending surgeon or rehabilitation therapist using recommended standardized terminology and definitions,[38] where outcomes were defined as full function (restoration or maintenance of the dog's intended level of activities and performance to preinjury status without medication), acceptable function (the dog's intended activities and performance [with or without medication] were similar to the preinjury status but limited in level or duration, or equaled the preinjury status but required medication to achieve), and unacceptable function (all other outcomes). These assessments encompassed evaluation of gait, range of motion, and subjective comfort levels. Return to sport or previous use and the level of performance or activity was determined on the basis of owner assessment at the final follow-up appointment.

Results

Thirty-nine dogs met the criteria for study inclusion. Mean age of the dogs was 4.8 years (median, 4 years; range, 1 to 12 years) and mean body weight was 23.5 kg (51.7 lb; median, 22.2 kg [48.8 lb]; range, 2.4 to 48.9 kg [5.3 to 107.6 lb]). Breeds included Border Collie (11), Labrador Retriever (6), Australian Shepherd (5), Toy Poodle (2), German Shepherd Dog (2), Maltese (1), Bernese Mountain Dog (1), Nova Scotia Duck Tolling Retriever (1), Yorkshire Terrier (1), Beauceron (1), Chesapeake Bay Retriever (1), Shetland Sheepdog (1), Border Terrier (1), Flat-Coated Retriever (1), Standard Poodle (1), Cavalier King Charles Spaniel (1), and Golden Retriever (1); 1 was a mixed-breed dog. Twenty dogs (15 males and 5 females) were sexually intact, and 19 (11 females and 8 males) were neutered. The primary uses or activities of dogs included agility (n = 21 dogs), companion (9), obedience work (3), field trials (2), hunting (2), tracking (1), and police work (1).

Preoperative clinical and diagnostic imaging findings

All dogs had unilateral thoracic limb lameness with perceived resistance, signs of discomfort, or both on shoulder joint extension in the affected limb. Fifteen dogs were evaluated after an acute onset of clinical signs (lameness began immediately after a specific event), 8 were examined because of chronic signs (lameness began ≥ 3 months before the examination where the diagnosis was made), and 16 had lameness of unknown duration. All dogs had been treated with some type of nonsurgical management, which varied widely in terms of type and duration, prior to evaluation at one of the study centers. Two dogs had undergone previous surgical treatment consisting of arthroscopically assisted radio-frequency capsulorrhaphy.

The most common causes of MSI were training-related injury (n = 9), jumping or falling from furniture (2), and rough play with other dogs (2). Mean abduction angle in the unaffected limb (n = 29) was 31.4° (median, 32°; range, 15° to 42°). Mean abduction angle for the affected limb (n = 35) was 47.8° (median, 48°; range, 37° to 61°). Four of the dogs with luxation or severe subluxation did not have abduction angles measured in either limb, and 6 other dogs did not have this angle measured for the unaffected limb.

All dogs underwent preoperative radiographic evaluation; 31 were additionally evaluated by ultrasonography prior to surgery. Results of radiography were considered unremarkable for 22 dogs. Other findings included sclerosis (n = 7), joint effusion (5), luxation (4), subluxation (4), supraspinatus tendon calcification (3), degenerative joint disease (2), and osteophytosis of the bicipital groove (1). Dogs with chronic clinical signs commonly had soft tissue mineralization, sclerosis, or irregularity of articular surfaces. Two dogs had radiographic evidence of dysplasia, including a shallow glenoid cavity and flattened humeral head, and 1 of these dogs had a severe subluxation. The most common ultrasonographic finding was thickening of the medial aspect of the joint capsule and tissues (n = 15). Other ultrasonographic findings included biceps brachii tendon effusion or synovitis (n = 16); pathological changes of the subscapularis, supraspinatus, and infraspinatus muscles (11, 5, and 1, respectively); MGL abnormalities (9); hypertrophy of the lateral aspect of the capsule and regional tissue (3); periarticular fluid (3); and joint effusion (3).

On the basis of arthroscopic assessments, the structures most commonly affected were the MGL and SST. Some dogs had multiple findings. Thirty-two dogs had MGL abnormalities (partial tear [n = 19], complete tear [7], laxity [5], and fibrillation [1]). Thirty-three dogs had pathological changes of the SST (partial tear [n = 16], complete tear [10], and laxity [7]). Other findings included synovitis (n = 14), labral fraying (13), biceps tendon abnormalities (avulsion [3], adhesion [2], and partial tear [1]), joint capsule tear (5), pathological cartilage changes (fibrillation [9], erosion [4], and fragmentation [2]), LGL defects (partial tear [2] and fibrillation [1]), supraspinatus tendon injuries (partial tear [1] and complete tear [1]), degenerative joint disease (2), and focal erosions on the caudal aspect of the humeral head and glenoid cavity consistent with chronic osteochondrosis lesions (1).

The MSI was graded as 1 (n = 3), 2 (25), 3 (7), and 4 (4). Four dogs with shoulder joint subluxation had MSI grades of 3 (n = 3) or 2 (1). Comorbidities determined to require surgical treatment by the attending surgeon (eg, biceps tendon adhesions and cartilage fibrillation) were addressed through standard-of-care arthroscopically assisted techniques (eg, tenolysis and abrasion arthroplasty) at the time of MSI treatment, and others were managed nonsurgically in conjunction with postoperative rehabilitation for the MSI.

Surgical results and postoperative treatment

Minimally invasive prosthetic ligament stabilization of the shoulder joint was successfully performed in all of the dogs. Seven dogs had a miniature (suture-type) prosthetic ligament placed, and 32 dogs had a standard prosthetic ligament placed. Thirteen dogs had the procedure performed with fluoroscopic guidance. Postoperative radiographs obtained for all dogs confirmed appropriate positioning of the implants **(Figure 3)**. Thirty-four dogs had commercially available hobbles placed on the forelimbs immediately after surgery. Use of hobbles was maintained for 4 to 16 weeks in all but 1 dog (owner compliance was poor in this case). Four dogs that had shoulder joint luxations had spica splints applied immediately after surgery, and these were maintained for 4 to 8 weeks and then replaced by hobbles, which were maintained for another 4 to 8 weeks. Thirty-one dogs had dedicated rehabilitation therapy with a trained therapist or practitioner weekly to biweekly for ≥ 6 weeks after surgery, beginning on or after day 10 following surgery (after suture removal).

Thirty-five dogs had radiography performed at long-term follow-up visits. Evaluation of the images confirmed that appropriate implant positioning was maintained in all 35 dogs **(Figure 4)**.

Complications and patient outcomes

The mean duration of follow-up was 20 months (median, 15 months; range, 6 to 68 months). Difficulty seating the toggle button during surgery was reported for 2 dogs, but neither of these had complications, and both subsequently regained full function. Mild tension when cranial or dorsal traction was applied to the scapula was reported for 4 dogs approximately 4 to 8 weeks after surgery; this was attributed to secondary muscle atrophy attributable

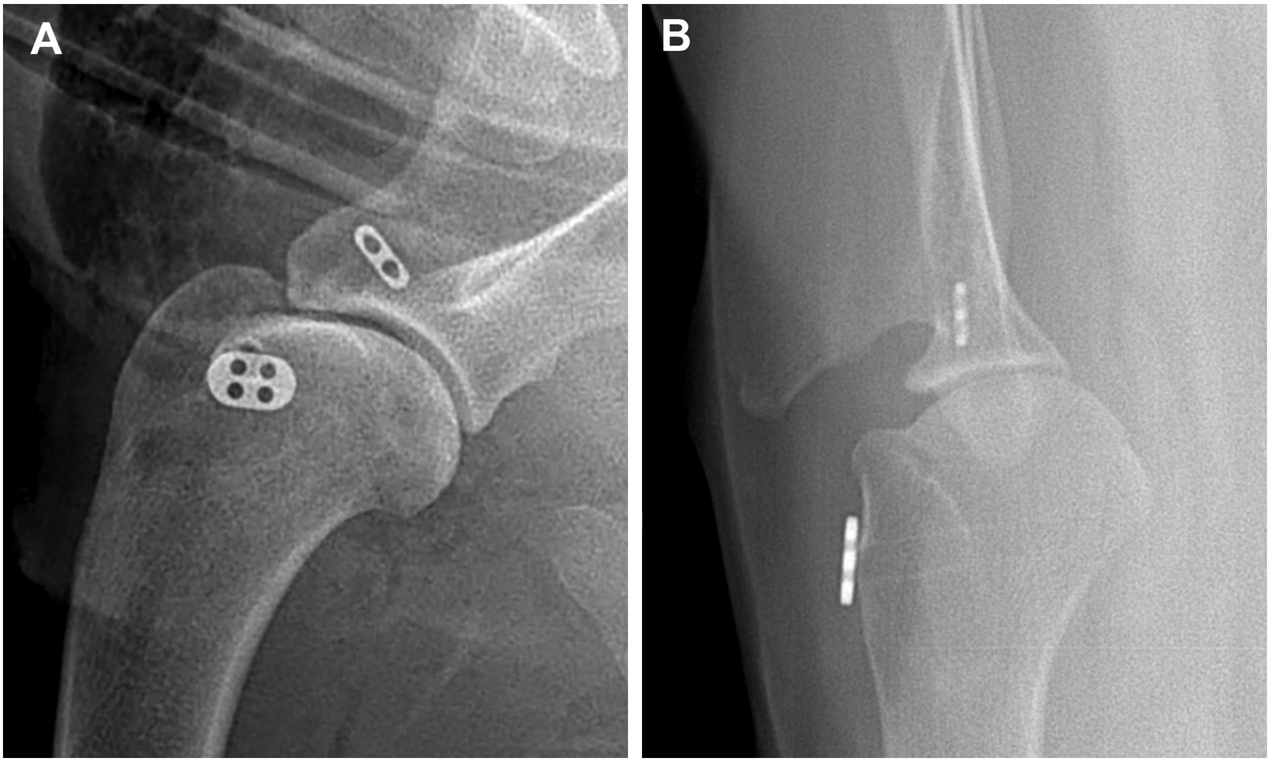

Figure 3—Postoperative lateral (A) and craniocaudal (B) radiographs of the shoulder joint of a dog depicting proper positioning of the prosthetic implant used for treatment of MSI.

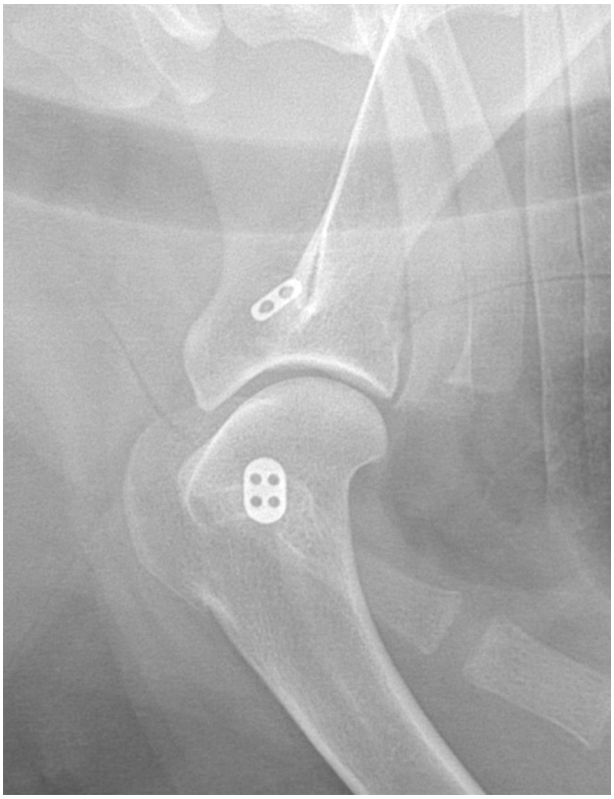

Figure 4—Mediolateral radiograph of the shoulder joint of a dog. The image was obtained 14 months after surgical placement of the implant and confirmed that appropriate positioning was maintained.

to restriction from the hobbles. This occurrence was resolved in all 4 dogs 4 to 6 weeks after hobbles were removed and activity was increased. Minor complications were reported for 2 dogs. These 2 dogs had mild incisional seromas that resolved with warm-packing by the owners.

Four dogs had major complications. A Cavalier King Charles Spaniel with grade 2 MSI had intraoperative failure (suture breakage) of a miniature prosthetic ligament. Replacement with a standard-sized implant was performed 2 days later, and the dog went on to have acceptable function. Two dogs had shoulder joint luxation in the treated limb after surgery. One of these dogs, a Nova Scotia Duck Tolling Retriever with grade 4 MSI and radiographic evidence of shoulder dysplasia (shallow glenoid cavity and flattened humeral head) prior to implant surgery, fell down a flight of stairs after having a seizure 3 weeks after surgery, causing reluxation. Closed reduction was achieved with the patient under general anesthesia, and a spica splint was placed and maintained for 18 weeks. Reduction was maintained such that acceptable function was achieved at final follow-up (36 weeks after surgery). The owners of the other dog, a German Shepherd Dog with grade 3 MSI, shoulder joint subluxation, and radiographic evidence of shoulder joint dysplasia prior to implant placement, did not comply with instructions for maintaining hobbles or activity restriction, and the patient jumped off a deck 2 weeks after surgery, resulting in complete shoulder joint luxation. An open reduction with medial and lateral prosthetic ligament stabilization was required because of implant breakage. The dog was not able to return to its previous level of sport (agility) activity, but was deemed to have acceptable function at last follow-up. A Border Collie with grade 3 MSI at the time of implant placement developed irritation attributed to the implant and subsidence of the toggle into bone 11 months after surgery; this required removal of the prosthetic ligament, which was performed with a minimally invasive arthroscopic procedure. This dog returned to full function (agility performance).

Overall, at the time of final follow-up, 30 of 39 (77%) dogs had regained full function, and the remaining 9 (23%) dogs were determined to have acceptable function. Of the 3 dogs that had grade 1 MSI, 2 had full function and 1 had acceptable function. Of the 25 dogs with grade 2 MSI, 22 had full function and 3 had acceptable function. Of the 7 dogs with grade 3 MSI, 3 had full function and 4 had acceptable function. Three of 4 dogs with grade 4 MSI had full function, and 1 had acceptable function. Twenty-eight of 30 (93%) dogs used for performance activities returned to the sport, and 8 of 9 companion dogs (89%) returned to their preinjury activity levels. Two of the 8 dogs that did not have formal rehabilitation therapy were among those that failed to return to preinjury level of activity. Two dogs were retired before attempting to return to their sport.

Discussion

In the present study, all dogs with MSI surgically treated with the described minimally invasive prosthetic ligament stabilization technique had successful outcomes (full or acceptable function) at last follow-up (≥ 6 months after the surgery), with most (28/30 [93%]) dogs with uses other than companionship achieving their previous level of performance activity. Complication types and rates were considered acceptable, and all dogs with complications subsequently had successful outcomes. There did not appear to be a correlation between dog size, implant size used, and final outcome; however, statistical evaluations were not performed.

Surgical stabilization of the shoulder joint may be indicated in dogs with MSI, including those with shoulder joint luxation and those for which previous nonsurgical treatments have failed. Radio frequency–induced thermal capsulorrhaphy has been used extensively for treatment of MSI in human patients.[39–45] The most commonly reported complications in humans are recurrence of MSI, inefficacy of treatment, and axillary neuropathy. Use of radio frequency is inappropriate in cases of multidirectional instability and can lead to treatment failure.[7,43] Extensive data are not available for MSI or MSI treatment protocols in dogs, but Cook et al[4] reported improved limb function in 40 of 43 (93%) dogs that had follow-up of ≥ 1 year after radio frequency–induced thermal capsulorrhaphy, and results of another study[7] showed the success rate for the same type of procedure to be 4 of 5 (80%). Dogs in previous studies[7,28] typically did not reach improved function until 12 to 16 weeks after treatment and did not reach optimal function until 5 to 6 months after treatment. We found a more rapid return to function in our patient population, with most (28/30 [93%]) dogs returning to full sport activity at approximately 16 to 20 weeks after the procedure. Dogs with severe MSI or shoulder joint luxation usually do not benefit from arthroscopic (radio frequency) treatment alone, as the pathological changes most commonly consist of complete tears of the MGL and severe disruptions or tears of the SST. These patients are generally thought to require reconstruction of the medial joint compartment by synthetic capsulorrhaphy or by primary stabilization (as in our patient population), and therefore, a reliable implant and placement technique are needed.

Rehabilitation therapy is thought to be a crucial component of recovery from MSI surgery. The goals of postoperative shoulder joint rehabilitation therapy should be to protect the joint during healing, improve comfort level, maintain range of motion, minimize muscle atrophy and limb disuse, and rebuild limb strength. On the basis of these premises, dogs in the present study initially had a support device (hobbles or spica splint) placed, and owners were instructed to keep the device in place for ≥ 4 weeks[4] after surgery. Custom-sized hobbles are preferred by the authors because adjustable straps can be used to ensure an appropriate fit for the patient. A spica splint rather than a sling vest was chosen for postoperative management of dogs with shoulder joint luxation in this study because of a perceived risk for soft tissue contracture. After the initial non–weight-bearing and protective period, gradual reintroduction of weight-bearing and strengthening was initiated. Staged increases in load on muscles, tendons, and ligaments will encourage tissue regrowth and remodeling over a ≥ 12- to 16-week period. A variety of rehabilitation protocols are available that include use of an underwater treadmill, laser therapy, and range of motion and proprioceptive exercises, all of which are aimed at strength building and tissue modulation. Patients at each center had rehabilitation programs recommended that were tailored according to their individual progress. There was a wide range in follow-up among dogs, and this was mostly related to variation in the follow-up protocols among the 3 treatment centers and in client compliance. However, most dogs appeared to return to training and attain preinjury levels of activity around the same period of time, and the duration and types of physiotherapy provided were fairly similar among the centers. Two of the 8 dogs that did not participate in formal rehabilitation failed to return to preinjury level of function, which underscores the importance of postoperative physiotherapy.

Techniques for use of the prosthetic ligament system applied in the present study for stabilization of stifle and hip joints of dogs have been described in the veterinary literature. Major complications in vivo or issues ex vivo have included instability or reluxation attributed to implant failure, implant infection, and bone fracture.[29,33,35,46,47] Previous reports describing the use of toggle rods and toggle fixation have indicated low rates of joint reluxation and superior results for tape, compared with other materials.[29,34,46] Reluxation rates following toggle rod placement reportedly range from 7 of 62 (11%) to 4 of 14 (29%).[33,48,49] In our patient population, shoulder joint luxation occurred in 2 of 8 dogs that had luxation or subluxation before treatment, although both incidents were the result of owner noncompliance with postoperative management instructions.

Complications in the present study ranged from minor (incisional seromas) to major (implant breakage, shoulder joint luxation, or both). One dog with shoulder joint subluxation and luxation of the same joint after surgery had evidence of implant breakage, but there were no other appreciable injuries. We believed that substantial impact trauma would have been necessary to cause the luxation. Additionally, this dog had preoperative radiographic evidence of shoulder joint dysplasia and we considered that the subluxation at the time of the initial surgery was likely the result of congenital joint instability. This dog had a successful outcome with acceptable function at last follow-up, suggesting that the technique used in the study might be a suitable option for management of congenital shoulder joint instability; however, further investigation with a large number of dogs would be needed to provide definitive recommendations. Although the study was retrospective in nature, the low complication rate suggested that the treatment was safe when properly performed.

A recent modification of the technique guide[37] allows for placement of the guidewires from the lateral aspect of the shoulder joint, avoiding the obstruction of the trunk and the associated difficulty in effectively directing the guidewires for optimal exit site placement (Figure 1). This method was not used in the present study. However, special care should be taken to preserve the integrity of the suprascapular nerve during dissection with the described technique.

Major limitations of the present study included the retrospective design, lack of objective measures of function, and the lack of cohort or control groups. Owing to variability among treatment centers in attaining preoperative measurements of range of motion (by goniometry) and determining abduction angles, objective measures were not the primary focus in postoperative follow-up assessments. Gait analysis could not be performed for many of the patients before surgery because of presence of shoulder joint luxation, non–weight-bearing lameness, or small size (insufficient body weight), and therefore, postoperative comparisons were precluded. Because many of the dogs in the study were involved in performance or sport activities, return to the previous activity level and associated resolution of lameness were deemed relevant in assessing outcomes for the population. There were also variations in postoperative management protocols among centers. As such, these data need to be interpreted with caution and should not be extrapolated to the larger population of dogs with MSI or used to draw conclusions regarding therapeutic protocols for treatment of MSI. Finally, although the general guidelines for rehabilitation therapy were consistent across all treatment centers, not all dogs had the recommended professional rehabilitation treatment, and the protocols were tailored according to individual dogs' progress. Duration of follow-up also varied substantially among dogs, although the minimum follow-up time was 6 months after surgery.

Minimally invasive treatment of MSI in dogs by placement of a prosthetic ligament for extracapsular stabilization was associated with successful outcomes in all dogs in the present study, and almost all dogs involved in performance or sport activities were able to return to those activities after treatment. No catastrophic complications developed, and all complications were effectively managed. The limited results of this study suggested that postoperative management including activity restriction and coaptation in the form of hobbles or splints might have an important role in successful management of these patients. The authors believe that rehabilitation therapy is also an important contributor to outcome, but this was not assessed in our study. Prospective studies to evaluate long-term safety and efficacy of the treatment used in this study, use of different test strengths of prosthetic ligaments in dogs, and outcomes for dogs with MSI treated by different techniques are warranted.

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Footnotes

a. ACL Tightrope System, Arthrex Inc, Naples, Fla.
b. FiberTape suture, Arthrex Inc, Naples, Fla.
c. FiberWire suture, Arthrex Inc, Naples, Fla.
d. Arthrex Suture Tensioner, Arthrex Inc, Naples, Fla.
e. Shoulder Stabilization System, DogLeggs Therapeutic and Rehabilitative Products, Reston, Va.

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Appendix

Grading system used for evaluation of MSI in 39 dogs that were treated by extracapsular stabilization with a prosthetic ligament.[8,12]

Grade	Description	Typical range of abduction angles (°)	Typical arthroscopic findings
1	Mild MSI	30 to 39	Laxity Fiber separation and fraying of SST, MGL, or both Joint capsule rent at MGL origin Focal synovitis
2	Moderate MSI	40 to 55	Partial tearing of SST, MGL, or both Fraying of SST, MGL, or labrum (alone or in combination) Joint capsule rent at MGL origin Synovitis Focal cartilage damage*
3	Severe MSI	> 55	Complete tear or avulsion of SST, MGL, or both Subluxation (partial displacement) of the humeral head from the glenoid cavity Labral and cartilage damage Joint capsule tears Synovitis Degenerative changes
4	Shoulder joint luxation	NA	Complete tear or avulsion of SST, MGL, or both Joint capsule tears Synovitis* Degenerative changes* Complete displacement of the humeral head from the glenoid cavity

*Sometimes present.
NA = Not applicable.