This article discusses the diagnostic and therapeutic applications of arthroscopy for various forelimb joint disorders. The advantages of arthroscopy over arthrotomy are emphasized. As veterinarians become familiar with arthroscopic instrumentation and techniques, it is hoped that this will improve not only understanding of joint pathophysiology but also prevention and treatment of joint disease.

ABSTRACT:
This article discusses the diagnostic and therapeutic applications of arthroscopy for various forelimb joint disorders. The advantages of arthroscopy over arthrotomy are emphasized. As veterinarians become familiar with arthroscopic instrumentation and techniques, it is hoped that this will improve not only understanding of joint pathophysiology but also prevention and treatment of joint disease.

Significant advancements have been made in veterinary arthroscopy during the past 10 years. Its use in dogs has become common in diagnosing and treating common joint diseases (see box on page 581). The goals of this article follow:

- Emphasize the usefulness of arthroscopy compared with that of arthrotomy.
- Review the diagnostic and therapeutic applications of arthroscopy in dogs. (Discussions of types of arthroscopes, necessary instruments, and arthroscopic techniques for the shoulder, elbow, carpus, hip, stifle, and hock have already been published.)

ARTHROSCOPY VERSUS ARTHROTOMY
The published advantages of arthroscopy over arthrotomy include the following (for a summary, see box on page 581):

- Patient morbidity is decreased, thus decreasing hospitalization time and postoperative costs.
Multiple joints can be treated simultaneously, leading to earlier treatment of secondary joints.

It is minimally invasive:

— The arthroscope and instrument portal incisions transect fewer nerve endings in the highly innervated joint capsule, thus reducing postoperative pain.

— The incision is small, and the arthroscopic holes require 0-2 staples or sutures for closure, thus reducing soft tissue damage.

— Minimal invasiveness allows periodic reevaluation of the joint to monitor therapy or disease progression.

The wounds require little care, and dogs do not need an Elizabethan collar or extensive bandages after surgery.

Recovery is faster, allowing earlier return to function and preservation of range of motion.

The cosmetic appearance is better.

Magnification and illumination of the joint within its natural fluid medium allow better visualization of intraarticular surfaces and structures.

There is less risk of infection than with open surgery. Infections occur in significantly fewer than 1% of cases, and the overall rate of complications (i.e., 0.56%) is extremely low.

The video connection to the arthroscope allows assistants and students in the surgical room to see the procedure, which is a good teaching tool.

The published disadvantages of arthroscopy over arthrotomy include the following:

Arthoscopes and their instruments are expensive and fragile.

Extensive and intensive training is needed. There are many challenges to learning arthroscopic surgery, including locating portals, developing the unique hand–eye coordination needed for minimally invasive
The arthroscope and its instruments can be difficult to manipulate in small joint spaces, resulting in inadequate or poor visualization of intraarticular structures. Most arthroscopic equipment cannot be autoclaved. It is sterilized with glutaraldehyde, which is a known carcinogen. In some cases, the procedure has to be finished with arthrotomy. This prolongs surgery, increases the cost, and negates some of the benefits of using arthroscopy.

The published complications and difficulties of arthroscopy include the following:

- Fluid extravasation in the surrounding soft tissue can result from the subcutaneous escape of pressurized fluid.\textsuperscript{13}
- Insertion and manipulation of instruments can result in iatrogenic damage to articular cartilage.\textsuperscript{13} This can also occur with routine arthrocentesis and open surgery. To avoid this damage, the surgeon has to use appropriately sized instruments, adequate joint distention and positioning, and gentle manipulation within the joint. Lactated Ringer’s solution may cause less damage to cartilage than does saline solution. Thermal injuries to articular cartilage may occur if patients are not properly grounded when cautery units are used.\textsuperscript{3}
- The view can be obstructed by hemorrhage, hyperplastic synovial villi, or a fat pad.\textsuperscript{7} However, this problem could be largely overcome with frequent intermittent or continuous lavage and manipulation of the tip of the scope in several directions.\textsuperscript{7}
- Neurologic injury has been reported\textsuperscript{9,14} but is very rare.

**INDICATIONS FOR ARTHROSCOPY OF THE SHOULDER JOINT**

**Osteochondritis Dissecans**

**Cause and Clinical Signs**

Osteochondritis dissecans (OCD) is a manifestation of osteochondrosis in which a fragment of cartilage is lifted from the articular surface. A disturbance in endochondral ossification leads to increased thickness of the
articular cartilage, which may fissure as deeper chondrocytes undergo necrosis as a result of an inadequate nutritional supply. The peripheral area of thickened cartilage separates because of increased local shear stress, and a loose fragment of cartilage elevates into the joint or completely detaches from the underlying bone (Figures 1 and 2). In dogs, the site of osteochondrosis of the shoulder is the caudal humeral head.

OCD is most common in medium- and large-breed dogs (males slightly more than females) 4 to 8 months of age presenting with a gradual onset of unilateral, weight-bearing, forelimb lameness. The condition is often bilateral; therefore, bilateral radiographs should be obtained, even if only one limb is clinically affected. There is characteristic pain during hyperflexion of the shoulder, and dogs often have more clinical signs after exercise.

**Diagnosis**

OCD can be diagnosed radiographically,

Conservative and Surgical Treatment

Conservative management (i.e., antiinflammatories, moderate exercise, weight restriction) may be successful in some patients, especially those in which OCD is an incidental finding with no clinical signs of pain or lameness. An osteochondral flap can be removed by traditional arthrotomy or arthroscopy. Arthroscopic treatment allows better visualization and access to cranial and caudal areas of the shoulder and is associated with less morbidity. Most dogs use the treated limb immediately after surgery, although some lameness may persist for several weeks. The long-term prognosis is generally excellent but may depend on the severity and duration of the condition as well as subsequent arthrosis. In advanced cases of arthrosis, the benefit of surgery is questionable. Arthroscopy can be used for osteochondral flap removal, abrasion or microfracture of the subchondral defect, and partial synovectomy. Both shoulders can be treated simultaneously if the condition is bilateral.

Bicipital Tenosynovitis

**Cause and Clinical Signs**

Bicipital tenosynovitis is an inflammatory and degenerative process of the biceps brachii tendon and its surrounding synovial sheath. Many patients may actually have an incomplete tear in the origin of the biceps tendon rather than true bicipital tenosynovitis (Figures 1 and 3). The disease may occur with intraarticular disease and joint mice entrapment, mineralization of the supraspinatus tendon, or acute trauma that causes partial or complete tearing of the tendon. Possible causes include irritation from frequent use, acute injury, chronic repetitive injury, or a sedentary lifestyle. It is common in adult, medium to large dogs and presents clinically as chronic weight-bearing lameness that worsens after exercise. Pain during palpation of the bicipital tendon within the intertubercular groove occurs occasionally, but weight-bearing lameness and shoulder pain during flexion and extension are more common.

**Diagnosis**

Radiography should include lateral, ventrodorsal, and skyline views (i.e., craniocaudal projection of the humerus with the shoulder flexed) to see the bicipital groove. In case of complete or partial rupture of the biceps tendon, bone proliferation or resorption of the supraglenoid...
tuberosity at the origin of the biceps tendon may occur. Other findings are calcification of the biceps tendon sheath or osteophytes in the intertubercular groove. Ultrasonography is a useful tool in evaluating the tendon and its condition. The biceps tendon commonly appears inflamed in patients with OCD because of a generalized inflammatory response of the joint. The arthroscopist should not confuse this with bicipital tenosynovitis and cut the tendon unnecessarily (Figures 1 and 3).

**Conservative and Surgical Treatment**

Conservative treatment includes restricted activity for at least 3 weeks, analgesics such as intraarticular NSAIDs, or methylprednisolone acetate injected into the tendon sheath. Surgical treatment consists of release of the biceps tendon from the supraglenoid tubercle by arthrotomy or arthroscopy. Some surgeons reattach the tendon to the greater tubercle of the humerus (tenodesis), and other surgeons simply cut the tendon and do not reattach it.

**Shoulder Instability**

**Cause and Clinical Signs**

Shoulder instability occurs if the joint capsule or collateral ligaments are torn or stretched. Dogs of any age or breed may be affected, especially medium- and large-breed dogs, which can present with chronic foreleg lameness that is usually permanent and sometimes intermittent. In most cases, muscle atrophy and pain during manipulation of the shoulder are evident. The biceps tendon test is usually positive, and excessive abduction/adduction or abnormal craniocaudal translation of the shoulder can be detected in anesthetized dogs.

**Diagnosis**

Radiographic findings of shoulder instability may be unremarkable except for degenerative osteoarthritis in long-standing cases. Arthrography can be used to show irregularities and filling defects that suggest synovial hyperplasia, tendon rupture, and joint mice. Ultrasonography, CT, and MRI can help diagnose collateral liga-

The prognosis for normal limb function with shoulder instability varies, depending on the degree of injury of the medial or lateral restraints. If stretching of soft tissue is the only pathology, treatment with imbrication or thermal contracture is usually successful. In the case of more extensive soft tissue injury or wearing of the labrum, the prognosis is fair to good.

**Strain of the Supraspinatus Insertion**

**Cause and Clinical Signs**

Calcifying tendinopathy affects the supraspinatus tendon. The lesion occurs close to the bone–tendon junction, and the mineral is located within the substance of the tendon. It is most common in middle-aged, large-breed dogs, and the lesion may not be clinically significant in all dogs. In certain patients, it may cause low-grade chronic foreleg lameness (sometimes only after exercise) and discomfort during manipulation of the shoulder.

**Diagnosis**

Radiographs show mineralization in the tendon of insertion of the supraspinatus muscle, adjacent to the greater tubercle of the humerus. A skyline view of the bicipital groove is helpful in visualizing mineralization, and arthrography and CT are also excellent diagnostic tools.
Conservative and Surgical Treatment

If medical management is unsuccessful, tenectomy of the supraspinatus insertion at its insertion onto the greater tubercle is recommended. Arthroscopy should be used to rule out other pathology in the joint.3

Incomplete Fusion of the Caudal Glenoid Ossification Center

Cause and Clinical Signs

Incomplete fusion of the caudal glenoid ossification center (i.e., radio-dense projection adjacent to the caudal edge of the glenoid) may be an incidental finding during lateral radiographic examination of the shoulder.30 Incomplete fusion can cause lameness, synovitis, and pain if an osteochondral fragment is loosely embedded in the joint capsule.

This condition is more common in large dogs that present with weight-bearing lameness with pain during flexion and extension of the shoulder.31

Diagnosis and Surgical Treatment

Radiographic views should include standard anteroposterior and lateral projections of both shoulders and both elbows. Other causes of lameness associated with pathology of the shoulder or elbow need to be ruled out because incomplete fusion of the caudal glenoid ossification center can be an incidental radiographic finding. A nuclear scan is useful in excluding other sources of inflammation. CT of the elbow can be used to exclude in situ osteomalacic medial coronoid process.

Arthroscopy can be used to remove the loose osteochondral fragment if it is causing lameness. Because incomplete ossification can be an incidental radiographic finding, other causes of forelimb lameness must be ruled out.31

Arthroscopy allows better visualization of intraarticular surfaces and structures than does arthrotomy.

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Reduction and Stabilization of Supraglenoid Tuberosity Avulsion

Cause and Clinical Signs

In dogs, the supraglenoid tuberosity has its own center of ossification and fuses with the remainder of the scapula at 5 to 6 months of age.32,33 In adult dogs, trauma to the area usually results in a ligamentous or tendinous injury, fracture, or luxation; in young dogs, trauma usually results in an avulsion fracture of the growth plate.33–35 Avulsion fracture of the supraglenoid tuberosity usually occurs during landing following a jump, when there is marked shoulder hyperflexion. This increases traction exerted by the biceps brachii muscle34,35 and prevents spontaneous healing.32–35

Dogs present with non–weight-bearing lameness of the affected limb. The scapulohumeral joint is swollen and painful during palpation.34
no palpable crepitus because the avulsed supraglenoid tuberosity is displaced distally.\textsuperscript{34,36}

**Diagnosis**

Supraglenoid tuberosity avulsion is detectable on mediolateral and caudocranial shoulder radiographs, but the intraarticular structures cannot be viewed in this manner.\textsuperscript{33} Arthroscopy is the best tool with which to view the integrity of cartilaginous, capsular, and ligamento-tendinous structures.

**Conservative and Surgical Treatment**

This type of articular fracture requires early surgical treatment with internal fixation. Some authors recommend rigid compressive internal fixation, although this can lead to growth deformities. Implants may be removed early to avoid closure of the growth plate.\textsuperscript{33} Fixation with only one cancellous bone screw has been described.\textsuperscript{35} The fracture can be reduced and stabilized via arthroscopic guidance using a Kirschner wire and a cortical bone screw. Arthroscopic reduction and percutaneous fixation should be considered an advanced procedure. If difficulties are encountered, an open approach should be used before fluid extravasation. In one case report,\textsuperscript{37} no lameness was reported during a follow-up period of 20 months. Radiographs taken 9 weeks postoperatively revealed complete bone healing, and the broken wire at the time of its removal (9 weeks) was the only complication.\textsuperscript{37} Arthroscopy avoids a surgical approach, which may lead to complications such as adhesion of the biceps tendon or synovitis.\textsuperscript{9}

**INDICATIONS FOR ARTHROSCOPY OF THE ELBOW JOINT**

**Osteochondritis Dissecans**

**Cause and Clinical Signs**

Osteochondrosis of the most medial and distal region of the humeral condyle often occurs in both elbows and can occur in combination with a fragmented medial coronoid process (FMCP; Figures 4 and 5). Affected dogs have a history of unilateral or bilateral lameness and exercise intolerance starting at 3 to 4 months of age. During physical examination, they can have pain and decreased range of motion of the elbow joint.

**Diagnosis**

The typical radiographic finding is a region of subchondral bone loss on the distal and medial portion of the humeral condyle that is best appreciated on a craniocaudal radiograph. More advanced findings include sclerosis around the affected region and osteophyte production in the proximal aspect of the anconeal process, which is best visualized on a flexed lateral view. Early stages of OCD can be difficult to diagnose radiographically; CT is more sensitive for confirming an OCD lesion. Arthroscopy can also be used as a diagnostic tool to provide information unavailable on radiographs.\textsuperscript{35}

**Conservative and Surgical Treatment**

Medical treatment (i.e., antiinflammatory medication) and control of activity and body weight may be useful, but surgical intervention (i.e.,
arthrotomy or arthroscopy) is the treatment of choice. Arthrotomy or arthroscopy includes osteochondral flap removal, abrasion or microfracture of the subchondral defect, and partial synovectomy. Because arthroscopy allows a quicker recovery, improved visualization, magnification, and minimal invasiveness, it has advantages over arthrotomy in treating OCD. Furthermore, with arthroscopy, both elbows can be treated simultaneously if the condition is bilateral. Arthroscopy can contribute to early diagnosis of these conditions, allowing surgery to be performed at an early stage, if indicated.

**Fragmented Medial Coronoid Process**

**Cause and Clinical Signs**

The pathophysiology of fragmentation of the cartilage and subchondral bone in the lateral aspect of the medial coronoid is not well defined. Hypotheses include developmental incongruity of the elbow, leading to abnormal loads on the coronoid process and thereby causing fragmentation, as well as a form of OCD. FMCP is reported in young dogs (i.e., 4 to 5 months of age), but dogs may not present with clinical signs until later in life. They present with a history of unilateral or bilateral lameness and exercise intolerance. Manipulation of the elbow joint elicits pain, and there is decreased range of motion. The joint may have mild to severe effusion in the acute stage.

**Diagnosis**

Because of superimposition of various bony structures on plain radiographs, it is very difficult to visualize the coronoid process (Figures 4 and 5). Therefore, FMCP can be indirectly diagnosed only by the appearance of secondary osteophytes, which are best visualized on a flexed lateral view, especially at the proximal aspect of the anconeal process. Cranio-caudal views show lipping and osteophytosis in the region of the medial coronoid process and epicondyles. These osteophytes are signs of secondary osteoarthritis and do not appear until dogs are approximately 7 to 8 months of age. In the mildest cases, sclerosis of the ulna in the region of the medial coronoid process is the only radiographic sign. Linear tomography, CT, and arthroscopy (Figure 5) allow visualization of the fragment and may show the abnormally shaped medial coronoid. CT and arthroscopic findings usually concur; in some cases, however, CT shows fissuring of the medial coronoid process (i.e., incomplete fragmentation of the...
coronoid) that is not visible arthroscopically. In these cases, palpation of the cartilage with a probe may show chondromalacia (i.e., soft and fragile cartilage) or mild fissuring. MRI is an excellent diagnostic tool for this condition, and nuclear scintigraphy can help identify the anatomic location of inflammation.

Conservative and Surgical Treatment
Medical treatment (i.e., antiinflammatory drugs) and control of activity and body weight are commonly suggested conservative treatments. Most surgeons recommend surgical removal of the FMCP, although results are not always good. The prognosis after surgical treatment (i.e., arthrotomy or arthroscopy) may vary. In one study of 175 joints of 150 dogs treated arthroscopically for FMCP or OCD, 90% of dogs had clinical results that were considered excellent (i.e., free of lameness) or good (i.e., occasional mild lameness). In 82% of the treated joints, radiographic arthrosis had progressed. Elbow osteoarthritis may require lifelong management that may include additional arthroscopies, corrective or modifying osteotomies, physical therapy, and medical management.

Ununited Anconeal Process
Cause and Clinical Signs
The center of ossification of the anconeus should unite with the proximal ulna at approximately 20 weeks of age, although it may occur later in German shepherds and greyhounds. Failure of unification can be caused by failure of endochondral ossification within this separate center of ossification or joint incongruence that places excessive pressure on the process. Dogs often present at 6 to 18 months of age with unilateral or bilateral forelimb lameness and muscle atrophy, elbow joint pain, effusion, and decreased range of motion.

Diagnosis
Flexed lateral radiographs are considered the ideal view to diagnose ununited anconeal process (UAP) in the elbow. Although arthroscopy can be used as a diagnostic tool for UAP, this condition is easily confirmed radiographically. The main benefit of using arthroscopy is complete evaluation of the elbow because concomitant FMCP or OCD is common.

Conservative and Surgical Treatment
Conservative treatment consists of antiinflammatory medication as well as control of athletic activity and body weight. Conservative therapy alone has been less successful, usually resulting in rapid progression of severe osteoarthritis, although spontaneous fusion has been reported. UAP responds favorably if surgery is initiated early in the course of development, before severe degenerative changes have occurred.

To avoid iatrogenic damage to the articular cartilage during arthroscopy, surgeons have to use an appropriately sized instrument, adequate joint distention and positioning, and gentle manipulation within the joint.

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Reported surgical therapies include fragment removal, screw-and-pin fixation, and ulnar osteotomy to reduce pressure on the process and encourage healing. Dogs with UAP often develop severe elbow osteoarthritis with variable degrees of disability. Ulnar osteotomy in combination with an anconeal compression screw provided successful results in two clinical studies. Arthroscopy can be used in conjunction with this treatment to visualize the fragment during screw fixation and decrease the risk of damage to the articular surface. A small Kirschner wire should be inserted, beginning at the caudal aspect of the ulna. The pin should be directed perpendicular to the line between the ulna and the anconeal process. Through the arthroscope, the surgeon can observe the pin passing between the ulna and the anconeal process. The UAP fragment can be removed arthroscopically if that treatment is chosen.

Humeral Condylar Fracture
Cause and Clinical Signs
Humeral condyle fractures are one of the most common fractures of the canine forelimb. Incomplete ossification of the humeral condyle may predispose dogs to these fractures.
Diagnosis

Radiographs are sufficient to make a diagnosis. CT can be used to aid diagnosis of incomplete ossification of the humeral condyle.

Conservative and Surgical Treatment

Methods of repair include open reduction and fixation and closed fluoroscopically guided reduction and fixation. Despite the obvious benefits of closed reduction and fixation, accurate reduction with fluoroscopic guidance is difficult. Arthroscopy may improve the outcome of the closed technique by allowing direct visualization of the fracture surfaces to confirm anatomic reduction.3

INDICATIONS FOR ARTHROSCOPY OF THE RADIOCARPAL JOINT

The radiocarpal joint (Figure 6) is the only joint within the carpus that can be evaluated with an arthroscope. Carpal arthroscopy allows evaluation of ligamen-tous damage and intraarticular fractures; removal of small bone chips; treatment of osteoarthritis and septic arthritis; biopsy of bone, cartilage, and synovial membrane; and evaluation of carpus instability.6

In carpus instability, lateral and anteroposterior radiographic views are often insufficient to yield a definitive diagnosis. These views occasionally suggest collateral ligament injury by the presence of soft tissue swelling or evidence of an avulsion fragment in the area of the collateral ligament. Stress radiographs (i.e., valgus and varus, extension and flexion) may show collateral and palmar ligamentous instability.

Medical management can relieve pain, but definitive therapy requires cooptation or surgical stabilization. If the ligaments or other structures in the radiocarpal joint are injured, the surgeon may choose to perform a pan-carpal arthrodesis.

CONCLUSION

Diagnosing and treating joint diseases in dogs is a major part of canine orthopedics. Previously, radiography was the standard diagnostic tool for joint diseases. CT and MRI have improved diagnostic accuracy. Arthroscopy is now another diagnostic tool and can also be used to treat many lesions that were treated with arthrotomy.

As surgeons become more adept at arthroscopy, it will continue to be the primary method of treating many joint disorders. Development of smaller arthroscopes and refinement of instruments and techniques will allow use of arthroscopy in small dogs. Furthermore, arthroscopy is an excellent choice when treating two or more joints at the same time. The minimal invasiveness of arthroscopy allows early examination and thus early detection of pathologic changes and subsequent treatment.

REFERENCES

1. Most arthroscopic equipment needs to be sterilized with a. glutaraldehyde. b. an autoclave. c. ethylene oxide. d. ionizing radiation. e. b and d.

2. The risk of infection and complications with arthroscopy is a. less than 1% and 0.56%, respectively. b. 0.56% and less than 1%, respectively. c. greater than 1%. d. greater than with arthrotomy. e. less than 0.56%.

3. Which complication(s) is associated with arthroscopy? a. extravasation of fluid in surrounding soft tissue b. iatrogenic damage to the articular cartilage c. obstruction of view by hemorrhage, hyperplastic synovial villi, or fat pad d. all of the above e. a and c.

4. The advantages of arthroscopy over arthrotomy include a. decreased surgical morbidity. b. simultaneous treatment of two joints. c. minimal invasiveness. d. better visualization of intraarticular surfaces and structures. e. all of the above.

5. The disadvantages of arthroscopy over arthrotomy include a. the cost and fragility of the arthroscope and its instruments. b. the need for extensive and intensive training. c. increased infection. d. all of the above e. a and b.

6. Which statement regarding the prognosis after arthroscopy of shoulder OCD is true? a. Osteoarthritis may continue to progress after surgical arthroscopy.

b. The prognosis after arthroscopy is good, and most dogs use the treated limb immediately after surgery.

c. Some lameness may persist for several weeks.

d. all of above

e. a and b.

7. Bicipital tenosynovitis can be diagnosed with a. radiography. b. ultrasonography. c. arthroscopy. d. all the above e. a and c.

8. Radiographic changes that typically occur with complete or partial rupture of the biceps tendon include a. bone proliferation or resorption of the supraglenoid tuberosity at the origin of the biceps tendon.

b. calcification of the biceps tendon sheath.

c. osteophytes in the intertubercular groove.

d. all of above

e. a and b.

9. Which statement(s) regarding arthroscopy of the carpal joint is true? a. The radiocarpal joint is the only one within the carpus that can be evaluated with an arthroscope.

b. Arthroscopy allows evaluation of ligamentous damage, intraarticular fracture, and carpus instability.

c. Arthroscopy allows removal of small bone chips; treatment of osteoarthritis and septic arthritis; and biopsy of bone, cartilage, and synovial membrane.

d. all of above

e. b and c.

10. Which elbow condition has not reportedly been treated arthroscopically? a. UAP b. luxation c. OCD d. FMCP e. humeral condyle fractures.