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Current Concepts

# Arthroscopy of the Elbow

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## HISTORY OF ELBOW ARTHROSCOPY

Burman[14] first discussed elbow arthroscopy in 1931, but he stated that the elbow is ". . . unsuitable for examination since the joint space is so narrow for the relatively large needle." He also stated that the ". . . anterior puncture of the elbow is out of the question, and the posterior puncture is poor for our purposes." Problems he cited included the inability to distend the joint and the inability to insert the needle far enough into the joint. In 1932, however, Burman[13] revised his opinion based on the arthroscopic examination of 10 cadaveric elbows, stating that the anterior compartment could be visualized arthroscopically. After Burman's studies were published, a small number of reports appeared in the Japanese and German literature, but it was not until the mid to late 1980s that reports began to appear in the American literature.[2,25,26,29,40,42,43,77] In 1985, Andrews and Carson[2] described the patient-supine technique and the use of anterolateral, anteromedial, and posterolateral portals, and, in 1989, Poehling et al.[57] described the patient-prone position for elbow arthroscopy. Over the past decade, there have been many more reports describing variations in operative technique and new indications for elbow arthroscopy.

## INDICATIONS

Initially, indications for elbow arthroscopy included diagnosis of elbow pain of undetermined cause, removal of loose bodies, excision of olecranon osteophytes, synovectomy, lysis of adhesions, and debridement of osteochondritis dissecans lesions of the capitellum and chondromalacia of the radial head.[2–4,6,7,11,17,19,23,27,28,42,43,51,56,57,61,66,68] Recently, indications have been expanded to include release of elbow contractures caused by trauma or degenerative arthritis, tennis elbow release, olecranon bursectomy, radial head excision, and fracture treatment.[8,15,24,32–34,36,48,50,52,55,60,71]

## CONTRAINDICATIONS

The primary contraindication to elbow arthroscopy is any significant distortion of normal bony or soft tissue anatomy that precludes safe entry of the arthroscope into the joint.[7] A previous ulnar nerve transposition, for instance, would interfere with safe medial portal placement. Also, a severely ankylosed joint may not allow for adequate distention. Joint distention is essential to allow proper displacement of neurovascular structures away from the portal sites and within the joint where intraarticular instrumentation is being used. Finally, a local soft tissue infection in the area of the portal sites is a contraindication.

## SURGICAL ANATOMY

Important anatomic landmarks include the lateral and medial epicondyles and the olecranon process, which are easily palpated. Another important structure is the radial head, which can be palpated 3 to 4 cm distal to the lateral epicondyle while the forearm is pronated and supinated. On the lateral side of the elbow, the lateral epicondyle, olecranon process, and radial head form a triangle. Located in the center of this triangle is a "soft spot," which is the location of the direct lateral portal—the portal from which the joint is distended in preparation for arthroscopic procedures.

Anteriorly, the antecubital fossa is formed by three muscular borders: laterally, by the "mobile wad of three"—the brachioradialis, the extensor carpi radialis brevis, and the extensor carpi radialis longus muscles; medially, by the pronator teres muscle; and, superiorly, by the biceps muscle. Posteriorly, the important structures are the triceps muscle and tendon and the olecranon tip. The anconeus muscle, which is located on the posterolateral aspect of the joint originates on the lateral epicondyle and posterior elbow capsule and inserts on the proximal ulna.

Sensory nerves around the elbow include the medial

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brachial cutaneous, the medial antebrachial cutaneous, the lateral antebrachial cutaneous, and the posterior antebrachial cutaneous nerves.[7] The medial brachial cutaneous nerve penetrates the deep fascia midway down the arm on the medial side and supplies skin sensation to the posteromedial aspect of the arm to the level of the olecranon. The medial antebrachial cutaneous nerve supplies sensation to the medial side of the elbow and forearm. The lateral antebrachial cutaneous nerve is a branch of the musculocutaneous nerve, which exits between the biceps and brachialis muscles laterally to supply sensation to the elbow and lateral aspect of the forearm. Finally, the posterior antebrachial cutaneous nerve branches from the radial nerve and courses down the lateral aspect of the arm to supply sensation to the posterolateral elbow and posterior forearm.

The main neurovascular structures about the elbow are the median nerve, radial nerve, ulnar nerve, and brachial artery.[7] The median nerve crosses the antecubital region medial to the brachial artery and biceps tendon and descends between the two heads of the pronator teres muscle. It then descends the forearm deep to the flexor digitorum superficialis muscle. The radial nerve spirals around the posterior humeral shaft, penetrates the lateral intermuscular septum, and descends anteriorly to the lateral epicondyle between the brachioradialis and brachialis muscles. The radial nerve then branches to form the superficial radial nerve, which supplies sensation to the dorsoradial wrist and posterior surface of the radial three and one-half digits, and the posterior interosseous nerve, which provides motor branches to the wrist, thumb, and finger extensors. The ulnar nerve penetrates the medial intermuscular septum in the distal one-third of the arm, courses posteriorly to the medial epicondyle, and then descends distally between the flexor carpi ulnaris and flexor digitorum superficialis muscles. Finally, the brachial artery courses just medial to the biceps tendon in the antecubital fossa and then descends to the level of the radial head, where it bifurcates into the radial and ulnar arteries.

## PREOPERATIVE EVALUATION

### History

A comprehensive patient history should be obtained, including details of whether a single traumatic event or repetitive traumatic episodes occurred before the onset of symptoms. One should inquire about the presence and character of the pain, swelling, and locking and catching episodes, which could indicate intraarticular disorders, such as loose bodies. A patient whose symptoms are related to throwing or an occupational stress should be asked to reproduce the position that causes the symptoms. A throwing athlete who reports lost velocity and control or inability "to let the ball go" may have pain on forced extension, which could be a sign of posterior olecranon impingement. Finally, the patient should be questioned about neurovascular symptoms, such as ulnar nerve paresthesia, which can be the result of a subluxating ulnar nerve or traction injury from valgus instability.

### Physical Examination

Each compartment of the elbow (medial, lateral, and posterior) should be carefully examined. Medially, one should test for valgus instability with the elbow flexed to 30° to relax the anterior capsule and free the olecranon from its bony articulation in the olecranon fossa. A valgus stress is then applied with the elbow in full supination. Discomfort along the medial aspect of the elbow can indicate ulnar collateral ligament injury. Valgus laxity, however, is often difficult to discern, particularly if there is partial tearing of the undersurface of the ulnar collateral ligament.[70,72,73] The proximal flexor-pronator mass and medial epicondyle should be carefully palpated, and resisted wrist flexion should be performed. Pain with these maneuvers can indicate medial epicondylitis or flexor-pronator tendonopathy. The ulnar nerve should be palpated in the cubital tunnel. The elbow is flexed and extended as the nerve is palpated to determine whether the nerve subluxates. Finally, one should assess for a Tinel's sign over the ulnar nerve.

Posteriorly, the triceps muscle insertion and the posterolateral and posteromedial joint areas are palpated to assess for bone spurs and impingement lesions. The so-called "clunk" test is performed to demonstrate posterior olecranon impingement.[6] The upper arm is grasped and stabilized as the elbow is brought into full extension. Reproduction of pain at the posteromedial aspect of the joint suggests compression of the olecranon into the fossa and indicates valgus extension overload.

Laterally, the lateral epicondyle and extensor origin are palpated to assess for lateral epicondylitis or tendonopathies. The radiocapitellar joint is palpated while the forearm is pronated and supinated to elicit crepitus or catching, which can be caused by chondromalacic lesions or impingement from a lateral synovial fringe.[17] The "soft spot" is also inspected to determine whether there is synovitis or an effusion in the elbow joint.

Finally, stability should be addressed with O'Driscoll's posterolateral rotatory instability test (Fig. 1).[50] Although the test is usually negative because of the patient's apprehension and is best done with general anesthesia, it can be performed with the patient awake. The test is done with the extremity over the patient's head and the shoulder in full external rotation. During the test, a valgus, supination, and axial compression load is applied to the elbow, which is flexed approximately 20° to 30°. With the elbow in extension, subluxation or dislocation of the radius and of the proximal ulna creates a posterior prominence and sulcus sign. When the elbow is flexed, the radiohumeral and ulnohumeral joints are visibly or palpably reduced.

The range of motion of the elbow in flexion and extension is determined and compared with that of the contralateral extremity. Pronation and supination are also tested. These motions are best tested by having the patient hold an object, such as a pencil, in each hand as a

**Figure 1.** O'Driscoll's test for posterolateral rotatory instability.

reference point for the examiner. Finally, a careful neurovascular examination of the extremity is completed.

### Radiographic Evaluation

Routine diagnostic radiographs include an AP view with the elbow in full extension and a lateral view with the joint in 90° of flexion. An axial view is also obtained to outline the olecranon and its mediolateral articulations. This is the best view for identifying and assessing a posteromedial osteophyte. Plain radiographs are carefully reviewed for fractures, subluxations or dislocations, degenerative changes, osteophytes, and loose bodies. Unfortunately, plain radiographs are not always able to demonstrate all loose bodies, particularly those in the posterior compartment.[12,24,53,75] Ward et al.[75] determined that plain radiographs had a 75% accuracy for detecting loose bodies; arthrotomograms have an accuracy of 89%, with 100% sensitivity.

A gravity stress test radiograph can be used to detect valgus laxity of the elbow.[10] The patient is placed in a supine position, and the shoulder is abducted and brought to maximum external rotation so that the elbow is parallel to the floor. If there is an injury to the ligament or bony attachment, increased joint space can be seen on radiographs.

### Arthrography

Contrast arthrography is often helpful in detecting loose bodies that may not be apparent on plain radiographs.[75] Contrast arthrography is also useful in evaluating the integrity of the medial ligamentous structures of the elbow.[70,72,73] Timmerman et al.[73] found that both MRI and CT-arthrograms were accurate in diagnosing a complete tear of the ulnar collateral ligament in all of their cases; however, the CT-arthrogram was more sensitive in detecting a partial undersurface tear of the ulnar collateral ligament, a lesion described by Timmerman and Andrews.[72] The authors described a "T-sign" that represents ". . . dye leaking around the detachment of the deep portion of the UCL from its bony insertion, but remaining contained within the intact superficial layer, UCL, and capsule."[73]

### Magnetic Resonance Imaging

Magnetic resonance imaging is useful for evaluating osteochondral lesions in the radiocapitellar joint.[27,68] It can demonstrate early vascular changes not yet apparent on plain radiographs, and it can be used to assess the extent of the lesion and the displacement of fragments. Magnetic resonance imaging is also useful for evaluating the soft tissue structures of the elbow; however, it may not demonstrate subtle undersurface tears of the ulnar collateral ligament.[73] Magnetic resonance arthrography with saline contrast or gadolinium, however, increases the sensitivity for detecting undersurface tears of the ulnar collateral ligament.[73]

## OPERATING ROOM ENVIRONMENT AND INSTRUMENTATION

### Anesthesia

Most surgeons prefer to use a general anesthetic for patients undergoing elbow arthroscopy because it provides total muscle relaxation and is comfortable for the patient. There is apprehension about using local and intravenous blocks because the patient's postoperative neurologic status cannot be monitored. For the same reason, local anesthetics are not commonly used in the postoperative period. To avoid intubation, some surgeons prefer regional blocks, such as an interscalene block, which can be administered safely and successfully. However, the surgeon is still unable to assess the neurologic status in the early postoperative period.

We prefer a general anesthetic because it is reliable, allows us to use the prone position without patient discomfort, and permits use of a tourniquet when needed.

### Instrumentation

A standard 4.0-mm, 30° arthroscope permits excellent visualization of the elbow joint (Fig. 2). A smaller 2.7-mm arthroscope is often useful for viewing small spaces, such as the lateral compartment from the direct lateral portal. Cannula systems are interchangeable for both the 4.0- and 2.7-mm arthroscopes. A cannula system allows one to switch viewing and working portals without repeated joint capsule injuries. This, in turn, minimizes the risk of injury to neurovascular structures and decreases the chance of fluid extravasation, swelling, and possible compartment syndrome. The use of nonvented cannulas also decreases fluid extravasation into the soft tissues. All trocars should be conical and blunt tipped to decrease the chance of neurovascular injury. Hand-held instruments (such as probes, grasping forceps, and punches) and motorized instruments (such as synovial resectors and burs) are used in elbow arthroscopy. A pump set at 35 mm Hg is used to maintain joint distention.

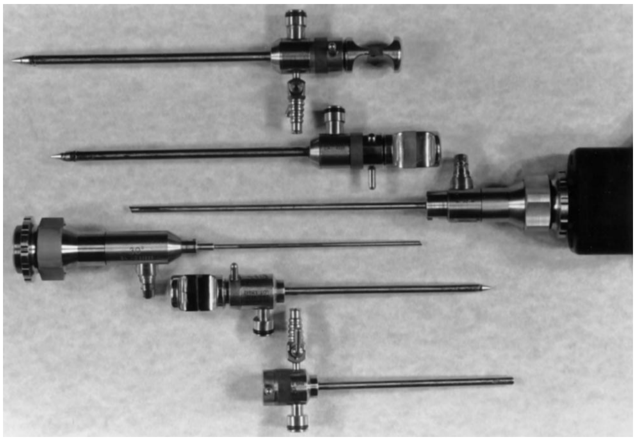

**Figure 2.** Standard 4.0 and smaller 2.7 mm arthroscopes and interchangeable cannula systems are used for elbow arthroscopy.

## Patient Position

There are four main patient positions for elbow arthroscopy: supine, supine-suspended, prone, and lateral decubitus. Each position has its own inherent advantages and disadvantages.

*Supine Position.* Initially, all elbow arthroscopy was performed with the patient in the supine position, with the arm placed on an arm board and laid across the body. The extremity is draped free so that the arm can be abducted to 90° and medial and lateral access to the elbow can be gained. This type of positioning, however, has been replaced, for the most part, by either the supine-suspended position, the prone position, or the lateral decubitus position.

*Supine-Suspended Position.* Andrews and Carson[2] first described the use of the supine-suspended position (Fig. 3). With the patient in the supine position, his or her arm is placed in a prefabricated forearm and wrist gauntlet, and the entire arm is allowed to hang freely over the table, with the elbow flexed to approximately 90°. The authors state that this allows excellent access to both the medial and lateral aspects of the elbow and permits pronation and supination of the forearm. Also, the neurovascular structures in the antecubital fossa are placed at maximum relaxation with the elbow flexed to 90°. Finally, because the patient is maintained in the supine position, the anesthesiologist has excellent access to the airway. There are, however, disadvantages to the supine position.[9,57] First, the arm is unstable and tends to swing like a pendulum in response to pressure. Next, orientation is relatively poor, and standard approaches can be awkward because the olecranon and forearm are superior to the elbow. Access to the posterior compartment is also more limited because the arm is suspended in the flexed position, and it is awkward to extend the elbow, which is necessary for entry into the posterior aspect of the joint. Also, when the arthroscope is in the posterior compartment, the surgeon is working in an “uphill” direction, which is not only awkward, but can potentially lead to contamination of the procedure because irrigating fluid often runs down the scope.

*Prone Position.* Poehling et al.[57] first described the prone position for elbow arthroscopy in 1989. After adequate anesthesia is obtained, the patient is positioned prone on chest rolls (Fig. 4). A well-padded tourniquet is placed high on the affected arm. The arm is then stabilized by either a soft foam arm holder on an arm board or in a custom-made arthroscopic arm holder. The shoulder should be abducted to 90° and the elbow flexed to 90° in this position. We prefer this position for several reasons. First, traction is eliminated, and the elbow is in a more stable position.[6,57] As a result, mobility is improved because a suspension apparatus is unnecessary. Gravity helps maintain stability and helps the irrigating fluid distend the antecubital fossa, thus further removing the neurovascular structures from danger.[9] Next, with the olecranon facing the surgeon, there is easier access to the posterior aspect of the joint, and orientation is im-

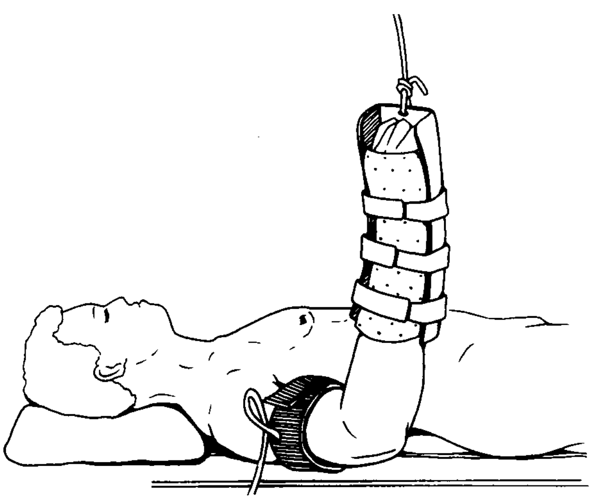

**Figure 3.** The supine-suspended position.

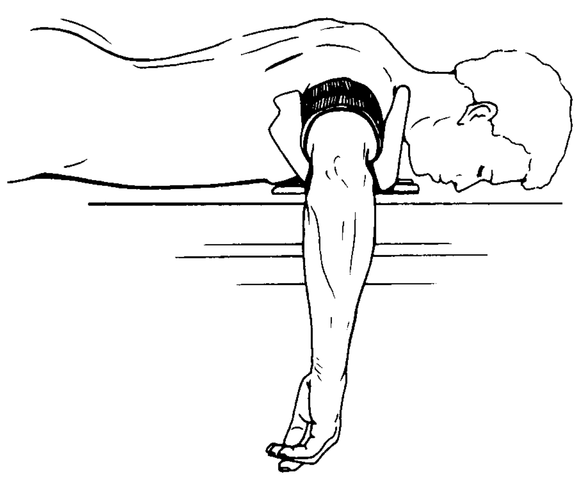

**Figure 4.** The prone position for elbow arthroscopy.

proved.[9,57] Finally, an added benefit is easier conversion from an arthroscopic to an open procedure if so indicated.[6] The entire extremity is already prepared and draped, and the arm board can be adjusted under the drapes for proper positioning. The main disadvantage to this position is a more difficult access to the patient's airway.

*Lateral Decubitus Position.* O'Driscoll and Morrey[51] prefer the lateral decubitus position because it has the advantages of prone positioning, including improved stability and posterior joint access, without compromising the anesthesiologist's access to the airway. The patient is positioned with the affected side upward (Fig. 5). The arm is then supported on a well-padded bolster with the forearm hanging free and the elbow flexed to 90°. In this position, the elbow is supported in front of the surgeon, who has good access to the various portal sites.

### Operating Room Setup

The anesthesiologist's position is at the head of the table (Fig. 6). The surgical assistant and nurse, along with the Mayo stand for instruments, are on the same side as the operating surgeon, who sits or stands facing the posterior aspect of the patient's elbow. The stand that supports the viewing monitor, camera equipment, recording equipment, and irrigating solution is placed on the opposite side of the patient.

## GENERAL SURGICAL TECHNIQUE

Elbow arthroscopy has a significant potential for complications, particularly neurovascular injury. It can, however, be performed safely and relatively risk free if the following recommendations are observed. First, it is important to identify and mark landmarks before the capsule is distended, which can make palpation of landmarks more difficult. Next, the joint should be distended with 20 to 40 ml of fluid through the lateral "soft spot" before establishing the initial portal. Good backflow of fluid verifies proper placement. Cadaveric studies have demonstrated that joint insufflation significantly increases the distance between the joint surfaces and neurovascular structures, thus helping to protect them from injury during joint entry and during the use of intraarticular instrumentation (Fig. 7).[1,13,14,37,41]

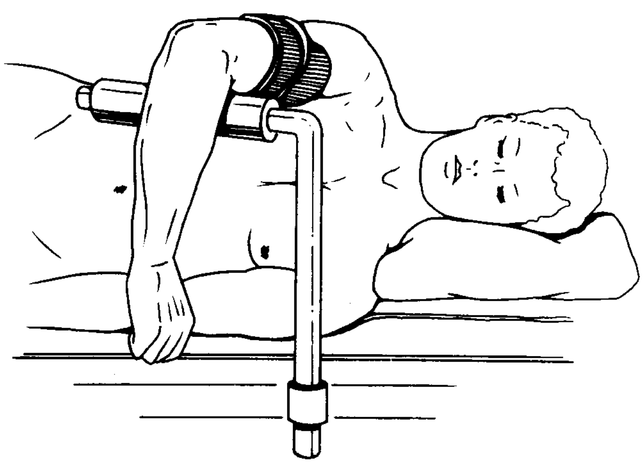

**Figure 5.** The lateral decubitus position.

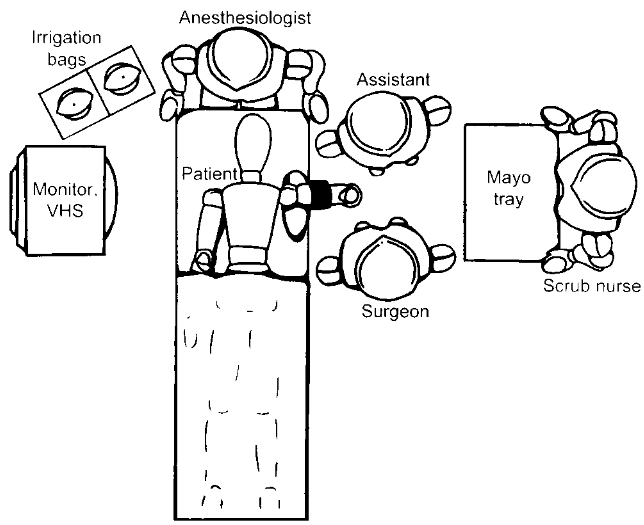


**Figure 6.** The operating room setup for elbow arthroscopy.

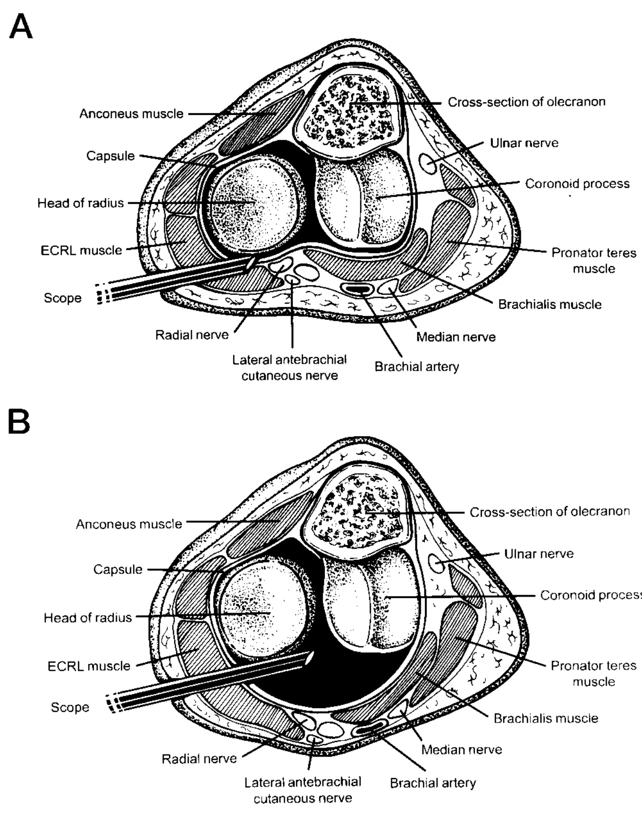


**Figure 7.** Nondistended (A) and distended (B) joint with the arthroscope in an anterolateral portal illustrating proximity to neurovascular structures. ECRL, extensor carpi radialis longus. (Reprinted with permission from Brooks and Baker.[12])

When the arthroscopic sheath is inserted, the elbow should be flexed to 90° to relax and protect the anterior neurovascular structures.[1,37,41] Only blunt trocars should be used. The trocar and sheath should be directed toward the center of the joint. When creating portals, the surgeon should avoid penetrating the subcutaneous tissue, thereby helping to prevent injury to the superficial cutaneous nerves. A hemostat or mosquito clamp should be used to spread tissues down to the capsule. Also, when performing a synovectomy, it is important to avoid aggressive debridement and capsular perforation. In a cadaveric study, Miller et al.[41] demonstrated that there is a small distance (as narrow as 6 mm) between the joint capsule and neurovascular structures, and that joint insufflation does not increase the capsule-to-nerve distance (Table 1). Finally, we do not recommend using a local anesthetic, because it prevents appropriate postoperative assessment of the neurologic status.

One final point of debate regarding general surgical technique is which portal should be created first—medial or lateral? Several authors create a lateral portal first and then establish a medial portal through visualization with a spinal needle or an inside-out technique.[2,4,51,52,55,60,63,71] Other authors establish the medial portal first.[7,9,30,35,57,62,66,74] We create a medial portal first and then establish the lateral portal under direct visualization with the aid of a spinal needle. We believe this is the safer technique because the average distance between the medial portals and the median nerve is greater than the distance between the lateral portals and the radial or posterior interosseous nerve. In cadaveric studies, both Verhaar et al.[74] and Lindenfeld[35] demonstrated that it is safer to establish medial portals than lateral portals. In addition, there is less fluid extravasation when starting medially because we use a superomedial portal that traverses predominately tendinous tissue and a tough portion of the forearm flexor muscles.[7,36] The thicker tissues minimize fluid extravasation more effectively than the softer, thinner, radial capsule.[7,36] Finally, most elbow disorders are located in the lateral compartment, which is best visualized from a medial portal.

## STANDARD PORTALS

The most commonly used portals are the direct-lateral, proximal-medial, anterolateral, anteromedial, posterolateral, and straight-posterior portals. There are, however, a few variations within each of these main groups.

### Direct-Lateral Portal

The direct-lateral, or midlateral, portal is located at the "soft spot," which is in the center of the triangle formed by the lateral epicondyle, olecranon, and radial head (Fig. 8). This site is used for initial joint distention. It is also useful as a viewing portal for working in the posterior chamber of the elbow with the patient in the prone position.[7] When using a 2.7-mm arthroscope, one can view the radiocapitellar joint through this portal. This is the only portal that provides easy access to the posterior capitellum and radioulnar joint. When the posterior chamber is being viewed, the portal passes between the anconeus and triceps muscles; however, when the radiocapitellar joint is being viewed, it passes through the anconeus muscle.[7] The closest neurovascular structure to this portal is the posterior antebrachial cutaneous nerve, which passes within an average of 7 mm.[1]

### Proximal-Medial (Superomedial) Portal

Poehling et al.[57] described the proximal-medial, or superomedial, portal. It is located approximately 2 cm proximal to the medial humeral epicondyle and just anterior to the intermuscular septum (Fig. 9). The arthroscopic sheath is inserted anterior to the intermuscular septum while maintaining contact with the anterior aspect of the humerus and directing the trocar toward the radial head. This portal provides excellent visualization of the anterior compartment of the elbow, particularly the radiocapitellar

TABLE 1
Narrowest Distance from Nerve to Capsule on Any Section During Elbow Arthroscopy

| Specimen[a] | Radial nerve (mm) | Ulnar nerve (mm) | Median nerve (mm) |
|---|---|---|---|
| 1 R | 7 | 2 | 9 |
| L | 5 | 4 | 6 |
| 2 R | 8 | 1 | 13 |
| L | 5 | 0 | 13 |
| 3 R | 13 | 1 | 18 |
| L | 10 | 1 | 13 |
| 4 R | 6 | 2 | 12 |
| L | 9 | 1 | 13 |
| 5 R | 8 | 1 | 13 |
| L | 8 | 1 | 9 |
| 6 R | 8 | 1 | 9 |
| L | 6 | 6 | 6 |
| Extended R | 3 | 2 | 2 |
| L | 4 | 3 | 4 |

[a] R, Right; L, Left.
(Reprinted with permission from Miller et al.[41])

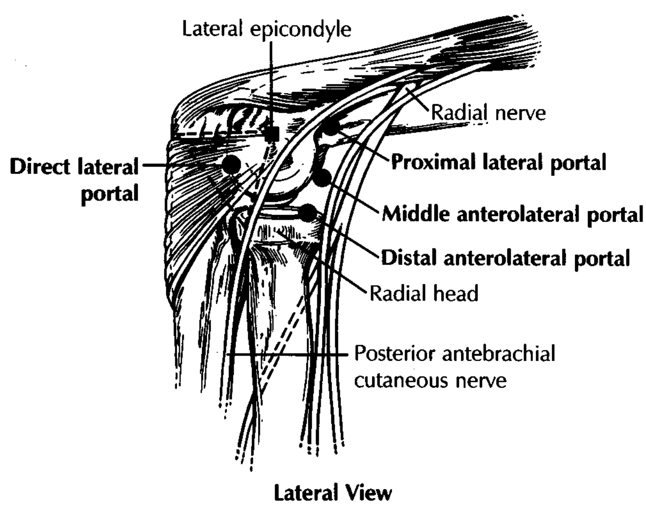


**Figure 8.** Portal sites on the lateral aspect of the elbow.

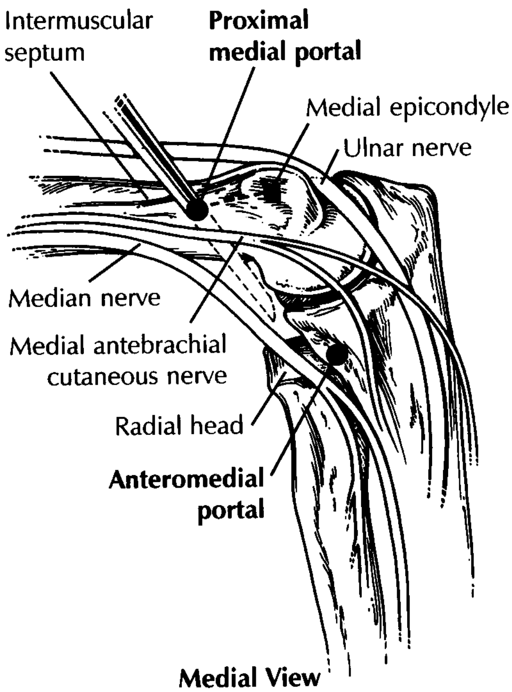


**Figure 9.** Portal sites on the medial aspect of the elbow.

joint. We establish this portal first because it is safer than the lateral portals.[35,74] We also believe that the proximal-medial portal is safer than the anteromedial portal because the more proximal portal allows the cannula to be directed distally. This results in the cannula being almost parallel to the median nerve in the anteroposterior plane.[35]

The anteromedial portal (Fig. 9), as described by Lynch et al.,[37] is located 2 cm distal and 2 cm anterior to the medial epicondyle and is at or near the distal extent of the elbow capsule. Because of the location of this portal, the cannula can enter the joint only by being advanced straight laterally, toward the median nerve.[35] The medial antebrachial cutaneous nerve is at risk superficially and is located an average of 6 mm from the portal.[1] The median nerve lies within 19 mm of the cannula in the distended joint and within 12 mm in the nondistended joint.[1] The ulnar nerve is located an average of 21 mm from the cannula, but it is generally safe as long as the cannula remains anterior to the intermuscular septum.[1] It is important, however, to confirm that the ulnar nerve does not subluxate or has not been transposed anteriorly before creating this portal.

### Anterolateral Portals

The anterolateral portal, as described by Andrews and Carson,[2] is located 3 cm distal and 2 cm anterior to the lateral humeral epicondyle and lies within the sulcus between the radial head and the capitellum anteriorly (Fig. 8). This portal provides an excellent view of the medial capsule, medial plica, coronoid process, trochlea, and coronoid fossa. The cannula passes through the extensor carpi radialis brevis and supinator muscles as it courses posterolateral to the radial nerve. The most superficial structure at risk is the posterior antebrachial cutaneous nerve, which is an average of 2 mm from the sheath.[37] The radial nerve is also at significant risk. Lindenfeld[35] demonstrated the radial nerve could be as close as 3 mm to this portal. The distance from this portal to the posterior interosseous nerve varies from 1 to 13 mm, depending on the degree of forearm pronation, with greater pronation increasing the distance.[39] Field et al.,[21] Day,[19] and Stothers et al.[66,67] all state that this portal is too distal in most patients and places the posterior interosseous nerve and radial nerve in danger.

Stothers et al.[66] compared a proximal-lateral portal created 1 to 2 cm proximal to the lateral epicondyle (Fig. 8) with the standard distal anterolateral portal in cadaveric specimens and found that the proximal-lateral portal provided better visualization and was safer. Field et al.[21] compared three lateral portals: a proximal anterolateral portal (located 2 cm proximal and 1 cm anterior to the lateral epicondyle), a distal anterolateral portal (as described by Andrews and Carson[2]), and a middle anterolateral portal (located 1 cm directly anterior to the lateral epicondyle). The authors found that the proximal anterolateral portal was safer than the middle anterolateral portal, which was safer than the distal anterolateral portal. They also demonstrated that radiohumeral joint visualization was most complete and technically easiest using the most proximal portal.

We use the middle anterolateral portal (Fig. 8) created under direct visualization with a spinal needle. It provides access to the radiocapitellar joint and lateral compartment and is a good working portal for instrumentation. It also functions as a good viewing portal for the anterior ulnohumeral joint.

### Anteromedial Portal

The anteromedial portal is more commonly used when the patient is in the supine position. It is established 2 cm distal and 2 cm anterior to the medial humeral epicondyle and passes through the common flexor origin (Fig. 9).[2] The anterior branch of the medial antebrachial cutaneous nerve and the median nerve are at risk. With the elbow extended, the sheath lies in contact with the median nerve in 56% of elbows.[66] With the elbow in flexion, the brachialis muscle protects the nerve. This portal allows visualization of the radiocapitellar and humeroulnar joints, the coronoid fossa, the capitellum, and the superior capsule. Used in conjunction with the proximal-lateral portal, the two portals are interchangeable as viewing and working portals.[7]

### Posterolateral Portal

The posterolateral portal is located 2 to 3 cm proximal to the tip of the olecranon at the lateral border of the triceps tendon (Fig. 10).[7,20] The trocar is directed toward the olecranon fossa, passing through the triceps muscle to reach the capsule. This portal permits visualization of the

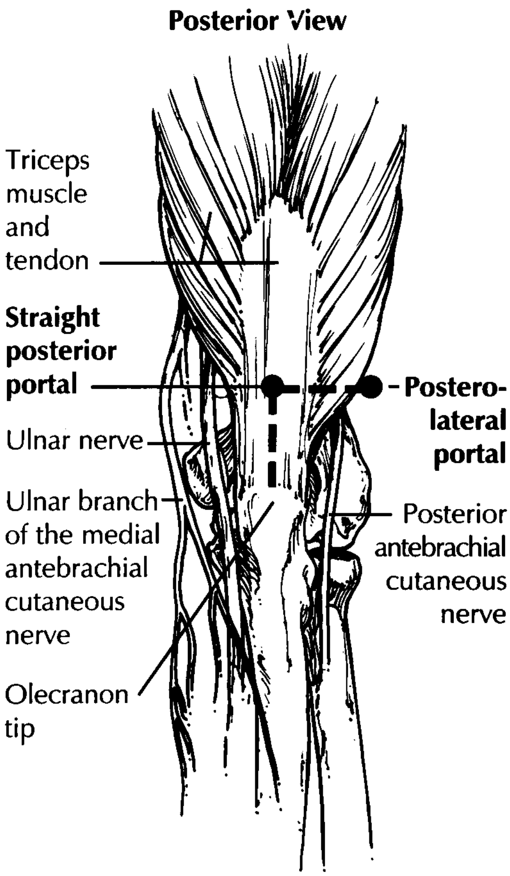


**Figure 10.** Portal sites on the posterior aspect of the elbow.

olecranon tip, olecranon fossa, and posterior trochlea, but the posterior capitellum is not well seen. With a 4.0-mm, 70° arthroscope, the posterior portion of the ulnar collateral ligament can be seen. The medial and posterior antebrachial cutaneous nerves are the two neurovascular structures most at risk; they are at an average of 25 mm from this portal.[37] The ulnar nerve is also approximately 25 mm from this portal, but as long as the cannula is kept lateral to the posterior midline, the nerve is not at risk.[7]

### Straight-Posterior Portal

The straight-posterior portal is located 3 cm proximal to the olecranon tip and is used primarily as a working portal (Fig. 10). It is created under direct visualization from either the direct-lateral or posterolateral portal using an 18-gauge spinal needle placed through the center of the musculotendinous junction of the triceps muscle. This portal is helpful for removal of impinging olecranon osteophytes and loose bodies from the posterior elbow joint.[4] It is also needed when a complete synovectomy of the elbow is done. The straight posterior portal passes within 23 mm of the posterior antebrachial cutaneous nerve and within 25 mm of the ulnar nerve.[7]

## COMMON ARTHROSCOPIC PROCEDURES AND CONDITIONS TREATED ARTHROSCOPICALLY

### Diagnostic Arthroscopy

After general anesthesia is administered, the patient is positioned prone on chest rolls. A tourniquet is placed on the arm at the midhumeral level, and the arm is supported in a well-padded arthroscopic arm holder with the elbow in 90° of flexion. After sterile preparation and draping of the patient, the medial and lateral humeral epicondyles, the radial head, and the olecranon tip are outlined with a surgical pen. The various portals are carefully mapped out with the aid of a ruler. The extremity is then exsanguinated, and the tourniquet is inflated to 250 mm Hg. Next, the joint is distended with 20 to 40 ml of saline through the direct lateral portal with an 18-gauge spinal needle. Backflow of saline from the needle and observing the elbow extend and supinate as fluid is instilled confirms accurate portal placement and adequate joint distention.

The proximal medial portal is created first, and the anterior compartment is carefully examined. The lateral capsule, radial head, capitellum, and radial fossa are observed. As the arthroscope is withdrawn medially, the coronoid and its humeral articulations are visualized. The proximal-lateral portal is then established using an outside-in technique after locating the proper portal placement with an 18-gauge spinal needle. This portal can then be used as a working portal. With the aid of a switching stick, the arthroscope is switched to the middle anterolateral portal, and the medial aspect of the anterior elbow joint is inspected.

After the anterior compartment has been thoroughly examined, the posterior compartment is entered through either the posterolateral or direct-lateral portal. The joint is entered posteriorly with the elbow in approximately 30° to 45° of flexion, which relaxes the triceps muscle, allowing easier access. If a second posterior working portal is required, a straight posterior portal is created under direct visualization with the aid of an 18-gauge spinal needle.

Diagnostic arthroscopy may be useful when the clinical diagnosis is unclear and other studies, such as radiographs, arthrograms, and MRI, have failed to lead to a diagnosis. Unexpected synovitis, osteoarthritis, loose bodies, and chondral defects may be discovered. Arthroscopy is particularly useful for evaluating ulnar collateral ligament injuries in throwing athletes when clinical examination and MRI or CT arthrography are equivocal.[20,22,70,72,73] The important anterior bundle of the ulnar collateral ligament is poorly visualized with the arthroscope, as demonstrated by Field et al.[22] To evaluate instability, Timmerman et al.[73] developed an arthroscopic valgus instability test in which a valgus stress is applied to the elbow while it is in 70° of flexion. With the arthroscope in the anterolateral portal, the medial aspect of the ulnohumeral joint is then observed for any opening. In a cadaveric study, Field and Altchek[20] showed that the medial ulnohumeral joint opened 1 to 2 mm in all specimens in which the anterior bundle of the ulnar collateral ligament was completely sectioned. These authors also demonstrated that the opening was greatest when the forearm was pronated and that it could be visualized best at 60° to 75° of elbow flexion.

### Removal of Loose Bodies

Removal of loose bodies from the elbow joint is the most common therapeutic intervention performed arthroscopically.[7] Loose bodies are often osteochondral or chondral fragments of the articular surface that have broken free as a result of a traumatic event or some underlying pathologic condition (Fig. 11). Patient symptoms include pain, loss of motion, swelling, catching, or clicking. Most loose bodies can be seen on plain radiographs; however, if a loose body is a noncalcified cartilaginous lesion, the radiograph will be negative.

The senior author (CLB) has described several "pearls" for finding and retrieving loose bodies.[7] First, one should attempt to determine the underlying disorder, which often dictates the location of the loose bodies. For instance, loose bodies of capitellar osteochondritis dissecans lesions are most often located in the lateral compartment of the elbow, while loose bodies from synovial chondromatosis are usually located anteriorly. Second, if a loose body is suspected to be in a particular compartment but cannot be seen, placing a motorized shaver with full suction in the compartment can facilitate evacuation. When a loose fragment is visualized, restricting inflow or impaling the fragment with an 18-gauge spinal needle can prevent further migration. Finally, it is important to view all elbow compartments, because the fragments can migrate between compartments.

Andrews and Carson[2] demonstrated that removal of isolated loose bodies from the elbow was the most successful arthroscopic therapeutic intervention. Similarly, O'Driscoll and Morrey[51] showed that patients who had removal of isolated loose bodies or loose bodies with osteochondritis lesions improved significantly; however, patients with posttraumatic arthritis or degenerative joint disease who had loose bodies removed had minimal improvement. Rupp and Tempelhof[63] and Jerosch et al.[28] echoed these findings. Ogilvie-Harris and Schemitsch[53] reported that pain was relieved in 85%, swelling in 71%, and locking and catching in 92% of 34 patients who had arthroscopic removal of loose bodies.

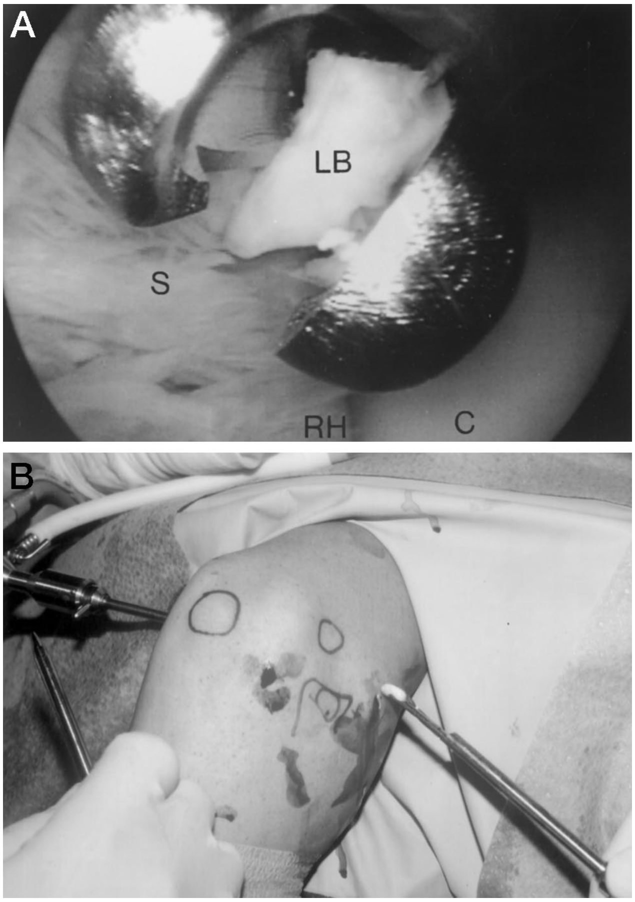


**Figure 11.** A, arthroscopic view of a large loose body above the radiocapitellar joint. S, synovitis; LB, loose body; RH, radial head; C, capitellum. B, removal of the loose body from a right elbow.

### Synovectomy

A synovectomy can be done for a generalized synovitis, such as rheumatoid arthritis (Fig. 12) or synovial chondromatosis, or for a localized synovitis, such as an inflamed lateral synovial fringe (plica), as described by Clarke.[17] The elbow joint is affected in approximately 20% to 50% of patients with rheumatoid arthritis, and 50% of these patients develop pain and associated loss of motion.[45,51,58] Most of these patients respond to nonopera-

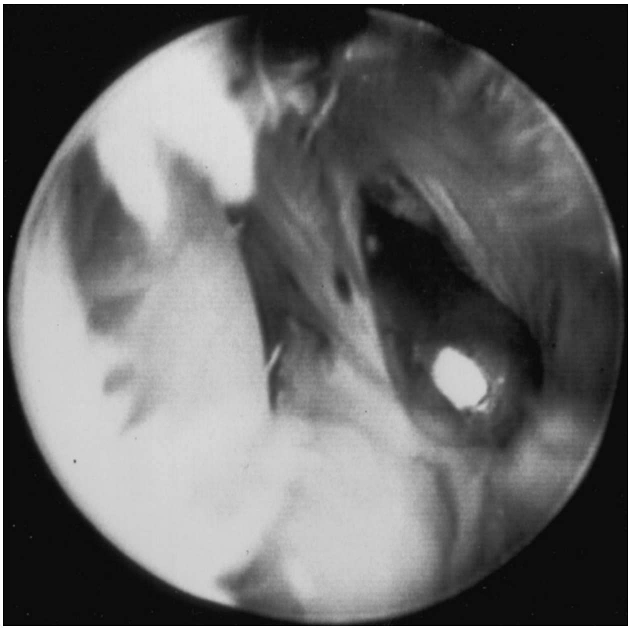

**Figure 12.** Debridement of rheumatoid synovitis.

tive management. For those who do not and who have minimal articular destruction, surgical intervention is indicated. Porter et al.[58] reported pain relief continuing at least 6 years after open synovectomy. Unfortunately, the results of arthroscopic synovectomies deteriorate more rapidly. Lee and Morrey[34] achieved 93% excellent or good results in short-term follow-up of 14 arthroscopic synovectomies in 11 patients. However, only 57% of their patients maintained excellent or good results at an average of 42 months after surgery.

Clarke[17] presented a series of three patients who had symptoms of loose bodies but did not have loose bodies at elbow arthroscopy. Instead, arthroscopy revealed a fibrotic synovial fringe that impinged between the radial head and capitellum on repetitive flexion and extension of the elbow, particularly with the forearm in pronation. All three patients were successfully treated with arthroscopic removal of the synovial fringe.

### Osteochondritis Dissecans and Panner's Disease

Osteochondritis dissecans of the capitellum is characterized by pain, swelling, and limitation of motion, and it usually occurs during adolescence or young adulthood in a throwing athlete or gymnast.[64] The underlying cause of this lesion is probably repetitive microtrauma to a vulnerable epiphysis with a precarious blood supply.[64] The lesion may progress to joint incongruity or associated loose body formation.

Panner's disease, on the other hand, is an osteochondrosis; it involves the entire capitellum, is usually self-limiting, and resolves with rest.[64] Reconstitution of the capitellum occurs without late sequelae or limitations. Panner's disease may, in fact, represent an early stage of osteochondritis dissecans.

Indications for surgery in patients who have osteochondritis dissecans or Panner's disease are failure of nonoperative management, the presence of loose bodies, and a locked elbow. The procedure is performed arthroscopically and involves removal of loose bodies, excision of loose or detached cartilage, and curettement and drilling of the base of the lesion.[62]

### Valgus Extension Overload

The tremendous repetitive valgus forces generated during the acceleration and follow-through phases of pitching, as the elbow goes into extension, can result in osteochondral changes of the olecranon and distal humerus. The term "valgus extension overload" was coined to describe this process.[76] A significant osteophyte forms on the posteromedial aspect of the olecranon process and impinges on the articular wall of the olecranon fossa with continued pitching, creating an area of chondromalacia.

The typical patient is a baseball pitcher in his mid 20s who has posterior elbow pain during the acceleration and follow-through phases of pitching. Physical examination reveals a flexion contracture and pain over the posteromedial olecranon tip. Pain is also elicited with valgus stress and extension. Radiographs reveal a posterior osteophyte on the olecranon tip on the lateral view and a posteromedial osteophyte on the axial view.

Initial treatment should include nonoperative measures such as rest, nonsteroidal antiinflammatory drugs (NSAIDs), and gradual strengthening exercises. If these measures fail, arthroscopic resection of the posteromedial osteophyte using an osteotome and bur should be performed. This procedure has been successful in relieving the pain and allowing a return to pitching.[7]

Andrews and Timmerman[5] warn against missing an underlying ulnar collateral ligament injury when diagnosing and treating this problem. In a study of 72 professional baseball pitchers who underwent arthroscopic or open elbow procedures, those who had removal of posteromedial olecranon osteophytes had the highest rate of reoperation, with 38.5% (5 of 13) requiring subsequent ulnar collateral ligament reconstruction. The authors proposed two reasons for this finding. First, after debridement of the osteophyte, valgus laxity may have been present because of the absence of the posteromedial buttress, or, most likely, the ligament was injured in many of these patients but that fact was not recognized initially.

### Osteoarthritis

Arthroscopic treatment of degenerative arthritis can be successful in the early stages by removal of loose bodies and osteophytes from the olecranon and coronoid processes, as well as from their respective fossae.[49] It is important, however, not to ignore the presence of osteophytes or capsular contractures since simply removing the loose bodies does not help patients with these diagnoses.[49] Ogilvie-Harris et al.[52] successfully treated 21 patients who had posterior impingement associated with degenerative elbow arthritis by using anterior debridement and removal of loose bodies followed by posterior removal of loose bodies and removal of osteophytes from the posterior olecranon and olecranon fossa. Redden and Stanley[60] described a technique that is an arthroscopic variation of the Outerbridge-Kashiwagi[31] procedure. In this technique, the elbow is explored through a posterior approach, allowing fenestration of the olecranon fossa (approximately 1 cm in diameter). Loose bodies are then washed out through this fenestration. All 12 patients treated with this procedure had relief of elbow locking and experienced a reduction in elbow pain. Finally, it is important to release any capsular contractures by bluntly stripping the anterior capsule off the humerus at its proximal attachment with a blunt periosteal elevator under direct vision.[49]

### Arthrofibrosis

Loss of elbow joint motion can be a result of bone or soft tissue problems. Trauma and degenerative or inflammatory arthritides can lead to the development of arthrofibrosis. Patients experience decreased flexion or extension, or both. When interviewing and examining these patients, it is important to attempt to determine the cause of the contracture, because this can influence treatment. Radiographs can be helpful in this regard.

Initial treatment includes NSAIDs, stretching exercises, splinting, and other modalities. If nonoperative treatment fails, then arthroscopic release and thorough joint debridement may be indicated in properly selected patients.[15,30,37,48,49,55,71] The procedure is technically demanding, and there is an increased risk of complications because of the limited ability to distend the arthrofibrotic capsule.

The elbow capsule is released from its anterior humeral attachment along with adhesions in the radiocapitellar joint area.[7] If there is extreme extensive scarring posteriorly, with osteophyte formation on the olecranon and in the olecranon fossa, a thorough posterior debridement with removal of osteophytes is done.[7] Postoperatively, the patient's arm is splinted in full extension and supination for 48 hours. At that time, passive and active motion is initiated.

Timmerman and Andrews[71] reported excellent and good results in 79% of their 19 patients who had arthroscopic debridement for posttraumatic elbow arthrofibrosis. Extension improved from a mean of 29° to 11°, and flexion increased from an average of 123° to 124°. Better results were obtained in patients who had fewer arthritic changes. Jones and Savoie[30] cited a mean improvement in flexion contracture from 38° to 3° and improved supination from 45° to 84° in 12 patients with flexion contractures managed by arthroscopic release of the proximal capsule and debridement of the olecranon fossa. These authors, however, did have a severe complication in their series, a permanent posterior interosseous nerve palsy. Phillips and Strasburger[55] achieved similar markedly improved range of motion in 25 arthrofibrotic elbows treated with arthroscopic release and debridement. The patients in this study with posttraumatic arthrofibrosis had more severe flexion contractures preoperatively than patients with osteoarthritis, but they had greater overall improvement in range of motion postoperatively. Byrd,[15] Nowicki and Shall,[48] and Kim et al.[33] have also had success in treating arthrofibrotic elbows with arthroscopic release and debridement.

## Olecranon Bursectomy

Olecranon bursitis is most often a result of repetitive microtrauma or macrotrauma. Individuals with occupations in which they use their elbows for support are more susceptible to this condition. Sports-related olecranon bursitis usually involves wrestlers or other athletes who wear protective elbow gear.[8] Concomitant pathologic conditions can include the development of an infection or crystal deposition.

Nonoperative treatment involves a brief period of immobilization, NSAIDs, compression dressing, aspiration or injection, an indwelling angiocatheter for drainage, and incision and drainage. Fluid analysis of the aspirated olecranon bursa should include a Gram's stain, culture, and crystal analysis.

When the bursitis becomes chronic or recurrent and refractory to nonoperative management, bursal resection is usually indicated. Traditionally, an open olecranon bursectomy has been the treatment of choice. Most complications from open bursectomy are related to the surgical wound.[59] To decrease the incidence of wound complications, Kerr[32] developed a technique for arthroscopic excision of the bursa. Three portals are established at equal intervals at the perimeter of the bursa. The arthroscope is placed in one portal, while an inflow cannula and instrumentation are placed in the other two portals. Using a combination of suction basket forceps and a motorized full radius cutter, the surgeon then resects the anterior and posterior walls of the bursa.

Baker and Cummings[8] described the use of three slightly different portals: a lateral, proximal-central, and distal-central portal. To prevent injury to the ulnar nerve, medial portals are not used. The bursal tissue is removed using these three portals, and spurs on the olecranon tip are removed with an arthroscopic bur. Postoperatively, a sterile compression dressing is placed on the arm and is maintained for 3 weeks.

Kerr achieved successful resolution of the bursitis without recurrence in four of five patients.[32] The one failed result was in a patient with gouty arthritis who developed an infection that was successfully treated with open incision and drainage and intravenous antibiotics.

## Radial Head Excision

Lo and King[36] described a surgical case in which posttraumatic arthritis of the radiocapitellar joint secondary to radial head fracture was treated with arthroscopic radial head excision. With this procedure, the patient's pain decreased to approximately 60% of its preoperative level. Using the midlateral portal as a viewing portal and an anterolateral portal as a working portal, a motorized bur is used to resect the radial head in a piecemeal fashion past the level of the sigmoid notch of the ulna. A full radius resector and a pituitary longeur are used to remove the remaining cartilage and bony debris from the joint. Advantages of arthroscopic treatment include a more complete visualization of the articular surface of the elbow and associated chondral lesions or ligamentous disruptions. Debridement of chondral defects and the removal of loose articular fragments are also possible.

## Arthroscopic Management of Select Fractures

Excision of osteochondral fragments and evaluation of the degree of displacement are the main indications for arthroscopy in fracture care. Occasionally, arthroscopic fixation of acute fractures with percutaneous pins can be performed, but the procedure is useful only in certain types of minimally displaced fractures.

## Tennis Elbow Release

Tennis elbow, or lateral epicondylitis, is defined as a "painful overuse tendinitis at the lateral aspect of the elbow."[38] This overuse syndrome occurs primarily in patients who are involved in repetitive occupational or recreational activities that require pronation and supination with the elbow near full extension.[18] Diagnosis is based on the patient's history and the physical findings of tenderness over the lateral epicondyle and pain on resisted wrist and finger extensions. Radiographic findings are usually normal, but Nirschl[46] and Nirschl and Pettrone[47] reported tissue calcification in 22% of 88 elbows (82 patients) that were treated surgically.

Repetitive microtrauma to the common extensor origin at the lateral epicondyle produces inflammation and may lead to microscopic tears or, occasionally, frank rupture (Fig. 13).[18,47] The injury usually involves the extensor carpi radialis brevis tendon and consists of an angiofibroblastic hyperplasia (immature fibroblastic vascular infiltration of the tendinous attachment of the muscle).[47]

Initial treatment of tennis elbow consists of rest, avoidance of provocative activities, strengthening exercises, counterforce bracing, and NSAIDs. Corticosteroid injections can provide symptomatic relief as well. After 6 to 12 months of failed nonoperative management, surgery is indicated. Open techniques are based on two surgical principles: 1) reduction of tension at the origin of the extensor carpi radialis brevis musculotendinous unit and 2) removal of the diseased portion of the tendon. Reduction in tension is accomplished by performing a proximal fasciotomy or by lengthening the tendon distally. Excision of the pathologic tendon can also be performed, along with

**Figure 13** Lateral epicondylitis. A tear of the origin of the extensor carpi radialis brevis tendon exposes the deep layer of the extensor carpi radialis longus muscle below.

repair or reattachment of the extensor carpi radialis brevis tendon.

Arthroscopic release offers several potential advantages over open techniques. It preserves the common extensor origin by addressing the lesion directly.[8] It allows for an intraarticular examination for possible chondral lesions, loose bodies, and other disorders, such as an inflamed lateral synovial fringe. It also permits a shorter postoperative rehabilitation period and an earlier return to work or sports.

A standard arthroscopic examination of the joint is performed, beginning with the arthroscope in the proximal-medial portal. The senior author (CLB) has noted three distinct patterns of pathologic changes in the lateral capsule in patients treated for recalcitrant lateral epicondylitis. Type I lesions have inflammation and fraying deep to the extensor carpi radialis brevis tendon without evidence of a frank tear. Type II lesions are linear tears at the undersurface of the extensor carpi radialis brevis tendon. Type III lesions are retracted with partial or completed avulsions of the tendon. Using the middle anterolateral portal for instrumentation, the joint capsule is resected at the lateral epicondyle and lateral condylar ridge. The lateral epicondyle and distal portion of the lateral condylar ridge are then decorticated. The senior author found symptomatic improvement after 1 year of follow-up in 33 of 35 patients who had arthroscopic release for lateral epicondylitis.[44] These patients were able to return to work at an average of 2.2 weeks. Of the patients who were able to return for grip-strength analysis, the affected limb's grip strength averaged 96% of the strength of the unaffected limb.

## POSTOPERATIVE COMPLICATIONS

Most complications of elbow arthroscopy are neurovascular in nature. In a series of 21 arthroscopic procedures, Lynch et al.[37] reported one transient low radial nerve palsy, believed to be the result of overdistension of the joint; one transient low median nerve palsy, believed to be secondary to a local anesthetic; and a neuroma of the medial antebrachial cutaneous nerve that required resection. Kim et al.[33] also reported two transient median nerve palsies after elbow arthroscopy. Casscells[16] described a referred case in which use of a motorized instrument posteromedially resulted in irreparable damage to the ulnar nerve. Thomas et al.[69] reported on posterior interosseous nerve damage in a 20-year-old athlete undergoing elbow arthroscopy, and Ruch and Poehling[61] documented a direct injury to the anterior interosseous branch of the median nerve during an elbow debridement and synovectomy in a 65-year-old patient with rheumatoid arthritis. Papilion et al.[54] reported on a compression neuropathy of the radial nerve during elbow arthroscopy. Similarly, Jones and Savoie[30] noted a permanent posterior interosseous nerve palsy in a patient undergoing an arthroscopic capsular release for arthrofibrosis. In a 1986 review of 569 arthroscopic elbow procedures performed by members of the Arthroscopy Association of North America, only one neurovascular complication (radial nerve injury) was reported.[65] Finally, in a review of 465 arthroscopic procedures in 431 patients over a 17-year period, Kelly and coworkers found their complication rate was 17% (E. Kelly, personal communication, 1998). The complications included excessive draining, excessive swelling causing portal adjustment (6%), persistent portal drainage (4%), transient nerve paralysis (3%), loss of motion postoperatively (2%), and superficial wound infection (1%). There were no permanent neurovascular injuries in this series, and the surgeons found it difficult to determine whether the postoperative loss of motion in their patients was a result of surgery or a consequence of the underlying disease process (inflammatory arthritis). Their findings indicate that the risk of more technically challenging elbow arthroscopies can be kept low provided a surgeon's skills and experience match the technical difficulty of the procedure performed.

## CONCLUSIONS

Diagnostic and operative arthroscopy of the elbow has come a long way from its early beginnings. It has now become an accepted treatment modality for numerous conditions about the elbow. It is most successful for removing loose bodies and improving range of motion in selected cases of synovitis and posterior impingement.

As with any operative procedure, careful preoperative planning, which includes a detailed history and physical examination, and careful portal placement are necessary to ensure a successful procedure. The surgeon's experience and skill level should determine the complexity of the procedures that are attempted. Elbow arthroscopy does not make open operative procedures obsolete, but it serves as an adjunct in the successful operative treatment of common and not so common conditions of the elbow.

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