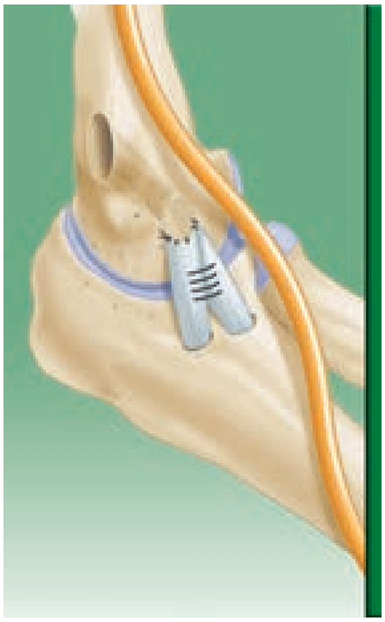

69

Loss of Elbow Motion

DEBDUT BISWAS • ROBERT W. WYSOCKI

Acute and chronic disorders of the elbow are frequently observed in both recreational and professional athletes, particularly athletes who participate in sports that involve throwing. Although clinicians most frequently evaluate athletes in throwing-related sports who have elbow pathology related to overuse injuries, including ulnar collateral ligament insufficiency, valgus extension overload syndrome, and epicondylitis, acute elbow trauma may affect athletes in all sports. These acute injuries most commonly include elbow fractures/dislocations after falls onto an outstretched hand. The injuries may occur in sports such as wrestling, as a result of the combination of compression and torque applied to the arm when competitors are driven into the mat, or weight lifting, as a result of spontaneous dislocation from massive exertion, as was witnessed at the 2012 Summer Olympic Games. Elbow osteoarthritis is almost uniquely seen in middle-aged muscular men who may have been involved in repetitive, strenuous athletic endeavors, especially boxing and weightlifting.

Loss of mobility is the most common complication after elbow injury. The predisposition of the elbow to the development of posttraumatic contracture has been attributed to several factors, including the intrinsic congruity of the ulnohumeral articulation, the presence of three articulations within a synovium-lined cavity, and the intimate relationship of the joints to the intracapsular ligaments and extracapsular muscles.[1-3] Several authors have studied the degree of elbow motion necessary to complete daily activities. Their conclusions have yielded a functional arc of 100 degrees (range, 30 to 130 degrees) of flexion and extension of the elbow and 100 degrees of rotation of the forearm (50 degrees each for pronation and supination).[4] The inability of the elbow to achieve this degree of flexibility after trauma may lead to substantial impairment of upper extremity function. For patients whose elbow contracture is refractory to conservative management, surgical debridement and release of the elbow is offered to restore functional motion of the joint. Although open approaches have classically been described for the surgical treatment of the posttraumatic elbow contracture, arthroscopic techniques have recently emerged as a less invasive alternative with similar efficacy for the treatment of elbow stiffness.

Although several authors have attempted to formulate classification schemes to grade the severity of elbow stiffness, the system devised by Morrey[5] most accurately accounts for both osseous and soft tissue pathology contributing to loss of motion. Morrey divides the etiologies of elbow stiffness into either intrinsic or extrinsic factors. Intrinsic factors include intraarticular adhesions and loose bodies, articular malalignment, and loss of articular cartilage, whereas extrinsic factors include capsular and ligamentous contracture, heterotopic ossification (HO), extraarticular malunion, ulnar neuropathy, and postburn contracture of the superficial soft tissues. All of these potential sources of motion loss should be considered and separately addressed in patients who present with a stiff elbow.

History

Assessing Impairment

It is imperative for the practitioner to determine the extent to which the loss of elbow motion compromises a patient's functional capabilities. The magnitude of functional impairment, rather than absolute loss of motion, ultimately directs management decisions when treating the patient with posttraumatic contracture of the elbow. In this regard, the chief complaint is often related to functional loss rather than pain, swelling, deformity, or another manifestation of previous trauma. From the standpoint of activities of daily living, loss of flexion can restrict the ability to bring the hand to the face and head, which makes it challenging to button clothing, eat, and wash the face and hair. A loss of extension is less functionally significant with regard to activities of daily living, because most patients can make accommodations for this deficit by moving closer to an object, but it can cause problems with overhead reaching. In modern society, loss of pronation is often reported because it causes difficulties with writing and typing; however, further abducting the shoulder as necessary can help compensate for this deficit. Loss of supination is less commonly a problem, although it may present difficulties with activities such as carrying an item with two hands, holding a bowl/plate, or using a drive-through window, especially because no effective compensatory motions exist for a lack of supination.

When participating in a sport, lack of extension even to a mild degree often has greater consequences than interfering with activities of daily living alone. Two-handed weighttraining for which symmetry is important (e.g., bench press and military press) are affected for all athletes, and basketball players and throwing athletes especially struggle as they lose follow-through. Gymnasts' mechanics and ability to propel themselves are affected by loss of extension as well. With the possible exception of quarterbacks, football, hockey, and lacrosse players tend to accommodate very well to mild or even moderate elbow flexion contractures.

Intrinsic Causes

Several elements of the history can help the practitioner determine if elbow stiffness is related to intrinsic pathology. When the patient has a history of an intraarticular fracture, radiographs and preferentially a computed tomography (CT) scan should be closely reviewed for evidence of intraarticular malunion or resultant osteoarthritis, especially when the trauma is remote. An inability to achieve full range of motion in the setting of malunion may suggest a true bony impingement, whereas a gradual decline over several years is more suggestive of posttraumatic arthritis as the cause of stiffness. The history should determine if the patient has mechanical symptoms such as locking or catching that would be suggestive of intraarticular loose bodies, which can be confirmed by a CT scan, magnetic resonance imaging, or preferably CT combined with an arthrogram.

Stiffness from elbow osteoarthritis presents with months to years of gradually progressive loss of motion and pain at terminal flexion and extension, usually with less pain within the mid arc of motion until the process is very advanced. These patients usually identify pain with triceps and biceps strengthening exercises from the forced terminal motion, and fluctuations of pain and swelling often occur that increase in severity the more the elbow is used.

Extrinsic Causes

When evaluating a patient for extrinsic causes of elbow stiffness, it is important to elicit the length of the immobilization period after an acute injury, because immobilization for longer than 7 to 14 days after elbow trauma predisposes the joint to capsular contracture. Except in rare circumstances of persistent instability despite surgical intervention, acute elbow fractures and dislocations should either be inherently stable enough to allow range of motion to begin within the time frame of 7 to 14 days, or the elbow should be surgically stabilized from a bony and/or soft tissue standpoint to allow range of motion within that time frame. HO, if it occurs, typically starts to appear within a few weeks of injury and can continue to progress and mature for months. Patients with symptomatic HO initially demonstrate appropriate progress with range of motion and then their condition deteriorates as the HO progresses. Surgical intervention for posttraumatic HO should be delayed until it appears to be mature radiographically, typically 3 to 6 months later.

The practitioner should specifically inquire about any associated symptoms of ulnar neuropathy, because in addition to accompanying a loss of flexion, ulnar neuropathy may also cause a loss of flexion after a relatively innocuous elbow trauma. A history of a burn, a degloving injury, or infection of the skin and soft tissues should raise suspicion that the soft tissues are contributing to the contracture, although this situation is uncommon.

Forearm Contracture

Stiffness specific to loss of forearm rotation has several causes. Although one must consider causes intrinsic to the elbow, such as radial head fracture malunion and HO affecting both the ulnohumeral and proximal radioulnar joints, other injuries such as a Monteggia fracture, a Galeazzi fracture, and fractures of both bones of the forearm are more common scenarios for isolated forearm contracture. Even with appropriate treatment, a loss of 10 to 20 degrees of forearm rotation is not uncommon after these injuries. Performing a corrective osteotomy in this setting is technically challenging with somewhat poorly reproducible results, and thus the corrective osteotomy is reserved for persons with more severe contractures.

A unique complication of distal biceps tendon reattachment, especially two-incision techniques, is HO at the level of the radial tuberosity that limits forearm rotation. This condition can be treated very successfully through resection of the HO, with excellent return of range of motion and biceps strength[6] and improved outcomes compared with HO resection associated with other forearm trauma.[7]

Prior Treatment

If prior operative treatment was performed, it is especially important to obtain and review any operative documentation and arthroscopic images where applicable, especially when further surgical treatment is being considered. Complications related to initial treatments, including infection or neurologic deficits, can potentially account for posttraumatic stiffness and should be investigated. The physician should also ascertain the duration of physical therapy that has already been undertaken, the types of splinting that have been used (e.g., static progressive or dynamic), and to what degree progress has plateaued.

Physical Examination

Physical examination begins with inspection of the entire upper extremity, specifically evaluating for soft tissue contracture, deformity, swelling, and muscle atrophy, while noting the location of any previous arthroscopic portal sites or surgical incisions that would influence further surgical planning.

Range of motion evaluation should include the hand, wrist, forearm, and elbow and be compared with the contralateral, unaffected extremity. Crepitus, locking, and mechanical symptoms may occur as a result of loose bodies or osteochondral injuries. Pain at the extremes of motion with mechanical blocks may be the result of osteophyte formation and impingement in the coronoid fossa at terminal flexion or within the olecranon fossa at terminal extension. Pain during the mid arc of motion in a young athlete is frequently due to osteochondral lesions. The examiner should test both active and passive motion and characterize the type of end point at the extremes of motion. A gradual passive stretch obtained after the initial limitation in active range of motion is suggestive of a residual myostatic contracture that usually would be expected to resolve with time. Varus and valgus stress testing, especially posterolateral drawer testing, is imperative, particularly in the setting of previous trauma, because posttraumatic posterolateral rotatory instability can often present with stiffness as the chief complaint rather than subtle instability.

Performing a careful neurologic examination is essential. As it traverses the cubital tunnel adjacent to the medial joint capsule, the ulnar nerve may become entrapped in scar tissue along the medial elbow after trauma, resulting in posttraumatic ulnar neuropathy. Traction ulnar neuritis of the elbow may manifest as medial elbow tenderness and subjective paresthesias in an ulnar nerve distribution, particularly with elbow flexion. Patients with posttraumatic ulnar neuropathy may present simply with loss of flexion and medial elbow pain in the absence of overt symptoms of ulnar neuropathy. Two-point discrimination, grip and pinch strength, and intrinsic muscle function should be documented.

Imaging

Standard plain radiographs of the elbow are obtained and include anteroposterior, lateral, and oblique projections. Radiographs may demonstrate evidence of malunion of distal humerus, radial head/neck, or proximal ulna fractures, as well as bony loose bodies and degenerative changes in the ulnohumeral or radiocapitellar joints. HO is readily identifiable on radiographs and gradually progresses from a more poorly defined “fluffy” appearance when immature to a well-defined morphology with clearly visible borders when mature.

A CT scan is frequently acquired to localize HO, intraarticular loose bodies, and degenerative joint disease within the elbow when surgical intervention is being considered (Fig. 69-1). Although plain radiographs are typically sufficient for establishing a diagnosis for these conditions, they often underestimate the pathology. Accordingly, two- and three-dimensional CT reconstructions are helpful in further delineating bony and articular anatomy. CT arthrography demonstrates filling defects around osseous and nonosseous loose bodies, as well as areas of osseous impingement resulting from overgrowth in the olecranon or coronoid fossae and at the tips of the coronoid and olecranon processes.

For posttraumatic HO, we favor standard CT imaging without arthrography because loose bodies are less often present and the HO is better appreciated without intraarticular contrast obscuring its borders. The use of CT is less common but also beneficial when evaluating intraarticular malunion if corrective osteotomy is being considered. We have found that magnetic resonance imaging has a limited role for the evaluation of stiff elbows.

FIGURE 69-1 A sagittal computed tomography image demonstrating complex osteophytes in the olecranon and coronoid fossae.

Decision-Making Principles and Treatment Options

Nonoperative management remains the initial means of treatment and prevention of elbow contracture after acute injuries and typically includes early range of motion and supervised therapy as long as the elbow joint and any internal fixation are deemed stable enough to withstand it. Motion is typically initiated no later than 2 to 3 weeks after elbow trauma as long as the injury is stabilized by operative or nonoperative means. In most cases, active or active-assisted motion commences prior to passive motion. When posttraumatic HO is identified, patients usually continue to undergo supervised therapy until their range of motion plateaus and the HO is mature radiographically.

For cases of elbow stiffness due to osteoarthritis and loose bodies, physical therapy typically does not have a role given the mechanical nature of the disease process, although cortisone injection can be safe and effective in the short term for athletes trying to complete their season.

Static progressive or dynamic splinting for passive stretch of the soft tissues is an effective adjunct to physical therapy once sufficient bony and/or ligamentous healing is present at 6 to 8 weeks after an acute injury. These types of splints should also be used for patients who present with an established contracture after prolonged immobilization and can be used for contractures in either forearm rotation or elbow flexion/extension. Static progressive splints are adjusted by the patient and apply a constant tension to the soft tissues; these splints are generally locked in a given position and do not allow motion of the elbow while the splint is applied. Dynamic splints work by applying a constant tension through an elastic-based mechanism but do permit motion; they usually require a longer continuous period of use, typically 4 to 6 hours. We tend to favor static splints in our practice because patient compliance has been better than with dynamic splints, as static splints are generally worn for only approximately 30 minutes per day.

Splinting is most useful during the first 3 to 6 months after an injury, particularly for patients whose stiffness is due to extrinsic soft tissue contracture and who do not show radiographic evidence of bony deformity, arthrosis, or osteophyte impingement. Recent evidence has demonstrated that static progressive and dynamic splinting have equivalent results with benefits still observed as long as 12 months after injury.[8] We typically reexamine patients at monthly intervals to document continued improvements with their splinting regimen and discontinue use of the splints when no improvement is demonstrated at successive visits, especially given their cost and time investment.

Surgical management is indicated for patients who continue to experience significant loss of mobility with resultant impairment of upper extremity function and limitation with daily activities or sport. Although a flexion contracture of at least 25 to 30 degrees and/or less than 110 to 115 degrees of active flexion was historically reported as an indication for elbow contracture release, operative management may also be offered to persons with greater motion requirements for specific lifestyle, occupational, or athletic demands. Most importantly, patients must be willing to comply with extensive postoperative therapy, because operative outcomes depend on diligent participation in a structured rehabilitation program. Compliance with extensive postoperative therapy is especially important for adolescents, who may be less dedicated to improving their elbow motion than other patients whose livelihood depends on maximal functional recovery.

In the setting of acute stiffness after elbow trauma, 4 to 6 months are typically required for swelling and inflammation to decrease sufficiently for "tissue equilibrium" to be achieved, after which surgery is advisable for patients who fail to progress with use of the aforementioned nonoperative methods.

Although patients with degenerative disease that results from anterior or posterior impinging osteophytes are good candidates for debridement, persons with diffuse joint space narrowing and pain throughout the arc of motion are better candidates for salvage-type procedures such as interposition arthroplasty or total elbow arthroplasty.[9]

The timing of operative debridement for osteoarthritis is flexible, and many athletes elect to manage the condition with intraarticular steroid injections during the playing season and then have surgery during the off-season, with an expectation that 4 to 6 months will pass before they are capable of returning to their sport.

Treatment of a stiff yet unstable elbow is particularly challenging. Subtle elbow instability may exist concurrently with loss of motion after elbow fracture-dislocation. Accordingly, special attention should be devoted to evaluating elbow stability either with stability testing or stress radiographs. If instability is present, ligament reconstruction may be combined with capsular release in certain patients, although most cases are treated with staged procedures. The priority is to achieve stability first and restore motion later with an elbow release procedure if necessary.

Surgical Techniques

Open and arthroscopic techniques are well described for the treatment of elbow contracture. Although success has been reported with use of open release via posterior, lateral, medial, and combined approaches, isolated releases from the medial or lateral side are now most commonly used. The choice of approach may be contingent on previous surgery, the location of the primary offending pathology, or simply the surgeon's preference based on his or her comfort level and experience with the approach. The anterior and posterior ulnohumeral joint articular surfaces and capsular tissues can be adequately exposed for debridement from either the medial or lateral side. However, significant involvement of the radiocapitellar joint requires a lateral exposure, whereas posteromedial osteophytes and associated ulnar neuropathy require a medial approach. Although a combined approach can be performed through a universal posterior incision, we favor the use of separate medial and lateral incisions.

Arthroscopic techniques have emerged as less invasive methods of restoring motion, and although these techniques are technically demanding, advances in instrumentation and arthroscopic equipment have resulted in expanding indications for arthroscopic elbow release. Relative contraindications to arthroscopic elbow release include the most severe elbow contractures, prior ulnar nerve transposition surgery, the presence of significant HO, and previous surgery involving the radial head, which may render the radial nerve susceptible to iatrogenic injury. Patients with these conditions are more reliably treated with open release with direct visualization and protection of neurovascular structures. Surgeons considering arthroscopic elbow release should inquire about previous ulnar nerve transposition and acquire records to confirm the exact nerve location. Although arthroscopic release has the theoretical benefit of less morbidity and a more rapid return to function, these benefits have yet to be convincingly demonstrated within the literature. Given the risks of nerve injury with complex elbow arthroscopy, the surgeon must still choose the procedure that is safest and most effective in his or her hands, because both open and arthroscopic techniques produce similar outcomes.

Arthroscopic Release

We offer arthroscopic elbow release as a less invasive alternative to open procedures, especially for athletes and other persons who place high demands on their elbow. This technically demanding procedure requires intimate knowledge of intracapsular elbow anatomy and advanced skills in elbow arthroscopy. Multiple portals are required and diligent fluid management is essential, especially because capsulectomy consequently creates unreliable joint distention. The use of joint retractors improves visualization and facilitates appropriate surgical debridement of contracted or impinging structures.[10-14]

From a basic mechanical standpoint, posterior debridement improves elbow extension and anterior debridement improves elbow flexion. However, optimal results are possible when the entire joint is considered regardless of the major motion deficiency and primary pathology. To increase extension, any cause of posterior impingement must be removed between the olecranon tip and the olecranon fossa. The fossa may require deepening to achieve terminal elbow extension. The anterior joint capsule and adhesions between the brachialis muscle and distal humerus must also be released. To increase flexion, any cause of anterior impingement must be eliminated in the region of the coronoid and radial fossae. For full flexion to occur, deep concavities must be restored at the fossae to accept the coronoid process centrally and the radial head laterally (Fig. 69-2). The posterior and posteromedial joint capsules and adhesions between the triceps muscle and distal humerus must be released.

Anesthesia and Positioning

We favor use of a regional block rather than general anesthesia when feasible. We position the patient in the lateral decubitus position with the affected extremity over a cradle and all bony prominences well padded. It is helpful to position the patient slightly overrotated toward the surgeon to prevent the arm from "sliding away" during the procedure. The shoulder is positioned at 90 degrees of abduction and adequate extension to keep the elbow elevated higher and allow enough clearance for maximal freedom of passive motion (Fig. 69-3, *A*). After the extremity is sterilely prepared and draped up

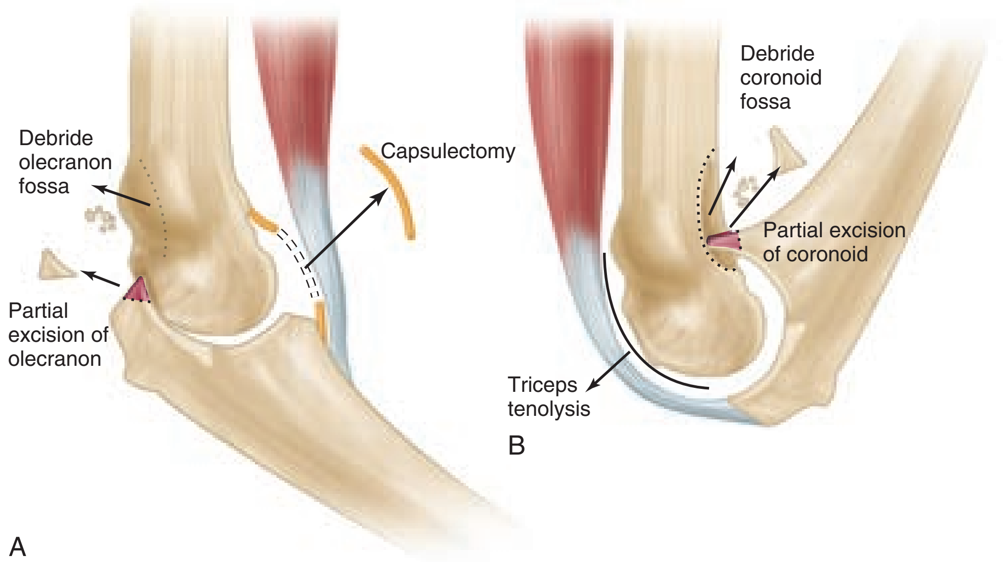

FIGURE 69-2 **A,** Improvement of elbow extension requires removal of posterior bony impingement and release of the anterior joint capsule. **B,** Improvement of flexion requires posterior soft tissue release and removal of any soft tissue or bony impingement anteriorly. *(Courtesy Hill Hastings, MD, Indiana Hand Center, Indianapolis, IN.)*

to the axilla, the hand and forearm are wrapped with an elastic bandage to limit fluid extravasation and a sterile pneumatic tourniquet is placed as proximally as possible around the arm.

The major external landmarks and portal sites are then marked, including the olecranon tip, the medial and lateral epicondyles, and the course of the ulnar nerve (Fig. 69-3, *B*). The extremity is exsanguinated with a compressive elastic bandage, and the tourniquet is inflated.

Surgical Landmarks, Incisions, and Portals

The elbow joint is first insufflated with 30 mL of normal sterile saline solution through the soft spot outlined by the lateral epicondyle, radial head, and olecranon tip to facilitate joint entry with the arthroscope (Fig. 69-4).

Anteromedial Portal

The proximal anteromedial portal is created through a stab skin-only incision, 2 cm proximal and 2 cm anterior to the

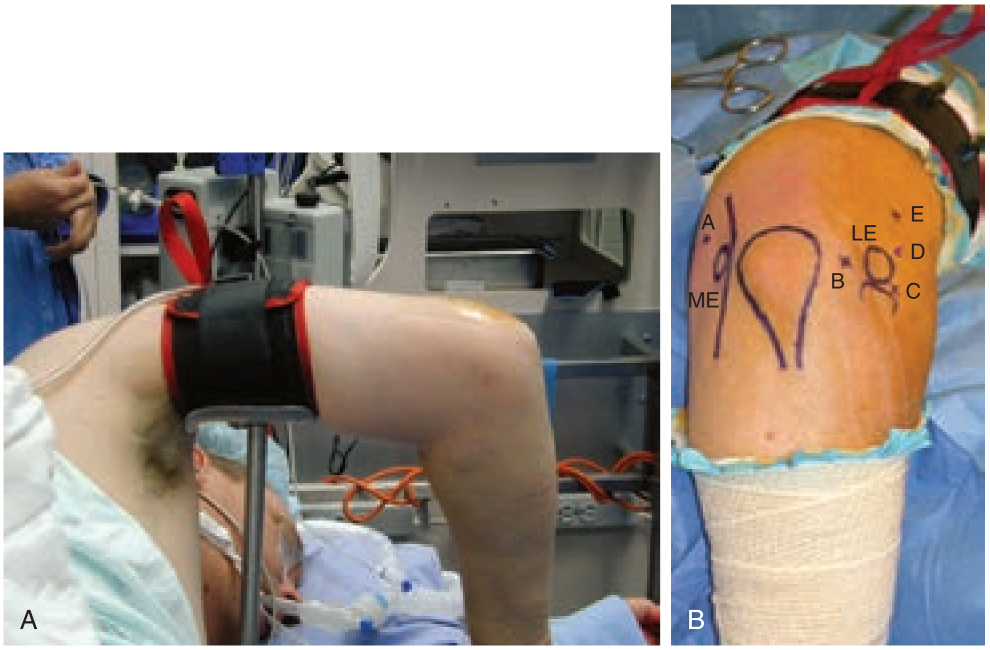

FIGURE 69-3 **A,** The arm is positioned over a cradle, allowing sufficient space for full flexion. **B,** Anatomic landmarks are marked: lateral epicondyle (*LE*), medial epicondyle (*ME*), proximal anteromedial portal (*A*), soft-spot portal (*B*), standard anterolateral portal (*C*), modified anterolateral portal (*D*), and proximal anterolateral portal (*E*). The expected path of the ulnar nerve is also depicted.

FIGURE 69-4 The elbow joint is insufflated with sterile saline solution through the lateral soft spot.

medial epicondyle, just anterior to the medial intermuscular septum. Subcutaneous tissue is spread with a hemostat clamp (Fig. 69-5, *A*), and the blunt trocar for the arthroscope is inserted, aiming straight medial to lateral. The surgeon should be able to sense the trocar flipping back and forth from posterior to anterior along the septum, ensuring that the trajectory is anterior to the septum to protect an anatomically positioned ulnar nerve. It should be noted that entry into the joint may be difficult, particularly in cases involving posttraumatic stiffness with a contracted capsule. Care must be taken to pass directly along the anterior humeral cortex because the capsule may be quite adherent, pushing the instrument into an extraarticular plane.

The anterior joint compartment is then penetrated with the tip of the trocar directed laterally toward the radial head (Fig. 69-5, *B*). The trocar is then advanced gently through the capsule and exchanged for a long standard 4.0-mm 30-degree arthroscope (or occasionally a 2.7-mm 30-degree arthroscope for small elbows). Gravity inflow of sterile saline solution is established to allow for distention of the elbow capsule. Specialized cannulas that do not have any holes near the tip (Fig. 69-6) may be helpful, because standard cannulas can lead to the inadvertent entry of fluid into the soft tissues during visualization of the joint.

This medial portal allows excellent inspection of the lateral joint including the radial head, capitellum, and lateral capsule. An examination of the anterior elbow joint compartment is performed to evaluate for loose bodies, synovitis, and cartilage injury. The arthroscope is then directed laterally, and the camera is rotated to visualize the radiocapitellar joint in the horizontal plane. If visualization is difficult, a retractor or freer elevator can be introduced through a proximal anterolateral portal (described in the next section). Improved visualization of the lateral capsule and soft tissues is achieved by providing tension to the capsule anteriorly.

Anterolateral Portal

After diagnostic arthroscopy of the anterior elbow through the medial portal, a modified anterolateral ''working'' portal is created with use of either an inside-out technique with a switching stick or direct needle localization while viewing the field from the medial side.

The portal is typically 1 cm proximal and 1 cm anterior to the superior aspect of the capitellum. Any lateral synovitis may be debrided through this portal (Fig. 69-7) with a resector. It is of utmost importance to understand the position of the posterior interosseous nerve just anterior to the midline of the radiocapitellar joint to avoid iatrogenic injury when advancing cutting or thermal instruments in the working portals.

Specific Steps

Anterior Release

After placement of anteromedial and anterolateral portals, the anterior joint is cleared of any synovitis or adhesions that are present. Typically the arthroscope is introduced through the anteromedial portal, whereas instruments to be used for debridement are initially placed through the anterolateral portal. Mechanical instruments (e.g., a shaver) are commonly

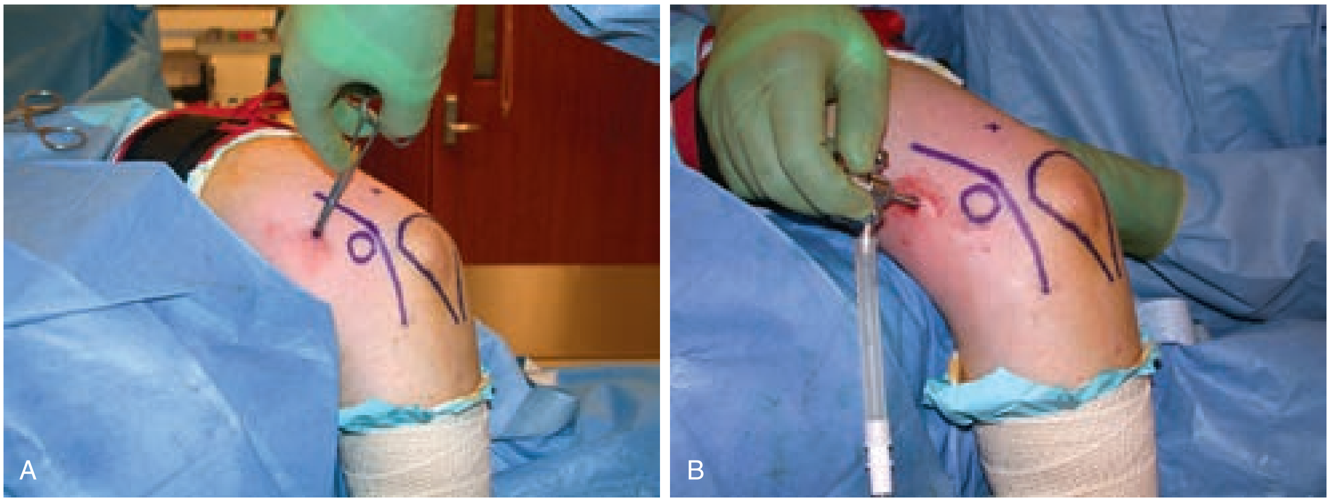

FIGURE 69-5 **A,** Subcutaneous tissue is first spread with a hemostat clamp when placing the anteromedial portal. **B,** The trocar is then introduced and directed inferolaterally toward the radial head and through the anterior elbow capsule.

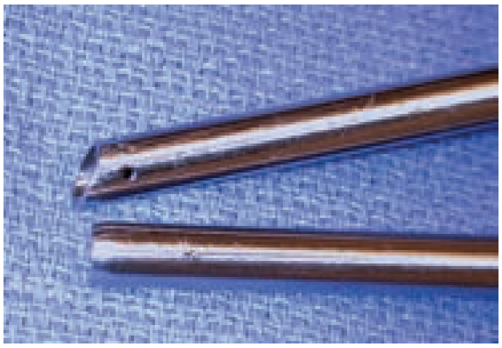

FIGURE 69-6 A close-up view of the arthroscopic cannulas used for the elbow. Traditional cannulas (*top*) for larger joints commonly have an oblique end with holes near the tip to facilitate flow. Specialized cannulas (*bottom*) for the elbow do not have outflow holes. This distinction is important because the distance between the cannula tip and the joint capsule can be quite small in the elbow, allowing fluid to extravasate inadvertently into the soft tissues. Fluid management is important when performing an elbow release arthroscopically.

used for debridement, although thermal devices may more easily facilitate the removal of soft tissue. If a surgeon elects to use thermal instruments, inflow should be gradually increased to avoid heat generation within the joint. The coronoid and radial fossae are debrided of any fibrous tissue down to the bony floor to allow visualization of the articulation of the coronoid and radial head, respectively, with the distal humerus during elbow flexion. Once the locations of bony impingement are clearly identified, they are resected with a high-speed burr until concavities are created within the fossae to permit further flexion of the coronoid process and radial head without impedance (Figs. 69-8 and 69-9). The arthroscope and the working instruments must be alternated efficiently and effectively from medial to lateral positions during debridement.

After debridement of the coronoid and radial fossae, attention is next turned toward the anterior capsule. Special care is devoted to the radial nerve, which lies directly anterior to the capsule near the midline of the radiocapitellar joint. Accordingly, debridement of the anterior capsule directly off of the humerus proximal to the trochlea is much safer than at its distal origin. The capsulotomy is usually initiated with a wide-mouthed duckling punch in a medial to lateral direction with viewing through the anterolateral portal; dissection in this direction is technically easier because the interval between the capsule and the brachialis muscle is more defined on the medial side. The portals are then reversed so that a medial view is achieved and working instruments are passed from the lateral portal, while continuing to strip the anterior capsule off its humeral origin. Use of a knife to extend the capsulotomy down to the level of the collateral ligaments on each side completes the capsulotomy. The capsular attachments should be resected off the distal humerus as far as the supracondylar ridges both medially and laterally.

A capsulectomy is then performed. Debridement performed more distally near the level of the joint must be conducted with extreme diligence to avoid iatrogenic injury to the radial nerve. The capsulectomy should be performed on the medial side extending from a proximal to distal direction. The lateral capsule should then be excised proximally and distally. This excision is the most dangerous aspect of the anterior release because the radial nerve is vulnerable immediately behind the capsule, just anterior to the radial head, between the brachialis muscle and extensor carpi radialis brevis tendon origin. If significant doubt exists regarding the tissue planes intraoperatively and working toward a complete capsulectomy is placing the radial nerve at risk, a simple capsulotomy off the humerus often suffices for motion restoration (Fig. 69-10).

The use of retractors during anterior capsulectomy is strongly advocated because they greatly aid in visualization, can obviate the need for increased fluid pressure, and can aid in fluid management, which is especially true after the capsulectomy has begun, because fluid distention is less effective and extravasation into the periarticular soft tissues occurs more rapidly. Bony work should be limited after a capsulectomy, because it is much more difficult to work within the elbow after a significant amount of fluid has extravasated. Retractor portals, both medially and laterally, are typically

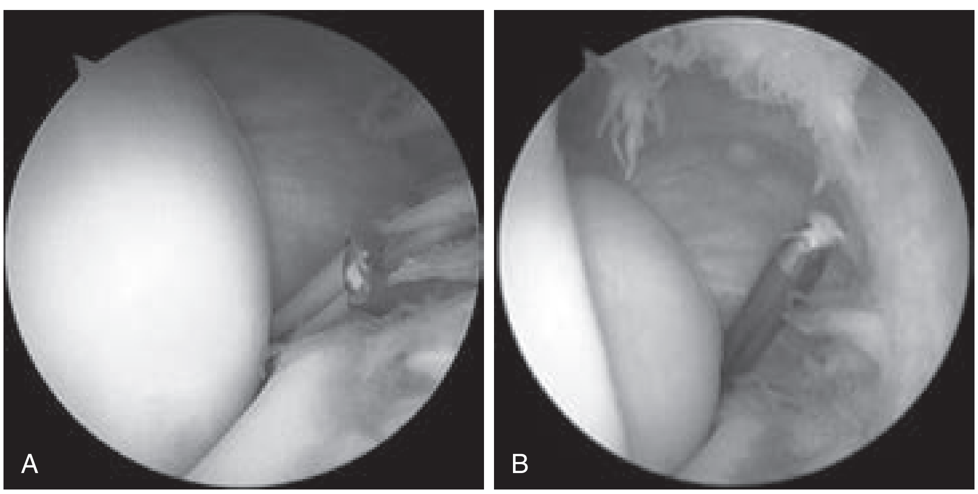

FIGURE 69-7 An arthroscopic view of the elbow joint as viewed from a medial portal with localization of an anterolateral portal with an 18-gauge spinal needle (**A**) followed by placement of a blunt trocar through the joint (**B**).

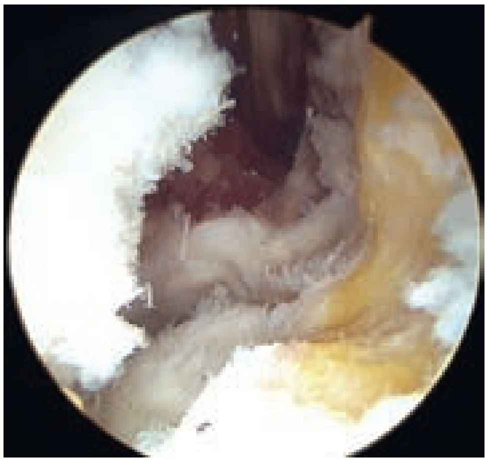

FIGURE 69-8 The coronoid and radial fossa have been debrided of any tissue that would cause impingement in flexion; a concavity is produced above the articular surface.

FIGURE 69-10 A capsulectomy has been performed anteriorly, revealing the undersurface of the brachialis. The capsular resection is performed proximal to the joint line; capsular debridement distal to the radiocapitellar joint would place the radial nerve, which lies directly anterior to the capsule at the joint line, at risk.

placed 2 cm proximal to the already described medial and lateral portals.

Posterior Release

After anterior release, we recommend maintaining a cannula in the anterior joint during the posterior release to establish outflow for the remainder of the procedure. The posterior portals may then be placed. The posterolateral portal is started approximately 1 cm proximal to the midpoint between a line drawn from the olecranon tip to the lateral epicondyle. The posterior portal is established 3 to 4 cm above the olecranon tip in the midline. With the elbow extended to protect the posterior trochlea, a blunt elevator is used to blindly strip and clear the olecranon fossa and elevate the posterior joint capsule using tactile feedback.

With the arthroscope in the posterolateral portal and the shaver in the posterior portal, a view is first established by debriding the olecranon fossa (Fig. 69-11). Visualization may be difficult initially, and all debridement should begin lateral of midline to avoid inadvertent injury to the ulnar nerve. Once a view is established, the shaver or a radiofrequency ablation device can be used to debride dense scar tissue and synovium, taking care to preserve the capsule in order to more easily perform the capsulotomy later. If necessary, the posterior capsule is partially freed from the humerus proximally with a shaver or periosteal elevator and can be partially resected to improve visualization. Typically, this capsule is less hypertrophic than the anterior capsule. Placing a retractor in a proximal posterolateral portal 1 to 2 cm proximal to the posterolateral portal is useful to maintain that space.

Bony resection is then carried out with a high-speed burr, particularly near the tip of the olecranon, within the olecranon fossa, and at the medial and lateral corners (Fig. 69-12). Special care must be taken medially to either fully delineate the medial gutter and protect the ulnar nerve or perform debridement through a small, open medial approach to directly visualize the nerve, particularly when significant posteromedial bone is encountered and extensive debridement is anticipated. After bony and synovial debridement, the posterior capsule is then resected, which is most easily performed with a shaver or radiofrequency ablation device

FIGURE 69-9 The concavity proximal to the trochlea is viewed from the lateral portal.

FIGURE 69-11 An arthroscopic view of the posterior joint, including fibrous tissue within the olecranon fossa.

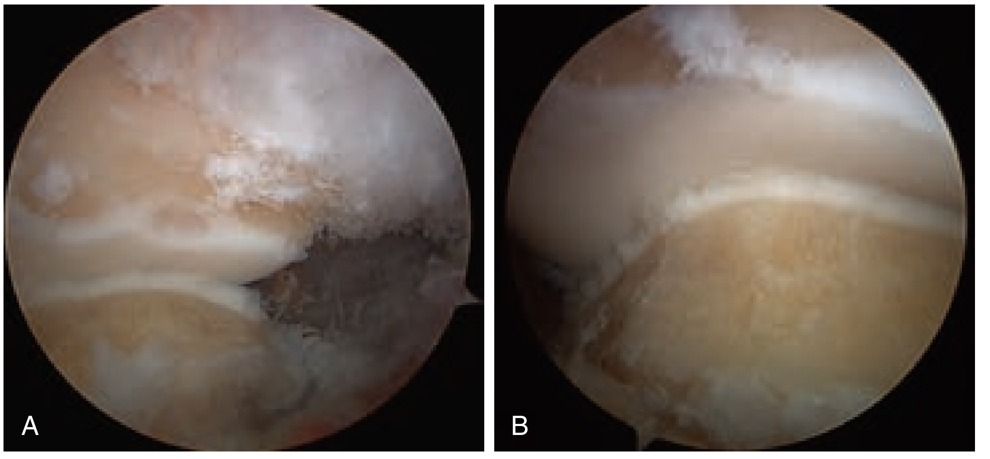

FIGURE 69-12 Lateral (**A**) and medial (**B**) views of the olecranon, demonstrating that the olecranon fossa and olecranon tip have been debrided of scar and osteophytes, thus removing any structures causing impingement and preventing extension.

through the posterolateral portal. The posterolateral capsule is initially resected, and the posteromedial capsule is released in cases in which there is a significant loss of flexion (i.e., flexion limited to less than 90 to 110 degrees).

Posteromedial Capsulectomy and Ulnar Nerve Decompression

The ulnar nerve lies along the medial joint capsule in the cubital tunnel and may become enveloped in scar tissue and develop adhesions to the soft tissues after trauma. We recommend that the ulnar nerve be decompressed and/or transposed in all cases when preoperative symptoms exist either at rest or with provocative positioning or testing (i.e., a positive Tinel sign or a positive elbow flexion test). This procedure is also recommended when significant preoperative loss of flexion exists, for which postoperative restoration in joint flexion may precipitate ulnar nerve symptoms. It has generally been recommended that ulnar nerve decompression be considered when preoperative elbow flexion is limited (less than 90 to 110 degrees).[15]

In cases in which a posteromedial capsulectomy is considered, any mechanical or thermal instruments used along the medial ulnohumeral joint and medial gutter render the ulnar nerve susceptible to injury. The concomitant use of suction makes the use of mechanical burrs and shavers even more dangerous. Although the posteromedial capsulectomy may be performed arthroscopically, our preference is to first identify and decompress the ulnar nerve through a limited open approach prior to arthroscopic elbow release, particularly in cases in which a posteromedial release is anticipated. If a limited open approach is chosen for the nerve, it is much easier to perform before the arthroscopic joint release because fluid extravasation and resultant swelling of the soft tissues can obscure tissue planes and local anatomy, rendering nerve dissection more difficult.

After ulnar nerve decompression, the posteromedial capsulectomy may be more safely performed. During the posteromedial release, it is important to understand that the ulnar nerve is closer to the epicondyle than the tip of the olecranon, and thus release of the capsule is safer along the olecranon. A retractor placed in the proximal posterolateral portal, or even in a proximal posterior portal (sometimes using two retractors), is invaluable at this stage.

After anterior and posterior release, intraoperative passive elbow range of motion is documented with an expectation for near full terminal flexion and extension regardless of soft tissue swelling. If the ulnar nerve was decompressed, it may be left in the cubital tunnel (i.e., in situ decompression) or formally transposed anteriorly, depending on the surgeon's preference.

Closure

We prefer to place a drain posteriorly through a separate exit wound rather than through a portal to help prevent formation of a synovial fistula. Portal sites and the ulnar nerve incision, if used, are closed. The elbow is wrapped in a soft compressive dressing; in our practice, we prefer to cut out some of the dressing anteriorly (in the antecubital fossa) to allow more flexion postoperatively because we start continuous passive motion (CPM) immediately.

Open Release

Open debridement should be considered in cases featuring severe elbow contractures with minimal joint motion, prior ulnar nerve transposition surgery, and the presence of significant HO; these patients are more reliably treated with extensive open debridement rather than arthroscopic debridement of the elbow to restore motion and protect the ulnar nerve.

The exposure may include either a medial or lateral approach, although we prefer to use a lateral approach for simple contractures because of its simplicity and access to the radiocapitellar, ulnohumeral, and proximal radioulnar joints. The lateral approach posteriorly uses the internervous Kocher interval between the anconeus and the extensor carpi ulnaris, reflecting the anconeus posteriorly while reflecting the triceps posteriorly from the supracondylar ridge of the humerus. A triceps tenolysis may be performed at this stage. The deeper exposure of the joint is carried out by excising the elbow capsule proximal to the lateral collateral ligament and annular ligamentous complex. The radiocapitellar joint may be visualized along with the posterior ulnohumeral joint, where osteophytes may be resected and the radial and olecranon fossae can be debrided of any offending tissue that may cause impingement. The anterior aspect of the joint and anterior capsule is exposed by dissecting the brachialis from the supracondylar ridge proximally and developing the interval between the extensor carpi radialis longus and extensor carpi brevis distally. A tenolysis of the brachialis may be performed; the capsule is then excised from the humerus and the radial and coronoid fossa are cleared of any fibrous or bony tissue responsible for anterior impingement. The posterior and anterior capsules are resected through the posterior and anterior exposures, respectively.

An analogous medial approach may be considered in cases in which significant contracture is present despite joint release from a lateral approach or if the ulnar nerve requires formal exposure and decompression. The subcutaneous tissues are carefully divided, preserving all branches of the medial antebrachial cutaneous nerve. The ulnar nerve is exposed proximal and distal to the joint and is reflected anteriorly. The triceps is then reflected posteriorly from the intermuscular septum, and the posterior ulnohumeral joint is debrided with use of the same technique as described for the lateral approach. The anterior aspect of the joint is exposed by reflecting the brachialis from the supracondylar ridge and dividing the flexor-pronator muscle origin through the juncture of the middle and posterior thirds of the muscle mass. The anterior joint capsule is exposed and debridement can then be carried out as described for the lateral approach. We prefer to transpose the ulnar nerve in a subcutaneous position after joint debridement.

Postoperative Management

Follow-up

It is imperative for the surgeon to diligently follow up on these patients in the postoperative period. Patients are typically seen in the office between 10 and 14 days after surgery for suture removal. Although most ultimate elbow motion is ultimately recovered during the first 6 to 8 weeks, patients can continue to make gains in terminal flexion and extension for several months postoperatively.

Rehabilitation

We typically prefer that CPM begin immediately in the recovery room and continue overnight until discharge the following day. Formal therapy is commonly begun on postoperative day 1, at which time the dressing is removed and edema-control modalities (e.g., an edema sleeve or an athletic wrap) are used to limit swelling. Weighted stretches and unrestricted active and passive elbow motion are immediately initiated, and patients use CPM and receive static progressive elbow bracing two to three times per day after discharge. Flexion and extension are alternated based on the preoperative deficit and the early progress of the elbow. CPM should be continued at home for 3 to 4 weeks along with a formal supervised rehabilitation program.

A nonsteroidal antiinflammatory agent (e.g., indomethacin) is commonly prescribed as prophylaxis against HO for several weeks after surgery. Use of such an agent also helps to limit inflammation of the periarticular soft tissues during rehabilitation. A single dose of radiation therapy, typically 5 to 7 Gy, is considered in select cases with abundant HO, typically in cases that required open capsular release and bony resection.

Return to Sport

Patients are extensively counseled that strengthening will not commence until the soft tissues have reached equilibrium and postoperative range of motion has maximally improved, typically at 2.5 to 3 months after surgery. Return to sport is typically considered at 4 to 6 months after surgery depending on the needs and demands specific to a given sport. The duration between surgery and return to sport is quite variable, however, and is based on the exact pathology present and the surgical procedure undertaken. A patient with mild stiffness from a loose body that resolves after loose body excision may typically return to sport within several weeks, whereas a patient who has severe stiffness from HO and must undergo open release may require more than 6 months before returning to athletic competition after surgery.

Results

With proper patient selection and surgical indications, excellent outcomes may be achieved with predictable recovery of a functional arc of elbow motion and substantial pain relief. Several studies have reported the efficacy of both arthroscopic and open elbow contracture release procedures (Table 69-1).[11,16-18] It is widely reported that patients regain about 50% of lost motion after either treatment. A metaanalysis of the literature suggests that 90% to 95% of patients regain lost motion (defined by at least a 10-degree increase in the arc of motion) and about 80% obtain a functional arc of motion (defined as ranging from 30 to 130 degrees); another 5% to 10% get to within 5 to 10 degrees at each end of this functional range. Currently no evidence definitively confirms the superiority of open or arthroscopic techniques for elbow contracture release, and thus the surgeon must closely evaluate the pathology that is present and choose the safest and most reproducible procedure in his or her hands.

The use of CPM remains controversial. Early studies demonstrated improved postoperative range of motion with CPM, and the use of postoperative CPM was found to improve the total arc of motion after anterior capsulectomy for posttraumatic flexion contracture.[19] However, a more recent retrospective series documented no clinical benefit of CPM after open contracture release.[20]

Complications

Pathologic HO after contracture release has become rare, especially with the development of structured, supervised rehabilitation protocols in the immediate postoperative period. The use of pharmacologic prophylaxis has also limited the development of HO. Although reports are limited regarding the efficacy of postoperative radiation therapy or nonsteroidal antiinflammatory medications as postoperative prophylaxis for HO, the use of these modalities has been demonstrated to be effective in the prevention of HO formation after surgical procedures of the hip.[21] Our institution recently published a retrospective review demonstrating the efficacy of combined radiation therapy and the use of indomethacin after surgical resection of HO around the elbow, as well as after surgical procedures that carry a high risk of the development of HO. We typically prescribe 75 mg of oral indomethacin to be taken twice daily for 2 weeks after

TABLE 69-1

OUTCOMES AFTER ARTHROSCOPIC RELEASE OF ELBOW CONTRACTURE

Author	Methodology	Results
Savoie et al.[16]	24 patients; arthroscopic debridement of coronoid/olecranon processes; olecranon fossa 18 patients underwent radial head resection	Average arc of motion 131 degrees, improvement of 81 degrees; significant decrease in VAS pain score (preoperative 8.2; postoperative 2.2)
Ball et al.[17]	14 patients, arthroscopic contracture release	Average VAS satisfaction 8.4/10, VAS pain score 4.6/10; mean flexion increased from 117.5 to 133 degrees, and extension improved from 35.4 to 9.3 degrees; mean self-reported functional ability score was 28.3/30
Nguyen et al.[18]	22 patients, arthroscopic contracture release	Mean flexion improved from 122 to 141 degrees ($P < .001$); extension improved from 38 to 19 degrees ($P < .001$); mean arc improvement was 38 degrees ($P < .001$); the mean ASES-e score was 31/36
Kelly et al.[11]	25 elbows, arthroscopic debridement	24 were "better" or "much better" postoperatively, with 21 patients reporting minimal or no pain; the average flexion-extension arc improved by 21 degrees

ASES-e, American Shoulder and Elbow Surgeons–Elbow; *VAS,* visual analog scale.

surgery.[22] However, diligent radiographic follow-up is the best way to monitor these patients for the development of this complication.

In a retrospective review of elbow arthroscopies performed for various orthopaedic conditions, Kelly et al.[11,12] reported four cases of deep infection, 33 cases of prolonged drainage or superficial infection at a portal site, and 12 transient nerve palsies (affecting five ulnar nerves, four superficial radial nerves, one posterior interosseous nerve, one medial antebrachial cutaneous nerve, and one anterior interosseous nerve). Several other cadaveric studies have carefully described the relationship between neurovascular structures to portal sites and cannula positions; the work of these authors has improved the understanding of anatomy in the area of the elbow and emphasized the importance of judicious portal placement.[23,24]

Several authors have suggested that the risk of nerve injury may be higher with arthroscopic versus open contracture release, which may be attributed to several factors, including the surgeon's experience and the complexity of the surgery. The majority of iatrogenic nerve injuries occurred early during the initial reports of arthroscopic contracture release.[13,25-27] Based on our experience, we believe that the majority of intraoperative nerve injuries can be avoided through the diligent use of retractors, the avoidance of suction near a nerve, the use of a shaver instead of a burr near a nerve to avoid the "power-takeoff" effect in which the burr wraps tissue and pulls the nerve into it, and a thorough knowledge and understanding of where the nerves are and/or actually visualizing and retracting them. Most importantly, however, the surgeon may avoid a majority of these complications by recognizing the limits of arthroscopic technique and switching to an open approach in situations in which contracture release is difficult or cannot be safely performed.

For a complete list of references, go to expertconsult.com.

Suggested Readings

Citation: Morrey BF: The posttraumatic stiff elbow. *Clin Orthop Relat Res* 431:26–35, 2005.
Level of Evidence: IV
Summary: This review article summarizes the surgical treatments for posttraumatic contractures of the elbow, including open debridement and arthroscopic release. Salvage procedures such as interposition arthroplasty and total elbow arthroplasty are also discussed.

Citation: Jupiter JB, O'Driscoll SW, Cohen MS: The assessment and management of the stiff elbow. *Instr Course Lect* 52:93–111, 2003.
Level of Evidence: IV
Summary: The instruction course lecture describes the evaluation of the patient with posttraumatic contracture of the elbow and discusses both nonoperative and operative treatments for restoring elbow motion.

Citation: Cohen AP, Redden JF, Stanley D: Treatment of osteoarthritis of the elbow: a comparison of open and arthroscopic debridement. *Arthroscopy* 16(7):701–706, 2000.
Level of Evidence: II
Summary: This prospective series compared outcomes after the Outerbridge-Kashiwagi (O-K) procedure with an arthroscopic debridement of the olecranon fossa for mild osteoarthritis of the elbow. The authors found that the O-K procedure resulted in significantly better motion, whereas the arthroscopic procedure provided suitable pain relief.

Citation: Savoie FH 3rd, Nunley PD, Field LD: Arthroscopic management of the arthritic elbow: Indications, technique, and results. *J Shoulder Elbow Surg* 8(3):214–219, 1999.
Level of Evidence: II
Summary: The authors report the outcomes of 24 patients who underwent an arthroscopic modification of the Outerbridge-Kashiwagi procedure for elbow stiffness as a result of arthrosis of the joint. The average arc of motion was 131 degrees, representing an 81-degree improvement from preoperative motion.

Citation: Marshall PD, Fairclough JA, Johnson SR, et al: Avoiding nerve damage during elbow arthroscopy. *J Bone Joint Surg Br* 75B(1):129–131, 1993.
Level of Evidence: III
Summary: The authors conducted a cadaveric study investigating the position of portals in arthroscopy relative to the position of motor and sensory nerves within the elbow. Dissection of 20 specimens was undertaken, and the relative positions of the radial, median, and ulnar nerves are reported.