Contracture of the elbow is a common problem that can be associated with significant morbidity. Elbow contractures may be classified as either intrinsic (intra-articular) or extrinsic (extra-articular). Patients who have known risk factors for heterotopic ossification (HO) formation and who sustain significant elbow trauma should be given prophylaxis in the form of either indomethacin or radiation therapy. Early excision of HO has been shown to be safe and effective.

A careful assessment of elbow range of motion (ROM) is mandatory. From the history and physical examination, one needs to determine whether the patient has functionally limiting elbow ROM. Nonoperative measures that can help increase elbow ROM include physical therapy, splinting, and continuous passive motion (CPM). These measures are most effective if used within 6 months of the onset of elbow contracture. If these measures are unsuccessful, surgical intervention can then be considered.

Satisfactory results have been published for arthroscopic elbow contracture release; however, this is a technically challenging procedure with the potential for serious neurovascular complications. Satisfactory results have been published for open procedures as well. The direction of the greatest limitation of motion, the presence of ulnar nerve dysfunction, and the location of osteophytes all help to dictate which surgical approach is selected.

Anatomy
The elbow joint is a modified hinge joint, comprised of three articulations and contained within one synovial lining. The three articulations are the ulnotrochlear joint, the radiocapitellar joint, and the proximal radioulnar joint. Anteriorly, the coronoid process of the proximal ulna articulates with the coronoid fossa of the distal humerus. Laterally, the radial head articulates with the capitellum of the distal humerus. Posteriorly, the olecranon articulates with the olecranon fossa of the distal humerus. In the lateral plane, the articular surface of the distal humerus is rotated approximately 30° anteriorly. In the axial plane, the articular surface of the distal humerus is internally rotated approximately 3° to 8°. In the frontal plane, the articular surface is tilted approximately 6° in valgus.

The ulnar collateral ligament (UCL) is located on the medial aspect of the elbow and consists of three bands: the posterior band, the transverse band, and the anterior band. The posterior band is an expansion of the posterior capsule. The transverse band contributes little to the overall structure of the UCL. The anterior band is cord-shaped or fan-shaped. The origin of the UCL is posterior to the axis of flexion-extension.

The lateral collateral ligament complex is located on the lateral aspect of the elbow. It is comprised of the radial collateral ligament, the lateral ulnar collateral ligament, the accessory collateral ligament, and the annular ligament. The annular ligament secures the proximal radioulnar joint. Injury to the lateral UCL results in posterolateral rotatory instability of the elbow.

Etiology
Elbow contractures can be classified as either intrinsic or extrinsic. Common intrinsic, or intra-articular, causes include posttraumatic arthritis, joint incongruity, ankylosis of articular surfaces, articular adhesions, loose bodies, and...
osteoarthritis with bone spurs and proliferative synovitis. Common extrinsic, or extra-articular, causes include heterotopic bone formation, capsular contracture of scar, collateral ligament contracture, and musculotendinous contracture, most commonly the triceps.

Posttrauma
The most common occasion for the development of elbow contractures is the posttraumatic setting, where intrinsic changes set causal conditions in motion. The mechanism of posttraumatic elbow contracture is intra-articular effusions that induce the elbow joint to assume a position of flexion. This position maximizes elbow capacity, thus, minimizing pressure in the joint. The capsule then thickens, limiting both flexion and extension, resulting in posttraumatic elbow stiffness.

Elbow dislocations have been closely associated with elbow contractures. On average, simple dislocations have been associated with a 10° loss of terminal extension. The capsule and collateral ligaments are torn in all cases of elbow dislocation. In a study of 200 elbow contractures, Mohan showed that 58% were secondary to periarticular fracture-dislocations. Concomitant fracture, along with dislocation, increases the risk of heterotopic bone formation. The incidence of HO in the elbow, following elbow trauma, ranges in the literature from 1.6% to 56%. The rate has varied, depending on the type of injury, and generally increases with fracture severity. Associated fractures include radial head, radial neck, coronoid, epicondyles, and unrecognized osteochondral fractures.

Heterotopic Ossification
HO is the most common extrinsic cause of elbow contracture. Heterotopic bone or ossification is defined as the formation of mature lamellar bone in nonosseous tissues. Myositis ossificans is defined as the formation of HO in inflammatory muscle. Periarticular calcification is defined as collections of calcium pyrophosphates within soft tissues. Periarticular calcification lacks trabecular organization and occurs in distinct structures, such as the collateral ligaments and the capsule.

Direct elbow trauma is the most common cause of HO around the elbow. Other causes include neural axis trauma (Fig. 1), thermal injury, and a genetic disorder termed, fibrodysplasia ossificans progressiva. This is a rare disorder that is characterized by progressive ossification of soft tissues. The incidence of HO seems to be directly correlated to the magnitude of the injury. In a series of isolated elbow dislocations, Thompson and Garcia reported a 3% incidence of HO. When the dislocation was combined with an additional fracture, in proximity to the elbow or a fracture of the radial head, the incidence rose to 16% and 20%, respectively. Therefore, the incidence of HO is five-times greater if there is an associated fracture along with the elbow dislocation.

Important elements of the patient history include subjective descriptions of pain, stiffness, sensory loss, or weakness. Difficulties with vocational or recreational activities must be documented. The timing, duration, onset of elbow contracture, and previously used treatment modalities should be ascertained. The physical examination of a patient with HO begins with the evaluation of the soft-tissue envelope. The skin is inspected with care, noting areas of skin loss or previous scars. Local tenderness is present in the majority of cases; foci of HO are often palpable. Passive and active elbow and forearm ROM should be accurately recorded. A complete neurovascular assessment should be performed. Careful attention should be paid to the presence of potential nerve palsies, with the ulnar nerve being the most commonly affected.

No laboratory value has been consistently correlated with HO activity or with HO recurrence after resection; therefore, routine laboratory assessment is unnecessary. The radiologic assessment for HO consists of standard anteroposterior and lateral plain films of the elbow. Most HO will be evident on plain films by 6 weeks after injury. Early radiographic HO has indistinct margins and lacks trabeculations. Mature HO has sharply defined margins on plain films with observation of trabeculations. Computed tomography (CT) scans can be helpful to better evaluate the articular geometry. Axial scans provide a good view of both the ulnotrochlear joint and the proximal radioulnar joint. A technetium bone scan turns positive before clinical manifestations of HO are usually apparent and before the plain film radiographs are positive for HO.

Hastings and Graham developed a classification system of HO, based on functional limitation. Class I includes radiographically evident HO but without functional limitation. Class II includes limited, yet functional, range of elbow motion. Class II can be subdivided into IIA, IIB, and IIC.
Limitation in the flexion-extension plane is IIA, limitation in the pronation-supination plane is IIB, and limitation in both planes is IIC. Class III includes ankylosis of the particular articulation. Class III can be subdivided into A, B, and C, in the same manner as Class II. Evans noted that bridging bone in one plane is amenable to excision with good functional return and low recurrence rate, whereas synostoses in two or more planes showed diminished results.6

There are several risk factors that may predispose a patient to form HO. These risk factors include significant elbow trauma, head injuries, burns, genetic predisposition, history of diffuse idiopathic skeletal hyperostosis, ankylosing spondylitis, Paget’s disease, hypertrophic osteoarthritis in males, and a history of previous HO. A patient with significant elbow trauma and/or one or more of the above risk factors should receive prophylaxis in an attempt to prevent the formation of heterotopic bone.

Prophylaxis of HO includes chemotherapy and radiotherapy. The most commonly used group of chemotherapeutic agents are the nonsteroidal anti-inflammatory agents (NSAIAs), represented by indomethacin. NSAIAs are thought to act by preventing precursor cells from differentiating into osteoblasts. Their efficacy has been documented in surgery about the hip; however, the role of indomethacin relative to the elbow is still unknown.

Low dose external beam radiation has also been used as prophylaxis against HO. Radiotherapy is a local measure that acts by inhibiting osteoblastic precursor cells. Radiotherapy has been shown to inhibit HO formation after total hip arthroplasty.8 Studies are now being performed to evaluate its efficacy around the elbow. Heyd and colleagues reported the use of preoperative or postoperative radiation therapy combined with excision of elbow HO in nine patients.9 They reported no recurrences of HO during a mean follow-up period of 7.7 months. The standard radiation dose has been a single dose of 600 rads to 700 rads, administered within 72 hours of elbow trauma. Kim and coworkers performed a 50-year retrospective review and found no radiation-induced sarcomas at levels less than 3000 rads that were delivered within a three-week period.10 Thus, the single dose of 600 to 700 rads appears safe.

Functionally limiting HO can be treated surgically. The goal should be to resect all clinically significant HO. One should use prophylaxis with either indomethacin or radiotherapy to prevent recurrence of HO. Safe contracture release and excision of HO can be performed as early as 3 to 6 months after injury. The notion of waiting for HO to mature before excision has been challenged recently by several investigators. Viola and Hanel reported on 15 elbows treated with HO excision at an average time from injury of 23 weeks.11 The mean preoperative arc of flexion-extension was 43°, improving to 120° at two-year follow-up. The mean preoperative arc of pronation-supination was 79°, improving to 152° at two-year follow-up. The investigators reported no recurrent contractures or loss of motion and concluded that early HO excision could be effective.

**Treatment of Elbow Contractures**

**Nonsurgical Treatment**

The management of elbow contractures begins with prevention. Best results are obtained if nonoperative measures are started within 6 months of the injury. Early elbow motion is instituted after traumatic injuries and with other conditions that precipitate inflammation around the elbow joint. NSAIAs combined with physical therapy modalities can help to increase as well as to maintain motion.12

Static progressive (turnbuckle) splints are often well tolerated by patients. These splints are most helpful for patients with a 25° to 40° flexion contracture. The force across the elbow joint can be varied with the turnbuckle. Gelinas and colleagues reported on 22 patients treated with turnbuckle splinting for a mean of 4.5 months.13 Mean ROM before splinting was 32° to 108°. After splinting, mean ROM improved and was 26° to 127°. The investigators concluded that turnbuckle splinting was a safe and effective treatment for established elbow contractures that previously failed physical therapy.

The use of CPM is controversial and may have a limited role in treating established elbow contractures. Gates and coworkers reported on 33 patients in a prospective, nonrandomized study.14 Group 1 had an anterior capsulotomy, and group 2 had an anterior capsulotomy with the postoperative use of CPM. Increased active flexion and total arc of motion was seen in group 2. However, this was a nonrandomized study that included possible selection biases.

If a functional motion deficit still exists after a course of both physical therapy and splinting, further nonoperative management is unlikely to be successful. At this point, surgical treatment should be considered.

**Surgical Treatment**

When nonsurgical treatment fails, the patient with realistic expectations may be a surgical candidate. Preoperatively, a careful assessment of motion loss is mandatory. Document both passive and active elbow ROM. Morrey and colleagues determined that the functional ROM required to perform 90% of normal daily activities is an extension-flexion of 30° to 130° and pronation-supination of 50° to 50°.15 Terminal flexion is more important in performing activities of daily living than terminal extension. Therefore, improved extension should not be obtained at the expense of flexion. An effort should be made to increase elbow flexion when it is less than 105°. These patients will have difficulty with simple, important tasks such as buttoning a shirt collar, shaving, tying a neck tie, or putting on earrings. An effort should be made to increase elbow extension when extension deficits are greater than 40°. These patients will benefit from improved motion and should be considered for contracture release.

Careful preoperative assessment of the ulnar nerve is mandatory. The ulnar nerve is vulnerable to injury, scar-
ring, and dysfunction. If the ulnar nerve is entrapped or shows signs of significant dysfunction, one should perform a neurolysis at the time of contracture release. This can be helpful by restoring sensibility and strength in the proximal muscles innervated by the ulnar nerve. Also, patients with severely limited flexion, who undergo elbow contracture release, require ulnar nerve transposition. If there is the potential for significant postoperative gains in elbow flexion, then the ulnar nerve should be transposed in order to avoid the nerve from becoming tethered postoperatively.

**Arthroscopic Release**

Elbow arthroscopy has become an increasingly useful tool in the setting of elbow contractures. Jones and Savoie reported on 12 patients who underwent arthroscopic release of the proximal capsule and debridement of the olecranon fossa.\(^\text{17}\) Mean preoperative flexion contracture of 38° decreased to 3° postoperatively. Flexion increased from 106° preoperatively to 138° postoperatively. They reported one permanent posterior intersosseous nerve palsy. The investigators concluded that limited arthroscopic capsular release appears to be a satisfactory treatment for elbow flexion contracture.\(^\text{16}\) Despite these good results, arthroscopic elbow contracture release remains a technically challenging procedure. Haapaniemi and coworkers reported a case of complete transection of the median and radial nerves during arthroscopic release of a posttraumatic elbow contracture in a 57-year-old female.\(^\text{17}\)

**Open Release**

Various approaches can be utilized to release the contracted elbow. The anterior approach was described by Urbaniak and colleagues in 1985.\(^\text{18}\) The medial “over-the-top” approach was described by Hotchkiss in 1997.\(^\text{19}\) The lateral approach (column procedure) was described by Morrey in 1990.\(^\text{20}\) Factors such as existing scars, suppleness of the skin, and location of intra-articular pathology help to determine which approach should be utilized.

The anterior approach allows access to the anterior capsule, brachialis muscle, and biceps tendon; however, the neurovascular structures must be manipulated. One must be certain that no posterior pathology is present, as the olecranon fossa cannot be visualized with the anterior approach. The anterior approach should be used for extrinsic contractures that limit extension. Flexion should be greater than 120°. Radiographically, the joint surface should be essentially normal. Urbaniak and coworkers reported on the results of 15 patients with posttraumatic elbow stiffness. These patients were treated with limited anterior capsulotomy through an anterior approach. At an average follow-up of 45.5 months, extension improved from 48° to 19°. Three patients had transient neurapraxia.\(^\text{18}\)

The medial “over-the-top” approach can also be used for elbow contracture release. The medial approach is preferred if the ulnar nerve requires exploration or release, there is a significant lack of flexion, or if there are osteophytes present along the posterior medial joint line. Limits in both extension and flexion can be addressed with this approach. Disadvantages of the medial approach include difficulty in removing heterotopic bone on the lateral aspect of the joint and that the medial approach provides poor access to the radial head.\(^\text{19}\) If forearm rotation is limited, then the lateral column procedure is preferred.

Recent results of elbow contracture release with the medial approach have been encouraging. Wada and colleagues reported on 14 elbows that underwent the medial approach to excise the posterior oblique bundle of the UCL, the anterior capsule, and the posterior capsule.\(^\text{21}\) Average follow-up was 57 months. Elbow extension improved from 43° to 17°. Elbow flexion improved from 89° to 127°. They concluded that the medial approach is a safe and effective method by which to correct posttraumatic contracture of the elbow. Thus, satisfactory results have been obtained with the use of the medial approach for elbow contracture release.

The lateral approach (column procedure) can also be used for elbow contracture release. The lateral approach is preferred for patients with a loss of extension of at least 40° and in patients with restricted forearm motion. Extrinsic pathology that has minimal articular surface change responds well to the lateral approach. However, the medial approach is favored in cases with ulnar nerve dysfunction or the presence of extensive medial HO. The column procedure consists of elbow arthrotomy, release of anterior and posterior capsules, and excision of osteophytes.\(^\text{20}\)

Recent results of elbow contracture release with the lateral approach have also been encouraging. Manset and Morrey reported on 38 elbows with extrinsic contracture that were treated with a lateral approach.\(^\text{22}\) Mean follow-up was 43 months. Mean arc of motion improved from 49° to 94°. Thirty-one elbows (82%) had a satisfactory result. Two elbows had hematoma formation and two elbows had transient ulnar paresthesia. The study concluded that the column procedure is associated with a low rate of complications and is a safe and effective approach for releasing extrinsic elbow contractures.\(^\text{22}\) Thus, good results can be obtained with the lateral approach as well.

**Summary**

Etiologies of elbow contractures can be classified into intrinsic versus extrinsic causes. Posttraumatic elbow stiffness is the most common intrinsic cause and HO formation is the most common extrinsic cause of elbow contractures. Patients who sustain significant elbow trauma and have one or more risk factors for HO formation should be given prophylaxis against HO formation in the form of either indomethacin or radiation therapy. Early excision of HO has been shown to be safe and effective.

Nonoperative measures are most effective if used within 6 months of contracture onset. These measures include physical therapy and an aggressive splinting program. If nonoperative measures are unsuccessful and the patient has
functionally limiting elbow ROM, then surgical intervention should be considered. Careful preoperative assessment of the ulnar nerve is mandatory, as it may need to be transposed. Satisfactory results have been reported with arthroscopic elbow contracture releases. However, this procedure is technically challenging, with the potential for serious neurovascular complications. Satisfactory results have been published for open procedures as well. The direction of the greatest limitation of motion, the presence of ulnar nerve dysfunction, and the location of osteophytes all help to dictate which surgical approach should be selected.

References