Loss of elbow function can severely affect activities of daily living as well as sport participation. Elbow injuries in sports are most commonly seen in throwing athletes where acute or chronic stresses can lead to problems in the soft tissue structures about the elbow joint as well as injury to the bones and articular surfaces. In other instances, contact injury or sudden tissue overload can lead to acute tendon or ligamentous rupture. Although many elbow problems respond to routine nonoperative measures including periods of activity modification and physical therapy, others may ultimately require surgery to restore satisfactory function. Following surgery, appropriate attention to rehabilitation is important to achieve optimal function. If return to sport is a desired goal following surgery, specific rehabilitation protocols may serve as a useful guide for the athlete and therapist. Although such protocols are typically based on time frames following surgery, the decision to return to sport is ultimately based on a critical assessment of when acceptable function has been restored and the risk of reinjury is believed to be acceptably low or minimized. This critical decision cannot be based on arbitrary postoperative time frames; instead, it must be based on an understanding of the sport-specific functional demands on the elbow in the context of the tissue biology and healing processes for the procedure performed. In addition, the feasibility of functional bracing may have an impact on the decision to return an athlete to sport at various time frames postoperatively.

Injuries to the elbow are common in sports, particularly in the overhead athlete or thrower, in whom repetitive forces across the elbow during sport can result in many different problems. For the clinician managing elbow injuries, an understanding of the biomechanics of throwing is imperative. This subject has been thoroughly reviewed elsewhere [1–3]. The mechanical forces with throwing are maximal during the acceleration phase during which a tremendous valgus force occurs across the medial elbow. Tissue injuries that involve the flexor pronator mass or underlying ulnar collateral ligament can result. The fulcrum-like activity of
the olecranon within the humeral fossa can result in painful posteromedial osteophytes or olecranon stress fracture.

Other sports such as tennis or crew may place higher demands on the lateral elbow, potentially resulting in lateral epicondyliitis. Contact sports such as football or rugby, or power sports such as wrestling or weightlifting may place sudden high loads across the elbow joint and associated muscles and lead to sudden tendon failure of the biceps or triceps.

For some injuries, surgery is the primary option; for others, surgery is required only when nonoperative treatment fails and the athlete is unable to perform at the desired level. Following surgery, the ultimate goal is to return the individual back to the desired sport at the same or higher level. For most athletes there is a critical balance between time off to fully rehabilitate and the risk of reinjury. This is a particular problem in an era in which “accelerated rehabilitation” has come to be the expected approach in the sports medicine population. Although surgical techniques have been refined to minimize postoperative morbidity and speed recovery times, physicians, therapists, and athletes must understand the inherent structural, mechanical, and biologic limits of any given condition. These limits are impossible to quantify perfectly for any one individual at any particular point in time, but general guidelines do apply and can be used. These guidelines have been established by basic science (understanding the biomechanical forces at play during sporting activity, initial tissue construct strengths following surgery, and so forth) and clinical practice.

Following elbow surgery, rehabilitation issues are twofold: those involving the elbow itself and those involving the entire body or the rest of the kinetic chain important to that individual’s particular sport. Although total body rehabilitation or conditioning is typically incorporated during the rehabilitation process, the focus of this article is on issues relating to the elbow itself. Given that most elbow injuries are seen in throwers or overhead athletes, a basic understanding of rehabilitation considerations in the throwing athlete is required. For example, once basic tissue and bone integrity and functional range of motion and strength have been restored at the elbow, the throwing athlete is typically progressed through an interval program that reconditions the entire kinetic chain so that he or she can return to competition at a minimized risk of reinjury. Improper lower extremity or shoulder mechanics and conditioning can elevate the risk of elbow reinjury. For an understanding of the thrower’s comprehensive rehabilitation program, the reader is referred elsewhere [4–6].

Valgus extension overload

Valgus extension overload is most commonly seen in pitchers. This condition results from the repetitive posteromedial elbow stress that occurs with the pitching motion: the valgus stress across the medial elbow as the arm moves into extension causes increased contact stress between the olecranon process, medial olecranon, and adjacent humerus. Painful osteophytes can form and an
acquired flexion contracture may develop. Associated findings of ulnar neuritis or frank ulnar collateral deficiency may coexist and will be discussed separately. In nonthrowing sports such as football, posterior fossa osteophytes may also develop from the chronic stresses of lifting and athletic maneuvers such as repetitive extension with blocking.

Radiographic studies including plain films, CT, and MRI are useful in identifying the presence of osteophytes and occasionally resultant loose bodies [7,8]. Debridement of the osteophytes either arthroscopically or openly may be indicated for those individuals for whom nonoperative treatment fails [9–11].

Debridement of the posteromedial compartment and posterior fossa can be performed by way of a limited open arthrotomy that protects the ulnar nerve and triceps insertion. Arthroscopic debridement allows for complete inspection of the anterior and posterior compartments of the elbow and may limit morbidity when compared with debridement by way of arthrotomy. Access to the posterior compartment that is the prime site of pathology in valgus extension overload is typically obtained by way of direct posterior (central triceps) and posterolateral portals [12,13]. Following arthroscopic or open debridement, passive and active range of motion can be started immediately, because avoidance of postoperative contracture is imperative. There is no need for strict immobilization, because neither arthrotomy or arthroscopy should violate any of the critical stabilizing tendinous or ligamentous structures about the elbow. Postoperative pain is typically the controlling factor and activities are advanced as the pain subsides. As range of motion improves, muscle strengthening and conditioning can be initiated. For throwing athletes, a traditional throwing program can typically be introduced at 6 to 8 weeks, provided that full range of motion and strength have been established [4].

Fig. 1. Lateral radiograph of a football player who presented with loss of elbow extension and loose body symptoms. The large posterior fossa loose body was removed by way of a limited posterolateral arthrotomy. The player underwent aggressive rehabilitation and was participating in practice without limitation at 5 weeks postoperatively. He regained full range of motion.
The criteria for return to play following elbow debridement are purely functional and are based on pain, functional range of motion, and functional strength. The overall sport-specific conditioning of the athlete will also need to be taken into consideration if the athlete has missed any length of time from the injury and subsequent surgery. Because there is no period of tendon or ligament healing involved, one can be relatively aggressive with return to play once adequate elbow function is believed to have been restored. Return to play may be as early as 6 to 8 weeks in nonthrowing sports such as football but typically is 3 to 4 months for individuals in throwing sports such as baseball (Fig. 1). The longer recovery time for throwers is attributed to the intricate demands placed on the elbow combined with the need to recondition the entire kinetic chain (legs, trunk, and shoulder) by way of a deliberate throwing program to avoid reinjury at the elbow or elsewhere. In addition, bracing may be an option in nonthrowing sports. Pain in the terminal few degrees of extension may persist for several weeks following debridement, and extension block bracing or taping may allow acceptable sports-specific function and return to sport despite some residual soreness.

Ulnar collateral ligament tears

Ulnar collateral ligament tears are most common in baseball pitchers but can also been seen in position players and other sports such as javelin, wrestling, and football [14]. Most commonly, tears of the ligament result from repetitive microtrauma, which may eventually lead to attenuation or elongation of the ligament and subsequent functional incompetence or frank rupture of the ligament from a single pitch or athletic maneuver (Fig. 2). In contact sports such as football and wrestling, ulnar collateral ligament tears may occur in conjunction with simple elbow dislocation. Although resultant instability is uncommon, acute ulnar collateral ligament repair or delayed reconstruction is sometimes required.

Fig. 2. MRI showing an acute complete proximal ulnar collateral ligament tear (arrow) in a professional baseball player. The player had been experiencing medial elbow pain with throwing but did not seek evaluation until a painful pop occurred with a single outfield throw.
Ulnar collateral ligament reconstruction is now a relatively common procedure, with most individuals returning to their prior level of play or better. The anterior band of the ulnar collateral ligament is believed to be the primary stabilizer of the elbow to valgus stress between the range of $0^\circ$ to $120^\circ$ of flexion [15–17]. The ultimate tensile strength of the ulnar collateral ligament has been reported to be 34 Nm [18]. Valgus stress across the elbow with throwing and the overhead tennis serve exceeds this amount, although some of the stress is shared by the overlying flexor pronator musculature [2,19]. With repetitive loads, tearing of the ligament can occur, and sports-related disability can result. Specific details on the evaluation and diagnosis and nonoperative treatment options for ulnar collateral ligament injury is detailed elsewhere [14,20–22].

Surgical intervention is indicated for those individuals in whom nonoperative treatment fails but who desire to return to athletic competition. Primary ligament reconstruction has replaced primary repair as the preferred surgical option in most cases [10,23–26]. The surgical technique involves placing a free tissue graft—usually the palmaris longus tendon—through bone tunnels in the medial epicondyle of the humerus and at the sublime tubercle of the ulna. This technique was initially reported by Jobe and Stark [26], and other authors have subsequently reported slightly modified techniques [27].

Jobe and Stark’s [26] initial technique involved detachment of the flexor pronator origin and routine transposition of the ulnar nerve. Others have subsequently advocated ligament reconstruction through a split in the flexor pronator musculature and have suggested that routine ulnar nerve transposition should be performed only in individuals who have preoperative symptoms of ulnar neuritis [28,29]. In an attempt to simplify graft passage and tensioning, use...
of soft tissue anchors has been reported, as have modified tunnel techniques (eg, the “docking technique”) [14,27,30,31].

Rehabilitation following surgery is based on the technique of reconstruction (initial graft security) and the technique of ulnar nerve transposition, if done. The elbow is typically immobilized for 7 to 10 days in a splint between 45° and 90° of flexion. Subsequently, a hinged brace is used to protect the elbow from valgus stress, and range of motion is progressively restored so that full range is achieved by 6 weeks postoperatively. Isometric activities begin at 4 weeks, and limited progressive strengthening is introduced at 8 weeks. Advanced strengthening and plyometric activities can begin at 12 weeks. At 4 months, acceptable graft incorporation should be present, allowing the athlete to advance to progressive strengthening and sport-specific activities. For throwers, a formal throwing program can be introduced provided that range of motion and baseline strengthening are present. For throwers, return to competition can often be achieved after 8 to 9 months. Studies have indicated a 68% to 97% rate of return to play in athletes (Table 1) [25,26,32,33].

Different guidelines may apply for nonthrowers such as wrestlers or football players in whom ulnar collateral ligament reconstruction has been performed for the rare instance of instability following acute dislocation. Once strength and motion have been achieved (often by 4 to 5 months), these athletes are more at risk for reinjury from contact as opposed to repetitive stress. Functional bracing may protect from recurrent macrotrauma, is an option for practice and competition for football players and may, after proper discussion with the athlete, be considered with return to sport allowed as early as 4 to 5 months. In wrestlers, practice or drilling may be allowed in a well-padded brace, with unprotected activity allowed at 6 months. For all athletes, protective bracing likely can be discontinued at 8 or 9 months postoperatively. Although there are no scientific studies that have evaluated the efficacy of bracing or the biology of ligament healing or incorporation in the clinical setting, this rationale is based on clinical experience; a similar rationale is used in the management of knee ligament injuries.

Table 1

<table>
<thead>
<tr>
<th>Reference</th>
<th>Patients (N)</th>
<th>Return to prior level</th>
<th>Average return to play</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jobe and Stark [26]</td>
<td>16</td>
<td>10/16 (63%)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Conway et al [25]</td>
<td>56</td>
<td>38/56 (68%)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Azar et al [32]</td>
<td>59</td>
<td>48/59 (81%)</td>
<td>9.8 months</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>12 months (professional)</td>
</tr>
<tr>
<td>Thompson et al [28]</td>
<td>83</td>
<td>77/83 (93%)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Rohrbough et al [27]</td>
<td>36</td>
<td>33/36 (96%)</td>
<td>9 months</td>
</tr>
</tbody>
</table>

*Free tissue sutured side-to-side; submuscular ulnar nerve transposition.
*Free tissue sutured side-to-side; subcutaneous ulnar nerve transposition.
*Muscle splitting approach; free tissue sutured side-to-side; nerve not routinely transposed.
*Muscle splitting approach; free tissue docking technique; nerve not routinely transposed.
Olecranon stress fracture

Olecranon stress injury and stress fractures have been reported in javelin throwers, gymnasts, baseball pitchers, and weight lifters [34–39]. The mechanism is repeated valgus stress such as that described previously with valgus extension overload. In addition, triceps traction and forced extension may contribute. Clinically, athletes develop posteromedial or posterior elbow pain with activity and have pain to direct palpation over the olecranon as well as discomfort to forced elbow extension. Loss of extension may be present. Plain radiographs or CT scan may show a stress fracture line. Alternatively, bone scan or MRI may make the diagnosis by showing reactive marrow edema with or without a discrete stress fracture [39].

For athletes who have symptomatic stress injury without a defined fracture, nonoperative treatment is typically successful [39,40]. Throwing is prohibited for 4 to 8 weeks, at which point a traditional throwing program can be initiated and progressed provided that the athlete remains pain-free. Return to competition is typically 2 to 4 months.

In the presence of a definitive stress fracture, surgery is indicated if nonoperative treatment fails or if one desires to reduce the time to return to sports, because nonoperative treatment may require as long as 6 months in some cases and may fail to resolve the problem altogether in others. Tension banding and screw fixation have been reported [22,36,37,41,42]. Bony union with return to sports has been reported to take between 3 to 6 months after surgery [36,42].

Ulnar nerve transposition

Symptoms related to the ulnar nerve can be seen in athletes, most commonly in throwers who have ulnar collateral ligament instability [43]. In others, symptoms may result from repetitive nerve subluxation from the cubital tunnel that occurs with repetitive elbow flexion and extension during sports [44]. Up to 16% of the general population have a subluxing ulnar nerve, which may predispose to symptoms with repetitive athletic activities [45]. Surgery is reserved for individuals in whom nonoperative treatment fails; there is some controversy with regard to the recommended procedures, which vary from in situ decompression to either submuscular or subcutaneous transposition [44,46–49]. In athletes who have ulnar nerve symptoms associated with ulnar collateral ligament insufficiency, surgery must address the ligament as well as the nerve. For athletes who do not have ligament insufficiency, an isolated transposition can be performed.

Submuscular transposition involves transposing the nerve to an anterior position beneath the flexor pronator mass [26,45,49,50]. Because of concerns over the morbidity to the flexor pronator with submuscular transposition, subcutaneous transposition has gained popularity [10,32,51,52]. Subcutaneous transposition does not violate the flexor pronator origin, but it does use a small strip of overlying fascia.
Following submuscular transposition, the flexor pronator origin must be protected in the early course of rehabilitation. Although elbow range of motion is generally started by the second week postoperatively, aggressive strengthening of the flexor pronator mass cannot begin until there is tendon–tendon healing. Thus aggressive strengthening cannot commence until 8 to 10 weeks postoperatively. For throwers, a throwing program cannot be initiated until the flexor pronator strength has recovered and any associated pain has resolved. Typical return to sports is at 5 to 6 months. In some individuals, soreness may persist at the flexor–pronator origin that delays functional strength recovery for a longer period.

In contrast, rehabilitation may be more aggressive following subcutaneous transposition. Range of motion can begin within the first 7 to 10 days, and flexor pronator strengthening can commence as early as 3 to 4 weeks postoperatively and be advanced as tolerated. For throwers, an interval throwing program can be started at 8 weeks, and return to competition can occur between weeks 12 and 16 [4,51].

Epicondylitis

Medial and lateral epicondylitis are common overuse injuries seen in the lay population. In athletes, it may result from weight training activities or from sport-specific activities in golf, tennis, crew, and the various throwing sports [53]. Nirschl and Pettrone [54] have identified the underlying histopathology as “angiofibroblastic hyperplasia,” in which the normal collagen architecture is disrupted. The descriptive term “angiofibroblastic tendinosis” is now commonly accepted [55]. The need for surgery is uncommon, because the vast majority of medial and lateral epicondylitis cases respond to nonoperative treatment consisting of activity modification, stretching, and strengthening. Oral anti-inflammatory medications, corticosteroid injections, and counterforce bracing may also be beneficial. Surgery is an option when the above measures fail [55,56].

Surgery for medial epicondylitis involves open debridement of the deep degenerative tendon tissue of the flexor pronator origin, often by way of a longitudinal split between the pronator teres and flexor carpi radialis [57]. In other cases, the origin can be dissected transversely off bone and reflected [58]. With either exposure, the deep ulnar collateral ligament must be identified and protected. Once the abnormal tendinous tissue is debrided, the exposed bone of the medial epicondyle can be prepared with either drilling or curettage, and the remaining healthy fibers can be repaired over or reattached to the epicondyle.

Surgery for debridement of lateral epicondylitis can be performed either openly or arthroscopically [55]. Open debridement is performed in much the same fashion as for medial epicondylitis and typically involves a split between the overlying extensor carpi radialis longus and common extensor origin to gain access to the degenerative fibers of the underlying extensor carpi radialis brevis and extensor digitorum communis [54,59]. Arthroscopic debridement does not
violate the overlying tendons and gains access to the extensor brevis by using traditional anterior arthroscopic portals and debriding the lateral capsule at the level of the capitellum just anterior to the lateral epicondyle [59–61].

Following surgery for epicondylitis, the elbow is splinted for 7 to 10 days before passive and active range of motion at the elbow and wrist are begun. The progression of strengthening activities and subsequent return to sports are ultimately dependent on the integrity of the common tendinous origin: if a substantial split or detachment has been performed at the time of surgery, patients typically experience more pain and the progression of strengthening activities needs to be controlled to avoid postoperative detachment of the repair. If detachment of the common origin occurs, relative lengthening of the muscle–tendon unit results, which can lead to persistent muscle weakness and ultimately permanent functional impairment [56,62]. For open debridement, isometric activities can be initiated at 3 to 4 weeks and progressive resistance training can be initiated at 6 to 8 weeks. From that point, activities can progress as tolerated, including introduction of a throwing program for overhead athletes. If a substantial detachment of the flexor extensor or flexor origin has occurred, aggressive progressive resistance training may need to be delayed until 8 to 10 weeks to avoid detachment of the repair.

Following arthroscopic debridement for lateral epicondylitis, with the exception of the pathologic tissue, the common extensor origin is not violated and rehabilitation can be more aggressive. Active range of motion can be started immediately, as can isometric activities. Progressive resistance activities can be introduced as early as 3 to 4 weeks postoperatively, and subsequent return to sport can occur based on routine functional criteria. Return to work and sport may be significantly accelerated in arthroscopic release compared with open release [55,63].

During rehabilitation, individuals who participate in racquet sports should assess their grip size and racquet size and composition, as well as their swing mechanics. A stiffer racquet with a larger grip, and less wrist flexion at and following ball impact, combined with a two-handed backhand technique, may all help to diminish the risk of recurrence [3,5,58,64]. The use of counterforce bracing may also facilitate recovery and can be used as early as 3 to 4 weeks postoperatively up to and during return to high-level sports [55]. Multiple authors have reported their surgical techniques and results, and 75% or more of individuals have returned to sport [57,58]. Given the intricate demands placed on high-level throwers, return to competition at this level is typically not achieved until 6 months or longer [65].

**Triceps tendon rupture**

Triceps tendon ruptures are uncommon but they do occur in contact sports such as rugby and football. Ruptures have also been observed in weight lifters [66,67]. The standard of care for complete ruptures is primary surgical repair in
which the tendon is repaired directly back to bone using suture-to-bone tunnel techniques [68,69].

The rehabilitation protocol is dependent on the initial fixation strength of the repair as well as the time frame for tendon–bone healing. Following surgical repair, the elbow is typically immobilized for 2 to 4 weeks before passive range of motion is initiated. The initial passive range of motion (eg, over an arc from full extension to 40° of flexion) may be based on immediate intraoperative findings; following suture repair, the elbow is carefully brought into flexion and the earliest point at which tension develops across the repair is noted. Once passive motion is initiated, the arc of motion can be advanced at a rate of 10° to 15° every 7 to 10 days. Active range of motion is started around 5 to 6 weeks. Careful limited isometrics may begin at 8 to 10 weeks, but heavier lifting should be avoided for 4 to 6 months, at which time adequate tendon–bone healing should have occurred [68]. Noncontact activities such as running can begin at 3 months. Return to contact sports is delayed until functional range of motion is restored, symmetric triceps strength is present, and there is no pain or tenderness at the repair site (typically 6 months or longer) [70].

**Distal biceps tendon ruptures**

Distal biceps tendon ruptures occur more commonly than ruptures of the triceps but are still relatively uncommon. Rupture is felt to occur as a result of high-energy rapid eccentric overload in the face of pre-existing subclinical tendinosis [71–73]. As with the triceps, the standard of care in the athletic population is primary surgical repair [68,74,75]. Surgical repair involves direct reattachment to the tendon to the radial tuberosity. One-incision and two-incision techniques have both been reported [69,75,76].

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**Fig. 4.** MRI of an acute distal biceps tendon rupture (*arrow*) in a 42-year-old male who was injured while lifting weights for general fitness. He underwent primary surgical repair by way of a two-incision technique. He returned to recreational jogging at 3 months and recreational weight lifting at 5 months. He regained full motion and strength.
Similar to rehabilitation following triceps repair, postoperative activities are dictated by the strength of the initial repair and tendon–bone healing. The arm is typically immobilized at 90° of elbow flexion (with the forearm in neutral supination–pronation) for 2 to 3 weeks, at which point passive range of motion is started. Passive range for flexion–extension is started over an arc of full flexion to 90° and is advanced at a rate of 10° to 15° per week. The terminal 20° to 30° of extension are limited for the first 5 weeks to protect the repair. Passive pronation and supination are also started at 3 weeks and advanced 5° to 10° per week. Active flexion and supination are avoided until 6 weeks, and aggressive strengthening and higher end plyometric activities are avoided until 3 to 6 months (Fig. 4). Although individuals can return to jogging for cardiovascular conditioning at 3 to 4 months, return to contact sports or other unrestricted upper extremity activities is 6 months or longer. With proper surgical technique and rehabilitation, results are typically excellent, with nearly full recovery of strength and function [77,78].

Summary

Although less common than injuries to the knee or shoulder, elbow injuries can be a substantial challenge to the sports medicine provider. Most common are the spectrum of elbow injuries seen in the throwing athlete, where the repetitive demands on the elbow are unique and pose a potential risk to the bones and soft tissues about the joint. Overuse injuries that subsequently impair an athlete’s ability to play at the desired level can result. Surgery may be an option for those individuals who do not respond to nonoperative treatment. In other sports, such as football, contact injury or macrotrauma can lead to substantial structural injury requiring surgery. The proper care of the athletes before and after surgery requires an understanding of the anatomy and sport-specific biomechanics of the elbow in conjunction with an understanding of the biology of muscle and tendon recovery after surgery. With an understanding of these issues, proper rehabilitation can be pursued and reasonable goals for return to play can be targeted. In the majority of instances, the athlete can successfully return to play and the risk of reinjury or suboptimal outcome can be minimized.

References


