Chapter 35

Elbow Injuries and the Throwing Athlete

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ABSTRACT

The stress of repetitive overhead throwing on the elbow causes many injuries in throwers, requiring medical intervention ranging from conservative rest and physical therapy to surgery with lengthy postoperative recovery. Proper evaluation of throwing injuries with targeted history-taking, physical examination, and diagnostic imaging are essential in making correct diagnoses and guiding interventions. Most, if not all, of elbow injuries in throwers are amenable to conservative treatment options, which generally produce acceptable return-to-sport rates. If initial therapy fails, surgical techniques continue to advance with improved patient outcomes and more throwers returning to their prior level of play. Medical management of elbow injuries is continuously evolving, with improvements to existing interventions as well as novel new interventions on the horizon, which will continue to optimize elbow injury prevention and treatment in throwers.

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Introduction

Overhead throwing imparts substantial stress to the elbow and can cause unique injuries. Biomechanical and clinical studies have elucidated the causative factors in these injuries and have allowed prevention and treatment strategies to evolve. The diagnosis of an elbow condition is facilitated by specific examination maneuvers, and radiography is useful for confirming the diagnosis. Prevention strategies, such as the monitoring of pitch counts, have been developed to decrease the risk of injury in young athletes. Evolving surgical strategies have contributed to changes in techniques for treating certain conditions in the throwing athlete.

Throwing-Related Elbow Anatomy and Biomechanics

The medial or ulnar collateral ligament (UCL) is the most clinically relevant anatomic structure in the elbow of the throwing athlete. The UCL is a complex composed of the anterior oblique, posterior oblique, and transverse ligaments. The anterior oblique ligament is the strongest ligament of the complex and the most important stabilizer to valgus stress in the throwing athlete. The anterior oblique ligament originates in the medial epicondyle. An evaluation of the ulnar insertion of the anterior oblique ligament in 2011 found that it extends distal to the sublime tubercle along a previously unnamed ridge and was present on all skeletal specimens.[1] Within the anterior oblique ligament, the anterior band and the posterior band alternately have primary responsibility for valgus stress throughout the ranges of flexion and extension; the anterior band is tight during extension, and the posterior band is tight during flexion.

The UCL receives dynamic support from the surrounding musculature. The flexor carpi ulnaris is the primary dynamic contributor to valgus stabilization of the elbow, and the flexor digitorum superficialis is a secondary stabilizer.[2] These two muscles help disseminate the substantial forces across the elbow during the throwing motion and thereby protect the UCL. Their relationship has implications for preventing and managing UCL injuries.

The throwing motion creates substantial energy and subsequent forces that are mediated by structures about the elbow. Moreover, different pitch types produce differing forces, with fastball, slider, and curveball pitches producing significantly greater elbow forces, torques, and injury risk when compared with the changeup.[3] Angular velocities as high as 3,000°/s have been observed at the elbow during the acceleration phase of the throwing motion. This velocity translates into 64 N/m of valgus torque. Because the tensile strength of the UCL is only 34 N/m, the other stabilizers of the elbow also are important for avoiding or minimizing injury.[4] The valgus load creates stress about the other aspects of the elbow: tensile forces occur on the medial aspect, shear and compressive stresses occur in the olecranon fossa as the elbow reaches extension, and compression forces occur laterally, primarily at the radiocapitellar joint. A 2011 cadaver study found that lateral contact pressures increased 67% after the UCL was transected.[5] Understanding these forces increases the ability to understand the relationships among the conditions that occur about the elbow.

Clinical Evaluation

History

A specific, detailed patient history is vital to understanding elbow pathology in a throwing athlete. Arm dominance and the duration, intensity, and location of symptoms should be noted as well as the type of activity that elicits symptoms (eg, does the pain occur at rest, with activities of daily living, or only with throwing?). Information should be elicited as to associated mechanical symptoms, paresthesia, or pain in other joints, especially the shoulder. It is important to determine the point in the throwing motion during which symptoms occur (windup, early cocking, late cocking, acceleration, deceleration, or follow through). The types of pitches, the number of pitches thrown per outing, and the throwing schedule should be determined. The curveball generates the greatest valgus stress at the elbow, the fastball and slider generate the greatest force, and the changeup generates less stress on the elbow and is considered a relatively safe pitch for athletes of all ages. However, skilled players are more likely to throw the fastball or the curveball, play on more teams, and pitch more frequently than other players.[6]

Physical Examination

General observations are easy to overlook during an evaluation of the elbow, but they can provide insight into stresses about the elbow. The patient's carrying angle should be observed to identify any side-to-side difference. The exact location and the medial, lateral, or posterior character of the pain should be determined. The range of motion should be evaluated; a lack of full extension is common in throwers.

Typically, the focus of the examination in a throwing athlete is on the medial elbow. An acute avulsion injury of the UCL usually occurs proximally at the medial epicondyle, and tenderness there or along the length of the anterior oblique ligament should be determined. Resisted strength testing of the flexor-pronator mass is done. Valgus stress at 0° and 30° of flexion also is typically assessed, but the instability is often more subtle in a throwing athlete. This test lacks the sensitivity needed to reliably identify a chronic injury. The milking maneuver and the moving valgus stress test also are used to assess valgus instability and UCL injury. The milking maneuver is performed by pulling on the patient's thumb with the forearm supinated and the elbow flexed beyond 90°. The moving valgus stress test begins in the same position, and the patient's thumb is pulled until the limit of external rotation is reached at the shoulder. The elbow is taken through a range of motion while the torque created by pulling on the thumb remains constant. Pain typically is most intense when the elbow is between 70° and 120°. The sensitivity of the moving valgus stress test is reported to be 100%, with 75% specificity.[7]

A patient with suspected UCL injury should be assessed for ulnar nerve pathology. Evidence of nerve subluxation, a positive Tinel sign, or symptoms with elbow hyperflexion testing should be noted. Pain associated with a flexor-pronator injury, as indicated by pain with resistance testing, should be differentiated from pain associated with medial epicondylitis, as indicated by tenderness over only the epicondyle with normal moving valgus stress.

Imaging

The initial imaging studies are plain radiographs in the AP, lateral, radiocapitellar, and axillary views. Valgus stress radiographs can be used to identify a medial joint line opening; an opening of more than 3 mm has been considered diagnostic.[8] The radiographs can be assessed for evidence of osteophytes, loss of joint space, loose bodies, or osteochondral defects. MRI can be used to confirm several diagnoses about the elbow, including osteochondritis dissecans (OCD), a UCL injury, avulsion of the flexor-pronator mass, and chronic thickening of the UCL. A 2011 study found that signal intensity on MRI can be used to predict rehabilitation outcomes; patients with a complete or high-grade UCL tear were most likely to require surgery[9] (**Figure 1**). A recent study for the first time classified UCL injury based on MRI imaging (**Table 1**). This classification system was applied to 240 patients and found to significantly predict the degree of valgus laxity and subsequently guide treatment.[10]

Ultrasonography and dynamic ultrasonographic examination have been described for defining UCL injury, but most available studies are small case studies or case reports. Several studies have found differences in UCL laxity among overhead throwing athletes as well as side-to-side differences between the athletes' throwing and nonthrowing arms.[11,12]

Arthroscopy has been used as a diagnostic tool primarily for closely evaluating a joint line opening with stress; 1 to 2 mm of joint line opening indicates a partial-thickness tear, and 4 to 10 mm of opening indicates a full-thickness tear. The ulnohumeral joint is viewed from the anterolateral portal, and the joint is stressed at 65° to 70° of elbow flexion with the forearm pronated.[13]

FIGURE 1 MRI showing a complete avulsion of the ulnar collateral ligament from the humeral epicondyle (arrow).

[AU6]

Table 1

Classification of Ulnar Collateral Ligament (UCL) Injury on MRI, as Proposed by Joyner et al[10]

Classification	Description of Injury
Type I	Edema limited to UCL only, low-grade partial UCL tear
Type II	High-grade partial-thickness tear of UCL with no extravasation of fluid on arthrogram
Type III	Full-thickness UCL tear with extravasation of fluid on arthrogram
Type IV	Tear or pathology in more than one location of the UCL

Conditions Causing Medial Elbow Pain

Medial Epicondylitis

Medial epicondylitis is less common than lateral epicondylitis and usually occurs as a result of repetitive wrist flexion and forceful pronation during golf, a racquet sport, or overhead throwing. Pain typically is elicited over the medial elbow and exacerbated by resisted forearm flexion and pronation. The diagnosis is primarily clinical, but ultrasonography and MRI are reported to be useful.[14] On MRI, increased signal is seen in the flexor muscular origin about the medial epicondyle.[15] Nonsurgical treatments have high success rates. The components of a typical nonsurgical treatment program include NSAIDs, flexibility exercises, ice, and guided physical therapy. Steroid injections have also been used. The use of iontophoresis was found to improve pain relief in a comparative study.[16] Ultrasound-guided autologous blood injection led to improved scores on the visual analog and modified Nirschl Pain Phase scales.[17] The use of platelet-rich plasma (PRP) has also shown promise as a nonsurgical intervention, with a recent randomized study showing significant improvements in both visual analog scale and Mayo Elbow Performance Score at 6 months compared with corticosteroid injection.[18] Another investigation demonstrated that PRP injections produce comparable outcomes to Tenex ultrasound-guided tenotomy in treating epicondylitis.[19] These investigations have included injections for both medial and lateral epicondylitis in the analysis, with future study required to further assess the use and efficacy of PRP. Surgical intervention typically involves resection of a portion of the diseased tendon by open, mini-open, or arthroscopic means. If the surgical goal has been accomplished, pain relief can be expected, but a strength deficit may remain.

UCL Injury

Incidence of both UCL injury and surgical procedures to address it are increasing in throwers of all ages, which is causing considerable concern. Some studies are reporting a 193% increase in reconstructions in the youth. To [AU7] categorize and mitigate this alarming trend, recent investigations have identified several risk factors predictive of UCL reconstruction in throwers. In Major League Baseball pitchers who had undergone UCL reconstruction, the following risk factors were identified: greater pitch speed, greater pitch count per game, fewer days between consecutive games, smaller repertoire of pitches, smaller stature, and a less pronounced horizontal pitch release location.[20] Another investigation on radiographic risk factors for failure of nonsurgical management of UCL injury found that distal UCL tears were 12 times more likely than proximal tears to eventually require surgical intervention.[21]

Regardless of the location of injury, the initial management of a UCL injury in an overhead throwing athlete should be nonsurgical. The regimen includes a 6-week period of rest from throwing as well as strengthening of the flexor-pronator musculature.[2] The athlete should be asymptomatic and have a normal examination before throwing activities are resumed. At that time, the athlete should optimize throwing mechanics and offset stress from the medial elbow. Late trunk rotation, reduced shoulder external rotation, and increased elbow flexion have been shown to increase valgus stress at the elbow.[22] Early investigations on the efficacy of physical therapy were not favorable, with a 42% return-to-sport rate for overhead throwing athletes at a mean 24.5-week follow-up.[23] However, recent reports have shown more promise, with a 90% return-to-sport rate reported for professional quarterbacks after 4 weeks, and 71% and 94% return-to-sport rates in professional baseball pitchers and position players, respectively.[24]

A developing area of interest in nonsurgical management of UCL injury is the use of PRP injections. Further investigation and standardization of PRP composition and administration are necessary, but early investigations have shown promise in the efficacy of PRP. One investigation in throwing athletes in whom 2 months of conservative management had previously failed had an 88% return-to-sport rate by 12 weeks following PRP injection and guided physical therapy. A similar investigation in professional baseball players in whom conservative management had previously failed showed a 67% return to preinjury level of competition. Notably, those in the investigation with distal tears all had poor outcomes.[24]

In the original Jobe technique for reconstructing the UCL, a figure-of-8 tendon graft was woven through bone

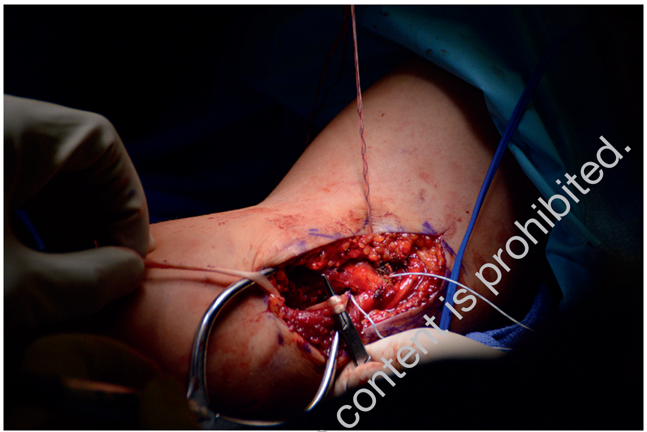

FIGURE 2 Intraoperative photograph showing anatomic reconstruction of the ulnar collateral ligament. One end of the graft is docked at the anterior-inferior aspect of the humerus and then looped through a tunnel at the sublime tubercle of the proximal ulna, and the second end of the graft is docked in the same tunnel at the distal humerus.

tunnels and sutured back onto itself (**Figure 2**). This technique required takedown of the flexor-pronator mass and exposure of the posterior humeral cortex for one of the tunnels. An ulnar nerve transposition always was performed. The substantial morbidity of the exposure led to modification of this technique and development of new techniques. The modified Jobe technique consists of a muscle-splitting approach to decrease morbidity to the flexor-pronator musculature, a change in humeral tunnel direction, and ulnar nerve transposition only if the patient has preoperative symptoms. The humeral tunnel is directed somewhat anteriorly to avoid ulnar nerve injury with graft passage and decrease the dissection necessary for exposure. The outcomes and the biomechanical strength resulting from using the modified Jobe technique have become the standard for comparison with any other technique. A 93% return-to-sport rate was reported for overhead throwing athletes.[8] Another study reported an 83% return rate to the previous level of throwing at a minimum 2-year follow-up after a modified Jobe technique was used.[25]

The commonly described docking technique also uses a muscle-splitting approach and two converging tunnels in the ulna. Only one primary tunnel is drilled in the humerus, and two smaller holes are drilled in the humerus to facilitate suture passage. One limb of the tendon graft is passed into the tunnel in the humerus. The second limb of the tendon graft is assessed for length and tension, sectioned to the appropriate length, and docked in the humeral socket. The sutures from each limb of the tendon graft are tied over a bone bridge after final tensioning. The use of the docking technique led to a good or excellent outcome in 19 of 21 athletes (90%).[26] An excellent result was defined as a return to previous level of play for at least 1 year, and a good result was defined as a return to throwing at a lower level for at least 1 year or the ability to throw at daily batting practice. A 92% rate of return to the preinjury level of throwing was reported at an 11.5-month follow-up after a quadrupled palmaris graft was used with the docking technique.[27]

Several techniques can be categorized as hybrid. A relatively new technique uses a single drill hole at the sublime tubercle and a single drill hole in the medial epicondyle. An interference screw is used at the sublime tubercle, with a docking technique on the humeral attachment. At 3-year follow-up after this technique was used, 19 of 22 patients (86%) had an excellent result.[28] Another technique uses the same single drill holes on the sublime tubercle and the medial epicondyle, with interference screws on each end of the construct. In a biomechanical study, this technique led to stability similar to that of intact UCL specimens.[4] These findings were corroborated by a 2014 investigation of 20 patients receiving the interference screw technique, which had a 90% return-to-sport rate.[29]

Although UCL reconstruction is the preferred surgical technique for UCL tear, recent developments in UCL repair have shown comparable outcomes in limited studies compared with reconstruction. A recent systematic review of UCL repair investigations found an 87% return-to-sport rate by 6 months after surgery. These results were far superior to early studies on UCL repair, which showed return-to-sport rates at only 71.4%.[30] The favorable postoperative timelines and recent outcome studies on repair are promising, but future investigations on outcome will be necessary before repair can be considered as an alternative to reconstruction.

Ulnar Neuritis

Approximately 40% of patients with UCL insufficiency have ulnar neuritis. A substantial valgus stress can create traction, friction, and compression on the nerve and induce neuritis. The presence of adhesions and/or osteophytes, nerve subluxation, a thickened medial triceps, or UCL injury also can increase stress on the nerve. Night pain and paresthesia into the ulnar nerve distribution can occur. Ulnar nerve symptoms can occur with throwing. On physical examination, a positive Tinel sign at the cubital tunnel, a positive elbow hyperflexion test, and/or evidence of ulnar nerve subluxation can be observed. Nonsurgical measures, including the use of night splinting, ice, NSAIDs, and activity modification, can be successful. Surgical management typically involves transposing the ulnar nerve into a subcutaneous position. This procedure has had great success with appropriate rehabilitation and a graduated return to throwing activities. The time to return to play with isolated ulnar nerve transposition is approximately 12 weeks.[31] If the patient has ulnar nerve symptoms associated with a UCL injury requiring reconstruction, ulnar nerve transposition should be done at the time of reconstruction. However, UCL reconstruction itself can have complications of ulnar neuropathy, with rates of 12% found at mean 3.3 years after surgery in a recent meta-analysis. Of those cases, 0.8% required surgical management to address ulnar neuritis. When looking at surgical techniques, the modified Jobe approach had complications of ulnar neuropathy in 16.9% of cases, whereas the docking technique had neuropathy in only 3.3% of cases.[32]

Recent investigations on the treatment of isolated ulnar neuritis in throwers have demonstrated mixed results. In one study, professional baseball players undergoing isolated ulnar nerve decompression/transposition had a 62% return-to-sport rate. Notably, those that did return performed statistically the same as matched control subjects.[33] However, another investigation on surgical outcomes in adolescent baseball players found that all of the players undergoing surgery returned to prior level of play at an average of 2 months postoperatively. This investigation also found a 60% return to prior play level following nonsurgical treatment, with UCL injury, ulnar nerve subluxation, and hand numbness on the ulnar side associated with poor nonsurgical outcomes.[34]

Conditions Causing Posterior Elbow Pain

Posteromedial Impingement or Valgus Extension Overload

Valgus extension overload is a relatively common condition in overhead throwing athletes in which posterior and, commonly, medial osteophytes impinge within the olecranon fossa as the elbow reaches extension. A review of 72 professional baseball players who underwent elbow surgery found that 65% had posterior olecranon osteophytes.[35] Athletes typically report posterior pain at the elbow during ball release and as the elbow reaches extension; this is the point at which osteophytes from the olecranon impinge within the fossa. The patient also commonly has some loss of terminal extension on examination. When valgus stress on the elbow is applied at 20° to 30° of flexion and the elbow is quickly taken to extension, a positive test re-creates the pain in the posteromedial elbow. Care must be taken to determine whether there is a concomitant UCL injury because there is a significant relationship between these diagnoses. Plain radiographs can reveal the posterior osteophyte.

Nonsurgical management begins with rest and 10 to 14 days of throwing restrictions followed by an interval throwing program to allow a gradual return to throwing. Pitching mechanics must be corrected during the interval throwing program to minimize stress at the elbow. A longer period of rest is recommended if symptoms persist or the patient cannot return to throwing at the earlier level. Intra-articular injection is not particularly helpful in patients with posteromedial impingement and should not be repeated.

Surgical management should be carefully considered. The medial elbow endures substantial valgus forces in the throwing athlete, and engagement of the olecranon in its fossa provides secondary stabilization to the elbow, particularly during extension. Any subtle laxity in the UCL may transfer stress to the posteromedial olecranon and cause it to impinge on the fossa as the elbow reaches extension. This stress induces osteophyte formation, which then increases impingement by shear mass effect. Overresection of the posteromedial olecranon can unmask or exacerbate symptoms of UCL injury. Twenty-five percent of professional baseball players who underwent osteophyte excision later had valgus instability requiring UCL reconstruction.[25] Studies conflict as to the amount of olecranon that can be excised before increased strain is seen at the UCL, and there is debate as to whether any excision of normal olecranon should be done. The procedure can be done in an arthroscopic or open fashion. In an open procedure, an osteotome is used to resect a portion of the olecranon tip, and a portion of the medial olecranon is removed. The arthroscopic procedure can be accomplished using a posterolateral portal for viewing and a central posterior portal for working. Care must be taken to remove osteophytes and minimize resection of normal olecranon. In addition, care must be taken to avoid ulnar nerve injury when resecting the medial aspect of the osteophyte as the ulnar nerve enters the cubital tunnel. A 2011 study reported an excellent outcome in seven of nine patients who underwent arthroscopic treatment of valgus extension overload.[36]

Olecranon Stress Fracture

Stress fractures of the olecranon have been described in javelin throwers and other throwing athletes.[37,38] These fractures are primarily described as transverse or oblique, with a mechanism of injury similar to that of a valgus extension overload injury. The olecranon is subject to increased stress as the elbow undergoes a valgus load and approaches extension. The substantial triceps forces at extension also have been implicated in this condition.

On physical examination, the athlete may have tenderness over the physis (if it is open), the posterior olecranon, or the posteromedial olecranon. Symptoms may be elicited by forceful extension of the elbow or resisted triceps muscle testing. Typically, the patient has less extension than in the contralateral elbow. Plain radiographs may show a sclerotic line of remodeling fracture if the condition is chronic. If the physis is open, it may be beneficial to obtain radiographs of the contralateral side to detect any physeal widening. A bone scan will reveal increased uptake in the area. MRI will show edema within the bone and allow characterization of the fracture line. MRI also is beneficial if an associated UCL injury is suspected.

The management of an olecranon stress fracture is somewhat controversial. Nonsurgical measures require rest from throwing and possibly temporary splinting. The return to an interval throwing program is delayed until symptoms have subsided and there is radiographic evidence of fracture healing. As a result, throwing can be restricted for as long as 6 months. Stress fractures may respond to bone stimulators, but this treatment has not been well defined. Recent surgical outcomes of olecranon stress fractures in the throwing athletes have been promising. In a recent systematic review in which [AU3] 76.9% of athletes with olecranon stress fractures underwent surgery, there was a 96% return-to-sport rate at or above preinjury levels.

Some experts recommend early surgical treatment to reduce the time to resumption of throwing.[39] Surgical treatment also is recommended if nonsurgical management is unsuccessful. Tension-band wiring, tension-band wiring with a compression screw, and a compression screw alone have been used. A 6.5- or 7.3-mm cannulated compression screw typically is used. A 2012 case report described a persistent fracture after fixation in a college pitcher, in which bone grafting ultimately was required for healing.[40]

Persistent Olecranon Physis

The persistent olecranon physis is similar to an olecranon stress fracture and may be responsible for an athlete's posterior elbow pain. The olecranon physis has two ossification centers: the posterior center is oriented transverse to the longitudinal axis of the ulna and contributes to longitudinal growth; a second center is more anterior at the olecranon tip, contributing to the joint surface but not to longitudinal growth. These two centers fuse and create a single physis that persists until approximately age 14 years in girls and age 16 years in boys. This physis can become sclerotic during the process of closing and can be as wide as 5 mm.

Posterior elbow pain typically develops during the years from adolescence through the late teens. The pain occurs at terminal extension in the follow-through phase of throwing, and it can be relieved with rest. The physical examination may be benign; motion is normal, the elbow is stable, and there is no tenderness to palpation. Plain radiographs reveal a persistent physis in the olecranon that may be wider on the involved side than on the contralateral side. There may be evidence of sclerosis about the physis that is unexpected for the patient's age. T2-weighted MRI may show edema about the physis, but this finding is not diagnostic.

Treatment starts with nonsurgical measures, including a period of relative rest and cessation of throwing activities. NSAIDs and ice may be used as needed. Nonsurgical measures appear to be successful in most patients but may require as long as 4 months. The options for surgical treatment include open reduction and internal fixation, bone grafting, and open reduction and internal fixation with bone grafting. The fixation techniques include tension-band wiring, compression screws, and a combination of screws and tension-band wiring. The available studies are largely limited to case reports and small case studies.[41,42] It appears that the highest rates of successful union were in patients who underwent bone grafting with or without fixation. Those undergoing fixation alone had an approximately 66% failure rate. A 2010 study found that those with a persistent olecranon physis and evidence of sclerosis had a 100% failure rate with nonsurgical measures.[43]

Conditions Causing Lateral Elbow Pain

Capitellar Osteochondritis Dissecans

OCD is a local disorder of the subchondral bone that results in separation and fragmentation of articular cartilage and its underlying bone. It is important to differentiate this condition from Panner disease, which occurs in younger patients, is idiopathic, usually is self-limiting, and improves without surgical intervention. OCD typically occurs at the elbow in adolescents who are high-demand, repetitive overhead throwing athletes. The pathogenesis is not completely understood. Genetic factors, blood supply, repetitive trauma, and a vulnerable epiphysis have been implicated. The underlying bone undergoes degradation and can destabilize the overlying cartilage. Probably a combination of factors contributes to the process by which the lesion is created.

Typically, the athlete has elbow pain during activity. The pain is insidious in onset, is relieved by rest, and progresses if the activity is continued. The pain is difficult to localize and often is accompanied by loss of motion. Occasionally, the symptoms are mechanical, with catching or locking of the elbow joint. The most common finding on examination is tenderness over the radiocapitellar joint. Crepitus can be elicited in the lateral joint with pronation and supination, and there is loss of motion of 15° to 30°. In the active radiocapitellar compression test, the elbow is fully extended while the patient actively pronates and supinates the forearm and contracts the muscles about the elbow. A positive test reproduces the athlete's symptoms.

The initial imaging is with plain radiographs. The standard AP view in full extension and lateral views in 90° of flexion show typical capitellar radiolucency and flattening of the joint surface (**Figure 3**). The lesion commonly occurs in the anterolateral aspect of the capitellum. In the Minami classification system, a grade I lesion is a translucent cystic shadow in the middle or lateral capitellum, a grade II lesion has a split line or clear zone between the lesion and its subchondral bone, and loose bodies are present in a grade III lesion.[44]

MRI has become the modality of choice for evaluating these lesions. Early changes not found on plain radiographs can be detected on MRI, and the size, location, and stability of the lesion can be assessed. The key to making a treatment decision is to determine whether the articular surface is intact and the lesion is stable as seen on MRI. A peripheral ring of fluid or fluid under the articular surface suggests an unstable lesion; these findings are similar to those of an OCD lesion in another area of the body. The

FIGURE 3 AP radiograph showing osteochondritis dissecans of the capitellum in which there is a complete fragment with subtle displacement. Such a lesion often has a relatively normal arthroscopic appearance because the articular cartilage is intact.

diagnosis sometimes is facilitated by the addition of an arthrogram or intravenously administered gadolinium.

OCD lesions are amenable to healing, and nonsurgical regimens are an option. The treatment begins with 6 months of elbow rest without throwing activity. Anti-inflammatory medications are used, and physical therapy is implemented to optimize motion and strength. Radiographs are assessed at 6-week intervals to ensure that the lesion is healing or is not progressing. MRI is repeated as needed at an approximately 3-month interval and compared with the initial studies. An interval throwing program is initiated at 6 months if the athlete has good motion, is asymptomatic, and has evidence of healing. Pitch counts initially should be monitored.[45] Patients with capitellar lucency or flattening have healing rates of 88% to 91%.[46,47] Those with open capitellar physes have a higher rate of healing. Advanced lesions have less capacity for nonsurgical healing. A stable lesion is characterized by an open capitellar epiphyseal plate, localized flattening or radiolucency of the subchondral bone, and good elbow motion. In an unstable lesion, the physis is closed, with radiographic fragmentation and loss of elbow motion of more than 20°.[48]

Surgical management is indicated if the patient has an unstable lesion or loose bodies or if nonsurgical treatment has been unsuccessful. Several surgical procedures have been described. Simple débridement can be effective for a contained lesion involving less than 50% of the capitellar surface. Microfracture or trephination of the subchondral base with a Kirschner wire also can be used after fragment excision and bed preparation (**Figure 4**). Fixation of a relatively large, unfragmented lesion can be achieved through different methods. Pullout wires, bone grafting, and Herbert screws have been successfully used. Several options exist for cartilage replacement, mirroring the options used in the knee and other joints. Mosaicplasty, osteochondral allograft, and autograft transplantation have been used to treat a relatively large OCD lesion or an uncontained lesion (in which there is loss of lateral column support).

FIGURE 4 Arthroscopic image showing an osteochondritis dissecans lesion after microfracture.

Radiocapitellar Plica

Radiocapitellar plica, first described as a cause of a snapping elbow, essentially is a hypertrophic synovial plica that snaps over the edge of the radial head as the elbow moves from flexion to extension. The differential diagnosis includes intra-articular loose bodies, instability, lateral epicondylitis, and subluxation of the medial triceps over the medial epicondyle. Some of these conditions can be ruled out on the basis of location. The elbow examination typically is otherwise benign, with stability, full motion, and normal strength. The patient may have tenderness posterior to the lateral epicondyle and centered over the joint. Plain radiographs usually are not informative, and the plica frequently is missed on MRI.

Nonsurgical measures should be initially considered, including relative rest, NSAIDs, and gentle motion. Intra-articular steroid injections have been used in an attempt to relieve inflammation and decrease pain. Surgical management with an arthroscopic procedure has yielded good results. The snapping of the plica typically can be replicated on arthroscopic examination and allows the surgeon to locate the area to be released. The goal is to adequately release the synovial plica so that it no longer snaps over the radial head. The examination is repeated to ensure the release is complete. Postoperative management allows early range of motion and advancement of strength. An interval throwing program typically is started at 8 weeks and can advance as long as the patient remains asymptomatic.

SUMMARY

The elbow of a throwing athlete endures substantial stress during the phases of the throwing motion. The key to the correct diagnosis is to analyze the condition by elbow region, obtain a detailed history, apply specific examination maneuvers, and obtain appropriate imaging studies. Nonsurgical measures can be successful during specific phases of the disease process, and advances in surgical techniques have improved patient outcomes. Arthroscopic procedures have an increasing role in treating many conditions, with acceptable outcomes and return-to-play rates. Postoperative management is stepwise and specific to restore optimal mechanics, flexibility, and strength to the affected muscle groups.

KEY STUDY POINTS

- Overhead throwing motion places significant valgus torque on the UCL and supporting muscle stabilizers, increasing susceptibility to elbow injury in throwers.
- Always assess a new throwing injury by evaluating the region of elbow pain and conducting a targeted history, obtaining specific information about pitch counts/days throwing/types of pitches, physical examination, and imaging to narrow down the differential diagnosis of elbow pain in that region.
- In most throwers, consider initial nonsurgical treatment, as advances in conservative therapies have produced increasingly comparable return-to-sport rates to surgical management. Platelet-rich plasma has demonstrated promise in multiple pathologies about the elbow.
- In those that fail initial therapy, surgical management of most elbow injuries produce excellent return-to-sport rates in throwers. Ulnar collateral ligament repair is demonstrating promise compared with reconstruction, but more studies are needed to better understand reproducibility and longevity.

Annotated References

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