Sports Medicine

Medial elbow pain in the overhead athlete

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ABSTRACT

This review aims to cover the anatomy, mechanics, injury mechanism, physical examination, imaging, diagnosis and treatment of medial elbow pain in overhead athletes. Due to the repetitive valgus stress overhead athletes place on their elbows, they are susceptible to common causes of medial elbow pain. These include ulnar collateral ligament tears, ulnar neuritis, medial epicondyle apophysitis or avulsion fractures, flexor-pronator muscle strains or tendinitis, and valgus extension overload syndrome. With a more detailed knowledge of the injury mechanisms and up-to-date treatment options for these patients, physicians will be able to prevent and better treat medial elbow pain in overhead athletes.

Key Words

elbow, overhead throwing, ulnar collateral ligament, valgus stress, pain

INTRODUCTION

The number of athletes participating in overhead type activities continues to increase, leading to a greater number of upper extremity injuries.[1,2] This rise places a greater importance on appropriately diagnosing and treating medial elbow pain. The high incidence of medial elbow pain in overhead athletes can be explained by the repetitive valgus stresses placed across the elbow joint. Knowledge of the anatomy and biomechanics will allow for improved diagnosis and treatment of these injuries. Common causes of medial elbow pain in the overhead athlete include: ulnar collateral ligament (UCL) tears, ulnar neuritis, medial epicondyle apophysitis or avulsion fractures, flexor-pronator muscle strains or tendinitis, and valgus extension overload syndrome (VEO).

The goal of this review article is to summarize the anatomy, biomechanics, physical examination, imaging, and treatment of common causes of medial elbow pain in the overhead athlete. This review will help physicians to not only improve their treatment for these types of athletes but also may help prevent some of these injuries.

ANATOMY

Both the bony articulations and the soft-tissue components afford the elbow stability throughout its arc of motion. In terms of bony stability, the olecranon and its corresponding fossa provide stability when the elbow is flexed less than 20 degrees and greater than 120°. However, when the elbow is between 20-120° of flexion, the soft-tissue components play a greater role in elbow stability.[3,4]

In overhead throwing athletes, the primary soft-tissue restraint is the ulnar collateral ligament (UCL). The UCL is composed of three main components: the anterior bundle, posterior bundle, and the oblique or transverse ligament (Figure 1). When injury occurs to the UCL, the anterior bundle is most commonly involved. The anterior bundle originates from the medial epicondyle of the humerus and attaches to the sublime tubercle, the medial aspect of the coronoid process.[4]

BIOMECHANICS

Understanding the biomechanics of overhead throwing will help physicians appreciate the injury mechanism and corresponding treatment of medial elbow pathology in this unique population. The overhead throwing motion can be broken down into five main stages: wind-up, cocking, acceleration, deceleration, and follow-through (Figure 2). During the late cocking and acceleration stages of throwing, the elbow experiences the most significant valgus forces.[5,6]

Valgus torque at the elbow in professional baseball pitchers has been reported as high as 90–120 Nm.[7] Cadaver studies have demonstrated that the UCL fails at approximately 34 Nm.[8] The bony anatomy, dynamic stabilizers, and other medial structures help counteract this force and prevent the UCL from being easily disrupted.

PHYSICAL EXAMINATION

When examining an overhead athlete who presents with medial elbow pain, a thorough history is important. The physician must elicit the type of sport, acuity or chronicity of the injury, level of competition, frequency and number of innings pitched by baseball players, and any changes in mechanics. Furthermore, the phase of throwing during which the pain occurs will be important because those with medial elbow instability will complain of pain during the

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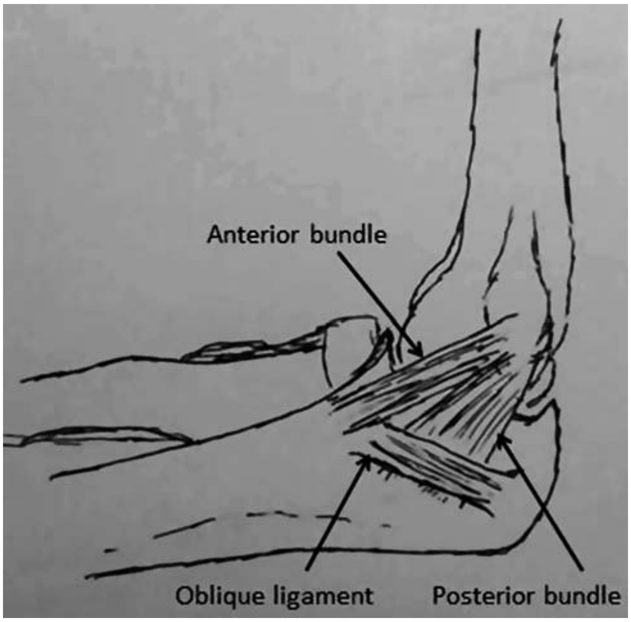

FIGURE 1. The anatomy of the ulnar collateral ligament showing the anterior bundle, posterior bundle, and oblique ligament.

acceleration phase, whereas athletes with VEO will tend to report pain more commonly at ball release.[9]

After a complete history, the physical examination begins by comparing the affected elbow with the contralateral elbow. Any signs of ecchymosis, effusion, or changes in carrying angle are noted. Localized tenderness to palpation, especially along the medial epicondyle, medial apophysis, or UCL complex, should be noted. A thorough neurovascular examination should also be completed, including checking for a positive Tinel's sign in the ulnar nerve distribution. Strength testing should be completed and compared with the contralateral elbow. Finally, elbow stability is assessed. A valgus stress should be applied with the elbow flexed approximately 20-30° and the forearm fully pronated. Any opening greater than 1 mm, especially when compared to the contralateral elbow, should be considered abnormal and may signify a possible UCL injury. To test for VEO specifically, the examiner holds the wrist with the elbow in approximately 20-30° of flexion and forcibly extends the elbow while applying a valgus stress. The recreation of pain, especially near the posteromedial tip of the olecranon, may signify VEO.

IMAGING

Imaging should start with a standard radiographic series of the elbow including anteroposterior, lateral, axial, and two oblique views. Comparison films of the unaffected elbow can sometimes prove useful, particularly in the skeletally immature elbow. If there is concern for medial instability, stress anteroposterior radiographs can be obtained with a valgus stress radiography machine (Telos, Weiterstadt, Germany). Plain radiographs often will help evaluate for olecranon osteophytes, apophyseal injuries, calcifications in the UCL, loose bodies, and olecranon tip spurs.

MRI-arthrogram is the mainstay diagnostic imaging choice when investigating the medial soft-tissue structures of the elbow (Figure 3). MRI arthrogram has been shown to have a 100% sensitivity and 100% specificity in diagnosing full-thickness tears of the UCL. However, with regard to partial thickness tears of the UCL, MRI has been found to be only 57% sensitive.[10] Although CT arthrograms have been shown to be more sensitive than nonenhanced MRIs for partial tears of the UCL, Schawartz *et al.*[11] showed an 86% sensitivity with saline-enhanced arthrogram MRI for identifying partial tears. MRIs are also useful in examining for loose bodies, synovial pathology, the stability of osteochondral lesions, and ulnar nerve entrapment.

Recently, ultrasound to study the UCL has been revisited. Ciccotti *et al.*[12•] utilized stress sonography to characterize the UCL in asymptomatic professional baseball pitchers. It was found that the mean UCL thickness and stress ulnohumeral joint space of the dominant elbow was significantly greater when compared with the nondominant

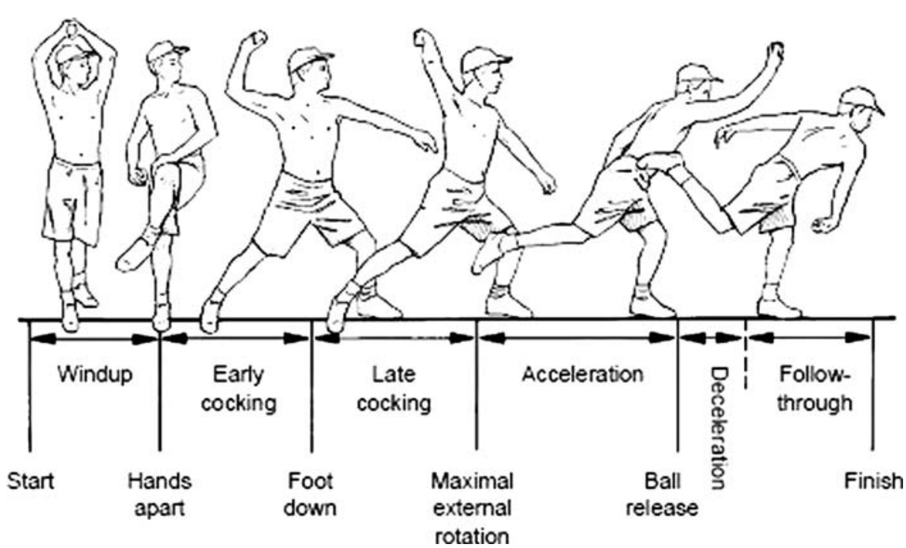

FIGURE 2. The five main stages of overhead throwing motion. (Reprinted with permission from Digiovine *et al.*[5]).

FIGURE 3. Coronal T2-weighted image from MR arthrogram showing a ulnar collateral ligament tear in a young baseball pitcher. Note the disrupted orientation of the proximal fibers.

elbow. However, the study did not show whether any of these abnormalities is associated with a greater risk for future UCL injury.

PATHOLOGIC CONDITIONS

Ulnar Collateral Ligament Injuries

The UCL sustains high tensile forces during overhead activities, as it is the primary stabilizer of valgus stress during the throwing arc of motion. Treatment for UCL tears ranges from conservative management to direct repair or reconstruction from a free tendon graft.

One should attempt a course of nonoperative treatment for incomplete tears or for those who do not plan to return to overhead throwing. In addition to rest from throwing, a course of rehabilitation is initiated with a focus on medial flexor-pronator muscle strengthening. This is followed by a gradual return to throwing via an interval throwing program.

Podesta *et al.*[13•] recently studied the use of platelet-rich plasma (PRP) injections in the treatment of partial-thickness tears of the UCL. Patients who had failed a 2-month course of nonoperative treatment received a single autologous PRP injection followed by a course of physical therapy. At a mean follow-up of 70 wk, 30 of 34 (88%) athletes were able to return to the same level of play without complaints. Although "partial tear" is a broad term, PRP may play a role in the treatment of partial-thickness tears of the UCL.

Operative treatment is often employed for overhead throwing athletes with complete UCL tears or those with partial tears who fail conservative treatment. Operative options include direct repair versus reconstruction with a free tendon graft.

Cain *et al.*[14] published the largest series of UCL reconstructions to date. One thousand two hundred and sixty-six UCL reconstructions were performed, and 743 patients were available for a minimum 2-year follow up. Six hundred and ten (83%) athletes were able to return to their previous level of competition or higher, with an average time of 11.6 mo to return to full competition.

Most previous studies demonstrating satisfactory results with direct repair generally involved patients who were not high demand overhead athletes. However, Savoie *et al.*[15] recently published a case series in which they studied primary repair of UCL injuries in young athletes. Good to excellent results were obtained in 93% of cases, and 58 of the 60 patients were able to return to sports at the same or higher level within 6 mo of surgery. The authors point out that young athletes often sustain UCL injuries isolated to either the proximal or distal end of the ligament, while older, professional athletes tend to experience ligament damage throughout its length. Thus, primary repair may be a viable option for young overhead athletes.

Jobe *et al.*[16] first reported the results of reconstructing the UCL with a free-tendon, figure-of-eight graft using bone tunnels in the ulna and medial epicondyle of the humerus. In addition, the flexor-pronator mass origin was detached, and a submuscular ulnar nerve transposition was completed. Azar *et al.*[17] later modified this procedure due to concerns about detaching the flexor-pronator mass. The authors elected to elevate the flexor-pronator mass without detachment and performed a subcutaneous rather than submuscular ulnar nerve transposition. Further modifications have been developed including the docking technique,[18] modified docking procedure,[19] docking plus technique,[20•] interference screws,[8] suspensory cortical buttons,[21•–23•] and a hybrid of these methods.[24] No one fixation method has been shown to be clearly superior to the others.

Several recent cadaver studies have been conducted to study the biomechanical differences between the methods. McGraw *et al.*[20•] compared the docking plus technique with the docking technique and found that, immediately after reconstruction, the docking plus technique resulted in greater ligament stiffness and a higher failure moment. Lynch *et al.*[21] compared fixation with suspensory cortical buttons to the docking technique. Fixation with suspensory cortical buttons was found to be less stiff but did show lower joint gapping and laxity. Jackson *et al.*[23•] showed that a bisuspensory technique was able to restore valgus stability and exhibited similar load-to-failure properties to the docking technique. Ciccotti *et al.*[25] published a study comparing the modified Jobe and docking techniques. The authors showed that both techniques provided valgus stability comparable to the native ligament at 90° of flexion and higher, but provided less stability at flexion angles less than 90°.

Several outcome studies have been performed regarding UCL reconstruction in overhead athletes. Most recently, Erickson *et al.*[26•] reported that of 179 Major League Baseball (MLB) pitchers who underwent UCL reconstruction, 83% returned to play at the level of the MLB while 97% returned to the MLB and minor league combined. Jiang *et al.*[27•] reported that there was no difference in mean pitch velocity or commonly used performance statistics in MLB players who underwent UCL reconstruction when compared to a pair-matched control group of MLB pitchers.

In addition to professional athletes, a greater emphasis has been placed on studying adolescent athletes over the last decade. Jones *et al.*[28•] reported results of reconstruction of the UCL in 55 skeletally mature adolescent athletes (range, 15–18 yr old) using the docking technique. At a 2 yr minimum follow-up, 87% had excellent results using the Conway scale.

Ulnar Neuritis

The ulnar nerve enters the elbow in the cubital tunnel and exits between the two heads of the flexor carpi ulnaris muscle. During overhead throwing, the ulnar nerve can become irritated due to traction from valgus stress or from friction caused by subluxation of the nerve. Patients will often complain of paresthesia in the small and ring fingers. A positive Tinel's sign may help localize the site of compression. The physician must rule out elbow instability as an underlying cause of the ulnar neuritis because treating only the ulnar nerve will likely fail to provide relief.

A period of conservative management is warranted first for ulnar neuritis. Nonoperative treatment entails non-steroidal antiinflammatory drugs (NSAIDs), physical therapy, and a slow, progressive return to throwing.

If nonoperative management fails, then ulnar neurolysis with anterior ulnar nerve transposition may help. There continues to be debate over whether submuscular or subcutaneous transposition is superior. Proponents of submuscular transfer emphasize the protection afforded to the ulnar nerve from trauma.[29] Results of submuscular transfer have been excellent.[29–31] On the other hand, those performing subcutaneous transfer noted faster rehabilitation times and less surgical morbidity.[32] Similarly, the outcomes of subcutaneous transfer have also been excellent.[33,34] There have been no randomized, controlled studies comparing submuscular to subcutaneous ulnar nerve transfers in overhead athletes.

Traditionally, when the ulnar nerve is transposed anteriorly, a single fascial sling is developed from the flexor-pronator muscle fascia.[32] However, there exists variability in the construct of this fascial sling. When there is a recurrence of ulnar neuritis, oftentimes there is perineural scarring. Danoff *et al.*[35•] recently reported a surgical technique by which a pedicled adipose flap is used as a sling. The theoretical advantage is that this fatty, vascularized sling resembles the natural environment of the nerve and may possibly reduce postoperative perineural scarring. To date, no study has compared the type of sling construct employed and its outcome in overhead athletes.

Medial Epicondyle Apophysitis and Avulsion Injuries

Medical epicondyle apophysitis and avulsion fractures are injuries that affect adolescent athletes. While adults more often experience injuries involving the UCL, children have weaker medial epicondyle apophyseal plates leading to unique injuries.

Medial epicondyle apophysitis generally presents with pain along the medial elbow, and radiographs may show apophyseal fragmentation. Treatment is largely conservative, including rest, ice, NSAIDs, activity modification, and a slow, progressive return to overhead activities.

Unlike medial epicondyle apophysitis, the treatment for medial epicondyle avulsion injuries (Figure 4) is controversial. Most authors recommend conservative treatment with a period of splinting for minimally displaced fractures.[32,36,37] A recent study by Lawrence *et al.*[38••] specifically investigated return to competitive sports after medial epicondylar fractures in adolescents treated either operatively or nonoperatively. The authors concluded that those with low-energy medial epicondyle avulsions with a stable elbow and minimal fracture displacement can be treated nonoperatively, even in overhead athletes. However, the study had several limitations including its low number of patients, lack of consistent guidelines regarding fracture displacement, and lack of objective follow up data. The senior author of this article (JRD) does advocate operative treatment for any displaced medial epicondyle avulsion fractures in overhead athletes due to the concern for compromised elbow stability and for potential further elbow injury with continued throwing into skeletal maturity.

Flexor-pronator Muscle Mass Injuries

The common flexor-pronator muscle arises from the medial epicondyle. During overhead throwing, this origin provides

FIGURE 4. Medial epicondylar avulsion fracture in a young baseball pitcher.

dynamic support to valgus stresses across the elbow. Injuries may range from mild overuse to acute muscle tears.

Treatment focuses on conservative management, including NSAIDs, physical therapy, and a slow, progressive return to throwing. Surgical treatment is not commonly indicated for these conditions.

Osbahr *et al.*[39] recently identified a subpopulation of baseball players who sustained combined flexor-pronator muscle mass and UCL injuries. These baseball players tended to be older with a mean age of 33 yr. Those treated for a combined injury had a 12.5% return to prior level of play. The study was limited, however, due to the few number of patients who sustained the combined injury, lack of objective methodology to diagnose a flexor-pronator mass injury, and the retrospective nature of the study.

Valgus Extension Overload Syndrome

Valgus extension overload (VEO) syndrome refers to a condition by which repetitive stresses lead to the formation of olecranon osteophytes, most characteristically in the posterior and posteromedial regions of the olecranon. These osteophytes can lead to posteromedial impingement. In addition, they may occasionally fracture and lead to loose bodies. VEO has been reported to be the most common diagnosis requiring surgery in baseball players.[33]

Initial treatment is conservative with active rest, including NSAIDs, physical therapy and an eventual interval throwing program.[9]

Surgical treatment is warranted when conservative therapy fails. Wilson *et al.*[40] described the results of operative treatment in five pitchers who experienced VEO. After open osteophyte excision, all pitchers were able to return to play for at least one season.

Over the past decade, greater attention has been directed at arthroscopic techniques to treat VEO. Reddy *et al.*[41] reported the outcomes of 187 elbow arthroscopies. Ninety-six (51%) underwent the procedure for posterior impingement, and 88 (85%) patients reported good to excellent results after surgery at an average follow-up of 42 mo. More recently, Cohen *et al.*[42] reported results of arthroscopic treatment of posteromedial impingement in overhead athletes. Eight of nine players returned to play at pre-injury level at a mean time of 12 wk, while one player returned to play at 17 wk with minor symptoms.

Several authors have cautioned about overresecting the olecranon. Some authors recommend that only osteophytes should be resected because any further resection may lead to greater valgus laxity and cause overhead athletes to be more susceptible to UCL injury.[43,44] Biomechanical studies examining strain on the UCL have differed in their results. Kamineni *et al.*[45] reported that the anterior bundle of the medial collateral ligament experienced greater strain with resection greater than or equal to 6 mm. In contrast, other studies have reported no statistically significant increase in strain on the anterior bundle due to olecranon resection.[43,46]

CONCLUSION

Medial elbow pain in the overhead athlete is a direct result of the unique forces imparted on the elbow during throwing. Common causes of medial elbow pain include ulnar collateral ligament injuries, ulnar neuritis, medial epicondyle apophysitis or avulsion fractures, flexor-pronator muscle strains or tendinitis, and VEO syndrome. As diagnostic and treatment modalities continue to evolve, it will be important for physicians to stay up to date in order to best manage medial elbow pain in the overhead athlete.

Key Points

- Medial elbow pain in the overhead athlete is a result of the unique forces sustained by the elbow during throwing.
- The anterior band of the ulnar collateral ligament is the primary restraint to valgus stress across the elbow.
- There are multiple causes of medial elbow pain in the overhead athlete, and a thorough history and physical examination will help lead to an accurate diagnosis.
- Due to advancement in diagnostics and surgical techniques, return to play is generally favorable in this group of motivated athletes.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. Lyman S, Fleisig G, Andrews JR, *et al.* Effect of pitch type, pitch count, and pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers. *Am J Sports Med.* 2002; 30:463–468.
2. Olsen S, Fleisig G, Dun S, *et al.* Risk factors for shoulder and elbow injuries in adolescent baseball pitchers. *Am J Sports Med.* 2006; 34:905–912.
3. Morrey BF, Tanaka S, An KN. Valgus stability of the elbow: A definition of primary and secondary constraints. *Clin Orthop Relat Res.* 1991; 265:187–195.
4. Schwab GH, Bennett JB, Woods GW, *et al.* Biomechanics of elbow instability: The role of the medial collateral ligament. *Clin Orthop Relat Res.* 1980; 146:42–52.
5. Digiovine NM, Jobe FW, Pink M, *et al.* An electromyographic analysis of the upper extremity in pitching. *J Shoulder Elbow Surg.* 1992; 1:15–25.
6. Chen FS, Diaz VA, Loebenberg M, *et al.* Shoulder and elbow injuries in the skeletally immature athlete. *J Am Acad Orthop Surg.* 2005; 13:172–185.
7. Werner SL, Murray TA, Hawkins RJ, *et al.* Relationship between throwing mechanics and elbow valgus in professional baseball pitchers. *J Shoulder Elbow Surg.* 2002; 11:151–155.
8. Ahmad CS, Lee TQ, ElAttrache NS. Biomechanical evaluation of a new ulnar collateral ligament reconstruction with interference screw fixation. *Am J Sports Med.* 2003; 31:332–337.
9. Dugas JR. Valgus extension overload: diagnosis and treatment. *Clin Sports Med.* 2010; 29:645–654.
10. Timmerman LA, Schwartz ML, Andrews JR. Preoperative evaluation of the ulnar collateral ligament by magnetic resonance imaging and computed tomography arthrography. Evaluation in 25 baseball players with surgical confirmation. *Am J Sports Med.* 1994; 22:26–31.
11. Schwartz ML, Al-Zahrani S, Morwessel RM, *et al.* Ulnar collateral ligament injury in the throwing athlete: Evaluation with saline-enhanced MR arthrography. *Radiology.* 1995; 197:297–299.

12. Ciccotti MG, Atanda A Jr, Nazarian LN, *et al.* Stress sonography
• of the ulnar collateral ligament of the elbow in professional baseball pitchers: a 10-year study. *Am J Sports Med.* 2014; 42:544–551.
13. Podesta L, Crow S, Volkmer D, *et al.* Treatment of partial ulnar
• collateral ligament tears in the elbow with platelet-rich plasma. *Am J Sports Med.* 2013; 41:1689–1694.
14. Cain EL, Andrews JR, Dugas JR, *et al.* Outcome of ulnar collateral ligament reconstruction of the elbow in 1281 athletes: Results in 743 athletes with minimum 2-year follow-up. *Am J Sports Med.* 2010; 38:2426–2434.
15. Savoie FH III, Trenhaile SW, Roberts J, *et al.* Primary repair of ulnar collateral ligament injuries of the elbow in young athletes: a case series of injuries to the proximal and distal ends of the ligament. *Am J Sports Med.* 2008; 36:1066–1072.
16. Jobe FW, Satark H, Lombardo SJ. Reconstruction of the ulnar collateral ligament in athletes. *J Bone Joint Surg.* 1986; 68A: 1158–1163.
17. Azar FM, Andrwes JR, Wilk KE, *et al.* Operative treatment of ulnar collateral ligament injuries of the elbow in athletes. *Am J Sports Med.* 2000; 28:16–23.
18. Rohrbough JT, Altchek DW, Hyman J, *et al.* Medial collateral ligament reconstruction of the elbow using the docking technique. *Am J Sports Med.* 2002; 30:541–548.
19. Paletta G, Wright R. The modified docking procedure for elbow ulnar collateral ligament reconstruction: 2-year follow-up in elite throwers. *Am J Sports Med.* 2006; 34:1594–1598.
20. McGraw M, Kremchek T, Hooks T, *et al.* Biomechanical evaluation of the docking plus ulnar collateral ligament
• reconstruction technique compared with the docking technique. *Am J Sports Med.* 2013; 41:313–320.
21. Lynch J, Pifer M, Maerz T. The GraftLink Ulnar Collateral Ligament Reconstruction. *Am J Sports Med.* 2013; 41:
• 2278–2287.
22. Armstrong AD, Dunning CE, Ferreira LM, *et al.* A biomechanical comparison of four reconstruction techniques for the medial collateral ligament deficient elbow. *J Shoulder Elbow Surg.* 2005; 14:207–215.
23. Jackson T, Adamson G, Peterson A, *et al.* Ulnar collateral
• ligament reconstruction using bisuspensory fixation: A biomechanical comparison with the docking technique. *Am J Sports Med.* 2013; 41:1158–1164.
24. Dines JS, ElAttrache NS, Conway JE, *et al.* Clinical outcomes of the DANE TJ technique to treat ulnar collateral ligament insufficiency of the elbow. *Am J Sports Med.* 2007; 35:2039–2044.
25. Ciccotti M, Siegler S, Kuri J II, *et al.* Comparison of the biomechanical profile of the intact ulnar collateral ligament with the modified Jobe and the docking reconstructed elbow: an in vitro study. *Am J Sports Med.* 2009; 37:974–981.
26. Erickson B, Gupta A, Harris J, *et al.* Rate of return to pitching
• and performance after Tommy John surgery in major league baseball pitchers. *Am J Sports Med.* 2014; 42:536–543.
27. Jiang JJ, Leland JM. Analysis of pitching velocity in major league
• baseball players before and after ulnar collateral ligament reconstruction. *Am J Sports Med.* 2014; 42:880–885.
28. Jones K, Dines J, Rebolledo B, *et al.* Operative management of
• ulnar collateral ligament insufficiency in adolescent athletes. *Am J Sports Med.* 2014; 42:117–121.
29. Glousaman RE. Ulnar nerve problems in the athlete's elbow. *Clin Sports Med.* 1990; 9:365–377.
30. Jobe FW, Nuber G. Throwing injuries of the elbow. *Clin Sports Med.* 1986; 5:621–636.
31. Childress HM. Recurrent ulnar-nerve dislocation at the elbow. *Clin Orthop.* 1975; 108:168–173.
32. Cain EL, Dugas JR, Wolf RS, *et al.* Elbow injuries in throwing athletes: a current concepts review. *Am J Sports Med.* 2003; 31:621–635.
33. Andrews JR, Timmerman LA. Outcome of elbow surgery in professional baseball players. *Am J Sports Med.* 1995; 23: 407–413.
34. Rettig AC, Ebben JR. Anterior subcutaneous transfer of the ulnar nerve in the athlete. *Am J Sports Med.* 1993; 21:836–840.
35. Danoff J, Lombardi J, Rosenwasser M. Use of a pedicled adipose
• flap as a sling for anterior subcutaneous transposition of the ulnar nerve. *J Hand Surg Am.* 2014; 39:552–555.
36. Gottschalk HP, Eisner E, Hosalkar HS. Medial epicondyle fractures in the pediatric population. *J Am Acad Orthop Surg.* 2012; 20:223–232.
37. Patel N, Ganley T. Medial epicondyle fratures of the humerus: how to evaluate and when to operate. *J Pediatr Orthop.* 2012; 32:S10–S13.
38. Lawrence JT, Patel NM, Macknin J, *et al.* Return to competitive
•• sports after medial epicondyle fractures in adolescent athletes: results of operative and nonoperative treatment. *Am J Sports Med.* 2013; 41:1152–1157.
39. Osbahr D, Swaminathan S, Allen A. Combined flexor-pronator mass and ulnar collateral ligament injuries in the elbows of older baseball players. *Am J Sports Med.* 2010; 38:733–739.
40. Wilson FD, Andrews JR, Blackburn TA, *et al.* Valgus extension overload in the pitching elbow. *Am J Sports Med.* 1983; 11:83–88.
41. Reddy AS, Kvitne RS, Yocum LA, *et al.* Arthroscopy of the elbow: a long-term clinical review. *Arthroscopy.* 2000; 16:588–594.
42. Cohen SB, Valko C, Zoga A, *et al.* Posteromedial elbow impingement: magnetic resonance imaging findings in overhead throwing athletes and results of arthroscopic treatment. *Arthroscopy.* 2011; 27:1364–1370.
43. Lee YS, Alcid JG, McGarry MH, *et al.* Effect of olecranon resection on joint stability and strain of the medial ulnar collateral ligament. *Orthopedics.* 2008; 31:648.
44. Kamineni S, Hirahara H, Pomianowski S, *et al.* Partial posteromedial olecranon resection: a kinematic study. *J Bone Joint Surg Am.* 2003; 85:1005–1011.
45. Kamineni S, ElAttrache NS, Ahmad CS, *et al.* Medial collateral ligament strain with partial posteromedial olecranon resection: a biomechanical study. *J Bone Joint Surg Am.* 2004; 86: 2424–2430.
46. Levin J, Zheng N, Dugas J, *et al.* Posterior olecranon resection and ulnar collateral ligament strain. *J Shoulder Elbow Surg.* 2004; 13:66–71.