Ulnar Collateral Ligament Tears of the Elbow

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Clinical History: A 22 year-old professional baseball pitcher experienced a painful pop and medial elbow pain while throwing. An (1a) inversion recovery coronal image of the elbow is provided. What are the findings? What is your diagnosis?

Figure 1: An (1a) inversion recovery coronal image of the elbow
Findings

Figure 2: An abnormal gap is present at the proximal attachment of the anterior bundle of the ulnar collateral ligament (arrow). The distal attachment upon the ulna (arrowhead) remains intact. Adjacent flexor pronator muscle edema (asterisk) is present.

Diagnosis

Acute, complete proximal tear of the anterior bundle of the ulnar collateral ligament, with an associated flexor-pronator muscle strain.

Introduction

The throwing athlete, particularly the professional baseball pitcher, places tremendous force upon the elbow in the performance of his sport. During the late cocking and early acceleration phases of pitching, medial elbow shear forces are extreme and elbow extension
may exceed 2500 degrees per second\(^1\). The ulnar collateral ligament (UCL) acts as the primary static restraint to the resultant valgus force upon the elbow, and the estimated force upon the ligament with pitching approaches the known limit of the ligament’s tensile strength. As a result, injuries to the ulnar collateral ligament in the professional baseball pitcher are quite common.

Relevant Anatomy

The ulnar collateral ligament of the elbow consists of three components, the anterior bundle (or band), the posterior bundle, and the transverse bundle (3a). The posterior bundle is a fan-shaped area of capsular thickening that extends from the medial epicondyle to the semilunar notch of the ulna. It is a secondary stabilizer of the elbow when the joint is flexed beyond ninety degrees. The transverse bundle bridges the medial olecranon and the inferomedial coronoid process. It does not attach to the humerus, and thus has little or no contribution to valgus stability\(^2\). The anterior bundle is the strongest\(^3\) component and by far the most important for valgus stability at the elbow.

The anterior bundle of the UCL itself has functional anterior and posterior components, with the anterior component being more important in extension and the posterior in flexion. However, these components are typically not seen as separate structures at surgery or on MR imaging. The anterior bundle of the UCL averages 6-7mm in width within its midportion, but it is not a uniform structure, generally increasing in width from its proximal to distal attachments. The origin of the ligament is round and located along the anteroinferior aspect of the medial epicondyle, distal to and lateral with respect to the adjacent common flexor tendon origin. The distal insertion of the ligament usually lies slightly distal to proximal ulnar cartilage, and is a fairly lengthy attachment that tapers at its insertion\(^4\).
Gross inspection of ulnar collateral ligamentous anatomy at the elbow is a challenge even at surgery. Using arthroscopy, only 20% of the anterior band can be directly visualized. Ulnar collateral ligamentous repair at the elbow is therefore almost always performed as an open technique. Even with open surgery, direct visualization of ulnar collateral ligamentous pathology is challenging. The common flexor tendon must be split or released in order to visualize the proximal attachment. And in cases where a tear is known to be present, the ligament may still appear intact at initial surgical inspection, as a superficial ligamentous layer closely associated with the elbow.
capsule typically maintains a normal appearance despite functionally complete underlying ligamentous injury (4a).

Figure 4:
An intraoperative view of the medial elbow is provided. The flexor pronator muscle complex (arrow) has been released from the medial epicondyle. The ulnar nerve (arrowhead) has been transposed and is retracted. The anterior band of the ulnar collateral ligament (dotted line) is visible posterior to the flexor pronator muscle mass. Although clinically known to have a tear, this patient's tear was not visible at surgery until the ulnar collateral ligament was split and a distal insertional tear was revealed. Photo courtesy of David Moore, MD, Elite Orthopaedics and Sports Medicine.

Normal Anatomy at MRI

As with open operative detection of UCL tears, the clinical evaluation of valgus laxity following UCL tearing is also challenging. Studies by experienced surgeons have demonstrated variability in the ability to detect UCL laxity via preoperative physical exam in the range of 26-82%. As a result, MRI's ability to provide a reliable preoperative evaluation becomes particularly critical with respect to the ulnar collateral ligament of the elbow.
The anterior bundle of the UCL of the elbow is most easily seen in the coronal plane (5a). Dependent upon slice thickness, it is usually visible on 2-3 consecutive coronal slices. It is normally of low signal intensity on both T1 and T2-weighted images, though it is common to visualize areas of higher signal intensity at the humeral attachment due to the presence of interspersed fat, particularly on short TE images. The adjacent flexor tendons lie in close proximity to the anterior bundle, particularly the contribution from the flexor digitorum superficialis. However, components of the common flexor tendon will always attach cephalad and medial with respect to the proximal attachment of the anterior bundle.

Figure 5:
The anterior band of the UCL (arrows) is well seen on this T1-weighted coronal image of the elbow. Note the relatively increased signal intensity within the proximal attachment, which lies along the undersurface of the medial epicondyle. The typical distal insertion site lies immediately adjacent to the proximal articular surface of the ulna. Common flexor tendon fibers (arrowheads) lie in close proximity to the UCL, but are seen to lie medial to the ligament, and to attach more cephalad, along the medial surface of the medial epicondyle.
As with any musculoskeletal structure of interest, the astute interpreter of MR is better served if he is able to fully evaluate the structure in more than one imaging plane. The anterior bundle of the UCL is usually seen en face in the sagittal plane, so this plane is suboptimal for the evaluation of the UCL. The axial plane, however, can be quite helpful, particularly for the evaluation of the mid to distal anterior bundle (6a). The ability to follow the anterior bundle and its relationships to adjacent structures in the axial plane is an essential component of a thorough MR evaluation of the medial elbow.
Sequential axial images of the elbow from distal to proximal demonstrate the anterior bundle of the UCL (arrows) from its distal attachment to near the proximal attachment. Note how the ligament courses from anterior to posterior as it extends from distal to proximal. The proximal attachment is rarely directly visible in the axial plane, as it lies en face due to its attachment along the undersurface of the medial epicondyle. However, the remainder of the ligament is quite well seen, as is its relationship to adjacent common flexor tendon components (arrowheads).

A final important anatomical point to make with respect to the normal MR appearance of the anterior bundle pertains to the location of the distal insertion. Classically, the distal insertion was thought to lie at the sublime tubercle immediately adjacent to articular cartilage. Indeed, Timmerman et al. described an arthroscopic T-sign in which the extension of contrast distal to hyaline cartilage was felt to represent an undersurface tear. However, it is now recognized that the distal insertion can lie distal to hyaline cartilage as a normal or developmental variant (7a), and insertions up to 3mm distal to the articular surface may exist in the absence of ligamentous injury.

Figure 7:
A gradient-echo coronal image in a 35 year-old with lateral elbow pain demonstrates the distal attachment of the UCL (arrow) approximately 3 mm distal to hyaline cartilage of the proximal ulna. The patient had no symptoms related to the medial elbow, and no history of prior valgus injury.

UCL Pathology of the Adult Throwing Elbow, with MR Correlation

The speed, force, and repetitive nature of the throwing motion in the elite athlete lead to several characteristic patterns of injury at the adult elbow. The most common and athletically significant of the abnormalities involve the medial elbow, which is subject to a high degree of repetitive valgus force (8a). The anterior bundle of the UCL, as the primary static restraint to valgus force, is particularly vulnerable. Its injuries are often associated with those of the flexor pronator muscle-tendon unit, an important dynamic stabilizer at the medial elbow. In a bit of a chicken and egg scenario, it is thought that strains and/or fatigue of the dynamic stabilizers may lead to increased tears of the UCL. Alternatively, stretching or insufficiency of the UCL results in a greater load upon the dynamic medial elbow stabilizers, resulting in increased injuries to the flexor-pronator muscle group. The ulnar nerve is also at risk for stretching or traction injury due to valgus force.
Partial or complete tears of the anterior bundle of the UCL in the baseball pitcher lead to chronic valgus instability. The clinical presentation is often one of medial elbow pain after pitching that initially may respond to conservative measures. Symptoms tend to worsen and treatment is sought when the pitcher loses accuracy or is unable to pitch at a velocity suitable for competition.

At physical exam, patients with UCL tears are found to have medial elbow tenderness, typically 2cm distal to the medial epicondyle. With recent tears, edema and ecchymosis may also be noted. Concomitant injuries to the flexor pronator muscles may be revealed by the presence of worsened pain with resisted wrist flexion. The mainstay of UCL clinical evaluation is the use of valgus stress tests, typically
performed with the elbow in partial flexion. A variety of maneuvers have been described, though their success varies widely, even in the hands of experienced examiners.

The pathologic MR appearance of the UCL in the throwing athlete is dependent upon the timing and severity of injury. In professional pitchers, ligamentous thickening (9a) may be seen even in asymptomatic players, and may represent an adaptive change rather than a pathologic finding\textsuperscript{10}. Chronic stress may also lead to heterotopic calcification, a finding that has been found to be highly associated with at least partial tearing of the UCL\textsuperscript{11} (10a).

\textbf{Figure 9:}
A T1-weighted coronal image from an 18 year old professional baseball pitcher demonstrates a generally thickened UCL (arrows), without focal abnormality.
Figure 10:
A T1-weighted coronal image from a 23 year-old baseball pitcher with chronic medial elbow pain reveals ossification (arrow) in association with the proximal attachment of the anterior band of the UCL. Distal ligamentous fibers (arrowhead) appear normal.

Following an acute injury in the throwing athlete, a variety of injury patterns to the UCL may be encountered. Avulsion fractures in association with UCL injury are well recognized in the adolescent thrower, in which the medial epicondyle is classically involved in the entity known as Little League Elbow. In the adult throwing athlete, the medial epicondyle is fully ossified and therefore is less likely to avulse secondary to valgus force transmitted from the UCL. However, fractures of the sublime tubercle are felt to be an under-recognized site of injury in the adult throwing athlete, and in many cases MR is able to diagnose this particular injury even when plain films appear normal.
Figure 11:
A fat-suppressed proton density-weighted coronal image in a 20 year old collegiate baseball player with persistent medial elbow pain after an initial painful event. The anterior band of the UCL is well visualized and intact (arrow). Marrow edema is evident deep to the distal attachment at the sublime tubercle (arrowhead).

Figure 12:
A corresponding fat-suppressed proton density-weighted axial image reveals interruption of cortex (arrow) at the site of the minimally displaced avulsion fracture of the sublime tubercle.

Acute tears of the anterior bundle of the UCL can be directly visualized on high quality MR images. Edema, abnormal laxity, and discontinuity of the ligament are all signs of UCL disruption. Partial tears demonstrate edema and focal areas of discontinuity with residual intact fibers (13a), whereas with complete tears laxity is more pronounced and edema and/or disorganized soft tissue extend across the width of the anterior bundle (14a-17a). Conway’s report on 70 athletes with UCL disruption revealed the large majority of tears to be midsubstance, followed by distal tears, with proximal tears being relatively rare. MR imaging, however, frequently visualizes both distal and proximal tears, usually in greater frequency than midsubstance tears. This discrepancy may be related to the relative difficulty in directly visualizing the proximal and distal ligamentous attachments at surgery. In contrast, careful inspection of both coronal and axial MR images of the elbow frequently allows identification of both the site and extent of UCL injury.

Figure 13:
Sequential fat-suppressed T2-weighted coronal images from a 20 year-old baseball pitcher. The image on the left reveals edema and laxity along the course of the anterior bundle of the UCL (red arrow), with attenuation at the distal attachment. The adjacent more posterior coronal slice reveals intact fibers of the anterior band (blue arrow).
Note also edema within the capitellum (arrowheads) on both images, secondary to lateral impaction forces.

**Figure 14:**
A STIR coronal image from a 23 year-old professional baseball pitcher reveals an edematous and disorganized proximal anterior bundle of the UCL (arrow).
Figure 15:
Sequential STIR axial images from distal to proximal reveal the anterior bundle to be intact at its distal to mid portion (arrows). Proximally, edema and soft-tissue thickening are present where normal ligamentous fibers should lie (asterisk), compatible with a complete tear. On the most proximal image, a tendon slip of the flexor carpi radialis (arrowhead) should not be mistaken for the UCL, as it lies too anteriorly at this level to represent the ligament.

Figure 16:
A STIR coronal image in a nineteen year-old baseball pitcher reveals an apparent distal tear (arrow) of the anterior bundle of the UCL.
Treatment of UCL Disruption, with MR Correlation

As with many musculoskeletal maladies, the initial treatment of a pitcher with persistent medial elbow pain consists of rest, anti-inflammatory medication, and physical therapy. If conservative therapy fails and if a tear of the UCL is suspected or diagnosed using MRI, then operative reconstruction of the ligament provides optimal results. Indeed, the development of the ulnar collateral ligament reconstruction technique is one of the greatest success stories in orthopaedic surgery and in sports. In his book, Saving the Pitcher, author Will Carroll comments “Since the invention of the breaking ball, there has been no more significant development in baseball than Tommy John surgery.”

Tommy John surgery is named for the Los Angeles Dodgers pitcher who underwent the first successful ulnar collateral ligament reconstruction in an elite overhead throwing athlete. The surgery was
performed by Dr. Frank Jobe and colleagues, and Jobe’s technique remains the standard on which all current UCL reconstruction techniques are based. Jobe’s technique involved the use of the palmaris longus tendon for graft material, detachment of the flexor-pronator tendon origin from the medial epicondyle in order to expose the operative region, and obligatory transposition of the ulnar nerve, the latter being necessary (and often desirable) in order to allow for placement of operative tunnels that penetrated posterior cortex of the humerus.

Since the original report by Jobe, numerous refinements in the technique for UCL reconstruction have been proposed\textsuperscript{15}, and the popularity of the procedure has steadily grown. Modifications to the technique include a muscle splitting approach that avoids detachment of the common flexor tendon, and various graft fixation techniques that simplify or reduce the need for osseous tunnels, the latter allowing the ulnar nerve to remain in situ. By some estimates, one in nine Major League pitchers have undergone UCL reconstruction, and there are anecdotal reports of overzealous parents of young athletes who request the procedure pre-emptively in order to increase strength or prevent future injury!

The variations in UCL reconstruction are important surgically, but in general have a similar MR appearance. The reconstructed ligament, most commonly created by a looped length of palmaris longus tendon, is considerably larger than the native UCL, and thus can be readily followed on coronal or axial MR images (18a).
Figure 18:
A fat-suppressed proton density-weighted coronal image in a professional baseball pitcher who underwent UCL reconstruction reveals an intact graft (arrows) demonstrating normal low signal intensity and no laxity along its course.

In patients who have undergone UCL reconstruction and have recurrent pain, MR provides excellent visualization of recurrent tears (19a), but also provides simultaneous evaluation for other causes of recurrent pain, including ulnar neuritis, stress reactions, loose bodies, and posteromedial impingement.
Figure 19:
A STIR coronal image from a 22 year-old pitcher who experienced acute pain and weakness one year following UCL reconstruction. The UCL graft is focally interrupted (arrow) compatible with a complete tear just distal to the humeral attachment.

Conclusion

The competitive nature of sports in today’s society is well demonstrated by the incidence of UCL injuries in the professional baseball pitcher. Elite pitchers frequently exceed the degree of valgus stress that nature intended the human elbow to sustain. The result is a preponderance of UCL tears in this population, and given the fact that the clinical and even operative evaluation of UCL integrity is challenging, the importance of MR in patient evaluation cannot be underestimated. Careful inspection of images and knowledge of the normal and pathologic states that may be encountered are critical in order for the MR interpreter to accurately assess the situation, thereby providing valuable guidance for future patient management.
References


- See more at: http://radsource.us/ulnar-collateral-ligament-tears-of-the-elbow/#sthash.9PHQ5Taq.dpuf