Elbow Pain and Injury in Young Athletes

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Abstract: Elbow pain and injury in young athletes include both acute traumatic and chronic overuse injuries. The anatomy of the developing pediatric elbow and the rapid growth of youth sports have led to an increase in chronic repetitive stress elbow injuries in the pediatric population. These injuries occur mostly in overhead athletes, throwers, and gymnasts. Force dissipation during throwing or axial loading results in lateral compression elbow injuries such as Panner’s disease and osteochondritis dissecans of the capitellum or radial head. Medial distraction forces are responsible for medial injuries such as UCL failure, medial epicondyle apophysitis, and avulsion. Valgus extension overload causes posteromedial elbow impingement, olecranon apophysitis, and olecranon stress fractures. Conservative treatment modalities such as activity modification and physical therapy are successful in most cases, but early recognition is important as delays in diagnosis may prolong symptoms and necessitate operative intervention.

Key Words: elbow injuries, sports injuries, pediatrics, UCL reconstruction, elbow trauma

(Pediatric and adolescent athletic elbow injuries include acute traumatic fractures and dislocations as well as chronic overuse injuries from repetitive stress. Traumatic injuries are well known to the pediatric orthopaedist and include elbow dislocations, medial epicondyle avulsions, olecranon “sleeve” fractures, supracondylar, lateral condyle, and radial head or neck fractures. These injuries often result from a fall on an outstretched hand and are common in gymnastics as well as in contact sports such as wrestling and football. Injury patterns are related to the relative weakness of the developing physes. Years of clinical experience and research have led to standardized management guidelines for most pediatric traumatic elbow injuries and is beyond the scope of this study. The treatment of displaced medial epicondyle avulsion fractures remains an area of controversy with some surgeons now favoring anatomic reduction and internal fixation in adolescent throwing athletes.

The rapid growth of youth sports has led to a shift in injury patterns in the pediatric and adolescent elbow. Chronic repetitive stress injuries are now more common than acute traumatic fractures and dislocations in the pediatric population. Year-round sports that lack significant rest periods have led to overuse injuries in pediatric and adolescent athletes, which resemble those of professional athletes. Repetitive stress injuries result from medial tension, lateral compression, and posterior valgus extension forces placed on the elbow while throwing. Gymnasts place similar forces on their elbow through repetitive upper-extremity axial loading during handsprings and handstands. Adult overuse elbow injuries such as medial epicondylitis, flexor-pronator tendinosis, ulnar collateral ligament insufficiency, and posteromedial elbow impingement are now also seen in the pediatric population.

The anatomy of the pediatric elbow predisposes the child athlete to unique injuries inherent to vulnerabilities related to growth and development. Elbow growth occurs through 6 secondary ossification centers that predictably arise and develop with age. During growth, these apophyses are sites of attachment of ligaments and tendons and are especially vulnerable to stress injury, termed apophysitis. Lateral compression forces across the radiocapitellar joint produce injury patterns unique to children such as Panner’s disease and osteochondritis dissecans (OCD) of the capitellum or radial head. There is a high incidence of OCD of the capitellum in the dominant extremity of male throwing athletes and female gymnasts. Vascular studies have documented that the capitellum has a precarious blood supply of end arterioles without metaphyseal contribution. Most investigators believe OCD lesions develop from repetitive microtrauma causing localized ischemia in the capitellum through interruption of these subchondral terminal arterioles. This ischemia progresses to a localized stress fracture of the subchondral bone, which becomes the OCD lesion.

Epidemiology of Pediatric and Adolescent Elbow Pain

The highest rates of pediatric elbow injuries occur in little league baseball, tennis, and gymnastics. The most common site of elbow pain in the young athlete is medial. In 1976, 2 surveys on more than 700 little league pitchers aged 11 to 12 years reported a 17% to 20% prevalence of elbow problems including 10% to 15% rate of elbow flexion contractures. More recently, Hang et al interviewed...
343 little leaguers and noted that 58% of pitchers and 63% of catchers reported elbow soreness whereas medial epicondyle separation was noted radiographically in 63% (pitchers) and 70% (catchers). Adolescent tennis players have high elbow injury rates as well. A 6-year injury surveillance study of 1440 athletes at the United States Tennis Association boys tennis championships showed a 1% incidence of new elbow injuries whereas 10% of athletes reported a history of elbow pain (most commonly attributed to lateral epicondylitis). In 1998, a United States Tennis Association survey reported that 20% to 25% of adolescent tennis players complained of current or earlier elbow pain. Axial loading during handsprings and handstands in gymnasts places high forces across the elbow. A high incidence of acute, traumatic elbow injuries including medial epicondyle avulsions and elbow dislocations occurs in gymnasts.

**THROWING MECHANICS AND INJURY PATTERNS**

“Little league elbow” comprises a wide spectrum of injuries including OCD of the capitellum or radial head, apophysitis of the medial epicondyle and olecranon, medial epicondyle avulsion, UCL insufficiency, and postero-medial elbow impingement. These injuries relate to the basic biomechanics of throwing. The act of pitching has been divided into stages: windup, early cocking, late cocking, acceleration, deceleration, and follow through. During the late cocking and early acceleration stages, rapid elbow extension is combined with a tremendous valgus stress, which produces peak compression across the lateral elbow compartment and distraction across the medial elbow compartment (Fig. 1). In the deceleration phase, a valgus extension shear force in the posterior elbow compartment occurs. Pediatric throwers develop the normal stages of throwing by the age of 9 years. The adolescent throwing motion produces similar stress patterns at lower magnitudes when compared with adults. Sidearm throwing is associated with greater elbow injury rates compared with the overhead motion.

Microtrauma from repetitive throwing stresses produces predictable injury patterns. Lateral elbow compression may result in Panner’s disease and OCD of the capitellum or radial head. Medial distraction forces can lead to UCL failure, medial epicondyle avulsion, medial apophysitis, and ulnar neuritis. Valgus extension overload in the posterior compartment can cause posteromedial osteophytes within the olecranon fossa. Adapted with permission from Refs. 23 and J Am Acad Orthop Surg. 1994;2:261–269.

**LATERAL COMPRESSION INJURY: PANNER’S DISEASE AND OCD OF THE ELBOW**

Panner’s disease generally occurs in younger children aged 4 to 8 years and is a self-limiting avascular necrosis of the developing ossific nucleus of the capitellum. Fragmentation of the entire ossific nucleus is seen on the radiographs. Although etiology is unclear, lateral compression forces across the radiocapitellar joint during a vulnerable period of growth are thought to play a role. In Panner’s disease, normal capitellar growth resumes after the initial period of fragmentation. The condition generally improves after a period of rest and rehabilitation and late sequelae are rarely noted.

Elbow OCD occurs from repetitive lateral compression across the radiocapitellar joint in adolescent athletes, especially male baseball players and female gymnasts. The OCD lesion usually occurs in the capitellum, which has a more tenuous blood supply but can also be seen in the radial head. Elbow OCD clinically presents with the insidious onset of lateral elbow pain with throwing or axial loading handstands. Physical examination commonly reveals an elbow effusion with loss of elbow extension and limitation of pronation and supination. Mechanical symptoms such as locking or catching or crepitus with elbow range of motion suggest lesion instability or loose bodies. Radiographs of the elbow, including an anteroposterior view in 45 degrees of flexion, may show irregular ossification in the capitellum. Comparative views of the contralateral elbow are helpful in identifying subtle abnormalities. Magnetic resonance images (MRI) are more sensitive than radiographs in identifying subtle abnormalities.
diagnosing elbow OCD and can also identify chondral loose bodies (Fig. 3). In addition, MRI allows visualization of the integrity of the chondral surface over the OCD lesion, which is necessary for classifying lesion stability. Stable OCD lesions have an intact overlying chondral surface, whereas in unstable lesions the chondral surface has been violated. Unstable OCD lesions may break off to form loose bodies.

Stable elbow OCD lesions are initially treated conservatively with a period of rest and occasionally immobilization followed by physical therapy to regain motion. Cessation of the offending activity is of prime importance. Baseball players must stop pitching and gymnasts must halt axial loading activities. A gradual return to full activity occurs after 6 to 12 months if the patient is clinically asymptomatic. Radiographic healing is often difficult to assess and may lag behind clinical healing. Education of patient, family, and coaches along with pitch count or axial loading restrictions can help prevent reinjury. Surgical indications for elbow OCD include unstable lesions, mechanical elbow symptoms, persistent pain, and loss of motion. Stable lesions are treated with arthroscopic or open transarticular drilling with or without internal fixation. Unstable lesions can be treated with lesion reduction and fixation, lesion debridement with drilling of the base or articular surface reconstruction.

Long-term studies suggest that the natural history of elbow OCD is not benign. Bauer et al. reported that in 31 patients with OCD of the capitellum at a mean follow-up of 23 years, 50% had elbow symptoms that most commonly were loss of motion and pain. Radiographic arthritis was present in more than half of these patients. Outcomes data on the surgical treatment of elbow OCD are limited. A recent study suggests that for large unstable lesions fragment fixation or articular surface reconstruction may lead to better results than simple excision. Return to sport can be difficult after surgery. In a series of 7 competitive female gymnasts with advanced OCD of the capitellum treated surgically, only 1 was able to return to high-level gymnastics at 2.9 years follow-up.

**MEDIAL DISTRACTION INJURY: MEDIAL EPICONDYLE APophysitis and Avulsion**

Medial epicondyle apophysitis is a repetitive overuse distraction injury to the medial epicondyle apophysis. It is commonly seen in male baseball players and female gymnasts. Clinically, medial epicondylitis presents with the insidious or acute onset of pain at the medial aspect of the elbow during pitching or handstands. On physical examination, loss of elbow extension and pain with valgus stressing are common. Pain localizes directly to the medial epicondylar region. Conservative treatment includes rest, ice and anti-inflammatory medications. Activity modification should include reducing or eliminating valgus stresses to the elbow. For baseball players, a gradual return to throwing (often the next season) is indicated. For gymnasts’ handstands, floor routine and vault should be halted and then gradually reinstated.

An acute valgus stress to the medial epicondyle may also produce an avulsion fracture. This injury is seen in young baseball pitchers and gymnasts. In the past most of these injuries were treated nonoperatively despite fragment displacement. Radiographic nonunions were thought to be benign. However, the UCL complex originates at the medial epicondyle and as the importance of the medial elbow stabilizers in baseball players and gymnasts has become apparent, concerns have been raised regarding medial elbow stability in these patients. For children active in sports, which places high distraction forces on the medial elbow (baseball, gymnastics, wrestling, and others) anatomic reduction and fixation of displaced medial epicondyle fractures may best restore the tension of the medial elbow stabilizers (Fig. 4).
MEDIAL DISTRACTION INJURY: UCL

The UCL complex is a capsular thickening that originates at the medial epicondyle and inserts on the sublime tubercle of the ulna. It comprises an anterior bundle, posterior bundle, and transverse ligament that form a triangle on the medial side of the elbow. Although the UCL complex is the primary stabilizer of the ulnohumeral joint, the osseous congruity of the ulna and humerus along with the dynamic muscle tone about the elbow provide a significant contribution to medial elbow stability. The UCL complex alone is not necessary for “normal” elbow function. The UCL is torn in 90% of primary elbow dislocations and is not routinely repaired. The UCL is essential in high-level throwers including baseball pitchers, football quarterbacks, and javelin throwers. These athletes place high demands on the medial elbow stabilizers and require all medial stabilizing forces to be functioning properly for peak performance. The UCL complex alone is insufficient to withstand the force of a single high-level baseball pitch.

UCL tears have historically been an injury of high-level skeletally mature throwing athletes. These injuries are uncommon in skeletally immature athletes because the UCL complex is stronger than the nearby growing physis.29 However, recent reports have noted an increased incidence of UCL injuries in adolescents and high-school baseball players.30 UCL failure can occur through either catastrophic or attritional modes. Catastrophic UCL failure is an acute UCL rupture associated with a distinct “pop” and immediate pain over the UCL. In these cases, radiographs are necessary to rule out a medial epicondyle or olecranon avulsion fracture. Acute UCL rupture is most commonly treated surgically with repair or reconstruction in high-level throwers.

Attritional UCL insufficiency occurs from chronic repetitive microtrauma to the UCL complex producing microtears. This mode of injury is more common than catastrophic UCL failure and produces the insidious onset of discomfort over the UCL, classically associated with high-velocity throwing. Medial elbow pain from attritional UCL insufficiency tends to recur immediately upon resuming high-velocity pitching even after a long period of rest. The differential diagnosis for insidious medial elbow pain in a thrower includes medial epicondyle apophysitis, flexor pronator tendinosis, and ulnar neuritis. An MRI may show changes in the UCL consistent with attritional UCL insufficiency. Attritional UCL insufficiency is first treated with a period of rest for 3 months. Steroid injections into the UCL are contra-indicated. An interval throwing program is then reintroduced and if symptoms recur, surgical reconstruction is considered.

UCL insufficiency was once a career-ending injury. Early attempts at direct repair of the UCL produced mixed results with a 50% rate of return to high-level sports.31 Dr Frank Jobe performed the first UCL reconstruction in 1974 on Tommy John, a major league baseball pitcher. UCL reconstruction relies on a free tendon graft placed in humeral and ulnar bone tunnels. Conway (and Jobe) et al31 first reported success with this procedure with 68% of athletes returning to high-level sports after UCL reconstruction including 12 of 16 (75%) major league baseball players. Technique refinements including a muscle splitting approach to the flexor pronator mass, no obligatory ulnar nerve transposition, and a docking technique for humeral fixation have improved outcomes and reduced complications.30 Recent studies have reported 90% to 95% rates of return to sports.32–35 UCL reconstruction has become the gold standard for surgical treatment for UCL insufficiency.

For the skeletally immature competitive throwing athlete, UCL reconstruction is considered only after failure of at least 6 months of conservative care.1,29 The reconstructive technique used is generally the same as for adults.31 Few data exist as to the efficacy of this procedure in high-school athletes.36 For proximal or distal UCL tears (not mid-substance tears), primary repair may be a viable alternative to reconstruction in the high-school athlete. Savoie et al37 reported 93% good-to-excellent results with return to sports by 6 months postoperatively in 60 high-school athletes, mean age 17 years, treated with direct repair of proximal or distal tears.

VALGUS EXTENSION OVERLOAD: POSTEROMEDIAL IMPINGEMENT AND OLECRANON APOPHYSITIS

Force dissipation in throwers also produces shear stresses across the posterior compartment, which has been termed valgus extension overload. Osteophytes may form at the posteromedial tip of the olecranon, which can impinge on the trochlea in the elbow extension. These osteophytes can fracture and produce loose bodies in the posterior elbow. Clinically, the athlete with posteromedial impingement from valgus extension overload presents with pain in the posteromedial elbow during the deceleration phase of throwing. Mechanical symptoms suggest the possibility of a loose body. Often subtle valgus instability because of ulnar collateral ligament insufficiency is present. On physical examination, the valgus extension overload test reproduces pain in the posteromedial elbow as the examiner forces the slightly flexed elbow into full extension while applying a valgus force. Radiographs may show osteophytes at the posteromedial olecranon but MRI is a more reliable test for the presence of loose bodies and chondral injuries to the trochlea.

Treatment of posteromedial elbow impingement initially is rest and activity modification followed by a gradual return to pitching. Surgical intervention consisting of open or arthroscopic removal of loose bodies and posteromedial osteophytes is considered for nonresponders. Concurrent UCL reconstruction should be considered if a component of valgus instability is present. Aronen38 described the posterior fossa syndrome, a similar injury in gymnasts, which causes posterior elbow pain with forced elbow extension.
Olecranon apophysitis is a traction injury unique to the pediatric elbow. Radiographs may show widening or asymmetry of the olecranon apophysis when compared with the contralateral elbow. Most cases are treated conservatively with rest and immobilization followed by rehabilitation. Delayed union or nonunion of the olecranon apophysis has been described in adolescent throwers and may require surgical fusion.

**SUMMARY**

Elbow injuries have become increasingly common in the pediatric and adolescent athlete. Chronic overuse injuries are more common than acute traumatic fractures and dislocations. The mechanism of injury to the elbow in the pediatric and adolescent athlete is the same as in adults. Force dissipation from valgus overload in overhead throwing athletes and gymnasts produces lateral compression and medial distraction injuries. However, anatomic differences in the pediatric elbow also produce unique injury patterns not seen in adults such as OCD and apophysitis. Although most conditions are initially treated nonoperatively, delays in diagnoses may worsen symptoms and necessitate operative intervention. Surgical outcomes may be inferior to what would have been achieved by early diagnosis and appropriate treatment.

Given the vulnerability of the developing pediatric elbow, the education of parents and coaches regarding elbow injuries in children is paramount to prevention and treatment. Depending on patient age, the American Academy of Orthopaedic Surgeons recommends limiting pitchers to no more than 4 to 10 innings per week, 30 to 40 pitches per practice session, and 60 to 100 pitches per game. Technique refinements such as avoiding the curve ball pitch and limiting sidearm throwing may also diminish elbow stresses. Through education, pitch counts, and technique training, the incidence of overuse injuries in this patient population may be diminished.

**REFERENCES**


