

Little League Elbow: Medial Epicondyle Apophysitis

Between 2013 and 2018, baseball and softball saw the largest growth in youth participation numbers of any other sport in the U.S., with an increase of almost 3 million children.¹ Nearly 25 million kids across the country played baseball or softball in 2018.¹ According to the Aspen Institute, baseball was the second-most popular sport in 2018 amongst children aged 6-12 years, with basketball coming in at number one.¹ These numbers are a positive sign for the sport of baseball and for the physical and social development of youth in the U.S. These numbers also indicate that many children are at potential risk of overuse injuries.

In throwing sports, about 30% of injuries occur at the shoulder or elbow, and roughly 50% of youth baseball players report experiencing shoulder or elbow pain during their season.² Studies of baseball players age 11-12 years have reported around 20% with medial elbow symptoms and around 30% with radiographic changes.³ Other studies have found between 50-60% of 17-year-old baseball players with elbow pain or radiographic changes.³ Little league elbow (LLE) has been reported to occur in 20-40% of school-aged pitchers.⁴ LLE is a catch-all term used to describe a number of injuries that cause medial elbow pain in youth overhead throwing athletes.² Lesions associated with LLE can include: flexor-pronator mass strain, medial epicondyle apophysitis, medial epicondyle fracture, radiocapitellar osteochondral lesions, ulnar collateral ligament (UCL) injuries, and ulnar nerve neuritis.^{2,5} All positions on the diamond have the possibility of developing symptoms, however pitchers and catchers are at the highest risk.³ This paper will focus on medial epicondyle apophysitis (MEA), however during discussion of evaluation of a patient with medial elbow pain, differential diagnosis and strategies to rule out the other pathologies will be discussed.

Pertinent Anatomy of the Elbow

The elbow joint encompasses three articulations contained within the fibrous joint capsule: the humeroulnar joint, the radiocapitellar joint, and proximal radioulnar joint.³ The humeroulnar joint is formed by the convex trochlear groove and the concave surface of the ulna. The radiocapitellar joint is located lateral to the humeroulnar joint, consisting of a convex capitulum and a concave radial head (See **Figure 1** in Appendix).³ The elbow joint complex has two degrees of freedom, flexion-extension and pronation-supination.³

In addition to the joint capsule, the UCL and radial collateral ligament (RCL) are the main stabilizers to valgus and varus stress at the elbow joint, respectively.³ Of particular interest, the UCL attaches to the humerus at the site of the medial epicondyle. In addition to the UCL, the medial epicondyle serves as the attachment site of common flexor and pronator tendons of the forearm (See **Figure 2** in Appendix). This attachment site of soft tissue into bone is called an enthesis.⁶

In the developing skeleton, entheses have epiphyseal plates underneath them, consisting of fibrocartilage that ossifies over time with growth.⁶ Apophysis is the term used to refer to entheses with unfused growth plates. These apophyses are considered traction epiphyses, such that physiologic tensile forces through the soft tissue-bone-growth cartilage-bone complex stimulate growth and maturation of the enthesis site.^{6,7} Too little tensile force will result in poor development of the insertion site, but this rarely occurs. Too much tensile force causes an inflammatory response at the apophysis, and may create long term damage if untreated.

There are six centers of ossification in the developing elbow.³ Most centers fuse around 14-16 years of age in adolescent boys.³ The last center to fuse is the medial epicondyle

apophysis.³ This is the site of concentrated tensile stress during the valgus moment imposed by the overhead throwing motion.⁸

Biomechanics of the Elbow and Overhead Throwing Motion

During valgus stress to the elbow, tensile stress is imposed on the UCL as the ulnar surface is distracted from the trochlear surface, while on the lateral side of the elbow the radial head is compressed against the capitellum.⁹ The UCL is most taut in full elbow extension. In extension, the UCL, joint capsule, and bony anatomy share the resistance to valgus stress roughly equally.⁹ As the elbow flexes towards 90 degrees, the joint capsule becomes loose and the UCL fills the void as the primary restraint.⁹ In order to stabilize the elbow joint during externally imposed valgus moments, the UCL and common flexor-pronator muscle tendon units respond by inducing an internal varus moment. This is achieved by large amounts of tensile force transmitted through the medial epicondyle apophysis. As stated earlier, tension on the growth plate is necessary for growth, however too much tensile stress can be problematic.

The pitching motion can be divided into 6 phases: windup, stride, cocking, acceleration, deceleration, and follow-through.⁷ The windup begins with the first movement and ends when the throwing hand leaves the glove.⁷ During this phase, the player must balance on the back leg while the lead leg is elevated off the support surface.³ The stride begins when the hand leaves the glove and ends when the lead foot contacts the ground.⁷ In this phase the arm is elevated to the throwing position (shoulder abduction and external rotation) while the hips and torso begin to rotate towards the target. The cocking phase begins when the stride foot hits the ground and ends when the throwing shoulder reaches maximum external rotation.⁷ It is during this phase that medial tensile stress and lateral compressive stress begin to be experienced by the elbow. Peak valgus torque is reached just before maximal shoulder external rotation.^{3,7}

The acceleration phase begins with maximum shoulder external rotation and ends when the ball leaves the hand.⁷ As noted above, medial soft tissues generate varus torque about the elbow to resist the valgus moment being imposed by the weight of the ball, forearm, and hand. During the late cocking and early acceleration phases, the medial elbow experiences excessive tensile forces, the lateral elbow compressive forces, and the olecranon undergoes both shear and traction forces.²

Deceleration begins when the ball leaves the hand and ends when the shoulder reaches maximum internal rotation.⁷ Peak elbow compressive stress, mostly concentrated at the lateral elbow, occurs during this phase.⁷ The follow-through is the final phase, and ends when the back leg contacts the ground and the player is in a fielding position.⁷ (See **Figure 3** in Appendix)

Other terminologies regarding the throwing motion would be helpful for the therapist to be familiar with, so as to effectively communicate with patients and families while providing treatment. Of note is the “arm slot,” which refers to the position of the throwing shoulder at the point of ball release.³ There are three typical arm slots: 12 o’clock, three-quarter, and side-arm positions.³ It is understood that the side-arm slot places greater valgus stress on the elbow.¹⁰ However, other studies have suggested that valgus stress at the elbow increases with increased shoulder abduction angle.¹¹ It has also been demonstrated that as elbow flexion angle in the late cocking/early acceleration phase increases, valgus stress decreases.¹² This is potentially because the moment arm to the elbow varus/valgus axis of rotation decreases, while the moment arm to the shoulder internal/external rotation axis increases as the elbow moves into greater flexion. Using this information, it can be inferred that a side-arm slot and positions of excessive shoulder abduction predispose the elbow to a more extended position during the acceleration phase, thereby increasing valgus stress at the elbow.

Tissue Properties, Mechanism of Injury, and Risk Factors

As stated above, peak valgus stress at the elbow occurs just before maximum shoulder external rotation, and remains high through the acceleration phase of throwing.^{3,7} The valgus torque places excessive tensile stress on the UCL and common flexor tendon complex, transmitting this force to the medial epicondyle apophysis. Due to the presence of the growth cartilage at the apophysis, the bone structure is weaker than the soft tissue.³ When repetitive excessive tensile stress is transmitted through the apophysis complex, tissue failure is more likely to occur in the region of the epiphyseal plate rather than in the soft tissue substance or enthesis site.¹³ The medial epicondyle is the weakest structure in a skeletally immature elbow, and it is consequentially the site of most of the pathology.¹⁰ This places youth athletes at a higher risk of developing apophyseal injuries in scenarios of overuse, especially for overhead throwing athletes.

Other risk factors for developing MEA have been identified as: excessive pitch counts, inadequate rest between days of high volume/intensity of throwing, year-round play, pitching despite arm pain/fatigue, poor pitching mechanics, lack of physical conditioning, and pitch type.^{2,7,14} Other risk factors have been found to be older age, greater body weight, and shorter stature in the age group of 9 to 12.^{11,14} Position players who don't pitch or catch have demonstrated abnormal magnetic resonance imaging (MRI) findings and elbow symptoms, therefore year-round play appears to be an overlooked risk factor.¹⁴ Pitch count limits are not completely addressing the problem. Pain and injury in the young thrower appear to be more closely related to the total number of throws in a year than pitches per game or season.¹⁴

Fundamental movement deficiencies place young athletes at a disadvantage when it comes to mastering the complex movements of the baseball pitch.⁷ Poor pitching mechanics,

such as shoulder abduction below 90 degrees and opening the hips and trunk before the stride foot hits the ground, are associated with more stress on the elbow during the pitching motion.⁷ Poor trunk and hip force production drive the pitcher to rely on arm strength to generate velocity for the pitch, thereby increasing stress in the upper extremity.⁷

With regards to shoulder and elbow position during the throwing motion, somewhat conflicting findings have been reported. A computer simulation study proposed that valgus stress at the elbow was at its lowest when the shoulder was in 100 degrees of abduction and the trunk was in 10 degrees of lateral tilt away from the throwing arm side.¹¹ The same study found peak elbow valgus stress with 120 degrees of shoulder abduction and 40 degrees of trunk lateral tilt.¹¹ In contrast, other research has concluded valgus stress in the elbow is increased when shoulder abduction is less than 90 degrees.⁷ There appears to be a “sweet spot” of shoulder abduction angle during the throwing motion to reduce elbow valgus stress, as mentioned above.

In adult pitchers, valgus torque in the elbow has been associated with late trunk rotation, reduced shoulder external rotation, and increased elbow flexion.³ This is contrasted with studies of youth overhead throwers that have shown players with a history of elbow pain have demonstrated decreased elbow flexion in the late cocking phase and increased lateral trunk tilt at ball release compared to healthy matched controls.¹¹ To add to the confusion, studies have found that a shoulder external rotation deficit increases elbow valgus stress, while greater shoulder external rotation in the late cocking phase has been associated with increased valgus stress.^{3,11} Meanwhile, youth baseball players with medial epicondyle lesions on ultrasound and MRI had significantly reduced shoulder external rotation passive range of motion.¹⁵ Despite the fact that adult and youth throwing mechanics differ, it appears that deviations from established technique

increases valgus torque at the elbow and increases risk of injury in both populations. Discussion of proper pitching mechanics for youth athletes can be found below.

Changes can be visualized on ultrasound of the medial elbow in a significant number of adolescent throwers with MEA. Morphologic changes such as acute bony avulsion, heterogenous ossification of the UCL, and varying degrees of widening or fragmentation of the medial epicondyle apophysis have been documented in youth baseball players.¹⁶ There has also been a correlation proposed between age and the prevalence of lesion presentations. A recent study of Japanese youth baseball players found that irregular and fragmented lesions reached their greatest respective prevalence around age 11-12 years, while hypertrophic lesions peaked in prevalence about 16 years of age.¹⁶ (See **Figure 4** in Appendix)

Visualization can be helpful in diagnosing the origin of medial elbow pain, as well as inform treatment decisions. Irregular lesions have been associated with less severe injuries, while fragmented lesions have been correlated with more debilitating elbow pain¹⁶ (See **Figures 5** and **6** in Appendix). Additionally, in the case of avulsion fractures of the apophysis, the degree of displacement on ultrasound or radiograph may indicate whether or not surgical fixation should be utilized.^{2,8}

Evaluation of a Patient with MEA

Evaluation of the adolescent athlete with elbow pain should include all the major components of any physical therapy (PT) evaluation. When taking subjective history, it is important to find out what position the patient plays, specifically if they pitch. Additionally, information about the number and types of pitches thrown per game and season, the frequency of pitching, and the number of leagues the patient plays in will be critical to gather.³ Pain description should be investigated. Specifically, the chronicity, timing of when the pain occurs

during the throwing motion, quality of pain, and previous treatments with outcomes should be investigated.³

Physical examination should include observation of the upper extremity for alignment or any appreciable redness or swelling, palpation of all major bony landmarks and soft tissue structures, assessment of active and passive range of motion, strength, and joint stability.³ In addition to MEA, differential diagnosis for medial elbow pain in the young athlete should include UCL sprain, flexor-pronator mass strain, medial epicondyle fracture, and ulnar nerve neuritis.^{2,3} Palpation of the UCL and flexor-pronator muscle-tendon unit, assessment of active and passive range of motion, and a strength assessment should be performed to rule out injury to those tissues.³ Palpation along the course of the ulnar nerve should be performed to rule out ulnar neuritis.³ Sometimes ulnar neuritis can occur in conjunction with or after resolution of MEA, so even if the patient simply has a history of LLE it is important to rule this out.⁵

Classical signs and symptoms of MEA have been documented as complaints of pulling, popping, or giving out while throwing, swelling, limitation of elbow range of motion, and point tenderness over the medial epicondyle.¹⁷ The patient with MEA will likely present with tenderness to palpation over the medial epicondyle and flexor-pronator tendon, localized swelling, and a possible elbow flexion contracture.² The moving valgus stress test should be performed to assess the integrity of the UCL (See **Figure 7** in Appendix). This test mimics the late cocking phase of the throwing motion. Pain during the arc of 70-120 degrees of elbow flexion indicates a positive test and possible UCL or MEA pathology.^{3,18}

Diagnosis can be aided by imaging, such as radiograph or ultrasonography. Radiograph is able to visualize avulsion fractures of the epiphyseal plate, whereas ultrasonography can help visualize tissue changes of the apophysis or surrounding soft tissue structures.^{2,16} Imaging studies

of the contralateral upper extremity are imperative to discern what is pathological and what is simply a variation of normal anatomy.³ Abnormal findings on ultrasound have demonstrated a strong positive predictive value of finding medial epicondyle abnormalities on MRI in youth baseball players.¹⁵ That being the case, it is important to consider that patients can exhibit tissue irregularities on imaging studies and still be symptomatic. As with any condition, imaging does not always coincide with patient presentation.^{2,19} Therefore it is important to give substantial weight the clinical examination findings and use the imaging results as supplementary data.

If an overhead thrower presents with medial elbow pathology, assessment should be performed of the lateral elbow as well. Often, pathologic changes to the articular cartilage of the radial head or capitulum develop secondary to excessive compressive stress.² Damage to the radiocapitellar joint is associated with two major pathologies, Panner disease and osteochondritis dissecans (OCD). These conditions have distinct differences and should be treated differently. Panner disease is an idiopathic osteochondrosis of the capitulum, with onset typically between 4-9 years of age.² Throwing is an aggravating factor, but not a cause.²

OCD of the capitulum typically presents in 12- to 16-year-old baseball players or gymnasts (See **Figure 8** in Appendix).² It is caused by repetitive compression microtrauma imposed on the capitellum.² Common presentation is poorly localized lateral elbow pain that worsens with provocative activity, such as throwing.² Radiographs typically reveal capitellar radiolucency with surrounding subchondral sclerosis.² Better prognosis is associated with patients with open physes, stable lesions, and no subchondral sclerosis.² Conservative management consists of rest, activity modification, and PT for strength and maintenance of range of motion.² Surgical intervention options are typically microfracture or osteochondral autograft transfer system (OATS) procedures.²

Evidence-based Treatments and Prevention Strategies for MEA

The most effective way to treat MEA and LLE is to prevent it from happening in the first place. Emphasis should be placed on limiting overall throwing volume and year-round play, physical conditioning of the youth athlete, and teaching proper pitching mechanics. By adhering to pitch count limits, allowing adequate rest during the season in between practices and games, and limiting the number of teams played on during the year can keep throwing volume within a tolerable and safe range.³ A group of researchers even created a pre-season checklist to help identify players who might be at higher risk of developing upper extremity injuries, so those players could be closely monitored by coaches and parents.⁴ Items on the checklist include history of shoulder or elbow pain/injury, volume of play/practice, and presence of fatigue while throwing (See **Figure 9** in Appendix).⁴ Pitch count restrictions have been enacted by USA Baseball and the corresponding governing body in Japan for Little League players. However, less than half of coaches in both countries correctly responded to survey studies about these guidelines.^{4,14} When interacting with coaches or parents of young baseball players, it may be prudent to take that opportunity to educate them on the existence of the guidelines and where to access them (See **Figures 10** and **11** in Appendix).

In terms of physical conditioning, youth athletes can respond well to safely prescribed strength and conditioning programs that emphasize trunk and hip strengthening as well as preserving shoulder range of motion.⁷ Some coaches and clinicians advocate for performing a functional movement screening assessment prior to the season to find out where each player has deficits.⁷ By training youth throwers to use their large muscle groups to generate force and maintain control with gross motor movements, this will reduce the risk of injury and potentially improve quality of athletic performance.

There are five critical features of youth pitching mechanics that should be emphasized to reduce valgus stress at the elbow (See **Figure 12** in Appendix). Three out of the five features occur before the stride foot contacts the ground, which speaks to how important body positioning is in relation to upper extremity stress. Leading with the hips is the first critical feature, which promotes hip and trunk translation to generate force for pitch velocity.⁷ Second is placing the hand on top of the ball as it leaves the glove. This promotes forearm pronation and shoulder internal rotation, preparing the throwing arm for proper shoulder abduction and external rotation later in the throwing phase.⁷ Proper shoulder abduction at or above 90 degrees is the third feature, which reduces upper extremity stress during the cocking and acceleration phases.⁷ Where the stride foot contacts the ground is the fourth critical feature. The foot should be directly toward the target to promote optimal hip and trunk rotation.⁷ Finally, keeping a closed front shoulder through the stride phase is the fifth critical feature. This prevents the pitcher from prematurely opening their shoulders and trunk towards the target, thereby preserving the force generating capacity of the lower body and trunk, and reducing the stress on the upper extremity.⁷ Various drills can be performed to promote proper pitching mechanics in the youth athlete (See **Figures 13 and 14** in Appendix).

When a patient presents in clinic with the presence of LLE, and specifically MEA, conservative management is quite successful depending on the presence or absence of physal plate separation on imaging. As mentioned above, if there is avulsion of the apophyses by greater than 5 millimeters, surgical fixation is recommended.² Conservative management typically consists of rest, activity modification, and PT to maintain elbow range of motion.² The opportunity should be taken to educate the parents and coaches about mechanics and pitch count limits.² Within the PT plan of care should be flexor-pronator strengthening activities, and when

appropriate, a progressive throwing program should be initiated.² Throwing mechanics should be addressed within the throwing program.

UCL injuries that fail with conservative management are typically good candidates for ligamentous reconstruction (Tommy John surgery). Results have been quite successful in the adolescent athlete, however there are risks of faulty fixation due to the presence of growth cartilage.² Clinicians should be aware of parents who are overly eager to advocate for reconstructive UCL surgery for their child. There have been some reports of parents seeking prophylactic UCL reconstruction, which is a dangerous trend.¹⁸ It is important that parents be aware of the best evidence currently available, notably that prophylactic UCL reconstruction will not make their child throw faster or become a better pitcher.

In cases where LLE goes untreated and the player continues to throw and exacerbates the injury, this can create permanent damage to the elbow structures. Players who continue to pitch or play catcher have demonstrated progressive medial epicondyle damage visualized on MRI.¹⁹ There have been many cases of a player's baseball career ending due to continued overuse and lack of treatment.⁴ If made aware of a young player with elbow pain while throwing, it is important to advocate for them to stop playing for the time being and to seek treatment to prevent further damage and a premature end to their baseball career.

Summary and Conclusion

LLE, and more specifically MEA, is a common pathology impacting young overhead athletes across the world. It is important to understand the underlying mechanical and tissue property factors that contribute to this overuse injury. The presence of growth cartilage, pitching mechanics, and throwing volume are the largest risk factors pertaining to this condition. When encountering a patient with this presentation, a thorough examination and evaluation should be

performed, using imaging studies to aide in diagnosis as needed. Conservative management should be the first-line of approach, while surgical intervention is only indicated in cases of avulsion fractures of a certain magnitude or if non-operative treatment fails. PT treatment of MEA typically consists of reduction of provocative activity, improvement of strength, and correction of pitching mechanics. Prevention is the most effective mode to treat LLE, with specific attention paid to pitching mechanics and volume of throwing. Pitchers and catchers are not the only positions affected by LLE, as any athlete who performs repetitive overhead throwing motions (baseball, tennis, volleyball) is susceptible. Education of parents and coaches regarding prevention strategies and how to recognize this condition should be performed at every opportunity.

Appendix

Figure 1: Bony Anatomy of the Elbow⁷

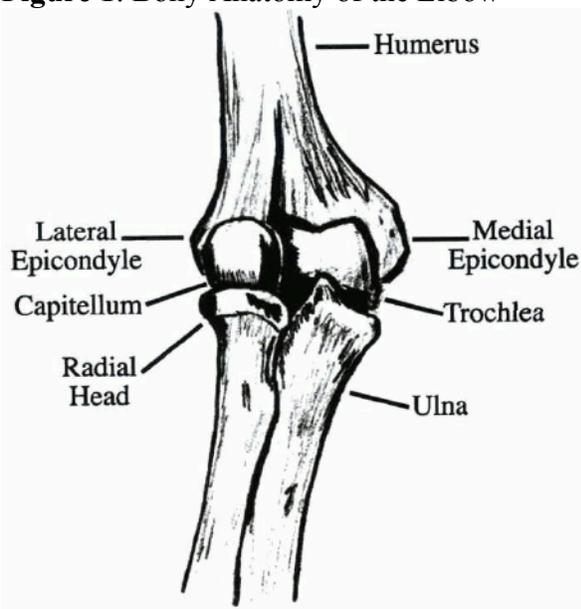


Figure 2: Medial view of the UCL and Flexor-Pronator entheses. This image shows the 3 separate bundles of the UCL complex. FDS = flexor digitorum superficialis, FCU = flexor carpi ulnaris²⁰

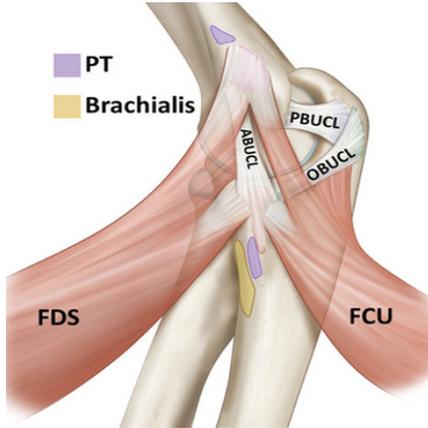


Figure 3: The 6 phases of the pitching motion. ER = external rotation, IR = internal rotation²¹

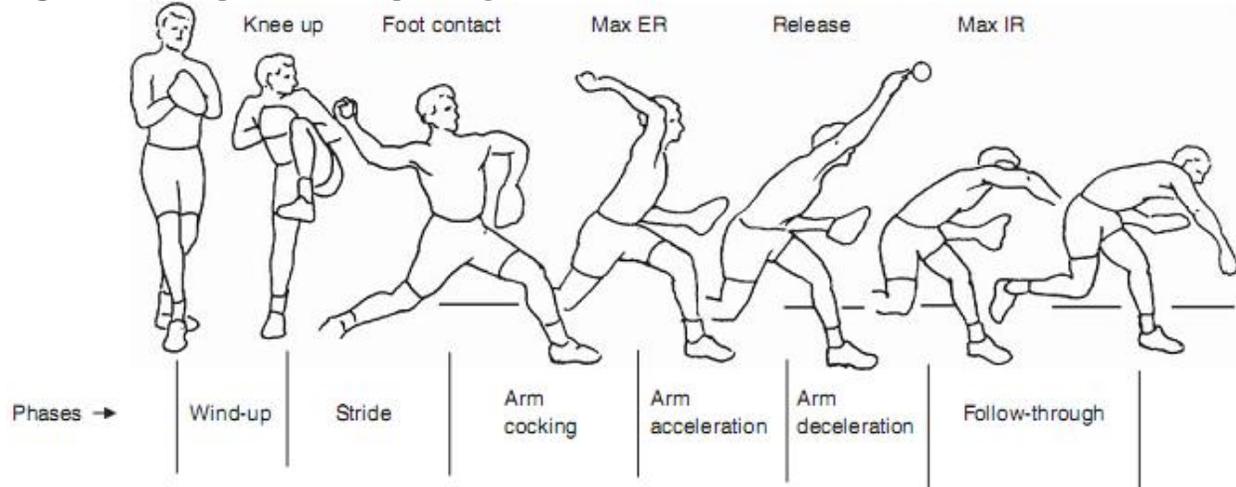


Figure 4: Prevalence of medial epicondyle lesions by age. N = no lesion, IR = irregular, HT = hypertrophic, FG = fragmented¹⁶

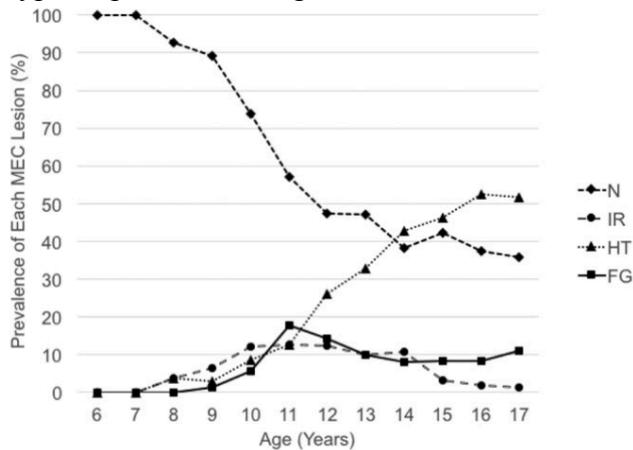


Figure 5: Ultrasound of the medial elbow. Arrows indicate the UCL, the (*) indicates the medial epicondyle¹⁶

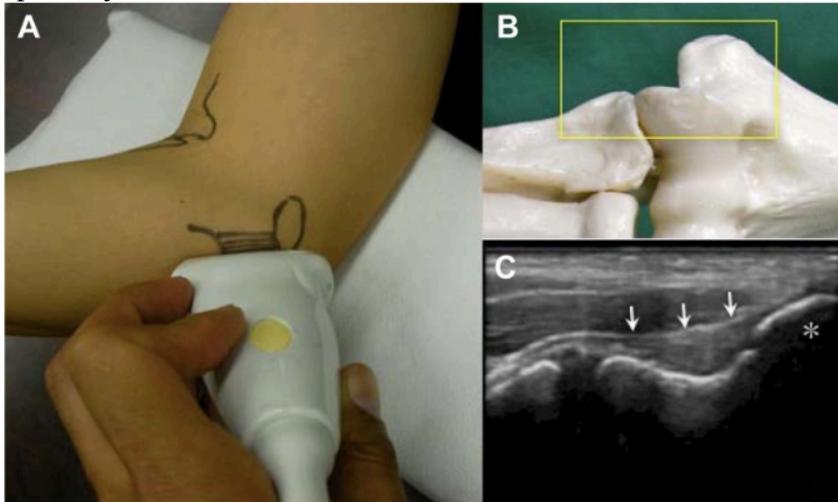


Figure 6: Lesion types as seen on ultrasonography. A = normal, B = irregular, C = fragmented, D = hypertrophic.¹⁶

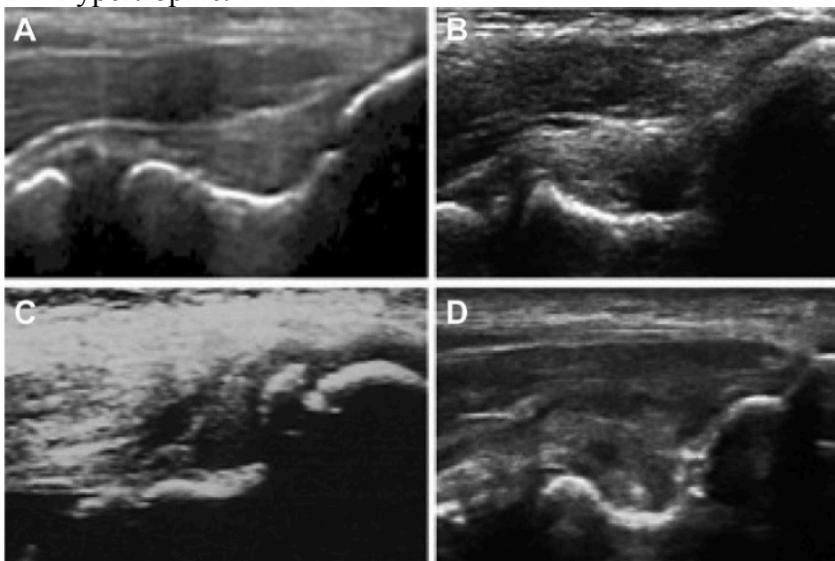


Figure 7: Moving valgus stress test. Start in maximum elbow flexion, stabilize the humerus while inducing valgus moment at the elbow. Maintain persistent valgus moment while moving the elbow into extension.¹⁸

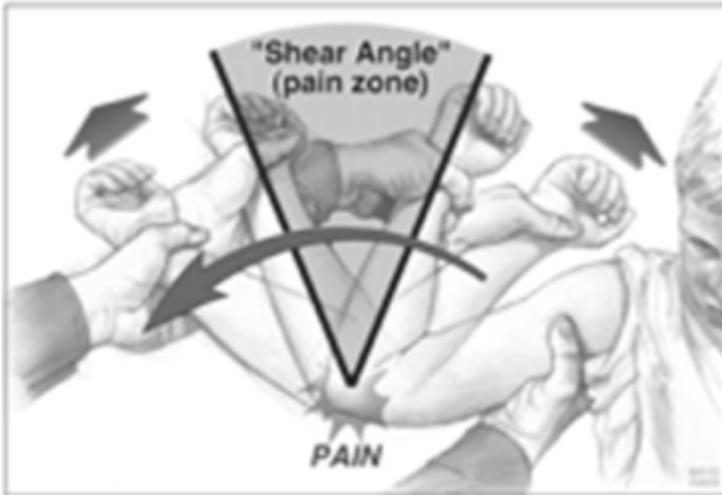


Figure 8: OCD of capitulum (arrows) as seen on ultrasonography¹⁶

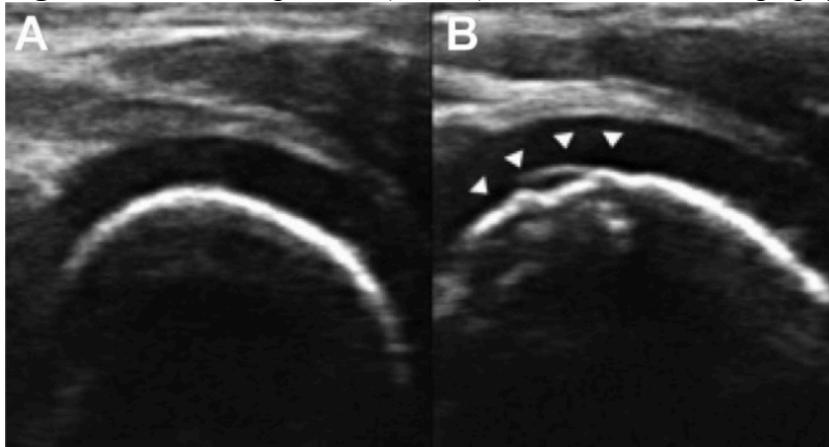


Figure 9: Pre-season checklist for risk of upper extremity injury⁴

TABLE 4
Final Version of Checklist

	Yes	No
1. Have you experienced shoulder or elbow pain while throwing in the preceding 12 months?	1	0
2. Have you ever experienced a shoulder or elbow injury requiring medical treatment?	1	0
3. Do you participate in team training ≥ 4 days per week?	1	0
4. Do you participate in self-training 7 days per week?	1	0
5. Are you in the starting lineup?	1	0
6. Does your pitching arm often feel fatigued while playing baseball?	1	0

Figure 10: USA Baseball pitch count limits³

Table 5. USA Baseball Medical and Safety Advisory Committee Pitch Count Limits⁶⁵

9–10 Years Old	11–12 Years Old	13–14 Years Old
50 pitches/game	75 pitches/game	75 pitches/game
75 pitches/week	100 pitches/week	125 pitches/week
1000 pitches/season	1000 pitches/season	1000 pitches/season
2000 pitches/year	3000 pitches/year	3000 pitches/year

Figure 11: Pitching safety recommendations as per Saltzman et al³

Table 4. Suggested Limitations by Pitch Count, Inning Count, and Batters Faced for Young Overhead Throwers³⁹⁻⁴¹

Timing Designation	Suggested Limitation
Pitches per game	75
Pitches per season	600
Innings per year	100
Batters faced per game	15
Batters faced per season	120

Figure 12: Critical pitching mechanics features. A = Lead with hips, B = hand on top of ball, C = arm position, D = stride leg towards the target, E = closed front shoulder⁷



Figure 3. Five critical features of youth baseball pitching: leading with hips (a), hand on top of the ball (b), arm in throwing position (c), stride foot toward home plate (d), and closed front shoulder position (e).

Figure 13: The tee drill to promote proper shoulder abduction during overhead throw⁷

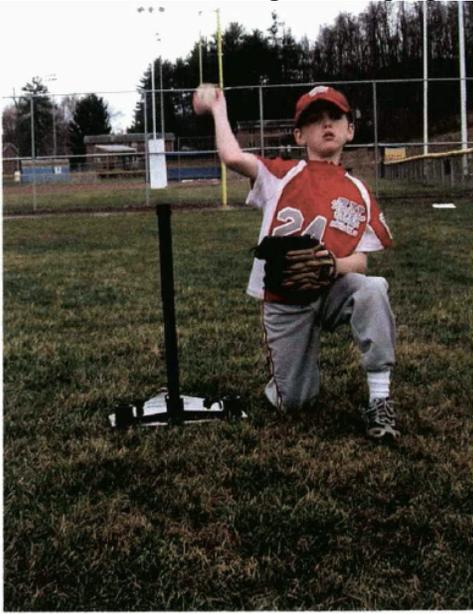


Figure 5. Tee drill.

Figure 14: The line drill to promote stride leg towards the target⁷



Line drill.

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