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Review Article

Overview of the Elbow Fracture in Children

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Abstract

Elbow injuries are a common presentation in children to the emergency department, and approximately 10% of children with a forearm fracture will also have an injury involving the elbow joint. Slightly more common in boys than girls, elbow injuries can occur at any age. Supracondylar fractures are the most common type of elbow fracture in children, accounting for 65 - 75% of all pediatric elbow injuries. Other common elbow injuries in children include lateral epicondyle fractures, medial epicondyle fractures, radial neck fractures, elbow process fractures, and elbow dislocations. With a propensity for risk-taking behavior, such as climbing on playground equipment and swinging from swings, children aged 5 to 8 years have the highest rate of acute elbow fractures and dislocations. Adolescents tend to have a lower rate of fractures than younger children but often suffer from chronic overuse injuries. However, sports- and recreation-related fractures can also occur in this age group. Although elbow fractures are not as common as other types of forearm fractures, they must be diagnosed promptly because they often require surgical intervention to prevent adverse outcomes.

Keywords: *Pediatric Elbow Injuries; Elbow Injuries; Elbow Region; Fractures Pediatric Elbow Dislocations; Common Elbow Injuries*

Introduction

The most common fracture in children is an elbow fracture. It is most common when a child falls on an outstretched arm. Timely assessment and management of elbow fractures is important because of the risk of neurovascular injury. Supracondylar fractures are the most common fracture in children under seven years of age and account for approximately 15% of all fractures in children. The peak incidence occurs around the age of six years, predominantly in males. However, there are many other variations of elbow fractures. This activity will review the causes, presentation, assessment and management of different types of elbow fractures and the role of the interdisciplinary team in assessing, diagnosing and managing the condition.

Diagnosing an elbow fracture can also be more complex than detecting other fractures in children. Before a growing child reaches skeletal maturity, the elbow joint is made up of cartilage, and X-rays, which show bone tissue more clearly than cartilage, may not provide a clear picture of the fractured area. To help confirm the diagnosis, Dr. Blanco and his colleagues at HSS sometimes take X-rays of the opposite arm to compare anatomy. In some cases, MRI and/or CT scans (which show cartilage more clearly) and arthrograms images obtained after injecting dye into the elbow joint are also used.

"It's important for parents to know that elbow fractures heal quite quickly in children", says Dr. Blanco. While this is good news when it comes to starting appropriate treatment, it also highlights the risk of delaying evaluation by a physician and, when necessary, referral to a pediatric orthopedist.

Once the elbow begins to heal on its own, if it is not in proper position, it is harder to achieve good long-term results.

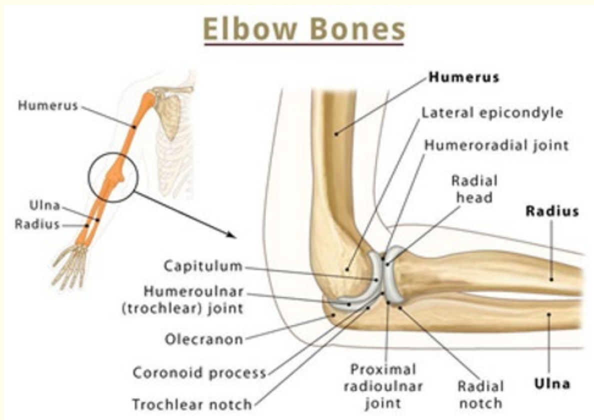


Figure 1: *Elbow joint.*

The anatomy of elbow joint

Normal anatomy

The elbow is a complex joint consisting of three osseous articulations and multiple ligamentous and myotendinous attachments, both proximally and distally (Figure 2A-2F).

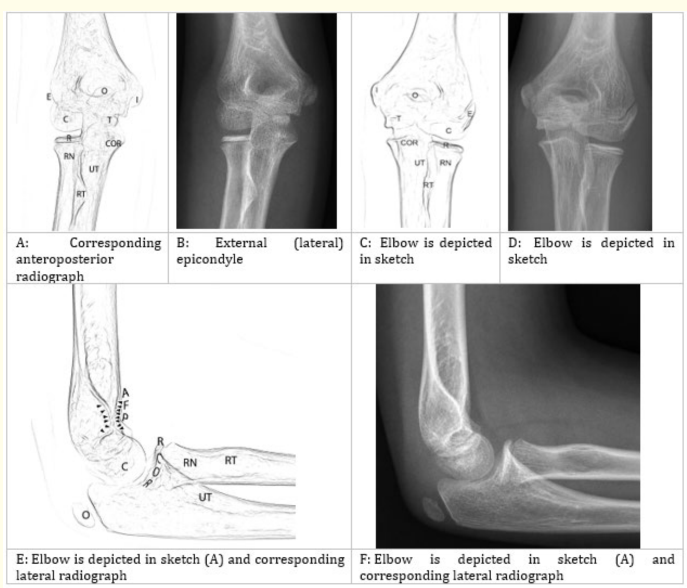
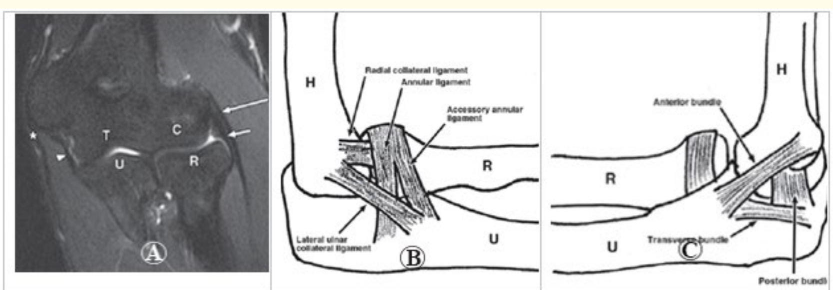


Figure 2A-2F: *10-year-old girl with normal elbow.*

The elbow has little intrinsic bony stability. Instead, it functions primarily as a hinge joint. The distal humerus flares outward in the coronal plane to form the medial and lateral columns. The medial column deviates from the long axis of the humerus at an angle approximately twice that of the lateral column, creating the bony prominence palpable along the medial elbow [1]. The trochlea and capitellum cover the articular surfaces of the medial and lateral columns, respectively. The medial and lateral condyles lie above the articular surfaces.

The depression along the anterior surface of the proximal ulna is called the trochlear facet or semilunar facet, which articulates with the trochlear facet of the humerus. Along the lateral elbow, the capitellum articulates with the head of the radius. The proximal radial articulation is called the radial neck, while the radial tuberosity serves as the attachment point for the biceps tendon.

Along the ventral surface of the distal humeral articulation are two depressions: the coracoid fossa medially and the radial fossa laterally. The olecranon fossa lies on the dorsal surface of the distal humerus. The coracoid fossa and the opposite olecranon fossa form the hourglass shape of the distal humerus as seen on lateral radiographs (Figure 2A and 2B). The coracoid process and the olecranon articulate with these humeral fossae. The anteroinferior surface of the coracoid process together with the ulnar tubercle serve as attachment sites for the brachialis muscle. The triceps muscle attaches to the olecranon. The medial and lateral portions of the joint capsule thicken to form the collateral ligament complex, which is depicted on MRI (Figure 3A). The collateral ligament complex or radial collateral ligament provides stability to the elbow (Figure 3B). The most important component is the lateral ulnar collateral ligament. This ligament is located posteriorly in the ulnar collateral ligament complex, originating on the lateral epicondyle and running diagonally across the radius to attach to the ulna at the crest supinatoris. The annular ligament circumferentially encircles the head of the radius and is the main stabilizer of the proximal radioulnar joint. The lateral collateral ligament actually originates from the lateral epicondyle and attaches to the annular ligament and fascia of the radius muscle. Along the medial elbow is the ulnar collateral ligament complex (Figure 3C). The anterior bundle of the ulnar collateral ligament is primarily responsible for valgus stability for the elbow. The posterior bundle of this the ulnar collateral ligament is a thickened, fan-shaped portion of the joint capsule that is best visualized when the elbow is flexed. The transverse bundle of the ulnar collateral ligament extends between the olecranon and coracoid processes and is formed from horizontally oriented capsular fibers. The posterior and transverse bundles are not well delineated on MRI but form the floor of the cubital tunnel along with the joint capsule [2].



A: Coronal STIR MR image shows ulnar collateral ligament complex (arrowhead), radial collateral ligament complex (short arrow), extensor tendon complex (long arrow), and flexor-pronator tendon complex (asterisk). C = Capitellum, R = Radial head, T = Trochlea, U = Ulna.

B and C: Schematic illustrations show radial (B) and ulnar (C) collateral ligament complexes with elbow in 90° flexion. H = Distal humerus, R = Proximal radius, U = Proximal ulna.

Figure 3A-3C: *A: Coronal STIR MR image shows ulnar collateral ligament. Schematic illustrations show radial. B and ulnar C: Collateral ligament complexes with elbow in 90° flexion. H = Distal humerus, R = Proximal radius, U = Proximal ulna. Normal elbow.*

MRI also demonstrates the muscle compartments around the elbow. The anterior compartment includes the brachialis and biceps muscles. Brachialis muscle injuries are seen in older teenage mountain climbers. Rarely, the biceps tendon may tear from the radial tuberosity. The triceps and anconeus muscles form the posterior compartment. Rupture of the triceps tendon at its attachment to the olecranon is rare in both children and adults. The medial compartment includes the common flexor tendon of the wrist and hand, which originates from the medial epicondyle and the teres radialis. The lateral compartment includes the common extensor tendon, which originates from the lateral epicondyle, the supinator, and the rotator cuff. Radiographic evaluation of the elbow in children is often difficult because of the cartilaginous nature of the elbow in early childhood, followed by the variable appearance of ossification centers around the elbow joint. The physical mechanism of injury also varies depending on the age of the patient. In infants and young children, the epiphyseal cartilage is relatively thick and therefore susceptible to secondary injury from shear or traction. In older children and adolescents, apophyseal fractures are more common and occur as a result of a combination of shear and compressive forces [12]. The secondary ossification centers, or apophyses, are subjected to tensile forces because they serve as attachment sites for the musculotendinous units. Apophyses are primarily composed of cartilage cells and are biomechanically less stable in the growing skeleton than the dense connective tissue of the musculotendinous units or the epiphysis or fused apophyses in adults. Therefore, excessive tensile forces in children or adolescents are more likely to cause apophyseal fractures than are ligamentous or tendon injuries in adults.

The six secondary ossification centers around the elbow ossify in a predictable manner depending on the age and sex of the child [3] (Figure 3A). Knowledge of the occurrence and pattern of secondary ossification is essential for accurate radiographic interpretation. In general, the appearance and fusion of ossification centers occurs earlier in girls than in boys, by up to 2 years. There is considerable variation between individuals of the same sex and between sexes, with respect to specific ages. However, the sequence of appearance and fusion of these ossification centers is predictable.

The first ossification center to appear is the capitellum, which is usually well formed in both girls and boys by 1 year of age. The radius and medial epicondyle usually appear later, at about 5 - 6 years of age, in that order. The trochlea and olecranon appear at 8 - 10 years of age. The lateral epicondyle is usually the last secondary center to ossify, appearing at about 10 years of age.

Blood supply of the elbow joint

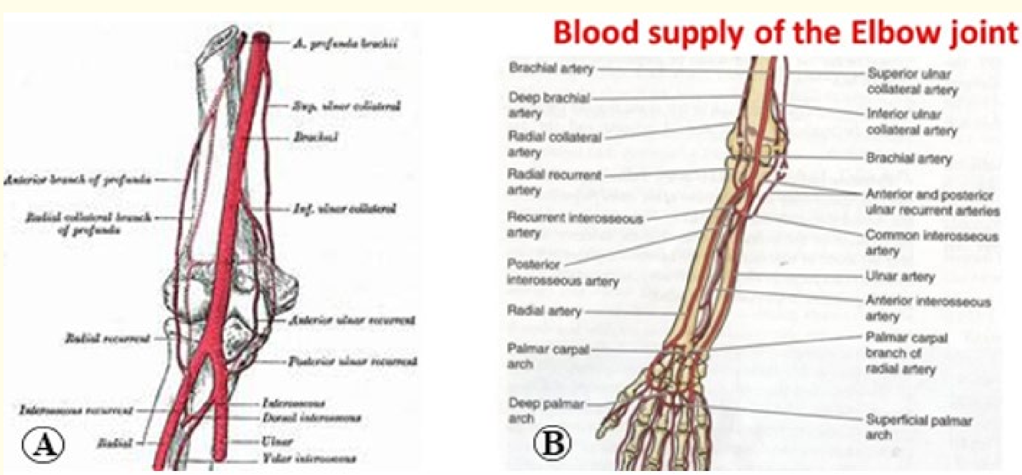


Figure 4A and 4B: *Blood supply of the elbow joint. A: Arterial around Elbow; B: Arterial around Elbow and Forearm.*

The main blood supply of the narrowed area is from a. brachialis and for the cam knee area is responsible for a. popliteal. There is a well-developed rural venous network, represented by v. cephalica for the limb; v. saphena lateralis, larger in dogs and v. saphena medialis - in cats, are the main venous vessels of the agricultural network (Evans HE and de Lahunta A 2013, Georgiev, 2014). The axillary lymph drains the limb and includes lymphatics and collateral lymphatics. In the limb, the main lymph comes from the popliteum lymphatic sheath. Dogs have only superficial popliteus lymph (lymphonodus popliteus Agriculturees) (Evans HE and de Lahunta A 2013). Of greater significance for the examination of the blood vessels are angiography and venography. Through contrast radiographic examination, the arterial and venous vessels are specifically formed, while computed tomography and angiography provide the opportunity to explore their tracks. Practical significance is also found in contrast-enhanced ultrasound to examine the soft and hard matches in normal and pathological conditions.

The supplying vessels originate appropriately from a weekend connection between the brachial artery and its terminal branches. The superior and inferior branch cylinders of the brachial arms and the lateral and medial branches of the deep brachial arms descend from above to reconnect on the joint capsule, where they also connect with the anterior and posterior regenerating branch cylinders of the dynamic ulnar pillars; the distributive branch of the ulnar artery; and the recurrent branch of the common ulnar artery.

Blood is returned by the vessels from the venous, ulnar and brachial vessels. There are two groups of lymphatics in the hand, usually located above the bridge between the deep and superficial (also called epitrochlear) bushes. The lymphatic drainage in the hand passes through the deep at the bifurcation of the brachial artery, the brachial and ulnar branches of the hand. The lymphatics that drain from the hand go to the internal fighting group.

Arteries of the elbow region

The main blood supply of the mixed is provided by branches of the a. brachialis, i.e. the continuation of the sliding artery, and posteriorly by the musculoskeletal nerve and anteriorly by the median and ulnar nerves and the brachial vein. The ulnar artery originates from the posterior aspect of the brachial plexus in the distal part of the arm and gives off a large branch that supplies the fat and the bursa of the rete articulare cubiti here. The a. brachialis gives off the superficial brachial artery which passes proximally to the head of the hand and goes to the flexor and ulnar regions, where the v. The mediana cubiti splits, as the artery lies beneath it and passes cephalad. The artery joins the lateral radial artery at the angle of the brachial plexus and continues as the superficial anterior brachial artery cephalad. The common brachial artery is the largest branch separating the brachial plexus, running from the surface of the brachial artery to the plexus. The vessels giving rise to the proximal branches: a. recurrens ulnaris runs laterally along the medial aspect of the brachial plexus and may also be supplied by the ulnar artery, which joins the ulnar plexus and the internal carotid plexus; a. recurrens interossei, which separates from the intracranial artery, passes proximally along the lateral aspect of the ulnar plexus and contributes to the ulnar plexus. The other branches of the brachial plexus in the region of the ulnar plexus are a. transversa cubiti curved laterally and cephalad through the fit (Davis DD 1941, J Schaller 2007, Evans HE and de Lahunta A 2013).

Veins of the elbow region

The cephalic vein, the most common choice for intravenous injection, runs along the cranial border of the forearm and is the only major superficial vein of the thoracic limb. The medial cubital vein (v. mediana cubiti) passes lateral to the elbow and extends between the brachial and cephalic veins and is the junction between the deep and superficial venous systems. The axillary vein of the arm (v. axillobrachalis), a continuation of the v. cephalica, passes lateral to the triceps and cauda to the humerus and anastomoses with the axillary vein. Another superficial vein, the v. omobrachialis, leaves the axillary vein close to the cephalic vein, joins the external jugular vein, and receives only small vessels from the fascia and skin. The deep venous system is represented by the v. brachialis and its branches follow the artery of the same name (Gómez O, Giner M and Terrado 2007, Dyce KM, Sack WO, Wensing CJG 2010, Evans HE and de Lahunta A 2013).

Nerve around elbow

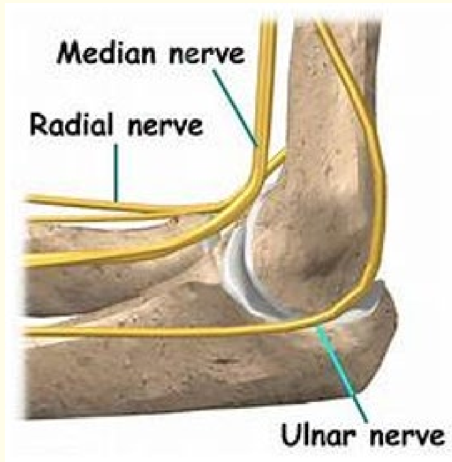


Figure 5: *Nerve around elbow.*

There are three main nerves that pass through the elbow. These nerves control the muscles in the forearm and hand and also provide sensation to the forearm/hand (Figure 5).

Median nerve: The median nerve passes through the elbow anteriorly (i.e. on the front of the elbow). The median nerve controls the muscles that allow the forearm and hand to flex (bend). It also provides sensation to the thumb, index finger, and middle finger. Compression of this nerve at the wrist (a common condition) can cause carpal tunnel syndrome.

Ulnar nerve: This nerve is located on the inside of the arm. This nerve, along with the median nerve, controls the flexion of the fingers and wrist. This nerve mainly provides sensation to the little finger and ring finger. Compression of this nerve can occur at the elbow. This results in a condition called cubital tunnel syndrome.

Radial nerve: The radial nerve is located on the back of the forearm. In fact, after crossing the elbow, it divides into two separate branches: the superficial radial nerve and the posterior interosseous nerve (PIN). The PIN allows for wrist extension and fingers (straightening). The superficial radial nerve supplies sensation to the back of the thumb, index finger, and middle finger.

Angles and lines around elbow

Baumann's angle

The Baumann angle (also known as the humerocapitellar angle) serves as an essential indicator of the alignment and development of the elbow joint. It is an important aid in the accurate reduction of supracondylar humerus fractures in young adults. It also provides valuable insights into the development of the distal humerus and can help identify discrepancies and abnormalities (Figure 6).

Radial head dislocation was assessed. A full-length forearm radiograph was obtained by placing the child's arm on an X-ray bench with the elbow flexed to 90° in a lateral position and the palm facing down (Figure 7). We found that this method provided a true anteroposterior

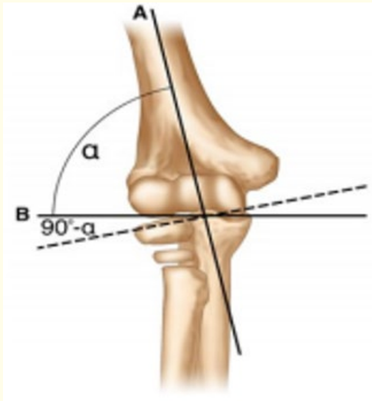


Figure 6: *Baumann's angle is a radiographic angle created by the intersection of a line drawn down the humeral axis. A. and a line drawn along the physis, B. of the lateral condyle of the elbow on the AP view of the elbow (normal range, 9° - 26°).*

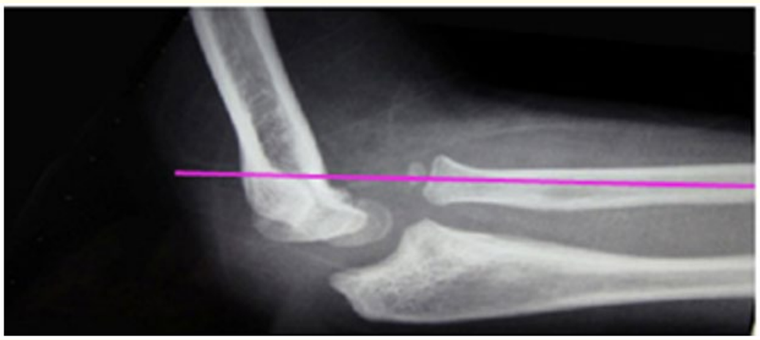


Figure 7: *Head radial dislocation.*

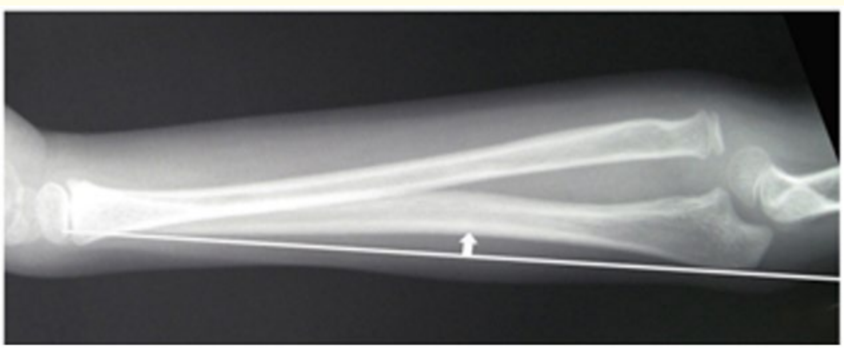


Figure 8: *Ulnar bow should be measured to detect ulnar bowing.*

view of the forearm, allowing visualization of any curvature present in the ulna (Figure 8). It also allowed visualization of the radial head dislocation by providing a true lateral view of the elbow.

Anterior humeral Line (AhL) (Figure 9)

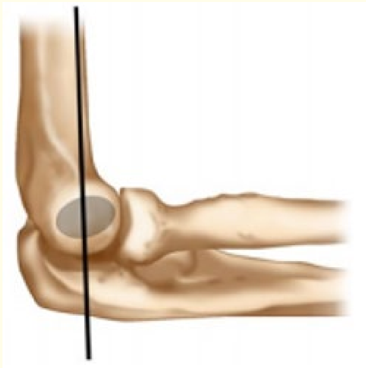


Figure 9: *The anterior humeral line should cross the capitellum on a true lateral view of an uninjured elbow.*

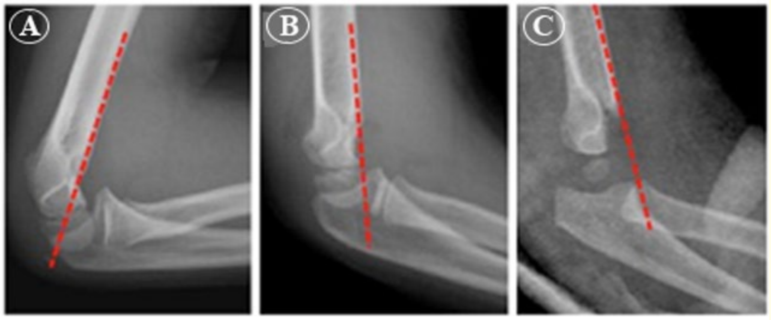


Figure 10A-10C: *A: The anterior humeral line (AhL) should traverse the middle third of the capitellum nucleus in normal anatomy and type I fractures; B, C: In extension-type fractures, the line crosses anteriorly.*

The humeroUlnar angle-HUA (Figure 11)

Figure 11: *HumeroUlnar angle defined as the angle formed between. A: The longitudinal axis of the humerus. and B: The axis of the proximal third ulna (normal range 5°-15°) [4].*

The humeroUlnar angle (HUA) or radiographic support angle, which is the angle formed, in the AP view, between the spray wing of the humerus and the axis of the proximal third of the ulna (Figure 12), is also obtained. It is used to assess deformities or curvatures of the spine and is more accurate and useful than the Baumann angle (normal 5°-15°).

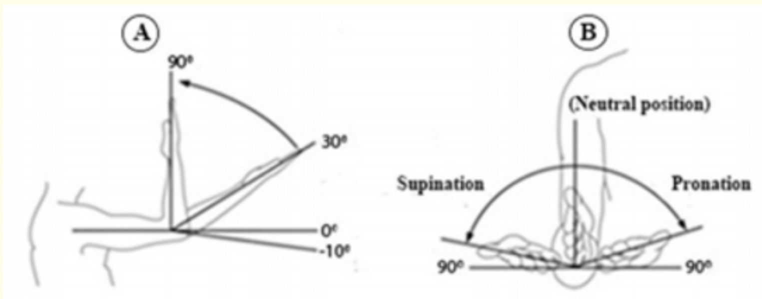


Figure 12A and 12B: *A: The measurement of elbow flexin-extension. B: The measurement of elbow supination -pronation [5].*

Joint action	Position for examination	Normal range of motion
Elbow		
Extension	Shoulder at 90 degrees abduction Palm facing up	0 degrees
Flexion	Shoulder at 90 degrees abduction Wrist supinated	150 degrees
Supination	Elbow flexed at 90 degrees touching the iliac crest Hand in neutral, perpendicular to ground.	90 degrees
Pronation	Elbow flexed at 90 degrees touching the iliac crest Hand in neutral, perpendicular to ground	90 degrees
Wrist		
Flexion	Elbow at 0 degrees Hand fully pronated	90 degrees
Extension	Elbow at 0 degrees Hand fully pronated	70 degrees

Table 1: *Range of motion of the elbow and wrist [5].*

Outcome	Rating	Cosmetic factor (carrying angle loss in degree)	Functional factor (movements Loss In degree)
Satisfactory	Excellent	0 - 5	0 - 5
	Good	6 - 10	6 - 10
	Fair	11 - 15	11 - 15
Unsatisfactory	Poor	< 15	> 15

Table 2: *Modified Flynn's criteria [6].*

The criteria developed by Flynn (Table 2) [6].

All patients were evaluated according to the Flynn criteria [6], which assesses both functional and aesthetic outcomes. The aesthetic component considers the loading angle and its deviation in curvature or valgus, while the functional component is evaluated by measuring the flexion and elongation. The lower of the two outcomes (aesthetic and functional) is considered the overall outcome. "Excellent", "Good", "Fair", "Poor", and "Fair" outcomes are considered satisfactory (these outcomes reflect a loss of loading angle and a movement angle ranging from 0-5°, 6-10°, and 11-5°, respectively) (15°), while a "poor" outcome (loss >16°) is considered unsatisfactory (Figure 7). Outcomes with cubitus varus are implicitly considered "poor" outcomes (Table 1).

Examination

Physical examination

Elbow injuries in children are often a difficult diagnostic situation due to their unique anatomy with a narrow treatment window and the relatively high complication rate associated with certain fracture types [7]. Acute fractures are often associated with high-energy trauma or falls from height onto an outstretched arm. Although most injuries are isolated elbow fractures, in these situations it is important to consider possible neurovascular injuries, which can complicate the overall treatment. Knowledge of normal growth patterns is extremely important for the proper evaluation and treatment of these injuries. In general, the younger the child at the time of injury, the more difficult the evaluation. For chronic injuries, it is important to ask questions about participation in sports. This includes an accurate description of the type of activity and duration. During the physical examination, it is important to determine whether there are any bruising, abrasions, tissue loss, or swelling of the skin that indicate acute trauma. Signs of open fractures such as small puncture wounds, occasional oozing or open bleeding, and exposed bone should also be assessed. In patients with chronic symptoms, long-term changes such as hypertrophy or atrophy of surrounding muscles and the possibility of joint contractures should be assessed. Areas of tenderness to palpation may indicate a fracture and require further investigation. Palpation of the soft tissues of the upper arm and forearm is useful in cases of severe trauma, considering the possibility of compartment syndrome [1]. The normal range of motion in the flexion-extension plane is usually described as 140° from flexion to extension with 0 to -10° hyperextension, with the assessment made with the patient holding the forearm in supination. Normal pronation and supination of the forearm are usually 75° and 85°, respectively. In cases of high-energy trauma, but even after isolated injuries to the elbow, a thorough neurovascular examination is required [1]. A thorough motor and sensory examination should focus on the median, ulnar, and radial nerves. Vascular assessment is important to differentiate between a normal hand, a perfused but pulseless limb, and a hand with vascular dysfunction.

Radiographic evaluation

In addition to the clinical challenge of diagnosis, the interpretation of elbow radiographs in injured children is even more difficult. Considering the variability of growth and ossification centers over the years, we often see errors in diagnosing injuries [8].

Initial radiographs should include an anteroposterior (AP) and lateral views of the elbow. Separate images of the humerus and forearm are often necessary to detect the full extent of the potential injury. To limit exposure to ionizing radiation, images of the contralateral elbow are not part of the routine evaluation unless comparison views are deemed necessary to assess whether the abnormal finding may be a fracture, ossification center, or growth variation. AP images are obtained with the forearm in full supination and the elbow joint in the maximum extension tolerated by each child. Lateral views should be obtained with the elbow joint flexed to 90° and the forearm in maximum supination. From the lateral view, attention should be paid to the anterior and posterior fat pads. Although the anterior fat pad is a normal finding, the exudate present in the joint pushes the fat more anteriorly, eventually changing the radiographic appearance of this fat pad (sail sign) which may indicate a hidden fracture. A positive posterior fat pad sign is always considered abnormal, i.e. indicating a hidden, non-displaced fracture. Regarding the lines from the lateral view, it is important to mention the anterior humeral line (AHL), which usually intersects the middle third of the mastoid. Dislocation, even if this line is minimally displaced anteriorly from the expected position for age, indicates posterior displacement of the supracondylar fracture of the humerus in children. The radial capitis line is another important landmark. In most children over 2 years of age, a horizontal line is drawn along the axis of the radius, and especially the neck of the radius, which usually cuts through the middle of the humerus, regardless of the position of the elbow or forearm. This radiographic line is useful in identifying Monteggia fractures in children [8]. With regard to the AP projection, it is important to distinguish the humeroulnar line (bearing angle) and the Baumann angle (humerocapitellar angle). The carrying angle of the elbow has important clinical significance and represents the degree of normal angle that exists in this joint. This angle varies with age and sex, but in most children and adolescents, it ranges from 5° to 20° valgus. A humeroulnar angle less than 5° is considered abnormal, and any patient with an angle greater than 0 is referred to as cubitus varus. A humeroulnar angle greater than 20° is also considered abnormal and is referred to as cubitus valgus. The Baumann angle is formed by the intersection of a vertical line bisecting the distal humerus with a horizontal line along the ossification center of the lateral condyle. Normal values can range from 64° to 81°. Fractures that cause internal or external rotation will increase this angle [9].

Elbow injury

1. Supracondylar humerus fractures

Supracondylar humerus fractures are the most common fractures of the elbow and the second most common fracture in children, after distal radius fractures. They typically occur between the ages of five and seven, with no gender predilection. Considering the relatively thin cortical bone layer in the supracondylar region, especially in the age group around six years when remodeling occurs in the aforementioned region, this is an area at high risk for fracture [10,30]. Considering the relatively small longitudinal growth of the distal humerus, this region has little potential for remodeling, in contrast to the proximal humerus.

Classification

Supracondylar humerus fractures can be flexion or extension fractures depending on the direction of travel of the distal fragment. Flexion fractures are extremely rare (usually due to a direct blow to the elbow), while extension fractures account for 97-99% of fractures (usually due to a fall on an outstretched arm). Extension fractures are commonly classified using the modified Gartland classification system [11] (Table 3).

Type	Radiographic Findings	Stability
I	Nondisplaced or minimally displaced (< 2 mm), AHL intersects center of capitellum	Stable
II a	Posterior cortex intact, AHL anterior to capitellum	Stable
IIb	Posterior cortex intact, AHL anterior to capitellum, rotational deformity	Rotational instability
III	No cortical contact, AHL anterior to capitellum	Unstable in extension
IV	No cortical contact, AHL anterior or posterior to capitellum	Unstable in flexion and extension

Table 3: *Modified Gartland classification [11].*

AHL: Anterior Humeral Line.

Clinical presentation and radiographic evaluation

Children with supracondylar humerus fractures often report pain and swelling around the elbow that may radiate into the forearm with limited mobility. Along with a basic visual inspection of the area, skin folds and the presence of bruising in the elbow fossa indicate more extensive soft tissue injury as a bone fragment may have penetrated the brachial muscle. The puckering sign (also known as skin splay, dimple, or anterior spicule) indicates that the proximal portion of the fracture has penetrated the brachial muscle and is a possible sign of entrapment of the median nerve and brachial artery. If bleeding is seen from the wound, it is usually an open fracture. By comparing the color and appearance of the skin of the limb, it is possible to determine whether there is adequate perfusion distal to the site of injury. By assessing the vascularity of the limb, it is often possible to determine whether the limb is normal in color, pink (limb with brachial artery spasm or injury but adequate collateral circulation), or white and pulseless. In addition to vascular assessment, sensory and motor function of each nerve (radial, median, and ulnar) should also be assessed [12].

Radiographically, the elbow is evaluated in the AP and lateral views of the elbow, with the lateral view being particularly useful for assessing supracondylar fractures as the elbow may appear normal in the AP view. Attention should also be paid to the presence of fat pads, which may indicate an occult fracture. Among the radiographic parameters, particular attention should be paid to the anterior humeral line (Roger's line) in the lateral view if it does not cross the humeral head and the Baumann angle in the AP view. The AHL is the most reliable radiographic measure for quantifying anteroposterior displacement in supracondylar humeral fractures and is important for achieving anatomic alignment. It has been found that after reduction of supracondylar fractures with the AHL passing anteriorly or through the anterior third of the epiphysis, children have poorer early elbow flexion and poorer overall elbow range of motion. The normal Baumann angle ranges from 9° to 26°, and a Baumann angle less than 9° indicates varus [13].

Management

No-Operative Gartland type I fractures are indicated for nonoperative treatment of supracondylar humerus fractures. Treatment consists of immobilization with the elbow flexed at 60° - 90° for three weeks, followed by exercise with or without formal physical therapy. Regarding Gartland type II fractures, there is still no clear consensus. While closed reduction and casting is advocated on the one hand, closed reduction and percutaneous fixation is advocated on the other. Advocates of percutaneous fixation rely on research showing that in a large number of children, residual deformity is left with closed reduction and casting alone [14].

Closed reduction and percutaneous pinning

Closed reduction and percutaneous pinning (CRPP) indications include type III and type II fractures if the former is supported (displaced fracture with anterior AHL drop or reduced Baumann angle). In addition, neurovascular injury itself is an indication for CRPP. Unless there is an open fracture, neurovascular insufficiency, floating elbow, or progressive compartment syndrome, there is no evidence that urgent surgical treatment reduces the rate of perioperative complications such as pin track infection, iatrogenic vascular and nerve injury, compartment syndrome, or end-of-life elbow function. If surgical treatment is delayed for more than 24 hours, most surgeons will avoid using skin or transosseous traction, instead using a fracture splint [15]. Currently, there is limited evidence to support prone versus supine patient positioning. The choice of position is based on surgeon experience. The prone position has been shown to facilitate reduction, facilitate C-arm use, and reduce the rate of iatrogenic nerve injury, but it makes airway management difficult and may lead to conversion to open reduction when the patient's position needs to be changed. Most surgeons prefer the supine position because it is quicker, allows for standard anesthesia control, and allows for an anterior, anteromedial, or anterolateral approach if conversion to open reduction is required. In terms of surgical technique, after aseptic preparation, a "milking procedure" is usually performed to separate the brachial and biceps brachii muscle fibers from the distal spine of the proximal fragment, if present. By positioning the fragments in the sagittal plane, the coronary artery alignment should be approached. After insertion, the elbow should be held in hyperflexion to maintain alignment and assess reduction. If anatomical reduction is difficult, neurovascular structures may be compressed at the fracture site, in which case open reduction is required. After anatomical reduction, percutaneous fixation of the fracture with pins is required. Generally, two pins are placed for type II fractures and three for type III fractures. To avoid iatrogenic injury to the ulnar nerve, lateral pinning has been shown to have comparable outcomes to cross pinning, although some studies still support the greater stability of cross pinning. After the fracture is stable with regular pulses, the pins are bent and cut.

The elbow is then casted in a 45° - 80° elbow flexion position. Postoperative X-rays taken within three weeks of surgery do not affect the outcome, and three weeks after surgery, the cast is removed and X-rays are taken to see the progress of callus formation. If callus formation is adequate, the pins are removed and the child is returned to normal activities with or without formal physical therapy to restore elbow range of motion.

Open reduction and pinning

Indications for open surgery are open surgery, non-reduction, nerve injury (median nerve) and vascular injury, pulseless limb after closed reduction, pulseless limb after reduction with preoperative pulse, and pink and pulseless limb after CRPP [16]. From a surgical point of view, the anterior approach to the cubital fossa is most appropriate. After skin incision, dissection is performed through the dermis and fascia while paying attention to neurovascular structures, identifying the median nerve and brachial artery. If soft tissue is found within the fracture, such as brachial muscle, it must be resected. If brachial artery injury is found, direct repair or a bypass vein graft is required. The placement of the nail is the same as in CRPP (Figure 13).

Figure 13A and 13B: *Postoperatively, pining two Kirschner wire, A: A-P Radiography; B: Lateral radiography.*

If the fracture remains unstable, a third-party entry point or a stopper from the middle of the elbow is inserted. We prefer to use a third-party entry point of a K-wire rather than a central pin because of the risk of damaging the ulnar nerve (Figure 14).

Figure 14A and 14B: *Postoperatively, pining three Kirschner wire, A: A-P Radiography; B: Lateral radiography.*

Complications

Complications include the possibility of loss of pulse or perfusion after CRPP, indicating entrapment of the brachial artery. The pin should be removed immediately and the brachial artery should be explored when converting to an open approach [17]. With concomitant ipsilateral forearm injury, the risk of compartment syndrome is increased. The typical signs of compartment syndrome (pain, pallor, pulselessness, paresthesia, paralysis) are unreliable in children and increasing analgesic requirements are the most reliable indicator. If developing compartment syndrome is suspected, immediate decompression and urgent fasciotomy should be performed if necessary. Iatrogenic injury to the ulnar nerve is common during midpinning. If this injury is noted, the pin should be removed. Most injuries are neurodystrophic and resolve spontaneously within 3 months [18]. As for the pin itself, migration or infection at the pin site is often possible, in which case the pin should be removed and the child given antibiotics. Migration is best prevented by placing the pin 1 cm from the skin and bending the wire at a 90° angle. Technical errors in pin placement can lead to loss of reduction (less than two pins attached to both fragments, less than two bicortical pins, insufficient pin separation at the fracture site (< 2 mm)). If significant varus deformity persists, osteotomy should be performed [19].

2. Distal humerus transphyseal fracture

Distal transverse humeral fractures are rare and can occur in children under three years of age, usually following a fall. They are usually detected by radiograph when the shaft of the forearm is no longer aligned with the shaft of the humerus.

There is no formal classification for these fractures, but most are Salter-Harris type 1 fractures, although Salter-Harris type 2 fractures can occasionally occur [20].

Clinical presentation and radiographic assessment

These fractures are often not detected promptly and parents often delay in bringing their children in because they notice that they are not using their arms. Physical examination may reveal swelling and redness, local tenderness, pain or discomfort when attempting to manipulate the child's arm [83]. While radiographs are sufficient to detect significant displacements, fractures with minor displacements are difficult to detect by radiograph and in these cases additional diagnostic work-up in the form of ultrasound or magnetic resonance imaging is required. In cases where there is visible displacement on the radiograph, the forearm axis may be observed to be out of alignment with the humeral axis. In slightly older children, a small bone fragment (Thurston-Holland fragment) may be observed, which facilitates diagnosis [21].

Management

Non-operation

Most cases described to date have been treated non-operatively. Studies support closed reduction with 90° elbow flexion and forearm pronation if the fracture is stable. Since these fractures are often detected late, when there is already a lot of scar tissue, non-operative treatment is usually sufficient if there is no major deformity. A very small number of patients treated non-operatively develop cubitus varus, of which a small number require osteotomy for correction [22].

Operation

For unstable dislocation fractures, surgical treatment is indicated. Although several open reduction series have been described to date, most authors advocate closed reduction with lateral percutaneous pinning. Care must be taken during fixation to ensure that there is no misalignment or malrotation of the coronal plane, nor of the AHL crossing the ulnar head [23]. Some surgeons prefer arthrography to better visualize the fracture.

After successful reduction in all planes and maintenance of hyperflexion, two K-wires are usually placed transversely percutaneously to avoid injury to the ulnar nerve. Three weeks after surgery and with the arm in cast, the pins are removed and further movements of the elbow in all directions are recommended to achieve adequate range of motion [23].

Complications

Since misdiagnosis, inaccuracy, and late diagnosis are common in this type of fracture, complications are also common. Particular attention should be paid to cubitus varus and cubitus valgus, which can be corrected by osteotomy. In addition, although rare, avascular necrosis may also occur, for which there is currently no adequate management. To minimize complications, especially in cases of fractures with minimal dislocation of this type, surgeons should be urged not to hesitate to use additional diagnostic methods in the form of ultrasound and magnetic resonance imaging [24].

3. Lateral condyle fractures

After supracondylar fractures, the lateral horn is the second most common type. It is usually caused by a fall on the straight hand with the forearm in a sitting position, a fall on the palm with a fall on the hand or a direct injury to the falling hand [25].

Classification

When considering the lateral horn, there are several classifications. The first classification is the Milch classification, which divides the bones into two types, type I and type II, depending on whether the bone system passes the read mesh or not (Table 4). In addition, the type II bone steel is associated with the order of the game with rotation [25].

Type	Radiographic Findings
I	Fracture line is lateral to trochlear groove
II	Fracture line extends medially into trochlear groove

Table 4: *Milch's classification.*

The following is Jakob's classification, which divides fractures of the lateral condyle into incomplete, complete or complete with a rotated fractured fragment (Table 5) [36].

Type	Radiographic Findings
Incomplete	Fracture does not extend to the articular surface
Complete	Fracture extends to the articular surface, no rotated fragment
Complete with rotation	Fracture extends to the articular surface, no rotated fragment

Table 5: *Jakob's classification.*

Finnbogason., *et al*. fractures with displacement < 2 mm were grouped into three groups (Table 6) [37].

Type	Radiographic Findings
A	Fracture does not extend to the articular surface
B	Fracture extends to the articular surface and is wider at the dorsolateral aspect of the humerus
C	Fracture extends to the articular surface and is equally displaced at the articular surface and dorsolateral aspect of the humerus

Table 6: *Finnbogason classification.*

Finally, Weiss., *et al.* described a classification scheme based on displacement and articular surface congruency (Table 7) [28]. Currently, this classification system is the most accepted by surgeons worldwide.

Type	Radiographic Findings
I	< 2 mm displacement, intact cartilaginous hinge
II	2 mm - 4 mm displacement, intact articular cartilage
III	> 4 mm displacement, articular surface disrupted

Table 7: *Weiss classification.*

Clinical presentation and radiographic evaluation

Regarding the clinical examination of children with lateral condyle fractures, they often have a sensitive feeling when palpated at the fracture site, and there is often bruising, which is caused by a tear of the brachioradialis fascia [29]. The initial imaging method is a conventional radiograph in AP and lateral view, noting that an additional internal oblique view can provide the best visualization. It is important to note and remember that the actual displacement is often greater than the displacement that can be measured on the radiograph. In severe cases, especially in young children, arthrography can be used as a diagnostic aid during surgery. Compared with conventional radiographs, computed tomography can more accurately determine the degree of displacement of the fracture in uncertain situations, but the harmful effects of radiation must always be taken into account. MRI may be useful for fractures involving the cartilaginous component, while ultrasound, in the hands of a skilled radiologist, may be helpful for the youngest lateral condyle fractures [30].

Management

Non-operative Although there are different opinions expressed in the literature, within which the limits of non-operative treatment are acceptable, the opinion that stable fractures with displacement up to 2 mm and joint union can be treated non-operatively has been established [98].

Such fractures should be immobilized with the arm in a neutral position for six weeks, noting that in the first three weeks, radiographic examinations should be performed to avoid displacement, which may be an indication for surgical treatment. After removal of the cast, physical therapy should be initiated until full mobility is achieved.

Indications for surgical treatment are unstable fractures, fractures with displacement greater than 2 mm, and failure of nonoperative treatment. Surgical treatment can be performed via CRPP or via open reduction and internal fixation (ORIF) [31] (Figure 14).

Closed reduction and percutaneous pinning

Indications for CRPP are fractures with displacement of 2 to 4 mm (Weiss type II) [28]. During reduction, the elbow should be flexed with gentle medial traction. For K-wires, two wires are usually used, while three wires have recently been recommended, as fixation with two wires may still allow for fragment migration.

A pin parallel to the joint line and two oblique bicortical pins perpendicular to the fracture line are placed at a 60° angle. The hand should then be immobilized with the elbow flexed to 90° and the forearm in a neutral position. The pin is usually removed after 4 - 6 weeks [32].

Open reduction and internal fixation

Indications for osteotomy are fractures with displacement greater than 4 mm, fractures with asymmetric articular surfaces, and fractures that cannot be resolved with CRPP. Among the approaches, the Kocher or the posterolateral Kaplan approach should be distinguished [32]. After dissection, the usual hematoma should be removed and the fracture surface cleaned with saline. After anatomical reduction, the bone fragment should be fixed with a K-wire, as in percutaneous fixation, or with a cannulated screw through the non-articular side of the lateral condyle and directed toward the medial epicondyle to fix the two cortices or by advancing the screw into the compact bone just lateral to the olecranon/acromial fossa. The arm should be immobilized with the elbow in a position of up to 9° with the forearm in a neutral position. Extraction of the osteosynthesis material is usually scheduled after 6 - 8 weeks, when physical therapy should be initiated [33] (Figure 15).

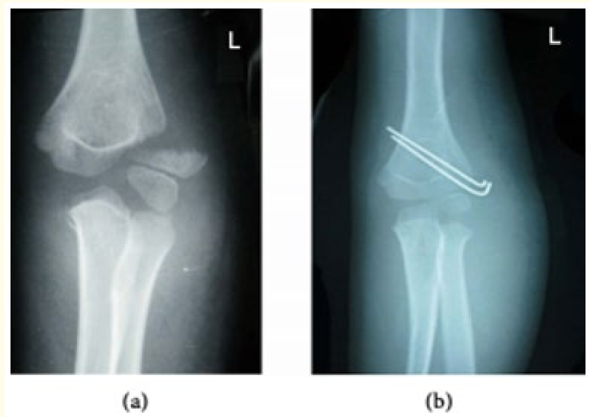


Figure 15: *Initial injury 5 weeks; (a) Pre-operation; (b) Post-operative 5 weeks.*

Complications

Among the possible complications, abnormal bone union and nonunion should be mentioned. If the surgeon fails to perform anatomical reduction of the bone fragment, abnormal bone union may occur, which may eventually lead to post-traumatic osteoarthritis and valgus or varus [34]. Nonunion is defined as a pseudoarthrosis or lack of bone union for more than 3 months after injury. Several treatments have been proposed to treat nonunion, including osteosynthesis with bone graft and cannulated pins or screws, *in situ* osteosynthesis, and closed reduction with percutaneous fixation using cannulated screws. If there is a disturbance in the blood supply to the pulley, a complication called fishtail deformity may develop, characterized by limited range of motion, stiffness, pain, and valgus deformity, which usually occurs 4-8 years after injury. Some proposed treatment options include removal of loose objects, osteotomy, osteotomy, or ulnar nerve transposition [35].

4. Medial condyle fractures

Medial epicondyle fractures are rare fractures with a peak incidence between the ages of 8 and 12, but can occur earlier and are most commonly caused by axial compression with associated valgus force (fall on an outstretched arm), direct compression of the olecranon (fall directly onto the olecranon with the arm flexed), and medial epicondyle avulsion due to forceful contraction of the common flexor muscles of the forearm. Medial epicondyle fractures are characterized by intra-articular fractures and the ulnar nerve passing nearby, making it vulnerable [36].

Classification

Today, the most widely accepted classification when we talk about medial epicondyle fractures is that proposed by Kilfoyle, who classified the fractures into three types (Table 8) [37].

Type	Radiographic Findings
I	Nondisplaced fracture line extends to the physis
II	Complete fracture through the epiphysis, no rotational displacement
III	Severe displacement with rotation of the fragment

Table 8: *Kilfoyle classification.*

Clinical presentation and radiographic evaluation

Fractures are often presented with a joint and bone. Diagnosis can be difficult in young children because the bone is difficult to see on X-rays and is often assumed to be a medial detachment [37]. Therefore, medial detachment in young children without a chemical filter should be checked by tension in the valgus position (if unstable, tension X-ray or sedation examination). Predictive criteria include AP and lateral radiographs, and cross-references may also be important. As with lateral detachment, it should be noted that actual movement is more common than radiographs. Additionally, in suspicious cases, especially in young children, CT, MRI, and ultrasound findings may be expected.

Management

No-operation

The only corrections for non-articular detachment are Kilfoyle type I and type II non-distended [37]. Such bones should be immobilized for 4 - 6 weeks with the arm in a neutral position and carefully monitored with X-rays, including Russian projections, for the first three weeks.

The literature also mentions a 2 mm movement limit as the limit after which surgical treatment should begin. After decompression of the cast, it is necessary to start the valuable material [38].

Operation

The only tactical correction is the type II combat and type III metallurgy according to the Kilfoyle classification, which is the boat with a vortex greater than 2 mm [37]. Tactical treatment includes open time with pins or open with fixed fixation [39]. Which option the surgeon will choose depends on the size of the bone fragment. It must be large enough to be able to exit. Although both posterior and medial approaches are described, the medial approach and the anterior discectomy allow better access to the anterior disc surface and assessment of the quality of the correction.

Complications

Special attention should be paid to the growth ratio of the variants compared to the detection of the posterior frame. First of all, it is necessary to point out the avascular butterfly state, because the blood supply to the pulley may be disturbed during the process of bone fusion or during the cultivation of the technique, which the surgeon must pay special attention to [40]. Considering the recreational position of the ulnar nerve, it should be noted that this nerve is likely to be super traumatized. There are some convex segments that can lead to non-continuity.

There is no clear definition of the non-continuity treatment in the request. While there are some neurologists who support the conservative method of survival, others argue about whether to respond to open fixation or osteotomy. Despite appropriate surgical resection, premature closure of the cartilage and avascularity at the head of the frame can be the cause of the fishtail deformity [41].

5. Medial epicondyle fractures

Medial epicondyle injuries typically occur between the ages of 9 and 14. They are often associated with elbow dislocations and radial neck fractures. Due to their proximity, the ulnar nerve is susceptible to compression, nerve dyskinesia due to tension and entrapment in the joint [41]. Among the mechanisms of injury, a direct blow to the medial aspect of the elbow, avulsion due to valgus stress, and association with elbow dislocation should be emphasized.

Classification

Although several classifications have been proposed by many authors, the most commonly used classification is the Watson-Jones classification, which classifies medial epicondyle fractures into four types (Table 9) [42].

Type	Radiographic Findings
I	Minimally displaced fragment
II	Displaced fragment
III	Displaced fragment entrapped in the elbow joint
IV	Displaced fragment with a dislocation of the elbow

Table 9: *Watson-Jones classification.*

Clinical presentation and radiographic evaluation

Patients typically present with limited range of motion with the elbow flexed, pain and tenderness over the medial portion of the elbow with swelling and sometimes bruising. Particular attention should be paid to the sensory and motor skills of the area innervated by the ulnar nerve [43]. For imaging, AP and lateral projections should be performed, but an additional internal oblique projection should certainly be performed, as medial epicondyle displacement is difficult to accurately measure on basic radiographs. If there is ambiguity on radiographs, CT is certainly an option, despite the additional radiation. MRI will accurately define the relationship between the bone fragments and the soft tissues within the elbow in elite athletes.

Management

Non-operation

Unfortunately, there are still no clear guidelines when deciding on non-operative versus surgical treatment. Given that radiographic findings largely do not correlate with actual displacement, it is generally accepted that displacements up to 5 mm on the AP view can be approached nonoperatively, but in addition to the above information, one must certainly take into account the mechanism of injury, the degree of elbow stability, the patient's functional goals, and the size of the displacement as measured by CT [44]. The arm should be immobilized for 3 - 4 weeks with the elbow held at 90°, some advocate for immobilization of the forearm in a pronated position. After cast removal, physical therapy should be initiated. In most patients, even if radiographic findings show incomplete union or fibrosis, range of motion will be complete.

Operation

The undisputed indications for surgery for medial epicondyle fractures are incapacitation of the bone fragment, ulnar nerve compression or neuropathy, and extremely rare open fractures. In modern practice, surgical treatment is also recommended for children with greater than 2 mm displacement if they play high-impact sports at the elbow [45]. Although there are various surgical approaches to the treatment of medial epicondyle fractures, the view that open reduction with transcondylar screw fixation is the method of choice for fixation has recently been established46. It is important to note that there is a possibility of difficult reduction, during which the arm should be flexed at the elbow and the forearm placed in supination with the wrist flexed, while an Esmarch bandage from the wrist to the elbow (milking manoeuvre) can also aid in reduction. Screws should be placed in correspondence with the bone fragment. If the bone fragments are very small or comminuted, a K-wire may be placed. During surgery, care must be taken to ensure that the ulnar nerve is not in the fracture site, compressed by hardware, or dislocated from the ulnar groove [46].

Complications

Complications include the possibility of bone fragment entrapment, which should be attempted with the Roberts maneuver (valgus force on the elbow, full extension of the wrist and fingers, and rotation of the forearm to pull the medial epicondyle out of joint). If you are not dexterous or this maneuver is difficult, you should definitely perform immediate open reduction and release of the fragment. If nonunion is detected late, the optimal treatment option is bone grafting with screw fixation [47]. There is a possibility of iatrogenic ulnar nerve injury during surgery, but symptoms can also result from local irritation of the nerve by fibrous adhesions, as well as nerve compression. In most patients, symptoms resolve within 4-6 months.

6. Lateral epicondyle fractures

Like medial epicondyle fractures, lateral epicondyle fractures are extremely rare and are often associated with other elbow fractures. The age of onset is usually around six years. They are caused by avulsion of the extensor muscles of the wrist and forearm [48].

Clinical presentation and radiographic evaluation

Clinical examination can usually confirm pain over the lateral aspect of the elbow along with swelling and limited range of motion. From the radiographic diagnosis, AP and lateral radiographs, and if necessary, medial oblique radiographs, are usually sufficient to establish the diagnosis and guide treatment decisions. CT is often required if there is associated trauma [49].

Management

Although there is no consensus on the degree of displacement that requires surgical reduction and fixation of the fracture, the absolute indication is a fracture fragment trapped in the elbow joint. Throughout the literature, authors generally opt for closed or open reduction and fixation with K-wires or screws if the fragment is slightly larger. In most cases of lateral condyle fractures, the displacement of the fracture fragment is minimal and the injury heals after short-term immobilization for 3 weeks. Even when pseudoarthrosis occurs, most patients remain asymptomatic [50].

Complications

Various complications of lateral condyle humeral fractures have been reported, including block of extension, medial elbow dislocation and medial condyle detachment, osteochondral fractures.

7. T-condylar fractures

T-condyle fractures are intra-articular, distal fractures of the humerus, characterized by separation of the central condyle and extension of the fracture line through the middle and lateral columns. They rarely occur in children with a peak incidence around the age of thirteen, presenting a challenge in treatment [52]. Mechanisms leading to these fractures include falls on an outstretched arm with a flexed elbow or falls directly onto the elbow.

Classification

The first classification system for T-condyle fractures was described by Riseborough and Radin, followed by Jarvis and D'Astous and Toniolo and Wilkins. Today, the most commonly used AO (Arbeitsgemeinschaft für Osteosynthesefragen) classification divides fractures into three types (Table 10) [53].

Type	Radiographic Findings
C1	Intercondylar fracture without comminution
C2	Fracture as one of split condyles with supracondylar comminution
C3	Fracture as one of split condyles with articular surface comminution

Table 10: *AO classification of T-condylar fractures.*

Clinical presentation and radiographic evaluation

T-condyle fractures of the distal humerus typically cause severe pain with diffuse swelling of the entire elbow. Careful assessment of the neurovascular status is required. Initially, standard radiographs should be obtained in AP and lateral views, and if necessary, oblique views. Some authors still advocate the use of intraoperative arthrography, but certainly the best radiographic modality for T-condyle fractures is CT with 3D reconstruction or MRI in young children to allow optimal preoperative planning [54].

Management

No-operation

The indication for nonoperative treatment is an undisplaced fracture or a minimally displaced fracture of up to 2 mm, but these are extremely rare in this type of fracture. The arm should be immobilized for 3 - 4 weeks, with regular radiographic follow-up to prevent further displacement. Physical therapy should be initiated after cast removal [52].

Operation

For displaced fractures, and because these fractures are intra-articular, closed reduction and fixation will usually result in a worse outcome, so open reduction and internal fixation is an option. Regardless of which open surgical treatment the surgeon decides to choose, their goals should be to resurface the joint, align the distal humerus in the supracondylar region, and minimize complications such as non-healing and avascular necrosis of the pulley. Surgeons often use a combination of cannulated screws and K-wires in surgical treatment. The wire or screw is placed across the condyle and then diagonally across the shaft, thus reducing the condyle first and then the condyle to the shaft. Some surgeons also decide to use a splint in adolescents. The most standard configuration includes a medial and posterior lateral splint (a double 90-90 splint configuration). Among the methods, the transolecranon approach and the triceps-preserving approach after Bryan-Morrey should be highlighted [55]. After surgical treatment, additional immobilization of the arm with a cast is usually required for a minimum of 4 weeks before the patient begins physical therapy.

Complications

Since these fractures are intra-articular, we always expect longer-term stiffness and more serious complications including nonunion, trochanteric osteonecrosis, ulnar neuropathy, and heterotopic ossification [56].

8. Coronal shear fractures

Coronal shear fractures are rare injuries with a peak incidence around the age of twelve due to a vertical force transmitted through the radius to the capitellum and lateral edge of the trochanter, usually resulting from a fall onto an outstretched arm with the elbow straight or slightly flexed [57].

Classification

Coronal shear fractures are classified into four types, each with a specific name (Table 11) [57].

Type	Radiographic Findings
I (Hahn-Steinthal)	Involves a large osseous portion of the capitellum in the coronal plane with little or no extension into the lateral trochlea
II (Kocher-Lorenz)	Involves a shell of the articular cartilage with a minimal subchondral layer of bone
III (Broberg-Morrey)	Comminuted or compression fracture
IV (McKee modification)	Involves more than the lateral half of the trochlea

Table 11: *Classification of coronal shear fractures.*

Clinical presentation and radiographic evaluation

Coronal fractures present with significant pain and swelling around the elbow, and limited elbow motion, especially flexion, as the fracture fragment acts as a mechanical block. Although plain radiography is the initial radiographic diagnosis, it is often misinterpreted, which can lead to misdiagnosis. Typically, the fracture will not be seen on the AP view, while a displaced anteriorly and superiorly (double bow or double bubble sign) of the semilunar fragment (double bow or double bubble sign) may be seen on the lateral view. If there is any further doubt, a CT scan with 3D reconstruction or MRI in young children should be performed [58].

Management

Non-operation

Non-operative treatment is indicated for non-displaced fractures. The arm should be immobilized for a minimum of three weeks with regular weekly radiographic examinations to prevent secondary displacement. Physical therapy is required after cast removal [58].

Operation

With the development of headless screws, coronoid fractures are treated surgically with open reduction and internal fixation. The optimal treatment is based on the anatomical reduction of the fragments, since even a small displacement causes loss of articular congruency. Among the methods used, anterior, lateral and transolecranon reduction are used, and in the literature, anterior reduction is considered the most optimal because it allows direct contact with the fragments, followed by reduction of the fracture and fixation of the fracture in the anteroposterior direction with headless screws [59]. It is important to note that bioabsorbable headless screws should be implanted as much as possible in children. After stable fixation of the fracture, early mobilization within the framework of physical therapy is mandatory.

Complications

Complications include arthritis at follow-up related to cartilage injury, joint stiffness, avascular necrosis that can lead to fishtail deformity and articular congruency. Reconstructive options are limited to compression or arthroplasty [60].

9. Proximal radius fractures

Radial head and neck fractures are relatively common fractures with a peak incidence between the ages of nine and twelve. The most common mechanism of injury is a fall on an outstretched arm and during anterior and posterior dislocation of the elbow [61].

Classification

For proximal radius fractures, there are many classifications described to date, such as the Salter-Harris classification, the Wilkins/ Chambers classification, the Judet classification, the O'Brien classification, the Mason classification, the Bado classification, etc. [62]. In daily clinical practice, the Judet classification is the most established classification (Table 12) [63].

Type	Radiographic Findings
I	Undisplacement or minimal displacement
II	Lateral displacement <50% shaft diameter, angulation <30°
III	Lateral displacement <100% shaft diameter, angulation 30°-60°
Iva	Complete displacement, angulation 60° –80°
IVb	Complete displacement, angulation >80°

Table 12: *Judet classification.*

Clinical presentation and radiographic evaluation

If elbow dislocation does not occur, deformity is usually absent, but there is pain on passive and active elbow motion, especially internal and external rotation. Plain radiographs in AP and lateral views are the first step in radiographic diagnosis, supplemented if necessary with oblique views. On plain radiographs, the most important thing is to assess the line of rotation of the femoral head (RCL) and determine the potential for displacement and angle relative to this line. Although plain radiographs are sufficient for diagnosis, additional radiographic diagnosis allows for ultrasound, often arthrography, MRI, and CT for additional preoperative planning purposes, especially when there is associated elbow joint trauma [64].

Management

No-operation

Nonoperative treatment is for Judet type I and type II fractures [63]. All greater angulations and displacements should be attempted with closed reduction. For techniques, it is often attempted by pressing on the proximal radial shaft with the elbow flexed to 90° with the forearm in supination or pressing on the distal head with the elbow at 90° while the forearm rotates from full supination to full pronation (Israel technique). This method is also described with the aid of an Esmarch bandage, which is wrapped tightly from the wrist to the elbow and often helps to reduce the fracture. If you have an assistant, you can try the Patterson maneuver (keeping the elbow straight and pronated with the forearm in supination and pulling the forearm into the varus while pressing directly on the head of the radius) or the Nehar and Torch technique (keeping the elbow straight and supinated with distal traction and varus with the assistant pushing laterally on the radial shaft and the surgeon pushing medially on the head of the radius). If closed reduction is successful, the arm should be immobilized for 3 weeks in a neutral position with slight tilt and regular radiographic follow-up once a week to prevent secondary displacement. After removal of the cast, physical therapy should be initiated [64].

Operation

If acceptable reduction cannot be achieved by closed reduction (angle up to 30° and displacement up to 50% of the shaft diameter), surgical treatment is initiated using either percutaneous or open techniques. For percutaneous methods, reduction of the fragment is usually attempted with a K-wire. After puncturing the skin with the sharp tip, the wire is rotated and the blunt end, with the help of fluoroscopy, attempts are made to localize the fragment by pushing [65]. The Metaizeau technique has also been described for fragments with bone contact and an angle of no more than 60°. This technique uses a K-wire or a soft titanium nail inserted retrograde from the distal radius. During fluoroscopy, an attempt is made to capture the fragment with the tip of the wire or nail. Once the fragment has been captured, the wire or pin must be rotated 180° to reduce the displacement and angle [66]. If satisfactory displacement cannot be achieved by any of the previous methods, an open reduction must be used. The most common reason is the presence of an interpositum. Using the Kocher, Kaplan or Boyd method, the fragment is accessed, then anatomically reduced and fixed with two K-wires. Postoperatively, the arm must be immobilized in a cast for a minimum of 3 weeks with the elbow at 90° and the forearm in a neutral position. After the cast is removed, physical therapy must be initiated.

Complications

Complications are the most common complication of ORIF and are mainly manifested by limited range of motion, especially forearm rotation. Also of concern are abnormal bone healing, overgrowth of the radial head, avascular necrosis, posterior interosseous nerve injury, fibrous adhesions or ankylosis of the radioulnar joint [67].

10. Olecranon fractures

Elbow fractures in children are relatively rare with a peak incidence between the ages of five and ten, and are often associated with other injuries such as fractures of the head and neck of the radius, distal radius/collar fractures, medial and lateral humeral condyles, and Monteggia lesions. The most common mechanism is a fall on an outstretched arm or a flexed elbow [68].

Classification

Elbow fractures are divided into the more common oblique and short transverse fractures and the less common trochanteric avulsion fractures. Oblique and short transverse fractures are usually caused by falls on an outstretched arm with an extended elbow or by falls directly onto a flexed elbow. Elbow and trochanteric fractures are common in adolescents during sports activities. Among several classification systems, the most commonly used is the Matthew classification system, which divides olecranon fractures into four types (Table 13) [69].

Type	Radiographic Findings
I	Non-displaced without an associated injury
II	Non-displaced with an associated proximal radius or distal humerus
III	Non-displaced with an associated soft tissue injury
IV	Displaced fractures (>4 mm)

Table 13: *Matthew's classification.*

Clinical presentation and radiographic evaluation

Children with oleocranial fractures usually present with posterior elbow swelling and pain that is most pronounced on attempting to extend the elbow. In oleocranial fractures, plain radiographs in the AP and lateral projections are usually sufficient for diagnosis. A posterior fat pad sign in the lateral projection or a longitudinal fracture may indicate an occult fracture. If the oleocranial fracture is associated with other fractures, a CT or MRI scan is sometimes required for detailed preoperative evaluation [70].

Management

No-operation

Indications for nonoperative treatment of oleocranial fractures are Matthew types I, II, and III and fractures displaced up to 4 mm. The arm should be immobilized with the elbow at 90° and the forearm in a neutral position for 3 weeks. In cases of minimally displaced fractures, radiographic examinations should be performed once a week to prevent secondary displacement. Physical therapy is required after cast removal [71].

Operation

The tension band technique is the gold standard for transverse and oblique fractures. Once the fracture is reached, it is reduced and held with a reduction clamp. A transverse drill hole is made in the distal fragment (through which the wire will pass), and K-wires are placed from the posterior aspect of the fibula through the fracture, bent proximally so that the wire can be wrapped around them, eventually forming a figure-of-eight loop. Instead of the wire, the use of absorbable tension band sutures is also an option [72]. Recently, surgeons have increasingly used screw fixation instead of the tension band technique. After reduction, either by closed or open reduction, a guide wire for a cannulated screw is inserted through the triceps tendon in such a way that it attaches to the anterolateral cortex at least 2 cm from the fracture. A cannulated screw is placed on either side of the cortex to provide compression. For comminuted fractures, ORIF is used, usually using a preformed proximal ulna plate. For longitudinal fractures, the best option is open reduction and fixation with interfragmentary screws [73].

Complications

Among the complications, hardware irritation should be considered the most common, followed by reduced range of motion, especially loss of full extension, and less commonly delayed union, nonunion, and ulnar nerve [74].

11. Elbow dislocations

Elbow dislocations in children are uncommon, with a peak incidence between the ages of ten and fifteen, and often occur in conjunction with fractures or tendon ruptures, usually of the medial epicondyle. The most common mechanism leading to elbow dislocation is a fall on an outstretched arm [75].

Classification

Based on the presence or absence of associated fractures, dislocations are classified as simple or complex, and in relation to the direction of movement of the proximal radius and ulna relative to the distal humerus, they are classified as posterior, anterior, medial, and lateral. If the interosseous membrane between the proximal radius and ulna is ruptured during the injury, it is a divergent dislocation [76]. Due to the mechanism of injury and anatomical predisposition, the most common form of dislocation is posterior dislocation.

Clinical manifestations and radiographic evaluation

In children with elbow dislocations, deformity is evident along with swelling of the elbow. Special attention should be paid to the possibility of neurovascular injury. Plain radiographs of the AP and lateral views are usually sufficient for diagnosis. When reviewing the radiographs, special attention should be paid to possible associated injuries (medial epicondyle fractures, lateral epicondyle fractures, radius head and neck fractures, proximal ulna fractures, especially coracoid process fractures). If there is any doubt on plain radiographs, CT or MRI may be performed, especially if osteochondral injury or soft tissue compression is suspected [77].

Management

No-operation

If there is no associated fracture or trauma, closed reduction should be initiated, preferably as early as possible, as progression of swelling makes the entire technique more difficult [77]. Posterior dislocations are reduced by placing the forearm in supination with gradual longitudinal traction. To reduce the anterior dislocation, traction is required in line with the distal forearm with posterior forces directed to the forearm and anterior forces directed to the distal humerus. For medial and lateral dislocations, traction is required first, followed by correction of the coronal plane deformity. After reduction, stability and the possibility of movement obstruction due to soft tissue entrapment should be assessed. In addition, after closed reduction, it is mandatory to repeat the X-ray to avoid missing any associated fractures, especially intra-articular entrapment fractures. If there is no associated trauma, the arm should be immobilized for 1-2 weeks with the elbow flexed to 90° and the forearm in a neutral position. After removal of the cast, physical therapy should be initiated [78].

Operation

Indications for open surgery, in addition to open dislocations, are usually unsuccessful closed surgery due to compression of bone fragments such as the medial epicondyle or osteochondral fragments or compression of neurovascular structures such as the median nerve, ulnar nerve, or brachial artery [79]. The method of opening depends mainly on the direction of the dislocation. If the capsule prevents reduction, then stretching of the capsule allows reduction. Any more superficial tightening of the fascia should be released to facilitate exposure and reduction. For the release of an intra-articular fragment, traction and valgus forces are usually sufficient. All elbow fractures should be treated surgically according to the principles mentioned previously. In addition, 2 - 3 weeks of immobilization is required after surgical treatment, after which physical therapy should be initiated [80].

Complications

The most common complication is stiffness of the elbow, especially in full extension. For this reason, physical therapy should be initiated as early as possible. Heterotopic calcification, chronic instability with recurrent dislocation, and neurovascular injury may also occur.

12. Monteggia fractures

Monteggia fractures are defined as proximal ulnar fractures or plastic deformities of the ulna with dislocation of the radial head. The mechanism of occurrence is usually a fall onto an outstretched arm with the forearm in a pronated position or direct trauma to the forearm in a pronated position with the highest incidence occurring between the ages of four and ten [81].

Classification

Monteggia fractures are classified according to the Bado classification into four types (Table 14) [82].

Type	Radiographic Findings
I (Extension type)	Anterior dislocation of the radial head and fracture of the ulna with anterior angulation
II (Flexion type)	Posterior or posterior-lateral dislocation of the radial head and fracture of the ulna with posterior angulation
III (Lateral type)	Lateral or anterior lateral dislocation of the radial head with fracture of the ulna
IV (Combined type)	Anterior dislocation of the radial head with fracture of the proximal radius and ulna

Table 14: *Bado classification.*

Clinical presentation and radiographic evaluation

Monteggia fractures usually present with pain, swelling, and deformity, usually of the forearm in a pronated position. Neurovascular assessment is also important. Diagnostically, plain radiographs in AP and lateral views, with the important note that the radiographs include both the forearm and elbow, are sufficient to establish the often overlooked diagnosis [83].

Management

No-operation

The focus of nonoperative treatment is reduction of the ulna or ulnar plastic deformity, which will also lead to reduction of the dislocated radial head. After reduction, the arm should be immobilized with the forearm in a pronated position with the elbow flexed at 100° for 6 weeks, with regular radiographic checks to prevent secondary displacement. Physical therapy should be initiated after cast removal [84].

Operation

Monteggia fractures with unstable transverse or short oblique ulnar fractures are best treated with closed reduction and intramedullary fixation (with titanium or soft stainless steel nails or Kirschner wires in young children), whereas patients with unstable or comminuted long ulnar fractures are best treated with open reduction and internal fixation with plates and screws (six- to seven-hole plates). The arm should be immobilized in a cast for 6 weeks, and the osteosynthesis material is usually removed after 3 - 6 months.

Complications

Complications following surgery for Monteggia fractures commonly include nonunion, poor union, nerve palsy, stiffness, and loss of range of motion. Late symptomatic cases can be successfully treated with reconstructive surgery (restoration of ulnar length and alignment with possible open reduction of the radial head and reconstruction of the annular ligament).

13. Little leaguer's elbow: Medial epicondyle apophysitis

School-age athletes are susceptible to all forms of sports-related injuries. Rapidly changing physical features, year-round single-sport training, and conditioning errors contribute to rising pediatric athletic injury rates. It is estimated that the incidence of baseball-related overuse injuries is 2 - 8%. More specifically, the annual incidence of elbow pain in 9-12-year-old baseball players is 20 - 40% (Figure 16) [85].

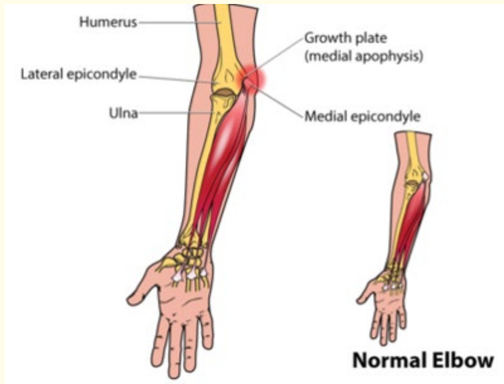


Figure 16: *Medial epicondyle apophysitis.*

Anatomy of little league elbow

Figure 17A-17C: *Position medial epicondyle avulsion.*

Little league elbow is an overuse injury to the growth plate or physis of the lower arm bone (called the ulna). Essentially, stress in the arm tends to injure the weakest link of the body. In older players, the bones are hard and relatively resistant to injury, therefore older players tend to deal with more soft tissue injuries like the UCL (Tommy John ligament) or the forearm flexor and pronator muscles. In younger players, the growth plate is made out of soft cartilage and is the "weak point" of the elbow.

In little league elbow, the cartilage of the growth plate undergoes a series of microtraumas from the repeated valgus stress of throwing a baseball, with pitching being the most stressful throwing motion in baseball. These small series of traumas to the growth plate can cause a widening of the growth plate, and eventually an avulsion fracture at the elbow if not managed correctly.

Pitching a baseball may place a tremendous amount of repetitious strain on the wrist, elbow, and shoulder. The elbow joint is whipped from a position of acute flexion into complete extension with either pronation or (if throwing a curveball) supination and ulnar flexion of the wrist. The latter maneuver places additional strain on the medial epicondyle, which serves as the attachment for the pronator and flexor muscles of the forearm. In 1965, Adams [86] evaluated the elbows of 162 boys 9-14 years old. He divided them into three groups- pitchers, nonpitchers, and a control group who had never played organized baseball. He found that radiographic changes involving the medial epicondylar ossification center and opposing articular surfaces of the capitellum and radial head in the throwing arm were directly proportional to the amount and type of throwing. These changes were most pronounced in pitchers. The conclusion of this and other similar studies is that these radiographic findings are the result of repetitive microtrauma associated with pitching.

The term "Little Leaguer's elbow" has been used to describe a multitude of overuse injuries downloaded frin adolescent athletes. These include medial epicondylar apophysitis, osteochondritis dissecans (OCD) of the capitellum, OCD of the trochlea, and olecranon apophysitis. It is important to recognize that overuse injuries can affect both medial and lateral aspects of the elbow. Medial injuries from throwing are more common. Medial side injuries are a result of valgus overload and distraction forces that occur during the cocking and acceleration phases of throwing. On the lateral side, these same movements result in compression forces at the radial head-capitellum articulation.

Classic Little Leaguer's elbow refers specifically to medial epicondylar apophysitis. The initial radiographic evaluation may be normal in up to 85% of cases. The most common radiographic manifestations of this entity are displacement and fragmentation of the medial epicondyle apophysis [87]. Additional findings may include epicondylar overgrowth resulting from chronic traction injury and overlying soft-tissue swelling. MRI evaluation may prove useful in cases of suspected medial epicondylar apophysitis and other sports-related overuse injuries, particularly when radiographs are normal. The epicondyle may exhibit low T1-weighted and high T2-weighted signal consistent with marrow edema. The physis interposed between the medial epicondyle and distal humerus may be widened and intrinsically hyperintense on a T2-weighted sequence. The common flexor tendon may also be thickened, with increased signal on both T1- and T2-weighted sequences. T2-hyperintense edema may also propagate into the muscle bellies of the forearm flexors (Figure 17) [87].

Treatment options for little league elbow

Discover the various treatment options available to help your child recover from little league elbow and get back on the field.

Physical therapy and rehabilitation

Overall, the goal of physical therapy and rehabilitation from little league elbow is to:

- Reduce pain in the elbow.
- Restore full strength and mobility of the throwing shoulder.
- Improve the kinetic chain to decrease stress on the arm.
- Prepare the arm for the stresses and demands of throwing.

Many times athletes are surprised by how many shoulder exercises are included in the little league elbow rehab, but it is important! Having weak shoulder musculature or restricted shoulder range of motion has been shown to increase the risk of shoulder and elbow pain in throwers. We need to make sure we target this area!

The shoulder exercises may vary based on the player and their individual presentations but some examples of exercises that would be incorporated into little league elbow rehab would be:

- Lumbar locked lat breathing.
- Posterior shoulder lacrosse ball.
- Eccentric shoulder external rotation.
- Kneeling lateral plank horizontal abduction.

Complications of little league elbow

The most common complication of little league elbow is an avulsion fracture of the medial epicondyle. This is a relatively rare, but significant complication that happens in roughly 16% of little league elbow cases [88]. This is most commonly found in athletes who continued throwing through pain or ignored medical guidance for a period of rest to recover from little league elbow.

Management of an avulsion fracture can vary based on the amount of displacement between the fracture and the bone. Some athletes may require a surgical fixation to ensure adequate healing [89].

14. Osteochondral lesions of the capitellum: Panner disease and osteochondritis dissecans

Osteochondral lesions are a relatively uncommon cause of lateral elbow pain in the pediatric population. The term "osteochondrosis" broadly encompasses all disorders of physical endochondral ossification. Two primary entities causing chronic lateral elbow pain fall in this category-OCD of the capitellum and panner disease.

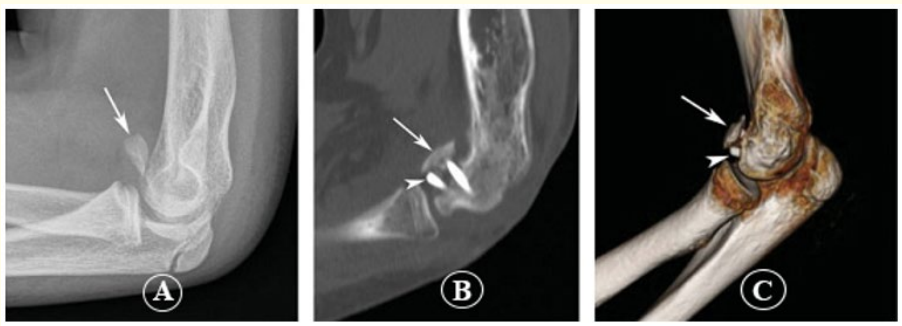


Figure 18A-18C: *Postoperative fixation of capitellar osteochondral fracture in an 11-year-old boy. A: Lateral elbow radiograph shows a proximally displaced and rotated anterior capitellar osteochondral fracture in a boy who fell off his bike and landed on his elbow. B: Sagittal two-dimensional and C: Three-dimensional surface rendered images obtained 3 weeks after open reduction and internal fixation of the capitellar defect with two Acutrak Mini screws (Acumed, Hillsboro, OR) (arrowheads). The osteochondral fragment (arrows) has been reduced to near anatomical alignment and incorporated before screw removal 6 weeks later.*

Panner disease is widely attributed to avascular necrosis of the capitellum, analogous to Legg-Calvé-Perthes disease involving the proximal femoral epiphysis. The condition typically affects the dominant elbow of boys aged 5-12 years. This age of onset is younger than that of patients with OCD. The clinical presentation is often elbow pain and stiffness lasting several months. The early radiographic manifestations of Panner disease include radiolucency adjacent to the capitellar articular surface with mild surrounding sclerosis. Later on, imaging reveals larger regions of capitellar radiolucency mixed with diffuse sclerotic changes [88]. MRI often provides more sensitive evaluation for Panner disease. There is usually diffuse capitellar marrow edema, depicted as hypointensity on T1-weighted sequences and high signal on T2-weighted and STIR sequences. There is typically no morphologic change in the capitellum. Normalization of capitellar appearance on both radiographs and MRI typically occurs within 1-2 years, which may lag behind clinical resolution of symptoms [88]. Treatment of Panner disease is conservative and involves activity restriction, with an excellent long-term prognosis (Figure 18).

In contradistinction to Panner disease, OCD of the capitellum presents in older adolescents 11-15 years old. The cause for OCD has not been universally agreed on. Many authorities think that it represents a combination of repetitive microtrauma across the radiocapitellar joint and the tenuous blood supply of the capitellum. Baseball pitchers and gymnasts are most susceptible to these injuries. As described in the section on Little Leaguer's elbow, the late cocking phase of pitching creates severe distraction forces across the medial elbow while producing tension forces across the lateral joint. Although far less frequently reported in the literature, gymnasts are also afflicted with capitellar OCD. The severe compressive and shearing forces across the radiocapitellar joint sustained during full extension in competitive gymnastics are similar to those experienced by baseball pitchers. A 1994 study performed by Schenck Jr., *et al*. [89] determined that differences in intrinsic osteochondral material properties between the central radial head and lateral capitellum contribute to the development of capitellar OCD. The tenuous blood supply of the capitellum is also a contributing factor. The entire capitellum receives its blood supply from one or two isolated vessels that enter posteriorly and traverse the entire cartilaginous capitellum. No metaphysical collateral flow exists. Thus, the ability of the capitellum to heal between repetitive traumatic events is limited, rendering it more vulnerable to osteonecrosis [90].

Imaging evaluation of a patient with capitellar OCD begins with conventional radiographs. The anteroposterior projection typically depicts OCD to greatest advantage. Classically, OCD begins on the anterolateral aspect of the capitellum, manifesting early on as faint subchondral lucency [3,69]. As the disease progresses, there are variable increasing amounts of lytic and sclerotic changes and flattening and fragmentation within the capitellum. Advanced OCD changes include loose body formation, adaptive expansion of the radial head, and osteophyte formation [69]. As with Panner disease, radiographic manifestations of OCD can be subtle. Obtaining anteroposterior projections in 45° of elbow flexion instead of the standard full extension position has been reported to improve detection of capitellar OCD [91].

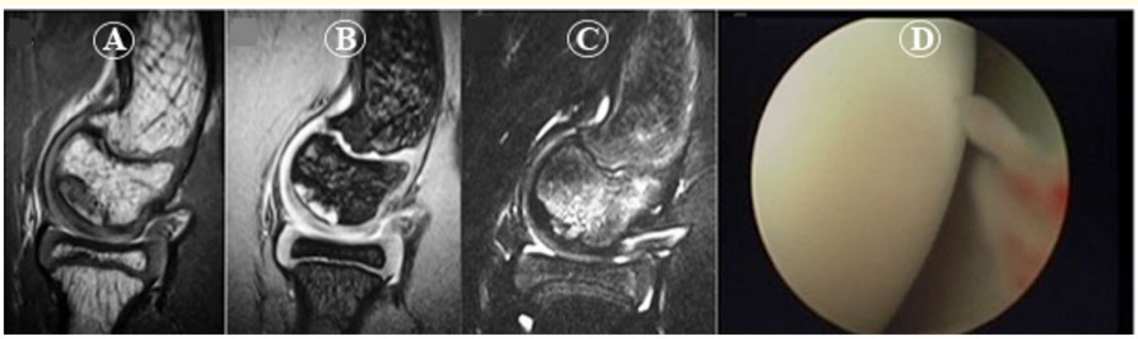


Figure 19A-19D: *Representative magnetic resonance imaging of stage 1 in a 12-year-old boy. A: The proton density-weighted image shows that the capitellum has a circular shape and no evidence of an abnormality of the articular cartilage. The osteochondritis dissecans lesion was identified beneath the articular cartilage on the B: T2 star-weighted image and C: T2-weighted fat-saturated image. D: Intraoperative arthroscopic view of the lesion showed no abnormalities of the articular cartilage.*

MRI can reliably detect and characterize OCD. The spectrum of capitellum abnormalities is more severe in OCD than in Panner disease and may include abnormal marrow signal, fragmentation, cystic changes, cartilaginous defects, and intraarticular loose bodies (Figure 18). MRI appearances of capitellar OCD and femoral head osteonecrosis share some similarities. The double-line sign seen in femoral osteonecrosis consists of a low-intensity band encircling the osteonecrotic segment with a hyperintense inner border, as depicted on T2-weighted imaging. A different segmental pattern of low signal on both T1- and T2-weighted imaging for the femoral head osteochondral lesion has also been described [92]. Similar MRI patterns have been reported for OCD of the capitellum with nondisplaced fragments. One pattern exhibits a low-signal ring surrounded by an intermediate-signal area on T1-weighted imaging; the inner portion of the low-signal ring is hyperintense on T2-weighted imaging. Another pattern commonly described is low segmental signal on T1-weighted imaging and conversion to high signal on a T2-weighted sequence. MRI arthrography with gadolinium improves staging of capitellar osteochondral lesions. Unstable lesions are characterized by fluid or contrast agent encircling the osteochondral fragment, or a cystic lesion subjacent to the fragment, on T2-weighted imaging. As with osteochondral fractures elsewhere, the fragment may displace completely from the humerus into the joint. OCD should be distinguished from a "pseudodefect", which represents normal posterior tapering of the capitellum at its inferolateral margin (Figure 19). The radiologist should be aware of this potential pitfall to avoid an erroneous diagnosis of an osteochondral lesion or impaction fracture of the capitellum.

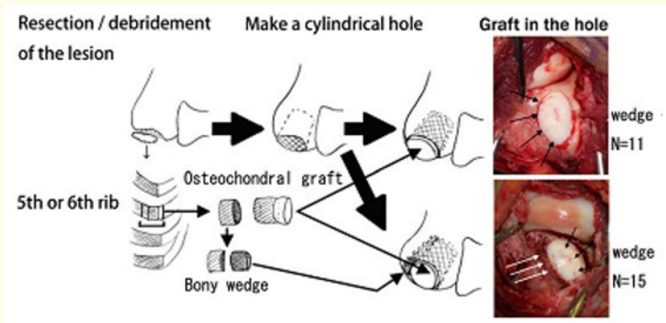


Figure 20: *Schematic showing the procedure. Detached or unstable articular lesions were completely debrided. Sclerotic subchondral bone was perforated, and the area of the cartilage defect was deepened cylindrically. The osteochondral junction of the fifth or sixth rib was shaped like a cone and was pressed into the prepared hole in the recipient site. The cartilage surface was shaped and contoured to fit the radial head with use of a scalpel (black arrows in the intraoperative photograph). In fifteen patients, residual rib bone was sliced like an osseous wedge and packed into the space between the osteochondral graft and the posterolateral cortex of the recipient humerus (white arrows in the intraoperative photograph).*

Treatment of capitellar OCD depends on the presence of fragment displacement. Nondisplaced lesions are managed conservatively with cessation of the inciting activity, nonsteroidal anti-inflammatory agents, and progressive physical therapy. Operative treatment is indicated when symptoms do not improve with nonsurgical management, the presence of intraarticular loose bodies causes mechanical impairment, or with an unstable fragment. A variety of surgical approaches have been used, including but not limited to, fragment screw fixation, drilling of the lesion, fragment removal with or without curettage or drilling of the residual defect, and reconstruction with osteochondral autograft [93].

15. Subluxation of the radial head (Pulled elbow)

In young children, the elbow may be injured by pulling on the arm, usually with the forearm pronated. This is sometimes called a subluxation of the radial head; more precisely, it is a subluxation of the rotator cuff ligament sliding up the head of the radius into the radioulnar joint. Children as young as 2 or 3 years of age present with a painful, dangling arm: there is often a history of jerking the arm and crying out in pain. The forearm is held in a pronated and extended position, and any attempt to pronate the forearm is resisted. There is no change on X-rays. Complete relief can be achieved by forcefully pronating and flexing the elbow; the ligament slides back with a snap (Figure 15).

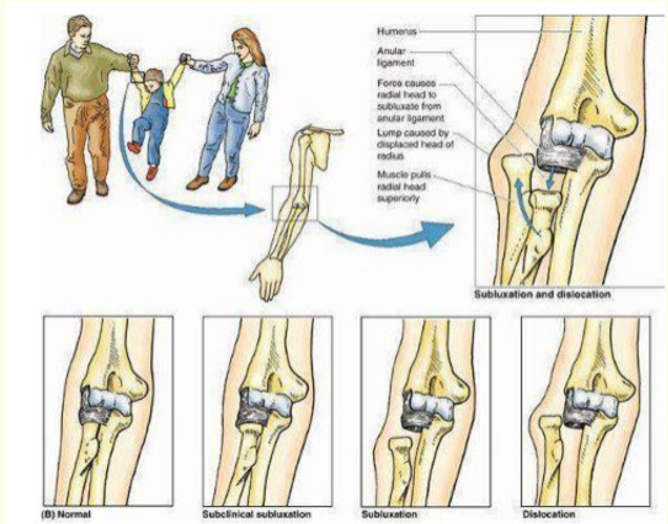


Figure 21: *Pulled elbow.*

Conclusion

Pediatric elbow injuries are a common entity encountered by emergency physicians, orthopedic surgeons, and radiologists. Although the prognosis is often excellent, the overlap in clinical presentation between entities and the risk of complications necessitate radiographic examination. On radiographs, careful examination of the anterior humeral and radius-humeral head lines, as well as assessment of the height of the humeral fat pad, is essential. A sound knowledge of the order of appearance of secondary ossification centers is required. Physiologic fractures occur at a younger age in girls than in boys due to earlier growth plate closure in girls. By adhering to current knowledge in the diagnosis and treatment of pediatric elbow fractures and dislocations, clinicians can minimize suspicion and complications to the satisfaction of children and their parents. Many new articles are published on the mentioned topic every day, in the future will bring some new scientific knowledge, maybe even better, all towards more optimal diagnosis and treatment.

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