Contents

EPIDEMIOLOGICAL, DIAGNOSTIC, AND THERAPEUTIC SPECIFICITIES OF FRACTURES IN PAEDIATRIC AGE

Each year in Europe, approximately 25% of children experience trauma, with 10-15% of these cases involving a fracture. On average, between 1.6% and 2.1% of children sustain a fracture each year. The percentage of children who experience a fracture by age 16 is 42% in boys and 27% in girls (male/female ratio = 6:4).
The incidence of fractures increases with age, and the non-dominant side is more frequently injured (left/right ratio = 1.3:1). The peak incidence of fractures occurs around age 15 in boys and around age 12 in girls (table 1).

Table 1. Number of fractures/year by age and gender

Number of fractures (#)					
Age	**1 year**	**5 years**	**10 years**	**12 years**	**15 years**
Males	100#/10000	200#/10000	250#/10000	-	500#/10000
Females	75#/10000	150#/10000	200#/10000	250#/10000	-

In children, fractures are often caused by low-energy trauma (falls, household accidents), and polytraumas are relatively rare.
Regarding the location, the upper limb is affected in 3/4 of cases. The most common sites are the wrist (mostly involving the radius, 23%), the hand (20%), the elbow (often requiring surgical intervention, 12%), the shoulder (clavicle, 6%), the leg (tibia, 6%), the ankle (tibio-talar joint, 4%), and the thigh (femur, 2%).

Bone, epiphyseal cartilage and periosteum

A child's **bone** differs from an adult's bone in several ways. A child's bone is still partially cartilaginous, which means that some parts are not visible in standard X-rays (as cartilage is radiolucent). During growth, these cartilaginous areas progressively ossify following the appearance of ossification centres. By the end of growth, the bone has acquired its definitive morphology and resistance.
The mechanical strength of a child's bone is lower than that of an adult. For this reason, low-energy trauma often results in a fracture in children. Additionally, a child's bone has greater flexibility (demonstrated by its capacity for plastic deformation), lower tensile strength, and lower flexural rigidity compared to adult bone.

The **physis** (growth cartilage) allows the bone to grow in length and thickness. Growth cartilages are located at the ends of long bones, at the boundary between the diaphysis and the epiphysis. This anatomical area is relatively weak and has reduced mechanical resistance to axial traction and torsional forces compared to the rest of the bone tissue. For this reason, epiphyseal separations involve the epiphyseal cartilages and are typical in paediatric patients.
The **periosteum** extends from one physis to the other, covering the bone along the entire diaphysis. This structure is biomechanically significant. In a child, the periosteum is thicker, stronger, and more metabolically active than in an adult. After a fracture, the periosteum often remains partially intact, helping to stabilize the fracture and guide its reduction. The periosteum produces a periosteal callus, which enables remodelling through bone resorption on the convex side and apposition on the concave side. The periosteal callus begins to be visible radiographically 2-3 weeks after the fracture.

Diagnosing a fracture

A careful clinical examination and meticulous analysis of radiographic images are essential to diagnose a fracture. Fractures in children have no unique features compared to adult fractures, except that, at times, the clinical examination of a child can be challenging, if not impossible.
The clinical examination should look for symptoms of a fracture: pain, limited function, antalgic posture, deformity, edema, swelling, skin lesions, and neurovascular issues. The clinical examination may sometimes reveal pseudo paralysis (common in infants and young children) or refusal to bear weight (especially in preschool-aged children).
Most fractures are diagnosed with standard X-rays (anteroposterior and lateral views). Comparative X-rays are rarely necessary, except in cases of diagnostic uncertainty around an ossification centre. When examining an X-ray for a potential fracture, it is essential to identify the epiphysis, growth cartilage (physis), apophysis, metaphysis, and diaphysis of the bone in question and to clearly understand the exact topography, as any of these areas may be the site of a fracture.
The **epiphysis** is cartilaginous, or radiolucent, at birth. At this stage, it is called the chondro-epiphysis. During growth, ossification centres appear within the chondro-epiphysis. As growth progresses, the entire chondro-epiphysis ossifies, leaving only the articular cartilage as the remaining cartilaginous part.
The **growth cartilage** (physis) is located between the epiphysis and the metaphysis of a long bone. The growth cartilage is not mechanically weaker than bone tissue but is reinforced by the periosteum and the ossifying epiphysis.
The **apophysis** of a bone typically represents the point of attachment for tendons.
The **metaphysis** is situated between the epiphysis and the diaphysis of a long bone. The metaphyseal zone is characterized by a relatively thin layer of compact cortical bone and a significant amount of trabecular bone. The metaphysis is broader than the diaphysis and is firmly covered by the periosteum. It has a high potential for bone remodelling.

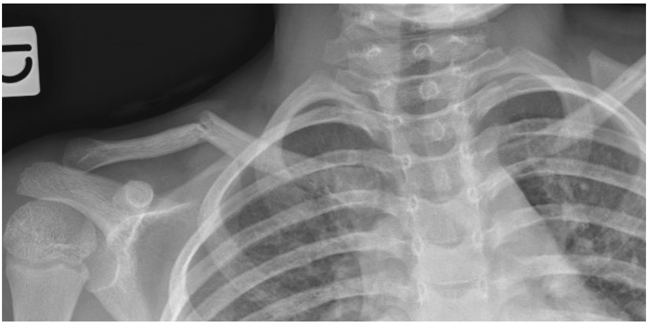


Fig. 1.
Diaphyseal clavicle fracture with mild angulation (Allman, type I)

Fig. 2.
Lateral clavicle fracture (Allman, type II)

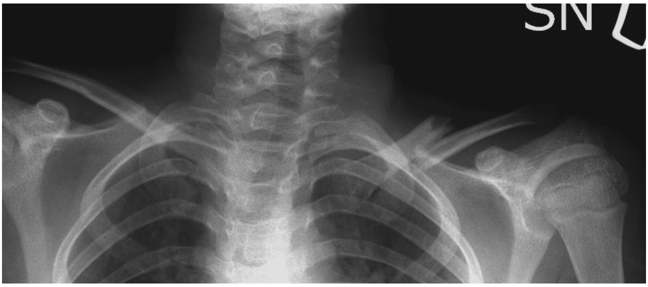


Fig. 3.
Displaced diaphyseal clavicle fracture with shortening greater than 20 millimetres (Allman, type III)

Surgical treatment

Surgical treatment is rare. It becomes necessary in cases of open fractures, vascular damage, and neurological injuries. It is also indicated for a **floating shoulder**, and in some hospitals, it is used if the bone fails to heal or if there is more than 20 millimetres of shortening in adolescent patients (fig. 3).

Immobilization

Treatment can be carried out with an eight-figure bandage or a specialized brace (fig. 4), which is worn for 3-6 weeks, depending on the patient's age.

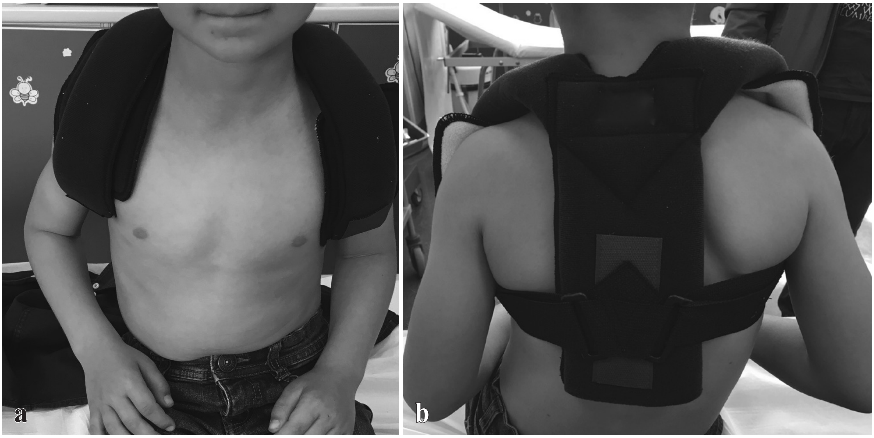


Fig. 4. Bandage for clavicle fracture: anterior view (a) and posterior view (b)

Fig. 5.
Healing bone callus with prominent volume, visible on X-ray

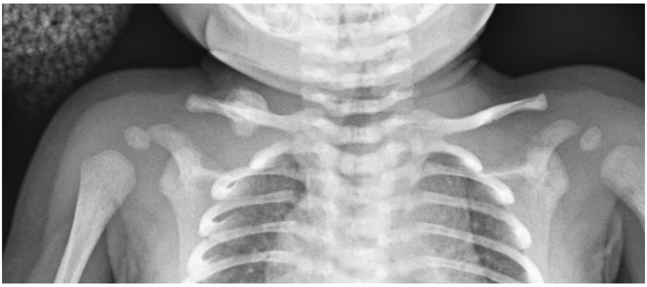


Fig. 6.
Hypertrophic healing bone callus, clinically evident

THE ACROMION-CLAVICULAR DISLOCATION

The medial clavicular articular facet of the acromion of the scapula and the distal clavicular portion form the acromioclavicular joint. This joint is typically injured following a direct fall onto the shoulder at the level of the joint.

Clinical evaluation

This type of dislocation is rare in young children. Pain on palpation is localized at the acromioclavicular joint.

Peripheral neurovascular examination
The skin and neurovascular condition of the upper limb should be checked. In particular, sensitivity and contraction of the deltoid muscle (axillary nerve) should be assessed.

Diagnostic tests

An anteroposterior X-ray of the clavicle should be requested (fig. 1). In younger children, although rare, fractures of the proximal epiphysis of the clavicle (Salter & Harris, type I) due to periosteal detachment can be observed; these detachments should be confirmed with a CT scan.

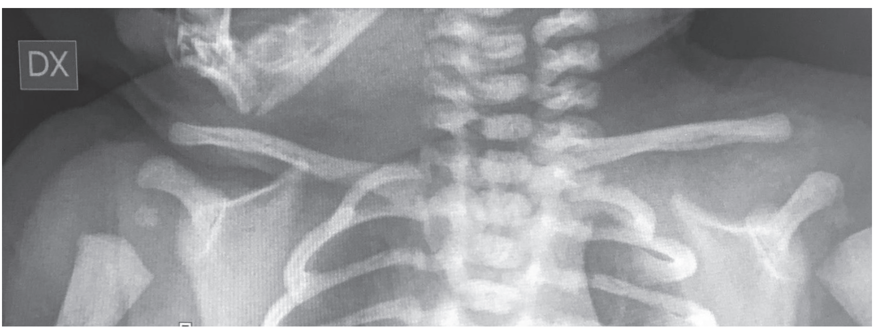


Fig. 1. Anteroposterior X-ray of an acromioclavicular dislocation on the left; note the degree of elevation of the acromion compared to the right side

FRACTURES OF THE PROXIMAL HUMERUS

The ossification centre or nucleus of the proximal humerus is not present at birth and begins to ossify around 2-3 months of life.

Clinical evaluation

Pain is detected on palpation and shoulder mobilization. Edema and functional impairment of the upper limb are also observed.

Peripheral neurovascular examination
The condition of the skin on the upper limb should be assessed. In particular, it is important to test the sensitivity and contraction ability of the deltoid muscle (**axillary nerve**).

Diagnostic tests

An X-ray of the shoulder in anteroposterior and lateral projections should be requested. Proximal humeral fractures may be metaphyseal (fig. 1) or epiphyseal. The latter can be categorized using the Salter & Harris classification (figs. 2 and 3).

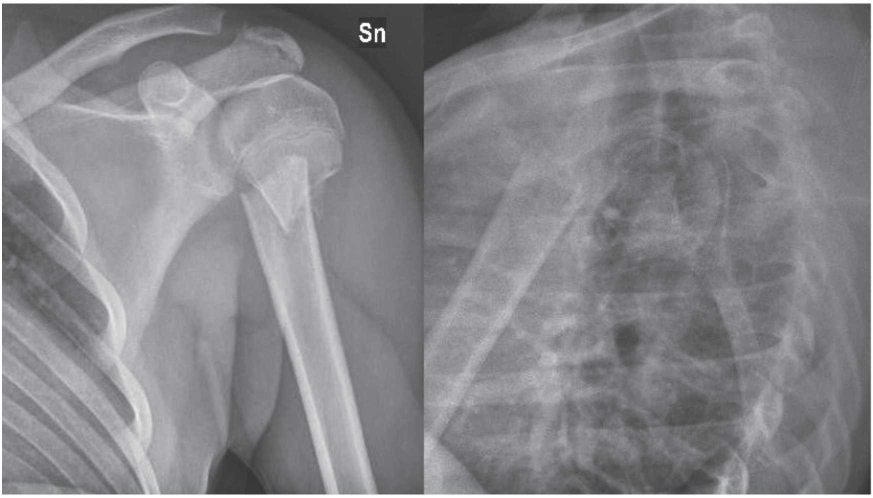


Fig. 1. Metaphyseal fracture of the proximal humerus

Fig. 2. Salter & Harris type I fracture of the proximal humerus

Fig. 3. Salter & Harris type II fracture of the proximal humerus

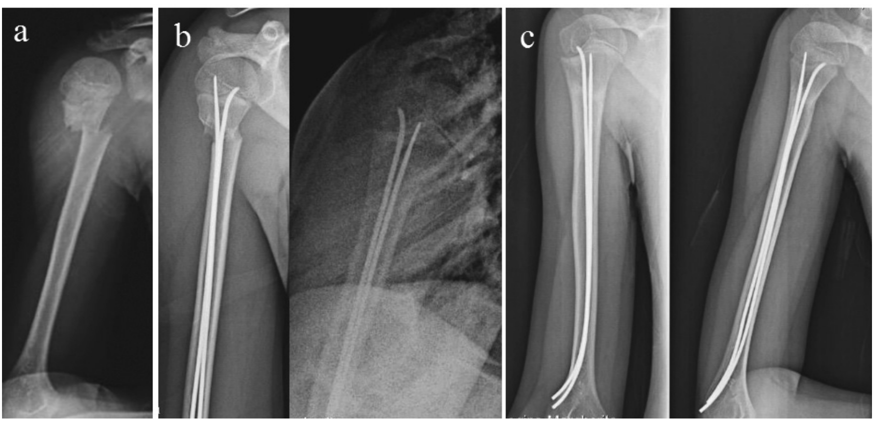


Fig. 4. Metaphyseal fracture of the proximal humerus: (a) treated with elastic intramedullary nailing; X-ray before removal of the fixation devices (b), and after showing complete fracture healing (c)

Fig. 5 Varus elbow deformity as a result of a supracondylar fracture: clinical presentation

What parents should know

The prognosis is generally good. Post-traumatic stiffness should gradually improve as the child grows. A possible complication of supracondylar fractures of the humerus is axial deviation, resulting in a cubitus varus deformity (fig. 5) and hyperextension of the elbow; selected cases may require periodic clinical and radiographic follow-up.

Practical tips

An elbow effusion without radiographic signs of fracture may suggest a type I fracture according to Lagrange & Rigault. Any possible neurological deficits present, are generally temporary, with spontaneous recovery typically occurring within 2 weeks to 4 months. Surgical nerve exploration is usually not indicated. Physiotherapy is not necessary and should not be prescribed, as it may lead to heterotopic ossification, resulting in elbow stiffness.

Fig. 2. Lateral condyle fracture, Type I (a) and Type III (b) according to Milch classification

Fig. 3. Lateral condyle fracture, Type I according to Milch classification, modified by Jakob & Fowles (a). Lateral condyle fracture, Type II according to Milch classification modified by Jakob & Fowles (b). Lateral condyle fracture, Type III according to Milch classification modified by Jakob & Fowles (c)

FRACTURES OF THE INTERNAL HUMERAL CONDYLE

The ossification centre or nucleus of the humeral trochlea appears between the age of 7 and 9.

Clinical evaluation

Evaluate edema and tenderness on the medial surface of the elbow.

Peripheral neurovascular examination
Check and examine the skin and neurovascular status of the upper limb. In particular, assess the **ulnar nerve** (finger abduction, sensation on the ulnar side of the fourth finger, and the fifth finger's sensation).

Diagnostic tests

Anteroposterior and lateral X-rays of the elbow and forearm should be requested. An oblique elbow projection can aid in confirming the diagnosis. CT of the elbow may be helpful if there is uncertainty regarding the fragment's type of dislocation.
Kilfoyle's classification (table 1) categorizes three fracture types (fig. 1 and drawing 1).

Table 1. Kilfoyle classification

Type I	Non-displaced fracture without articular surface involvement
Type II	Non-displaced or minimally displaced fracture involving the articular surface (fig. 1)
Type III	Avulsion fracture with fragment rotation (fig. 2)

Treatments methods

Conservative treatment
Conservative treatment (with immobilization) may be considered for non-displaced fractures (Kilfoyle Type I).

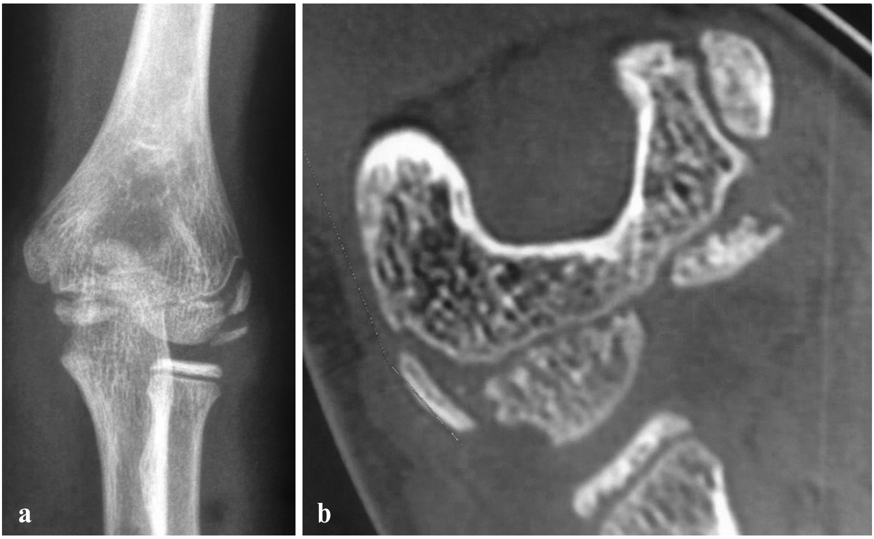
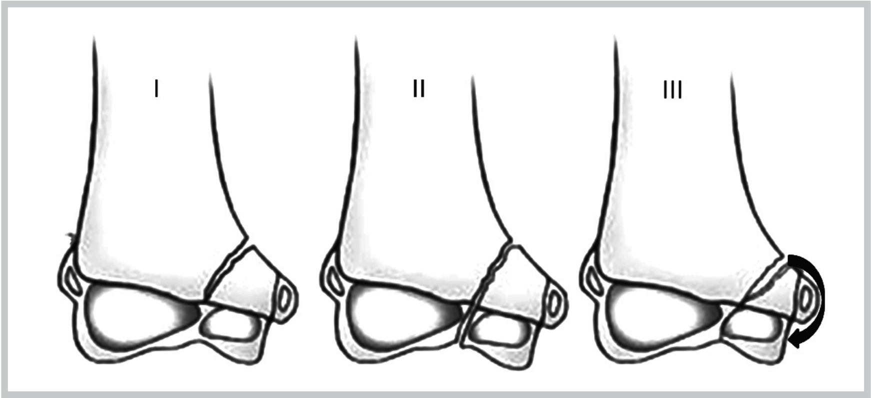


Fig. 1. Type II medial condyle fracture per Kilfoyle's classification with minimal articular surface involvement: X-ray (a) and CT scan (b)



Drawing 1. Kilfoyle classification

Surgical treatment
Displaced fractures require open reduction (using Kirschner wires or screws) (fig. 3) and brachio-metacarpal casting under general anaesthesia (Kilfoyle Types II and III).

Immobilization
In all cases, immobilization consists of a brachio-metacarpal cast with the elbow flexed at 90-100° and the wrist flexed. The upper limb is kept against the abdomen to prevent external elbow rotation.

Figs. 2-3. Type III medial condyle fractures per Kilfoyle: AP X-ray of avulsion and complete fragment rotation (2, left); postoperative X-ray following reduction and fixation with Kirschner wires (3, right)

Follow-up

X-rays
Repeat X-rays on days 1, 7, and 28 (after cast and Kirschner wire removal) and in three months. Additional X-rays may be necessary based on the healing process.

Mobilization
Active mobilization of the elbow and forearm should begin after cast removal (typically after four weeks). Percutaneous Kirschner wires should be removed alongside the cast, which can be done in an outpatient setting if the wires are exposed. Returning to do sports is possible starting from three months post-fracture.

What parents should know

There is a frequent risk of displacement in conservative treatment. Complications are rare.

Practical tips

This type of fracture is rare and typically occurs in children aged 7 to 13. Varus/valgus stress X-rays may be performed in the operating room to assess elbow stability.

FRACTURE OF THE MEDIAL HUMERAL EPICONDYLE

The ossification centre of the medial epicondyle of the humerus appears between ages 4 and 6. This fracture is also known as a medial condyle fracture.

Clinical evaluation

The degree of swelling and pain at palpation should be assessed in the medial region of the elbow. Epicondyle fractures are often associated with elbow dislocations.

Peripheral neurovascular examination
Examine the skin and neurovascular status of the upper limb, particularly the ulnar nerve (finger abduction, sensation on the ulnar side of the fourth finger, and sensation on the fifth finger).

Diagnostic tests

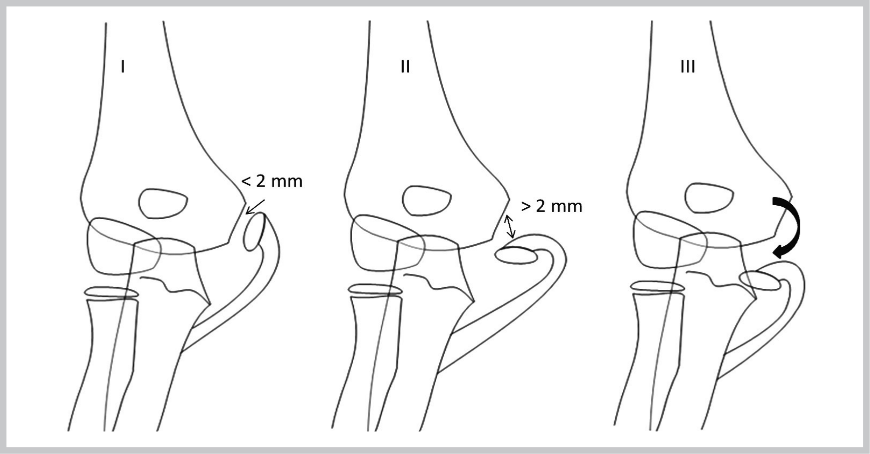
An anteroposterior X-ray of the entire forearm and elbow is required. A CT scan of the elbow may clarify any doubts regarding the degree of displacement. X-ray imaging helps identify four fracture types according to Watson & Jones' classification (table 1 and drawing 1).

Table 1. Watson & Jones classification

Type I	Non-displaced fractures
Type II	Displaced fracture with an interfragmentary gap greater than 2 millimetres
Type III	Avulsion fracture with intra-articular entrapment of the fragment (fig. 2)
Type IV	Fractures associated with elbow dislocation

Treatment methods

Conservative treatment
Non-displaced fractures (Type I, according to Watson & Jones) are managed with immobilization.



Drawing 1. Watson & Jones classification (stages I-III).
Stage IV is associated with elbow dislocation

Surgical treatment
Displaced or dislocated fractures (Types II, III, and IV, per Watson & Jones) require anatomical reduction and fixation with Kirschner wires or screws, depending on the patient's age and fragment size, followed by immobilization. Type II fractures may be stabilized with percutaneous Kirschner wires (fig. 1).

Immobilization
All fracture types require brachio-metacarpal casting with the elbow flexed at 90° for four weeks.

Follow-up

X-rays
X-rays should be taken at the time of injury, in 5 and 15 days post-trauma for conservative treatment, 2 days post-cast and Kirschner wire removal, and in three months. Further imaging depends on the healing progression.

Mobilization
Active mobilization of the elbow begins once the cast is removed. Kirschner wires or screws can be removed 4-6 months post-surgery. Returning to sport activities is allowed three months after injury.

Fig. 1. Type II epicondyle fracture according to Watson & Jones, with fragment separation greater than 2 millimetres

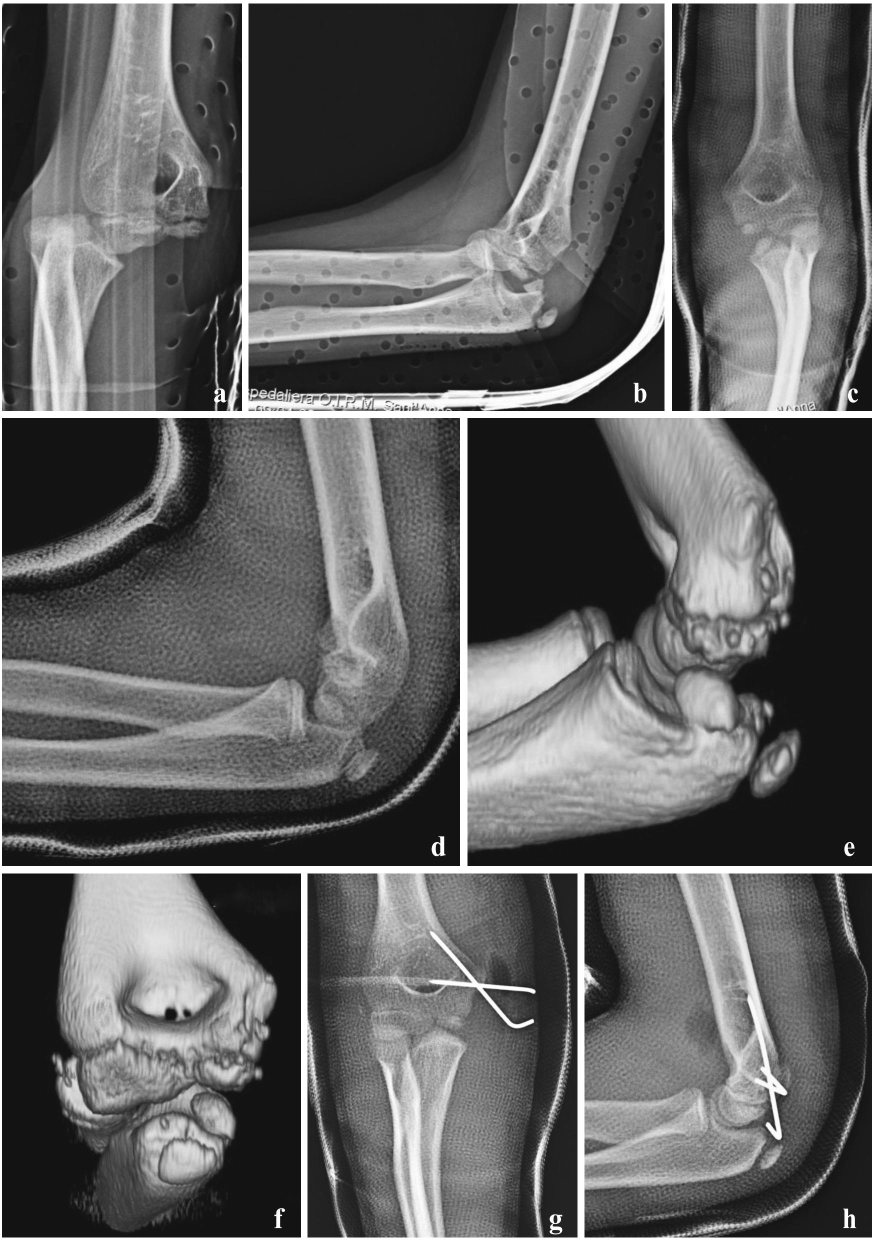


Fig. 2. Medial epicondyle fracture with elbow dislocation (a-b); after reduction, entrapment of the epicondyle is visible (c-d), better confirmed with CT images (e-f); post-reduction X-ray with Kirschner wire fixation (g-h)

What parents should know

The risk of secondary displacement during conservative casting is relatively common, but complications are rare.

Practical tips

Intraoperative fluoroscopic imaging with varus-valgus stress on the elbow can help assess stability. This fracture type can be associated with elbow dislocation, so a medial epicondyle fracture should be suspected in cases of elbow dislocation.
If a patient is referred for possible medial epicondyle fracture, it is essential to confirm there is no displacement. X-rays should be taken without casting, as a cast could obscure secondary displacement or, in rare cases, reveal intra-articular entrapment of the epicondyle (fig. 2).

Recommended readings

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