Paediatric supracondylar fractures of the humerus: acute assessment and management

Introduction

Paediatric supracondylar humeral fractures are very common injuries, accounting for approximately 65–75% of all elbow fractures in children (Kasser and Beaty, 2001). They are serious injuries which are associated with significant neurovascular complications and deformity if not recognized and treated promptly and effectively.

Epidemiology

The peak incidence is from 5–8 years of age, after which dislocations become more frequent. There is a male predominance of 3:2 and the non-dominant side is more frequently injured.

Anatomy

Classically there is a transverse fracture line through the apices of the coronoid and olecranon fossae. Remodelling bone in the 5–8-year-old causes a decreased anteroposterior diameter in this supracondylar region, making it susceptible to injury. Ligamental laxity in this age range increases the likelihood of hyperextension injury. The joint capsule is thicker and stronger anteriorly. Thus, in extension, these fibres are taut, serving as a fulcrum by which the olecranon becomes firmly engaged in the olecranon fossa. When a force travels through the extended elbow, the olecranon process impinges on the superior olecranon fossa and supracondylar region. *Figure 1* demonstrates the osteology, and *Figure 2* the intimate relationship of the neurovascular structures with the distal humerus.

Mr Breck Lord *is Core Surgical Trainee (CT3) Trauma and Orthopaedics and* **Mr Khaled M Sarraf** *is Specialist Registrar (ST4) Trauma and Orthopaedics on the North West Thames London Rotation, Trauma and Orthopaedic Surgery*

Correspondence to: Mr KM Sarraf, Department of Trauma and Orthopaedics, The Hillingdon Hospital NHS Trust, Middlesex UB8 3NN

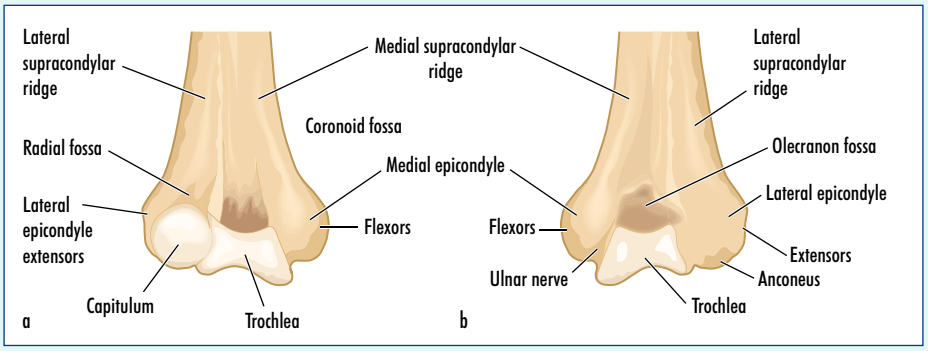


Figure 1. Osteology of the distal humerus. a. Anterior view. b. Posterior view.

Mechanism of injury

Hyperextension occurs during a fall onto the outstretched hand with the elbow extended. This indirectly applies force to the distal humerus displacing it posteriorly with or without varus or valgus force. This results in the 'extension' type injury that is present in 95% of cases. If the hand is supinated posterolateral displacement occurs; if pronated posteromedial displacement occurs. The latter is more common. Rarely, direct trauma or a fall onto the flexed elbow causes a 'flexion' type injury (5%) with anterior displacement.

Clinical evaluation

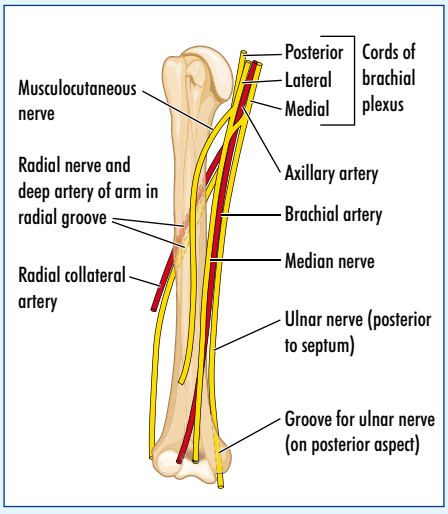
History

This injury should be considered when presented with a swollen, painful elbow with decreased range of movement associated with trauma. An appropriate age and mechanism of injury are highly suggestive factors. Questions that the doctor needs to answer on being faced with such an injury are:

- Does the history involve a fall from a height, e.g. monkey bars, a trampoline, tree climbing?
- Is it a flexion or extension injury?
- Was the hand supinated or pronated?
- What is the child's hand dominance?
- Any previous injury or surgery to either upper limb?
- What time did the child last eat and drink (when considering urgent surgical intervention)?

These all can impact on the clinical assessment and evaluation of the injury. Pain, loss of function and paraesthesia, their timing, distribution and progression are crucial. Is the mechanism consistent with your findings? Always be vigilant for non-accidental injury.

Figure 2. Relationship of vital neurovascular structures to the distal humerus.



Examination

This adheres to the classical orthopaedic mantra of look, feel, move, assess neurovascular status and examine the joint above and below.

Inspect for swelling, skin changes such as bruising or an open fracture. The pucker sign may be seen anteriorly, a firm prominence suggestive of a bony spike penetrating the anterior muscles of the forearm. This can make reduction difficult.

Palpate for tenderness around the elbow. In addition, assess swelling and tenseness of

the muscle compartments of the arm and forearm considering the possibility of compartment syndrome – a surgical emergency.

Gently assess range of movement. This will be overtly painful in supracondylar fractures. If there is an obvious deformity with a suspected off-ended supracondylar fracture, movement of the joint is unadvisable and should not be attempted.

Urgent treatment is paramount in cases where there is a suspicion of neurovascular compromise. A thorough neurological assessment of both upper limbs should be undertaken with clear documentation.

Median nerve injury is the most common, with altered sensation over the palmar tip of the index finger (the autonomous area of the median nerve). Can the patient make the 'OK' sign? This tests the anterior interosseous nerve, easily missed as it is a pure motor nerve. Injury impairs flexion of the interphalangeal joint of the thumb (flexor pollicis longus) and the distal interphalangeal joint of the index finger (lateral fibres of flexor digitorum longus).

Assess the radial nerve with wrist extension and sensation in the dorsal aspect of the first web space (autonomous area of the radial nerve).

Rarely, flexion-type injuries damage the ulnar nerve. This is apparent with weakness of the intrinsic muscles of the hand, tested by asking the patient to spread his/her fingers wide against resistance and altered sensation over the palmar tip of the little finger (autonomous area of the ulnar nerve).

These movements may be painful but be very wary of attributing any deficit purely to pain – always be suspicious of nerve injury and expedite treatment accordingly.

Vascular status of the limb is crucial, failure to recognize this can potentially lead to loss of the limb and lack of documentation can lead to medicolegal consequences. Inspect for pale, dusky extremities. Palpate the radial pulse and ulnar pulse – use of a hand-held doppler may be necessary. Is the capillary refill time greater than 2–3 seconds? Is the extremity cooler than the uninjured upper limb?

Given the age group of these patients, clinical examination can sometimes be very challenging. Optimization of analgesia is essential to aid examination (follow the analgesic ladder including nitrous oxide and oxygen (Entonox)) as well as frequent reassessment until the diagnosis and treatment path is established. If surgery is required, place an above elbow cast – with access to the wrist to assess pulses – for comfort only and do not attempt manipulation. Vigilant documentation by the assessing doctor is paramount, and should be done at every assessment.

Radiography

Such an injury requires antero-posterior, lateral and oblique radiographs of the elbow in addition to imaging of the joint above and below. The olecranon, medial and lateral epicondyles preserve their normal equilateral triangular relationship, unlike pure elbow dislocations. Interpretation is made difficult by the changing complexities of the epiphyses during childhood. The 'CRITOL' mnemonic (*Table 1*) is a classical way of remembering the ossification times (*Figure 3*). It is important for the junior doctor to recognize the normal anatomy in a child's radiograph and accurately identify the presence of any injury. Comparative radiographs of the uninjured upper limb are very useful in assessing the extent of the injury in suspicious or minimally displaced injuries.

With minimal trauma there may only be a slight cortical irregularity. With increasing force of injury, a transverse hairline fracture may be visible on the antero-posterior radiograph and then the lateral. With further force the distal fragment is tilted in a backward direction, this may progress to displacement of the distal humeral complex and loss of bony contact. The injury may be complicated by rotation, posteromedial or posterolateral displacement, significantly increasing the risk of neurovascular complications.

Table 1. Age (year) at which ossification centres around the elbow appear on X-ray

Ossification centre	Years at ossification*
Capitellum	1
Radius	4
Internal (medial) condyle	6
Trochlea	8
Olecranon	10
Lateral condyle	12

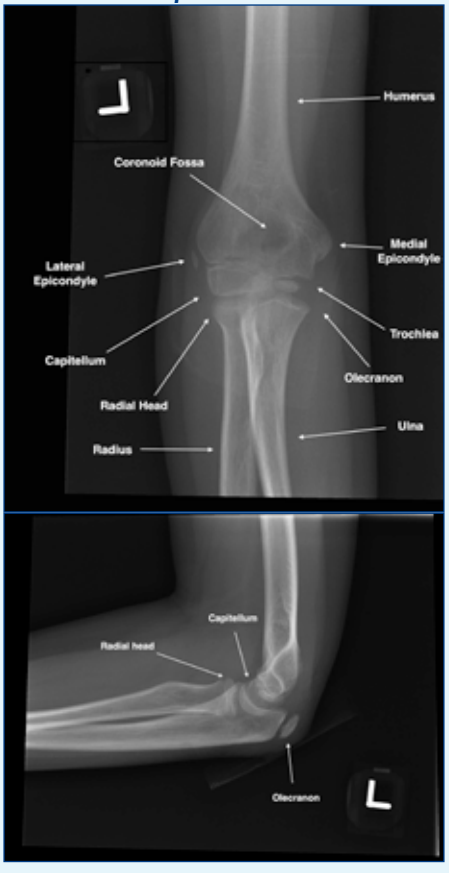
* +/- 1 year, girls earlier than boys

Treatment

Undisplaced supracondylar fractures (Gartland type I) are treated conservatively with immobilization in an above elbow cast or splint at >90° of flexion for 3 weeks. An antero-posterior and lateral radiograph should be taken after the plaster placement and a review 1 week later in the orthopaedic outpatient clinic is needed to ensure acceptable fracture alignment.

Displaced fractures with an intact posterior cortex (Gartland type II) are commonly amenable to closed reduction (if minimal displacement and minimal or no rotation, Gartland type IIA) with either elbow flexion alone or with longitudinal traction and posterior pressure applied to the distal fragment, while flexing the elbow >90°. O'Hara et al (2000) devised the Southampton protocol to easily determine the optimum management based on the presence of rotation (*Figure 4*). The Royal

Figure 3. (a) Antero-posterior and (b) lateral radiographs of an elbow of a child showing all ossification centres present.



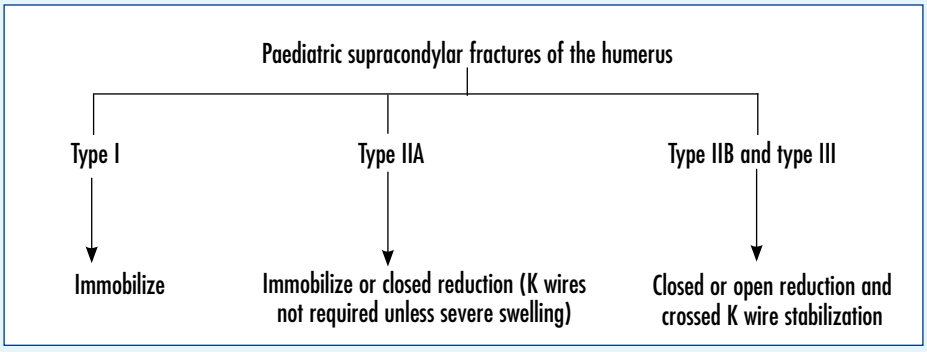


Figure 4. Southampton protocol for the acute management of supracondylar fractures in children.

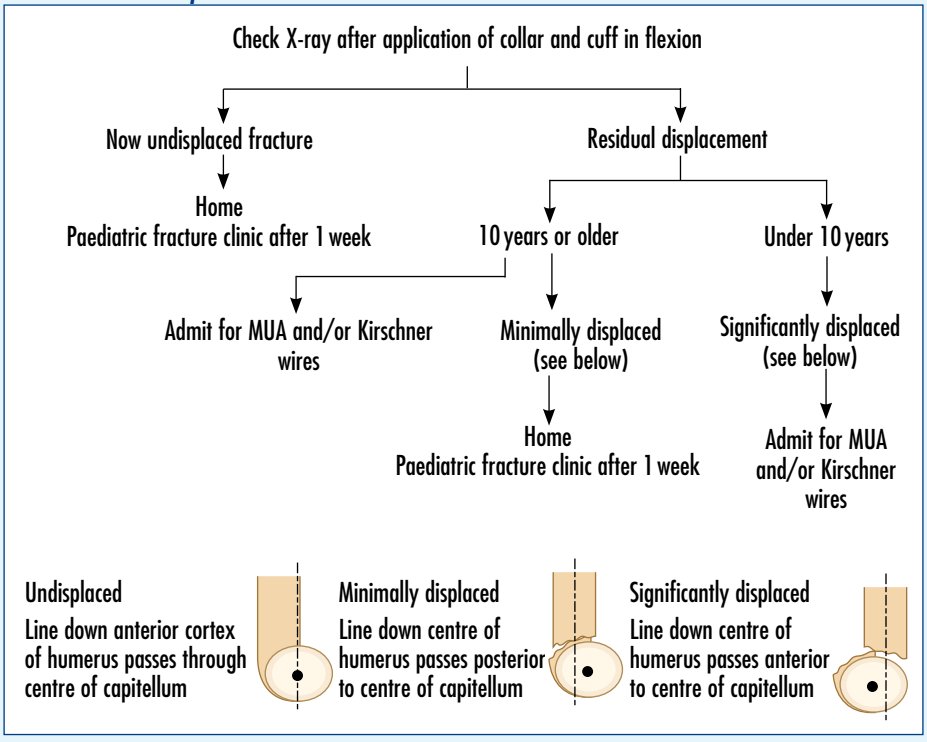
Berkshire Hospital advocates conservative management for all fractures with the centre of the capitellum anterior to the mid-humeral line (*Figure 5*), indicative of insignificant displacement responding well to conservative management.

However, there are two disadvantages to this method, described as the 'supracondylar dilemma' (McLaughlin, 1959). The necessary flexion, with associated swelling, can compromise circulation, while too much extension loses fracture reduction. Avoiding vascular compromise is paramount and stabilization of these fractures in a more extended position is the accepted practice (O'Hara et al, 2000).

This is also the case for significantly displaced and/or rotated Gartland type IIB fractures, as well as completely displaced Gartland type III (*Figure 6*) fractures. Stabilization with Kirschner wires (K-wires) can be in parallel or crossed (*Figure 7*). Wires crossed above the fracture site and bi-cortical are more stable (Herzenberg et al, 1988; Zionts et al, 1994). This is done under general anaesthetic with fluoroscopy guidance in theatre before immobilization in a plaster of Paris cast. However, failure to achieve a stable reduction, having an open fracture or vascular injury would require open reduction and K-wires, with care taken to identify and protect the ulna nerve.

Early mobilization is crucial to avoid joint stiffness and the patient should be encouraged to do active movement exercises to maximize functional outcome after the period of immobilization. Further surgery, such as a corrective osteotomy, is rarely required to correct any missed or mal-united rotational deformity which can limit function.

Figure 5. Royal Berkshire Hospital protocol for the acute management of supracondylar fractures in children. MUA = manipulation under anaesthesia.



Complications

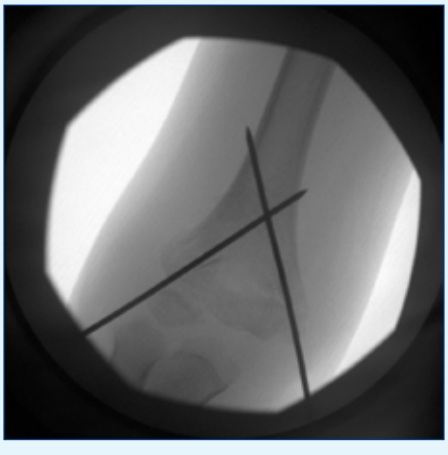
The surgical emergency: the pulseless limb

Vascular injuries are rare, occurring in 0.5% of cases (Egol et al, 2010), and are a result of direct trauma to the brachial artery or secondary to antecubital swelling. Be highly suspicious of brachial artery injury with marked posterolateral displacement. Vascular status of the limb must be assessed on presentation and after casting or manipulating the limb. Do not forget to accurately document the timings of all examination findings.

Supracondylar fractures, with associated vascular compromise, constitute a true orthopaedic emergency. Although it is often difficult to accurately examine the upper limb as a result of swelling, pain and the state of the child, it is essential to avoid any delay in detecting vascular injury as ischaemia, once established, can become

Figure 6. Gartland type III supracondylar fracture – extension injury (lateral radiograph).

Figure 7. An example of cross K-wire stabilization of a Gartland type III fracture.



irreversible. As mentioned above, palpate the radial and ulnar pulse (the brachial pulse as well if possible), measure capillary refill, and note the overall colour of the hand. The absence of a pulse is not necessarily a danger sign and its presence not a guarantee that ischaemia will be avoided (Blount, 1950).

When a complete and vigilant examination is suspicious of vascular compromise, both the orthopaedic and vascular surgeons should be urgently informed. The patient will need urgent exploration. Fixation of the fracture is usually recommended before addressing the vascular injury, as it is considered technically simpler and might improve perfusion of the limb especially in arterial spasm. It will also help stabilize the vascular repair and avoid damage of any vascular anastomosis performed (Kumar et al, 2001).

There is an increased risk of Volkmann's ischaemia in cases where exploration was delayed beyond 24 hours (Ottolenghi, 1960). There is evidence that prompt exploration can decrease the incidence of vascular complications.

Arteriography has been used to aid localization and define the nature of the vascular injury, however, this remains controversial and is usually not recommended as the site of injury is likely to be at the fracture site and arteriography might cause unnecessary delay in definitive treatment.

Neurological injury occurs in approximately 7–10% of cases (Cramer et al, 1993). This may be caused by traction at the time of injury or iatrogenic during attempted reduction and stabilization. Most nerve injuries associated with supracondylar fractures of the distal humerus are neuropraxias requiring no treatment and resolve within 18 months. If the radiograph shows posterolateral displacement be highly suspicious of a median nerve injury. Likewise, posteromedial displacement puts the radial nerve at risk.

The most common problem is angular deformity occurring in 10–30% of patients, cubitus varus more commonly than valgus (Smith, 1960). This is dramatically reduced to 3% with the use of K-wire stabilization (Egol et al, 2010).

Following completion of treatment, 5% of cases are left with greater than 5° of extension deficit; this is usually secondary to poor reduction or soft tissue contracture associated with late mobilization (Egol et al, 2010).

Compartment syndrome occurs in less than 1% of cases and can be induced by elbow flexion during reduction followed by swelling around the cubital fossa, especially in type II injuries (Egol et al, 2010). Myositis ossificans is a rare complication and is seen after vigorous manipulation (Mitchell and Adams, 1961).

Family counselling

Convey the nature of the fracture and the presence of any neurovascular compromise. Explain the risks involved in closed and surgical reduction with immobilization. These include further neurovascular damage – recovering in the majority of cases, and a degree of elbow stiffness initially – also improving with time. Reassure that residual varus or valgus deformity may correct with bone remodelling and surgical correction is a possibility if there is any rotational deformity causing functional deficit. Bone remodelling is largely dependent on the patient's age, sex and if female whether she is pre- or post-menarche.

Conclusions

Supracondylar fractures of the humerus are a common injury in children. They are usually associated with falls from a height onto the outstretched hand or direct trauma onto the elbow. If displaced, they should be referred to the orthopaedic surgeon for further assessment, and a treatment plan made involving the child's parents. Accurate clinical evaluation of the limb's vascular and neurological status is crucial and should be reassessed regularly and documented, with any deficit reported to the orthopaedic surgeon. A pulseless limb is an orthopaedic emergency and urgent exploration is indicated. BJHM

Conflict of interest: none.

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Further reading

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KEY POINTS

- Supracondylar fractures of the distal humerus are a common injury of the paediatric elbow.
- Always consider the age of the child and the points of ossification when evaluating X-rays of a child's elbow.
- Vigilant neurovascular examination is crucial with documentation and repeated evaluation.
- Referral of any displacement fracture to the orthopaedic surgeon is necessary while the child is in the emergency department.
- Anatomical knowledge of the elbow region and the neurovascular structures that pass through and around the antecubital fossa is paramount.