# Paediatric supracondylar humerus fractures


## ABSTRACT

This article gives a practical guide to the management of supracondylar fractures of the humerus in paediatric patients, from initial presentation to definitive treatment. It reviews the optimal management of this common and serious injury based on current evidence including the British Orthopaedic Association Standards for Trauma (BOAST) 11 standard.


Supracondylar fractures of the humerus are the most common fracture around the elbow in children, comprising approximately 12–17% of all paediatric fractures (Khoshbin et al, 2014). They are associated with a high risk of short- and long-term complications, both from the injury and its treatment. It is therefore essential that this fracture is managed well, from early diagnosis and initial management in the emergency department to prompt decision making regarding the need for surgical intervention and, if required, correct surgical technique. The British Orthopaedic Association, in collaboration with the British Society for Children's Orthopaedic Surgery, has published standards for the management of these injuries (British Orthopaedic Association Standards for Trauma, 2014). However, a multicentre study has shown poor compliance with BOAST 11 across the UK, highlighting the urgent need for further education (Goodall et al, 2018). This review provides a practical guide for those managing paediatric trauma to ensure that supracondylar fractures are managed according to accepted best practice.

## Epidemiology

Supracondylar fractures of the humerus are most commonly seen in children under the age of 10 years, with a peak incidence between the ages of 5–7 years. The injury usually occurs on the non-dominant (left) side and is equally distributed across boys and girls (Omid et al, 2008). As with other paediatric trauma, the incidence tends to be higher in dry, warm weather conditions occurring in summer months (Ali and Willett, 2015; Sinikumpu et al, 2017).


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## Classification

The fractures are broadly divided in two types: extension type (98%), where the distal fragment is displaced posteriorly as the elbow hyperextends and the olecranon is forced into the olecranon fossa, and flexion type (2%), where the olecranon acts as a fulcrum pushing the distal fragment anteriorly (*Figure 1*). Extension-type injuries are typically caused by a fall on the outstretched hand causing hyper-extension of the elbow, whereas flexion-type

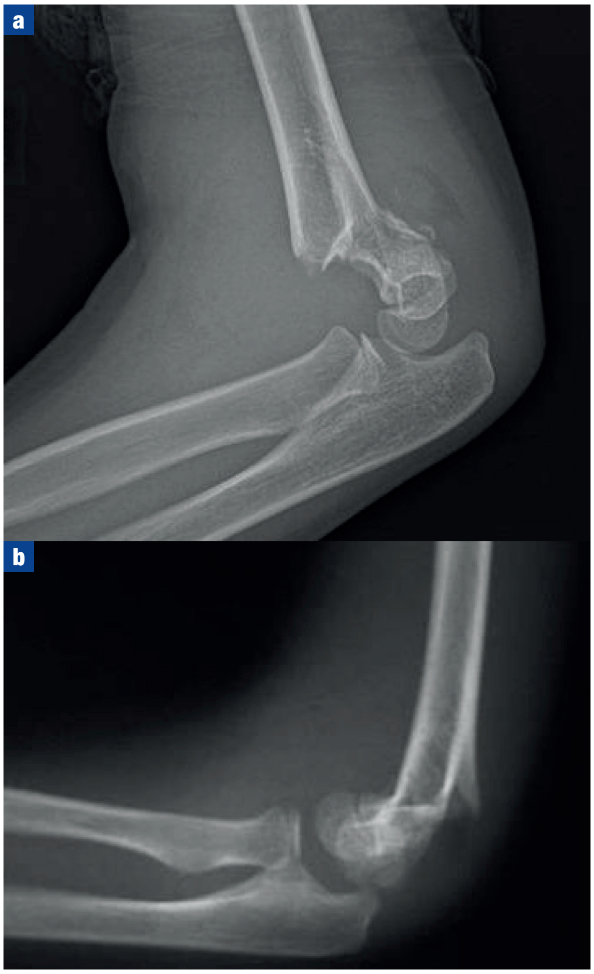


**Figure 1. a.** Lateral radiograph of the elbow in a extension-type supracondylar fracture. **b.** Lateral radiograph of the elbow in a flexion-type supracondylar fracture.

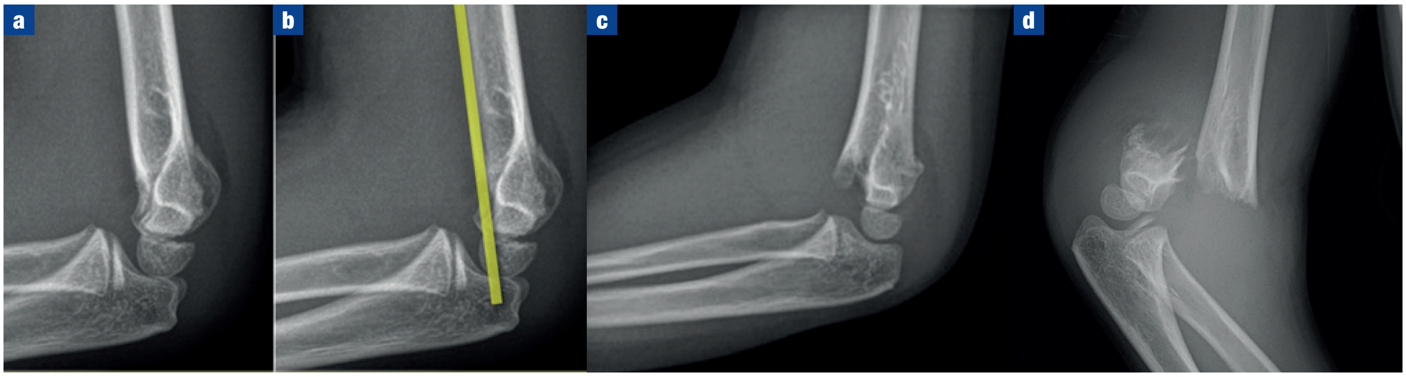


Figure 2. Lateral radiographs of the elbow demonstrating **(a)** a Gartland type I supracondylar fracture with **(b)** the disruption of the anterior humeral line (yellow), **(c)** a Gartland type IIB supracondylar fracture and **(d)** a Gartland type III supracondylar fracture with complete disruption of the anterior and posterior cortices.

injuries usually result from a fall directly onto the flexed elbow. The extension-type supracondylar fracture has been further classified by Gartland according to the amount of displacement. Type I injuries are non-displaced and may sometimes present with an apparently normal radiograph and elevation of the anterior and posterior fat pads. Type II injuries are displaced but with an intact posterior cortex and posterior periosteal hinge. These can be further subclassified into type IIA (no rotational deformity) and type IIB (rotational deformity present) injuries. Type III injuries are completely displaced, with discontinuity of the both the anterior and posterior cortices (*Figure 2*). Open injuries account for 1% of fractures and are more common in older boys (Holt et al, 2018).

## Clinical evaluation

This begins with a thorough history including the time and mechanism of injury, medical comorbidities and allergies. As with all paediatric trauma, it is vital to be alert for features in the history that raise suspicion of non-accidental injury, including a delay in seeking medical attention, inconsistent accounts of the mechanism and abnormal behaviour of the child or parent or guardian(s). It is also important to ask when the child last ate and drank to aid with anaesthetic planning. The most common presentation of this injury is a painful elbow following a fall, with the child refusing to move the arm and having associated swelling and deformity. More severe injuries may also show an 'S-shape' deformity of the elbow, with skin puckering or lateral bruising around the elbow suggesting that the proximal fragment has pierced the brachialis muscle. This is important to note as it may make reduction of the fracture more challenging.

Around 12–20% of displaced injuries have a neurovascular deficit, with the anterior interosseous nerve most frequently affected followed by the radial nerve and the ulna nerve. The latter is typically seen in flexion-type injuries (Colton and Monsell, 2016). The sensory and motor function of each nerve (i.e. ulna, radial, median and anterior interosseous) should be documented individually. The vascular aspect of the examination should include documentation of the capillary refill time and the presence or absence of a palpable radial pulse. In addition to this standard neurovascular assessment, Colton and Monsell (2016) suggest that the most sensitive test for emerging ischaemia is pain on passive digital flexion or extension. The authors suggest that an assessment proforma is introduced to ensure accurate and thorough documentation of the neurovascular status on presentation. This should be performed by an orthopaedic doctor before application of a plaster-of-Paris backslab.

## Imaging

Anteroposterior and lateral radiographs of the distal humerus should be obtained to confirm the diagnosis, exclude differentials such as lateral condyle fractures (where an oblique view can be most informative), allow classification and guide management. These images can sometimes be difficult to obtain in children with significant pain. Elevation of the anterior fat pad and a visible posterior fat pad are commonly seen with supracondylar fractures. Posterior displacement of the distal fragment, as occurs in extension-type injuries, leads to the capitellum being positioned posterior to the anterior humeral line (*Figure 2a*). Baumann's angle (the angle between the longitudinal axis of the humeral shaft and a line along the lateral humeral physis) should also be measured and where possible compared to the contralateral side (*Figure 3*). The normal angle is 70–75°, and an increase of 5–10° indicates significant coronal plane deformity. Baumann's angle is useful when considering non-operative management of this injury as well as assessing reduction of the fracture. It should be noted that Baumann's angle is sometimes defined as being the reciprocal of that described above (i.e. the angle between a line perpendicular to the long axis of the humerus and the lateral condylar physis) (Acton and McNally, 2001). If the nature of the fracture is unclear, an intraoperative arthrogram may be a useful adjunct to delineate the fracture pattern.

## Management

The choice of treatment modality (operative or non-operative) must consider the patient, the severity of

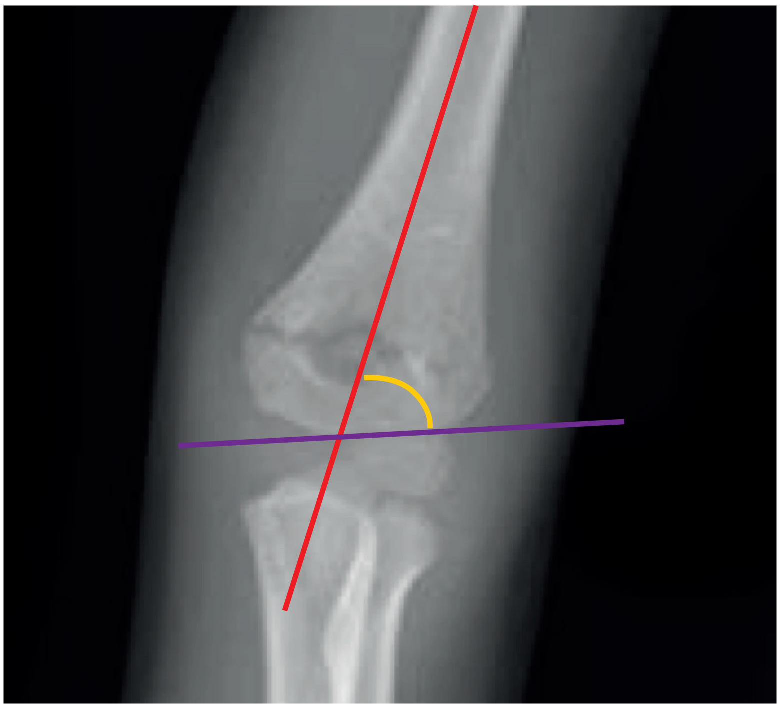

Figure 3. Anterior-posterior radiograph of a supracondylar fracture demonstrating Baumann's angle. This is the angle between a parallel line to the longitudinal axis of the humeral shaft (red) and a line drawn along the lateral epicondyle (purple). A normal angle = 70–75°.

injury sustained, any immediate complications (such as neurovascular compromise) and the likely outcomes of each treatment choice. In broad terms, treatment can be loosely based upon the Gartland classification. Gartland type I injuries require protection in an above-elbow cast or sling flexed to 90°. Gartland type IIA fractures may require manipulation under anaesthesia if there is significant posterior displacement or evidence of medial comminution, as the latter can predispose to varus deformity. Almost all Gartland type IIB (and all Gartland type III) injuries require closed reduction and percutaneous pinning (or, rarely, open reduction) to hold the fracture in a reduced position. If there is any concern regarding vascular compromise, BOAST 11 (British Orthopaedic Association Standards for Trauma, 2014) states the case must be discussed with the on-call vascular team in the trauma network before operative reduction, to ensure that assistance is available intraoperatively should this be required.

### Timing of surgery

In previous years there has been significant controversy around the timing of surgery for this injury. This particularly relates to the case of the pink, pulseless hand. In this situation, some felt that the hand was sufficiently perfused and therefore safe to leave overnight, whereas others felt this should be treated emergently in the same manner as a white, pulseless hand (Blakey et al, 2009; Mangat et al, 2009; Robb, 2009). There is no strong evidence for or against either stance, but the BOAST 11 guidelines remove this element of doubt, stating that patients with any evidence of compromise to the circulation, including loss of the radial pulse, should be considered a surgical emergency (British Orthopaedic Association Standards for Trauma, 2014).

### Surgical management

Following a decision that surgical management is required, the first step is to undertake closed reduction of the fracture under image intensifier (X-ray) guidance. For extension-type injuries, this is usually achieved through an initial period of traction followed by flexion of the elbow with direct manual pressure over the distal fragment. Supination or pronation of the forearm is required if the fragment is displaced posterolaterally or posteromedially respectively. In addition to checking satisfactory reduction on a lateral radiograph, anteroposterior and oblique (medial and lateral column) views allow the surgeon to ensure satisfactory reduction in the coronal plane and correct any varus or valgus angulation that may be present. In the rare instances of failure of closed reduction, most likely as a result of interposition of soft tissues including periosteum, open reduction may be necessary. Satisfactory reduction is achieved when the anterior humeral line passes through the middle third of the capitellum on the lateral radiograph, Baumann's angle is restored on the anteroposterior radiograph and there is satisfactory alignment on both the medial and lateral column views.

Once satisfactory reduction has been achieved, for unstable injuries (usually all type III and some type II fractures) reduction can be held using bicortical 2.0 mm Kirschner wires (K-wires), as recommended by BOAST 11, that remain in place for 3–4 weeks until union has occurred (British Orthopaedic Association Standards for Trauma, 2014). A minimum of two wires is required to ensure rotational stability but controversy exists as to whether two or three lateral entry wires, or a combination of lateral and medial entry wires, is preferable (Dekker et al, 2016). Maximal stability requires that the wires do not cross at the fracture site as this may allow rotation. If two lateral wires are used then these should be divergent (*Figure 4*). Biomechanically, there is some evidence that crossed K-wires (*Figure 5*) have a greater ability to resist torsional stress, but the wire on the medial side must be introduced through an open incision to avoid iatrogenic injury to the ulna nerve which can occur in up to 8% of cases (e.g. Lyons et al, 1998). Injury can also occur secondary to thermal insult from the power tool in close proximity to the nerve.

### Follow up

All children with supracondylar fractures of the humerus should be followed up with check radiographs at 4–10 days postoperatively to ensure maintenance of fracture reduction. The K-wires are usually removed in clinic at 3–4 weeks. Should any complications occur then longer follow up may be needed, but routine long-term follow up is not required. A summary of the BOAST 11 guidelines is provided in *Table 1*.

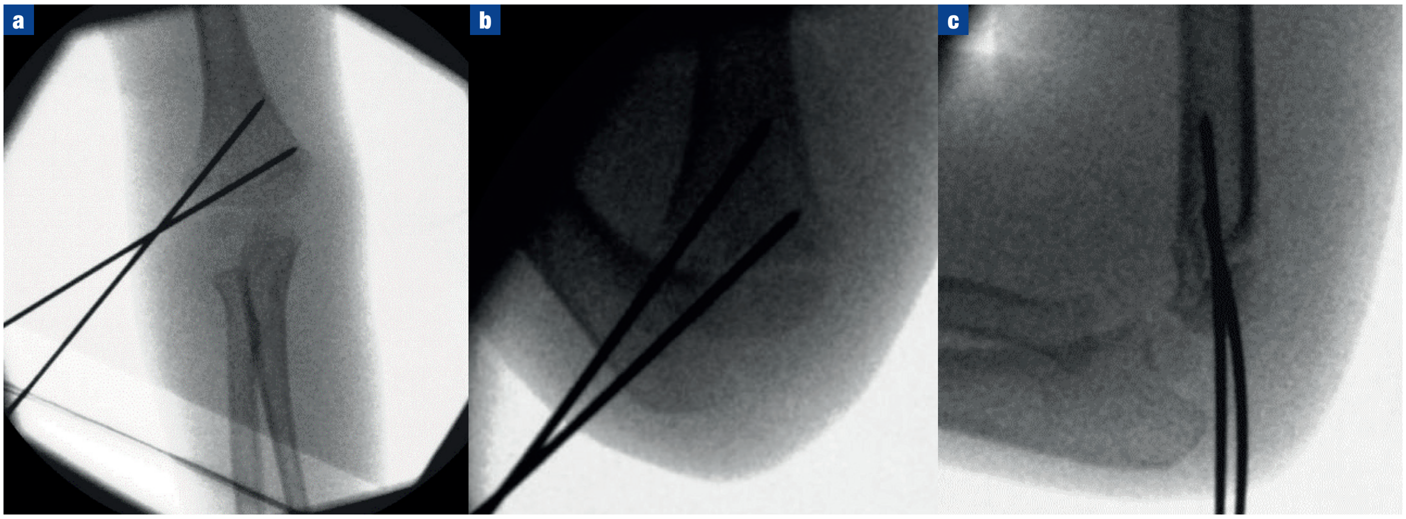


Figure 4. **a.** Anterior-posterior, **(b)** external oblique view highlighting the medial column and **(c)** lateral fluoroscopic images of the lateral wire fixation technique.

## Complications

Neurapraxia related to the initial injury usually resolves with time as the affected nerves are stretched or contused, rather than being transected by the bony fragments. Iatrogenic injury may also occur, particularly to the ulna nerve on insertion of medial K-wires. In the case of a positive Tinel's sign, neuropathic pain or a complete nerve palsy, a specialist opinion should be sought for consideration of exploration of the nerve(s) (Kwok et al, 2016). With regards to vascular injury, perfusion of the hand should be determined in theatre after manipulation and fixation, and if there is deterioration following these interventions then the position of the arm, for example the degree of flexion or pronation, may need to be adjusted. A vascular surgical opinion should be sought if the pulse does not return.

Inadequate reduction, or loss of reduction and subsequent malunion, may lead to cubitus varus ('gunstock' deformity) or cubitus valgus with delayed (tardy) ulna nerve palsy as the ulna nerve is stretched as it passes behind the medial epicondyle. Rarely, growth arrest may occur.

A rare but devastating complication of supracondylar fractures is compartment syndrome resulting in Volkmann's ischaemic contracture and permanent functional deficit (Diesellhorst et al, 2014). This most commonly occurs following hyperflexion of the elbow during cast immobilisation (Battaglia et al, 2002). Compartment syndrome occurs in 0.2–0.3% of supracondylar humeral fractures and is more common in those with floating elbow fractures, associated neurovascular injury and in older, male patients (Robertson et al, 2018). Other complications include pin migration, infection and postoperative stiffness.

## Conclusions

This article offers a practical guide to the management of supracondylar fractures of the humerus in children, from presentation to definitive treatment. It is based on current evidence and the BOAST 11 statement (British Orthopaedic Association Standards for Trauma, 2014). **BJHM**



*Conflict of interest: none.*


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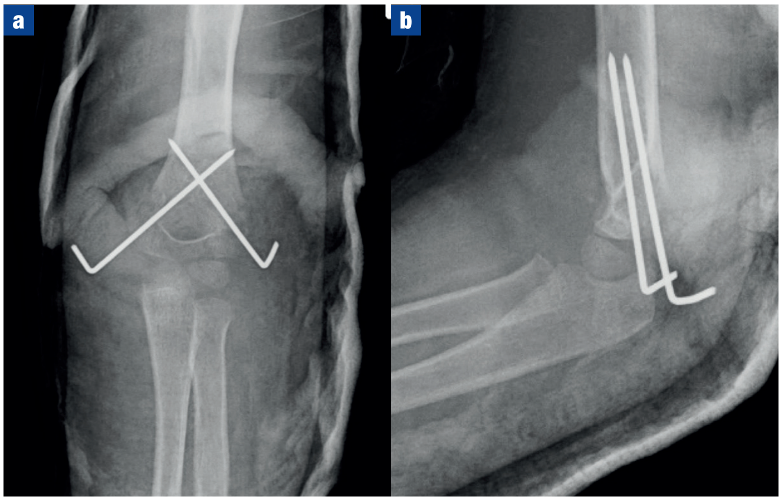


Figure 5. **a.** Anterior-posterior and **(b)** lateral radiographs of the crossed wire fixation technique.

## KEY POINTS

- Supracondylar fractures can lead to significant short- and long-term complications.
- The British Orthopaedic Association Standards for Trauma provide clear and comprehensive guidance for managing the supracondylar fracture.
- A pulseless hand should be considered a surgical emergency regardless of perceived perfusion (e.g. colour, capillary refill time).
- These fractures should be assessed using a standardized proforma to ensure accurate documentation of clinical findings.

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| Table 1. BOAST 11 Standards for the management of supracondylar fractures of the humerus in children |
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| A documented assessment of the limb, performed on presentation, must include the status of radial pulse, digital capillary refill time and the individual function of the radial, median (including anterior interosseous) and ulnar nerves. Both sensory and motor modalities for each nerve should be noted |
| These injuries require early surgical treatment, ideally on the day of admission. However, night-time operating is not necessary unless there are indications for urgent surgery (such as absent radial pulse, clinical signs of impaired perfusion of the hand and digits, or evidence of threatened skin viability) |
| Surgical stabilization should be with bicortical wire fixation. Crossed wires are associated with a lower risk of loss of fracture reduction, whereas divergent lateral wires reduce the risk of injury to the ulnar nerve |
| If a medial wire is used, techniques to avoid ulnar nerve injury should be used and recorded on the operation note |
| 2 mm diameter wires should be used, where possible, to achieve stability |
| Cubitus varus should be avoided by achieving a carrying angle (or Baumann angle) similar to the contralateral arm |
| The majority of nerve injuries associated with supracondylar fractures or their surgical management are transient neurapraxias and can be managed expectantly. If there is concern over iatrogenic injury then a thorough assessment with consultant input is required for consideration of nerve exploration |
| The majority of vascular impairments associated with supracondylar fractures resolve with fracture reduction. A perfused limb does not require brachial artery exploration whether or not the radial pulse is present |
| In case of children presenting with an ischaemic limb, the case should be discussed with the on-call vascular team in the network before operative reduction |
| If the limb remains ischaemic after open or closed fracture reduction then exploration of the brachial artery is required with a surgeon competent to perform a small vessel vascular repair |
| Documented postoperative monitoring of neurovascular status should occur until the treating surgeon is confident there is no risk of vascular compromise or compartment syndrome |
| Suspicion of compartment syndrome or deterioration of perfusion should prompt immediate vascular reassessment and intervention if required |
| Postoperative radiographs should be obtained between 4 and 10 days to ensure maintenance of reduction |
| Wire removal and mobilization is typically recommended at 3–4 weeks |
| Routine long-term follow up is not usually required |
| *From British Orthopaedic Association Standards for Trauma (2014)* |