REVIEW

THE MANAGEMENT OF ELBOW FRACTURES IN CHILDREN

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ABSTRACT

Pediatric elbow fractures can be challenging to manage. Compression of the medial column in Gartland Type I and Type II supracondylar fractures must be reduced to prevent varus deformity. Gartland Type III fractures may be stabilized with two lateral pins or a medial lateral cross-pin technique. Non-displaced lateral condyle fractures require vigilant follow-up. Open reduction of displaced lateral condyle fractures should avoid posterior dissection. T-condylar fractures in children rarely have the articular comminution found in adults. Monteggia fractures in children can be managed well if recognized and treated promptly. Restoration of the ulnar length often reduces the radial head. Angulated proximal radius fractures need to be reduced in order to restore the ability to supinate and pronate. It is important to recognize and understand the diagnostic features of each type of fracture in order to determine the best course of treatment.

INTRODUCTION

Pediatric elbow fractures are different from many other pediatric injuries. They are associated with a relatively high rate of complications, and the results of nonoperative management are not always good. The child’s elbow is well vascularized, and therefore fracture healing takes place very quickly. Such a narrow window of opportunity makes it imperative that the fracture be properly managed very quickly. This paper reviews some elbow fractures in children that are particularly challenging to manage.

Supracondylar Humerus Fracture

Supracondylar humerus fractures are the most common elbow fractures in children, accounting for 60-80% of pediatric elbow fractures. These injuries are associated with a high rate of complications and can be challenging to manage. These fractures have been classified according to both the direction and the degree of displacement. Extension-type supracondylar humerus fractures are overwhelmingly more common than flexion-type fractures (98% vs. 2%). While postero-medial fractures are more frequently encountered than posterolateral fractures (75% vs. 25%). However, posterolateral fractures are more often associated with neurovascular injury.

Gartland described three stages of supracondylar fractures of the humerus in children, based on the degree of displacement: Type I, undisplaced; Type II, minimally displaced; and Type III, completely displaced. This three-stage classification with modifications is the one used most commonly in recent pediatric fracture texts.

The diagnosis of an undisplaced supracondylar fracture (Gartland Type I) is made on the basis of the history of a fall in addition to local tenderness. Radiographic evaluation is not usually helpful. Type I fractures often require no more than simple immobilization for comfort and further protection. A simple long-arm cast with the elbow at 90° of flexion and the forearm in neutral is usually preferred. By three weeks after injury, the pain and swelling have usually subsided significantly and allow a protected active range of motion.

Gartland Type II fractures (displaced with intact posterior cortex) require closed reduction and percutaneous fixation if a long-arm cast does not adequately hold the reduction. Immobilization in a long-arm cast can be discontinued after three weeks.

In Gartland Type III fractures (totally displaced with no cortical contact), the posterior cortex is broken, resulting in proximal migration of the distal fragment because of muscle activity...
Displacement necessitates the reestablishment of length and increases the chance of interposed soft tissue. Displaced fractures are the result of more severe injuries that produce greater soft-tissue swelling, which in turn makes the reduction and its maintenance more difficult. Gartland Type III fractures are managed by closed reduction with percutaneous fixation followed by three weeks of immobilization in a long-arm cast. The exact method of maintaining the reduction has evolved over time. Medial and lateral cross-pin technique was the gold standard, but it places the ulnar nerve at risk. (Fig. 1C-D) Thus, some surgeons advocate a mini-open pin placement technique to avoid nerve injury. A direct injury to the ulnar nerve usually results in only neuropraxia, and children ultimately experience full recovery of the ulnar nerve function. Recent studies have confirmed that two well-placed lateral pins provide sufficient fixation in the vast majority of cases. Should a third pin be necessary to achieve adequate stability, a medial pin can be placed through a mini-open approach. The key to maintaining adequate stability with two lateral pins is to assure that both pins have good fixation of the distal fragment and engage the medial cortex.

An open reduction of a displaced supracondylar humerus fracture may be necessary on rare occasions. An anteromedial “hockey stick” incision provides a good exposure, and fixation is done percutaneously in the usual fashion. It is important to inform the patient and the family that an open reduction may be necessary for any supracondylar humerus fracture, and, should it be performed, may lead to some residual elbow stiffness not found in children treated by closed reduction.
Supracondylar humerus fractures can be associated with a vascular injury (5-12%) 2, particularly with posterolateral displacement of the distal fragment, which would displace the neurovascular bundle over the medial metaphyseal spike. Management of a suspected vascular injury can be challenging. A pulseless but pink hand can be observed. Patients in this group who underwent vascular intervention developed re-occlusion of the brachial artery without any sequelae, suggesting that careful observation and vascular intervention had equivalent outcomes 3. The presence of a pulseless and white hand after reduction and pinning is a clear indication for open exploration. The anteromedial approach provides good exposure for the vascular repair and an open reduction.

Nerve injuries occur in 5-19% of elbow fractures and are almost always neuropraxias. These may take three-four months to resolve 2. The anterior interosseous branch of the median nerve is the most commonly involved nerve. A thorough neurological examination should be performed and documented for all elbow fractures pre- and postoperatively.

Malunion is largely due to rotation and will result in the classic cubitus varus deformity. Inadequate correction of medial collapse can also lead to this deformity.

**Lateral Condyle Fractures**

Fractures of the lateral condyle represent 15-17% of pediatric elbow fractures 4. The orthopaedic surgeon must be aware of the fracture patterns, relevant anatomy including blood supply, risk of nonunion, and the importance of postoperative follow-up in order to assess potential deformity and neurologic sequelae. The lateral condyle functions as the origin of the extensor muscle mass as well as the lateral collateral ligament complex. Most fractures occur in patients with a peak age of 5-7 years. The most common mechanism of injury occurs when a varus force is applied to the elbow, causing the extensor muscles and lateral collateral ligaments to avulse the lateral condyle. Appropriate management requires an understanding of the mechanism of injury, as well as an awareness of operative indications and treatment methods to avoid complications.

The diagnosis of a lateral condyle fracture can be challenging because the fracture fragment is often rotated. Therefore, obtaining an oblique view of the elbow, in addition to the standard anteroposterior and lateral, can be very helpful. The most classical description of the fracture type has been described by Milch 1. The Milch Type I fracture travels from the metaphysis of the distal humerus through the distal lateral epiphysis and through the trochleocapitellar groove. The Milch Type II fracture travels from the distal lateral humeral metaphysis above the epiphysis and exits through the trochlea. Because the Milch Type II transverses through the lateral aspect of the trochlea, instability may ensue with posterolateral radius and ulna subluxation.

Non-displaced and minimally displaced fractures of less than 2 mm may be immobilized in a long-arm cast. In the first three weeks, good-quality plain radiographs of the elbow (best taken with the cast off) are obtained to make sure that the reduction has been maintained. Techniques have also been described for minimally displaced fractures with closed reduction and percutaneous pin fixation (with two divergent pins) in order to maintain the alignment 7. Fractures displaced more than 2 mm and with evidence of rotation are treated with open reduction and internal fixation followed by six weeks of immobilization. The exposure interval is between the brachioradialis and triceps. Posterior dissection is avoided to preserve the vascular supply. The fracture fragment is frequently much larger than it appears on plain radiographs, because it has a large cartilaginous portion.

A fully reduced fracture significantly diminishes risks of nonunion. Nonunion is more frequent in unstable fractures with significant displacement. Proximal migration of the fracture fragment may lead to valgus deformity with potential ensuing tardy ulnar nerve palsy. Nonunion with displacement most commonly leads to progressive cubitus valgus deformity, which may be addressed with an osteotomy and correction of any translation of the radius and ulna.

**Medial Epicondyle Fractures**

Fractures of the medial epicondylar apophysis in children are, fortunately, one of the more benign pediatric elbow injuries. However, the surgeon must consider several important issues in order to formulate a sound management plan and avoid complications. Unlike many fractures of the elbow, fractures of the medial epicondylar apophysis do not involve the joint surface or growth cartilage. The medial epicondyte is a posteromedial structure that serves as the origin of the flexor-pronator muscle mass as well as the medial collateral ligamentous complex. About 80% of medial epicondyle fractures occur in boys with a peak age in early adolescence. The
mechanism of injury is typically an acute valgus stress to the elbow, although chronic injuries can occur in growing athletes. Successful management of these injuries requires a heightened awareness of the commonly associated injuries (i.e., elbow dislocation and ulnar neuropraxia), an understanding of the operative indications, risks and benefits as supported in the literature, and the avoidance of complications such as stiffness or persistent stability.

Evaluation of a patient with a fracture of the medial epicondylar apophysis requires a careful history, physical examination and review of the radiographs to determine the full extent of the injury. In particular, radiographs should be studied for evidence of an incarcerated medial epicondyle fragment within the joint. Although incarcerated fragments can occasionally be removed with manipulation, surgical treatment is often necessary. There is approximately 50% incidence of associated elbow dislocations with medial epicondyle fractures. If the history or radiographs suggest that the elbow was or is dislocated, greater soft tissue injury is likely to be present, requiring increased need for early motion. The physical examination should also include a careful neurologic examination, particularly of the ulnar nerve and median nerve. Any change in the sensory or motor examination of the ulnar nerve should be noted in the initial evaluation. If ulnar nerve function is completely disrupted, operative exploration is indicated.

Non-displaced fractures should be treated with one-two weeks of cast or splint protection, followed by patient-directed active range of motion program. Results are usually excellent with this treatment program. If the minimally displaced fracture was associated with an elbow dislocation, earlier motion may be warranted. In general, re-dislocation is less of a risk than elbow stiffness.

There is an ongoing debate regarding the operative management of displaced medial epicondyle fractures. Although literature support for non-operative management continues to exist, it is generally the practice in most centers to treat medial epicondyle fractures displaced more than 5 mm with internal fixation and an early motion protocol.

Operative management of medial epicondyle fractures includes two fixation and two positioning strategies. As a general rule, children younger than 10 years old with small medial epicondylar fragments can be satisfactorily treated with open anatomic reduction and pin fixation. The pins can be removed at about three weeks. Early motion can be allowed even before the pins are pulled. In older children with larger fracture fragments, fixation with a single partially threaded cannulated screw allows optimal stability and motion within the first week.

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T-Condylar fractures
The T-condylar fracture of the distal humerus is a very rare fracture of the elbow region in the pediatric patient, accounting for less than 1% of elbow fractures. As such, there is very little data in the literature on the most reliable way to achieve the best outcome. This injury typically occurs in the adolescent near skeletal maturity, usually from a direct blow to a flexed elbow. The fracture line originates from the apex of the trochlea and extends proximally. Successful management of this fracture requires understanding the intra-articular aspect of the fracture and planning treatment based on the skeletal maturity of the patient. This fracture usually requires surgical management to restore anatomic articular congruence. However, the joint line often does not need to be directly visualized because, unlike adult fractures, articular comminution is rare.
The T-condylar fractures can sometimes be confused with other fractures, most commonly extension-type supracondylar fractures. Therefore, good-quality plain radiographs are key to the proper diagnosis and treatment. The key to differentiation from the other fractures is the presence of vertical fracture line extending down to the apex of the trochlea.

Recent papers support the use of open reduction and internal fixation as the best way to restore anatomic articular congruence and to provide enough fracture stability to start range of motion exercises as early as two-four weeks after the operation. The first goal is to achieve anatomic alignment of the articular surface. The reduction is held by a transverse screw through the center of the axis of rotation. This part of the procedure converts the fracture into a supracondylar fracture. The next surgical goal is stabilization of the supracondylar columns. In older patients near skeletal maturity, reconstruction plates with screw fixation placed at 90º to each other are recommended. This provides a construct that is stable for early range of motion exercises and addresses the fact that this is essentially an adult-type fracture.

**Monteggia Fractures**

Monteggia fractures in children are easily manageable if recognized and treated soon after injury. Only about 1% of all forearm fractures in children are classified as Monteggia fractures. Three out of four of such cases occur in boys. These fractures are characterized by dislocation of the radial head accompanied by an associated ulnar fracture, most often located in the proximal third of the bone. These injuries are typically sustained after a fall onto an outstretched hand resulting in hyperextension or hyperpronation of the elbow. Patients with Monteggia fractures present with elbow or forearm pain accompanied by tenderness localized over the radial head. The most reliable method to recognize a Monteggia fracture is to determine whether the axis of the radius bisects the capitellum on every view. The Bado classification of Monteggia fractures corresponds with the mechanism of injury and is useful in determining the optimal treatment for such injuries. Type I fractures are characterized by anterior radial head dislocation, whereas Type II fractures, which are rare in children, have posterior dislocations. Type III fractures are characterized by lateral radial head dislocation. Lateral Monteggia injuries are usually associated with a buckle-type or green-stick fracture of the ulna and may fail to be recognized. A Bado Type IV injury is characterized by a radial fracture in conjunction with a radial head dislocation and an ulnar fracture. The nature of the ulnar injury dictates the management of the injury.

Approximately 8-17% of Monteggia fractures have associated neurologic deficits, usually a neurapraxia, involving most commonly the posterior interosseous branch of the radial nerve. Recovery of nerve function takes several days to two months after injury.

The goal of treatment is to correct the ulnar deformity while restoring ulnar length and realigning the radiocapitellar joint. Reduction of the ulnar fracture often reduces the radial head. If initial closed reduction fails (or for an unstable fracture), the surgeon should proceed to fluoroscopically aided operative reduction, possibly with internal fixation. It is essential to confirm maintenance of reduction. Minimal internal fixation of the ulna with an intramedullary Kirschner-wire may allow reduction of the radial head. This method is preferred over plate fixation.

Complications arise when there is a delay in diagnosis of a Monteggia fracture or in case of a re-fracture. If the time between injury and diagnosis is prolonged, the patient may experience limited elbow range of motion, arthrosis, or additional nerve complications. These patients may also present with a partially or fully healed ulnar fracture with a radial head dislocation. In the treatment of late Monteggia fracture, achieving proper ulnar length and angulation is difficult, and usually, an ulnar osteotomy followed by open reduction of the radial head and reconstruction of the annular ligament is required.

**Proximal Radius Fracture**

Proximal radius fractures in children, unlike those in adults, generally involve the metaphysis or the physis, and not the radial head. These injuries occur most commonly between ages 8 and 12, and result from a fall onto an outstretched hand with a valgus moment directed through the radius. One should be aware of a Monteggia fracture (or “Monteggia equivalents”) when recognizing the proximal radius injury. The length and alignment of the ulna should be compared to the other side, when in doubt.

The goal of the treatment is to restore the ability to supinate and pronate, usually 60º in either direction. Displacement of the fracture fragment
results in a cam effect at the proximal radioulnar joint, thereby interfering with normal motion.

Patients with nondisplaced or minimally displaced fractures with less than 30º of angulation do not need to undergo reduction and can be treated in a long-arm splint and with a range of motion exercises 10-14 days after injury (Fig. 3). Fractures with angulation from 30º up to 45º should be treated with closed reduction. If closed manipulation is unsuccessful in restoring 60º of pronation and supination, a percutaneous reduction can be performed with a Steinman pin or a Kirshner-wire under fluoroscopic control. If all above methods fail, open reduction can be performed through the Kocher approach using the interval between the anconeus and the extensor carpi ulnaris. Once reduced, these fractures are usually stable and do not require internal fixation. After any sort of reduction, the elbow should be immobilized in a posterior splint for two-three weeks and then be started on a range of motion program.

Fig. 3. Anteroposterior plain radiograph of the elbow and proxima forearm shows a non-displaced, incomplete fracture of the proxima radius (arrow). Also note a fracture line in the proximal ulna. This patient had conservative treatment.

REFERENCES


