Pediatric Orthopedic Trauma
An Evidence-Based Approach

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KEYWORDS

• Supracondylar humerus fracture • Medial epicondyle fracture • Femoral shaft fracture
• Clavicle fracture • Evidence-based medicine • Open fracture

KEY POINTS

- Displaced supracondylar humerus fractures should be managed with closed reduction and pin fixation. Pin placement, size, and surgical timing should be selected based on fracture and patient characteristics.
- Femoral shaft fracture management can be guided by patient age, size, and fracture type. Guidelines are available, but have not yet demonstrated that they streamline how patients receive care.
- Grade 1 open fractures can potentially be treated with local wound debridement, antibiotics, and closed reduction, but this method needs to be proven in randomized studies.
- Although there is strong evidence to suggest that anatomic reduction of specific clavicle fractures in adults improves outcomes, this has not been proven in pediatric patients.

INTRODUCTION

Historically, many pediatric injuries were managed nonsurgically. However, with changes in implant selection and outcomes, studies of operative versus nonoperative treatment, orthopedists have moved toward surgical intervention for certain fractures. To streamline surgical decision making and patient care, the American Academy of Orthopaedic Surgeons (AAOS) has developed clinical guidelines for the management of pediatric diaphyseal femur fractures[1,2] and supracondylar humerus fractures.[3] Although helpful, the guidelines are limited by the lack of high-level evidence relating to certain aspects of these injures. Also, there are currently no other guidelines available for other types of pediatric fractures. The growing body of literature regarding grade 1 open fractures, medial epicondyle fractures, and clavicle fractures has made management of these injuries three of the most controversial topics in pediatric orthopedics today. This article analyzes the available evidence to help guide the management of each of these injury patterns and highlights areas where additional research is needed.

SUPRACONDYLAR HUMERUS FRACTURES

Supracondylar humerus fractures are the most common fractures involving the elbow in pediatric patients.[4] Given the frequency of these injuries, it is important for both pediatric and general orthopedic surgeons to understand the treatment recommendations for different types of supracondylar humerus fractures.

Nonoperative treatment with either splint or cast immobilization is recommended for Gartland type 1 (nondisplaced) supracondylar

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humerus fractures.[3] Studies comparing methods of immobilization have shown that the use of a posterior splint leads to decreased duration of pain, decreased analgesic use, and faster return to normal activity than collar and cuff immobilization.[5,6]

Treatment for type 2 supracondylar humerus fractures is difficult to discern from the current literature. According to the AAOS guidelines, closed reduction and pin fixation is recommended.[3] However, none the studies used to make these recommendations specifically analyzed Gartland type 2 supracondylar humerus fractures in isolation. Five focused only on type 3 supracondylar fractures[7–11] and the remaining included patients with both type 2 and type 3 fractures.[12–17] Moraleda and colleagues[18] specifically analyzed outcomes of patients who sustained type 2 fractures who were treated without attempted reduction or surgery. Compared with the nonoperative side, the total arc of elbow motion was unchanged, but the affected elbows had significantly more extension and significantly less flexion (8° and 7°, respectively).[18] According to the Flynn criteria, results were deemed satisfactory in 80% of patients.[18] This finding would suggest that not all type 2 supracondylar humerus fractures require operative treatment to ensure a satisfactory outcome. However, the increased risk of cubits varus and the altered arc of elbow motion that is seen with unreduced type 2 supracondylar fractures should be discussed with patients and families when considering nonoperative treatment without reduction for these injuries.[18]

The AAOS recommends that type 3 supracondylar humerus fractures be treated with closed reduction and pin fixation.[3] This method is supported by a wide range of studies that examine type 3 supracondylar humerus fractures alone as well as in combination with other types of fractures.[7–17] However, the urgency of closed reduction and pin fixation of type 3 fractures in patients who are neurovascularly intact upon presentation is not well-defined. There are studies that suggest that delayed operative intervention in this setting can increase the need for open reduction and potentially increase the risk of compartment syndrome.[19–21] However, multiple studies have reported no correlation between surgical timing and the need for open reduction or perioperative complications.[22–26] Therefore, surgical timing is left to the discretion of the surgeon. Important considerations include the patient's degree of swelling, status of the soft tissues, the time interval between injury and patient presentation, and access to an operating room in the morning should treatment be deferred. It is also important to consider that patients left unreduced can have continued swelling, which can cause the neurovascular status to change over time. Ho and colleagues[27] found that 8% of patients who presented to a level 1 pediatric hospital with a neurovascular injury in the setting of a supracondylar humerus fracture had evidence of progressive decline in their neurovascular status between the initial evaluation in the emergency department and the evaluation in the preoperative holding area.

Pin construct for supracondylar fractures has been a point of interest in the literature. Multiple studies support the use of crossed pins for biomechanical strength, especially against torsional stress.[16,28–33] However, 3 well-placed lateral entry pins that have bicortical purchase and adequate spread across the fracture site have been shown to be biomechanically equivalent to 2 crossed pins.[34,35] Increasing the pin size from 1.6 to 2.0 mm also increases construct strength for lateral entry pins.[36–38] An advantage of all lateral entry pins is that they minimize the risk of iatrogenic ulnar nerve injury.[39] The decreased incidence of iatrogenic nerve injury reported in the literature is one reason why the AAOS recommends that all lateral entry pins be placed when possible for supracondylar fractures.[3] However, the actual incidence of ulnar nerve injury in the setting of medial pin placement is highly variable in the literature and fractures with medial comminution are more stable and have less chance of loss of reduction when a medial pin is placed.[34,40] Making an incision has not been shown to be protective against iatrogenic nerve injury during pin placement, but elbow extension during pin placement is protective.[39] When possible, all lateral entry pins are the preferred method of fixation. However, because medial pins are sometimes essential to maintain fracture reduction, we support using a medial pin when it is necessary. In this setting, we recommend placing 1 or 2 lateral pins first with the elbow flexed to obtain control of the fracture, followed by elbow extension for medial pin placement to minimize the risk of nerve injury.

Patients who present with a cool pulseless extremity in the setting of a supracondylar fracture should ideally undergo emergent closed reduction to try to restore perfusion to the extremity.[3] Preoperative angiography is not recommended in this scenario, because it has only been shown to delay time to surgery with no appreciable patient benefit.[41–43] Fracture reduction has been