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Lateral Entry Compared with Medial and Lateral Entry Pin Fixation for Completely Displaced Supracondylar Humeral Fractures in Children

Surgical Technique

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ABSTRACT FROM THE ORIGINAL ARTICLE

BACKGROUND: Closed reduction and percutaneous pin fixation is the treatment of choice for completely displaced (type-III) extension supracondylar fractures of the humerus in children, although controversy persists regarding the optimal pin-fixation technique. The purpose of this study was to compare the efficacy of lateral entry pin fixation with that of medial and lateral entry pin fixation for the operative treatment of completely displaced extension supracondylar fractures of the humerus in children.

METHODS: This prospective, randomized clinical trial had sufficient power to detect a 10% difference in the rate of loss of reduction between the two groups. The techniques of lateral entry and medial and lateral entry pin fixation were standardized in terms of the pin location, the pin size, the incision and position of the elbow used for medial pin placement, and the postoperative course. The primary study end points were a major loss of reduction and iatrogenic ulnar nerve injury. Secondary study end points included radiographic measurements, clinical alignment, Flynn grade, elbow range of motion, function, and complications.

RESULTS: The lateral entry group (twenty-eight patients) and the medial and lateral entry group (twenty-four patients) were similar in terms of mean age, sex distribution, and preoperative displacement, comminution, and associated neurovascular status. No patient in either group had a major loss of reduction. There was no significant difference between the rates of mild loss of reduction, which occurred in six of the twenty-eight patients treated with lateral entry and one of the twenty-four treated with medial and lateral entry (p = 0.107). There were no cases of iatrogenic ulnar nerve injury in either group. There were also no significant differences (p > 0.05) between groups with respect to the Baumann angle, change in the Baumann angle, humerocapitellar angle, change in the humerocapitellar angle, Flynn grade, carrying angle, elbow flexion, elbow extension, total elbow range of motion, return to function, or complications.

CONCLUSIONS: With use of the specific techniques employed in this study, both lateral entry pin fixation and medial and lateral entry pin fixation are effective in the treatment of completely displaced (type-III) extension supracondylar fractures of the humerus in children.

LEVEL OF EVIDENCE: Therapeutic Level I. See Instructions to Authors for a complete description of levels of evidence.


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INTRODUCTION

Supracondylar fractures of the humerus are the most common elbow fractures in children. These fractures are classified according to Garland’s criteria as nondisplaced fractures (type I), hinged fractures with the posterior cortex intact (type II), and completely displaced fractures (type III). The standard treatment for type-III extension supracondylar fractures is with closed reduction and percutaneous pin fixation (Fig. 1).

The operative treatment of a displaced type-III supracondylar fracture in a well-perfused arm with no neurologic deficit is considered an urgent procedure. The patient should be taken to the operating room as quickly as possible, but a delay of eight to twenty-four hours does not increase the rate of complications or worsen the outcome.

OPERATIVE TECHNIQUE

After the induction of general anesthesia, the patient is placed in the supine position with the shoulder of the affected extremity at the edge of the table. The fluoroscopy unit is brought into position with its base at the foot of the table and the c-arm adjacent to the table so that the image collector serves as the operating-room table (Fig. 2, A). For patients weighing <20 kg, we often use a hand table in order to facilitate fluoroscopy of the limb during surgery since the size of the arm often does not allow the elbow to lie in the center of the fluoroscopic beam. The head is secured at the side of the operating-room table or hand table, and the field is draped in a sterile fashion (Fig. 2, B and C).

Closed reduction of the fracture is performed under the guidance of fluoroscopy. Gentle traction is applied to the forearm, and countertraction is applied to the proximal aspect of the humerus. An anteroposterior fluoroscopic image is obtained, and any varus or valgus malalignment is corrected. Rotation of the distal fragment is also corrected at this time, notably prior to flexing the elbow, which locks the distal fragment into position through the intact posterior periosteal hinge. The elbow is then hyperflexed to approximately 130° with anteriorly directed pressure being placed on the distal fragment over the olecranon with the surgeon’s thumb in order to reduce the fracture. The forearm is held in neutral or slight pronation, and fluoroscopy is used to assess the reduction. The Jones view, an anteroposterior radiograph of the humerus with the elbow flexed (Fig. 3), as well as internal and external oblique radiographs help to confirm the reduction. The lateral radiograph can be made by externally rotating the flexed arm at the shoulder. The anterior humeral line should pass through the middle third of the capitellum on the lateral radiograph (Fig. 4).

Once reduction has been accomplished, percutaneous pin fixation of the fracture can be carried out. Children who weigh ≤20 kg are treated with 0.062-in (1.6-mm) Kirschner wires, and those who weigh >20 kg are treated with 2.0-mm Steinmann pins. For the lateral entry technique, two pins are inserted from the lateral aspect of the elbow across the lateral cortex of the humerus, engaging the medial cortex. The pins can be inserted in a divergent or a parallel fashion. We consider fixation satisfactory only if one pin engages the lateral column of the distal fragment and the other pin engages the central column (olecranon fossa) of the distal fragment. The pins should not cross at the fracture site, and both pins should exit at the medial cortex. Pin entry should be confirmed on the anteroposterior image and, in some cases, the lateral image (Fig. 5).

For the medial and lateral entry technique, one pin is first inserted from the lateral entry site with the elbow hyperflexed. This pin must engage the lateral column in the distal fragment and penetrate the medial cortex. The elbow is then extended gently to slightly less than 90° of flexion to avoid injury to a subluxating ulnar nerve. It should be remembered that the prevalence of a sublux-
Anteroposterior (A) and lateral (B) radiographs after a type-III extension supracondylar fracture of the humerus.
FIG. 2

A: A typical operating-room setup with the image intensifier serving as the operative table. One should be able to center the elbow on the image collector. B: Use of an arm board to facilitate placement of the patient’s head. C: Final draping.
FIG. 3

A: Jones radiograph of the elbow. The elbow is held in maximum flexion with the x-ray beam directed at 90° to the shaft of the humerus. B: On the radiograph, note the superimposed proximal part of the radius and ulna.
A: After reduction of the fracture, confirmation of satisfactory position in the sagittal plane is mandatory. The anterior humeral line on the lateral radiograph should pass through the middle of the capitellum. 

B: Lateral radiograph.
ating ulnar nerve is 17.7% in children between birth and five years of age and 7.7% in children between six and ten years of age. A medial incision of 1.5 to 3.0 cm is made over the medial epicondyle. Blunt superficial dissection is performed down to the medial epicondyle to ensure that the ulnar nerve is not in the path of the pin; the nerve, however, does not have to be visualized. With the soft tissues retracted, the medial pin is then placed in the medial epicondyle and is driven across to engage the lateral cortex (Fig. 6). It is important that the pins not cross at the fracture site in order to avoid rotational instability of the distal fragment. The wound can then be closed around the pin.

The reduction and fracture stability are checked in both the anteroposterior and lateral planes with the image intensifier. If the fracture remains unstable, a third pin can be added from the lateral side. The Baumann angle and the carrying angle of the elbow should be the same as that of the contralateral side (Fig. 7). The pins are then cut, bent, and left protruding out-
A bivalved long-arm cast is applied with the elbow in approximately 70° to 90° of flexion and neutral rotation. Patients return in one week for postoperative radiographs to check the fracture reduction and pin fixation. The cast and pins are removed at the three to four-week appointment, and gentle range-of-motion exercises are begun. Patients should return for a clinical examination at six weeks and a final clinical and radiographic examination at three months.

FIG. 5C
Schematic drawing of the distal end of the humerus, identifying the lateral column, medial column, and central column.
FIG. 6

A: Dissection and anatomy of the medial side of the elbow. The absence of the ulnar nerve in the operative field should be verified. B: Placement of the lateral and medial entry pins.
The Baumann angle is formed by the line perpendicular to the humeral shaft and the line parallel to the lateral condyle.

**CRITICAL CONCEPTS**

**INDICATIONS:**
A displaced (type-II or type-III) supracondylar fracture of the humerus without neurovascular compromise.

**CONTRAINDICATIONS:**
- Open fracture. The proximal fragment often tents anteriorly through the brachialis muscle. This situation is best managed with irrigation, débridement, and open reduction and internal fixation of the fracture.
- Neurovascular compromise after reduction. In 90% of elbows in which vascular compromise is noted at the time of injury, closed reduction and stabilization of a displaced fracture restores vascular flow. If the hand is perfused prior to reduction and pulses are lost after manipulation, then open exploration is required.
- Severe swelling or an irreducible fracture. If swelling is severe or muscle or periosteum is interposed in the fracture site, closed reduction may not be possible and open reduction may be required.

*continued*
CRITICAL CONCEPTS (continued)

- Late diagnosis. If the fracture is greater than one week old, there is usually sufficient callus formation to make closed reduction extremely difficult. In these cases, we advocate open reduction.

PITFALLS:
- Pin placement. When two lateral pins are used, one pin must engage the lateral column and the other must engage the central column. Placement of these lateral pins too close to each other can result in poor fixation and loss of reduction.
- Ulnar nerve injury. Placement of the medial pin should be performed with the elbow in <90° of flexion. Direct visualization of the medial epicondyle ensures that the ulnar nerve is not within the operative field and that the pin is not placed within the ulnar nerve groove. Nerve injury does not necessarily result from direct penetration of the ulnar nerve, but it can also result from stretch over the medial pin, anterior fixation over the medial epicondyle, or tethering in the cubital tunnel. Blind percutaneous pinning of the medial side without an incision or without extending the elbow to <90° of flexion should be avoided.
- Unstable reduction. Stability of the reduction is assessed with dynamic fluoroscopy during a full range of motion. A third pin can be added from the lateral side as needed to enhance stability.
- Flexion supracondylar fracture of the humerus. The less common pattern of a flexion supracondylar fracture of the humerus should be recognized preoperatively. With this fracture pattern, there is a higher incidence of ulnar nerve injury with a subsequent need for ulnar nerve decompression as well as open management of the fracture. It is important to note that fracture reduction is performed in extension rather than in flexion.

AUTHOR UPDATE:
The techniques have not changed since the publication of this study. Given the equivalent nature of the two techniques, we prefer percutaneous pin fixation with two lateral entry pins placed in a divergent fashion. A third pin can be added for stability as needed.

REFERENCES