Supracondylar Humeral Fractures with Isolated Anterior Interosseous Nerve Injuries: Is Urgent Treatment Necessary?

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Background: It is unclear if pediatric patients with a supracondylar humeral fracture and isolated anterior interossous nerve injury require urgent treatment.

Methods: A retrospective, multicenter study of 4409 patients with operatively treated supracondylar humeral fractures was conducted. Exclusion criteria were additional nerve injuries other than the anterior interosseous nerve, any sensory changes, pulselessness, ipsilateral forearm fractures, open fractures, less than two months of follow-up, or pathological fractures.

Results: Thirty-five of 4409 patients met inclusion criteria. The average time to surgery was 14.6 hours (range, two to thirty-six hours). No patient developed compartment syndrome. There was no significant difference in time to return of anterior interosseous nerve function relative to the time to surgical reduction and fixation ($p = 0.668$). A complete return of anterior interosseous nerve function occurred in all patients with an average time of forty-nine days (range, two to 224 days). Ninety percent of patients recovered anterior interosseous nerve function by 149 days.

Conclusions: To our knowledge, this is the largest series to date of supracondylar humeral fractures with anterior interosseous nerve injuries. There is no evidence that a supracondylar humeral fracture with an isolated anterior interosseous nerve injury requires urgent treatment. A delay in treatment up to twenty-four hours was not associated with an increased time of nerve recovery or other complications. This series excluded patients with sensory nerve injuries, pulselessness, and ipsilateral forearm fractures, which all may require urgent surgery. Barring other clinical indications for urgent treatment of a supracondylar humeral fracture, an isolated anterior interosseous nerve injury (no sensory changes) may not by itself be an indication for urgent surgery. The anterior interosseous nerve injuries in this series showed complete recovery at a mean time of forty-nine days.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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Supracondylar humeral fracture is the most common elbow fracture in children[1]. The reported incidence of nerve injury in supracondylar humeral fractures varies widely from 6% to 16%[2-5] in most studies, but some studies have shown incidence as high as 42%[6]. Although the ulnar, radial, and median nerves are all at risk in supracondylar humeral fractures, isolated anterior interosseous nerve injury has been reported as the predominant nerve injury[3,7]. Typically in cases of anterior

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TABLE I The Time to Anterior Interosseous Nerve Recovery of Patients with and without Antecubital Fossa Ecchymosis*

	Patients without Antecubital Fossa Ecchymosis (N = 20)	Patients with Antecubital Fossa Ecchymosis (N = 15)
Average time to surgery *(hr)*	13.9	15.6
Average time to partial recovery *(d)*	36.5	32.4
Average time to complete recovery *(d)*	66.5	63.0

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interosseous nerve palsies associated with supracondylar humeral fracture, management consists of closed reduction and pinning of the fracture and observation of the nerve deficit. A number of studies have shown that the majority of cases resolved spontaneously over a period of six to ten weeks[2,4,8-10].

The urgency with which supracondylar humeral fractures need to be addressed remains a topic of debate. Several studies have shown that delayed surgical times do not lead to greater complication rates, even in those patients with more severe Gartland type-III fractures[11-15]. However, authors in other studies have suggested that there are benefits to treating these fractures urgently and have shown decreased complication rates with urgent treatment[16-18]. Those authors[11-18] did agree that, in cases of obvious neurological or vascular compromise, urgent treatment is indicated. It has not been clearly defined whether an isolated anterior interosseous nerve injury constitutes a neurological compromise that mandates urgent surgery. To our knowledge, this study is the largest series to date of supracondylar humeral fractures with anterior interosseous nerve injuries in the literature and the first to address the possible impact of delay of surgery on surgical outcome and the time to resolution of the nerve palsy.

Materials and Methods

A retrospective, multicenter review of all patients from January 2002 to December 2012 with all operative supracondylar humeral fractures by Current Procedural Terminology (CPT) code was conducted at three children's hospitals, all of which are pediatric level-I trauma centers. Charts were reviewed for the presence or absence of an isolated anterior interosseous nerve injury documented by the attending surgeon's physical examination both preoperatively and postoperatively. Charts were also reviewed to ensure that patients did not develop other neurological or vascular complications in the immediate postoperative period or at any of their follow-up clinic appointments. These patients had no sensory deficits, thus differentiating an isolated anterior interosseous nerve injury from a possible median nerve injury. Exclusion criteria included nerve injuries other than an isolated anterior interosseous nerve palsy, sensory changes, pulselessness, associated forearm fracture, open fractures, pathological fractures, or less than two months of follow-up. For all patients who met inclusion criteria, demographic information, time of injury, time to surgery, signs or symptoms of anterior interosseous nerve injury, time to partial return of anterior interosseous nerve function, and time to complete return of anterior interosseous nerve function were recorded. The operative records and radiographs were reviewed to classify the fracture type.

Statistical Analysis

All statistical analysis was performed using Stata/IC 12.1 for Windows (StataCorp, College Station, Texas). Analysis of variance (ANOVA) and linear regression were carried out to examine significant relationships between variables. Significance was assumed when $p < 0.05$.

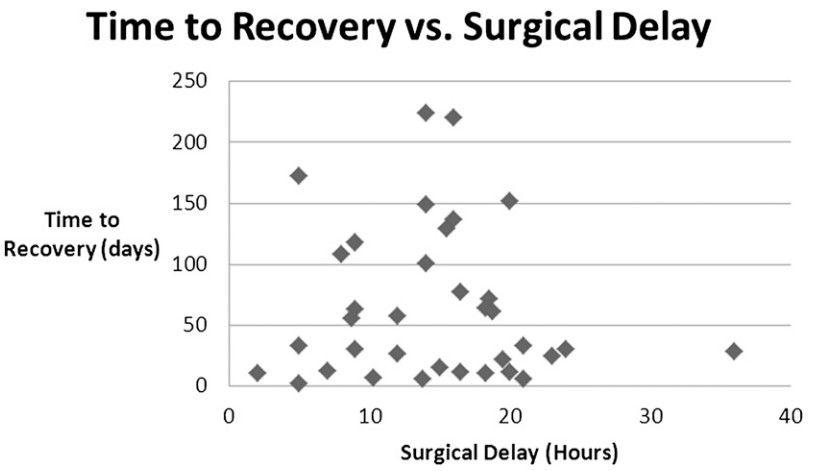

Fig. 1

A scatterplot of the time to complete return of anterior interosseous nerve function as compared with delay in time of surgery. (Reprinted, with permission, from: Children's Orthopaedic Center, Los Angeles, California.)

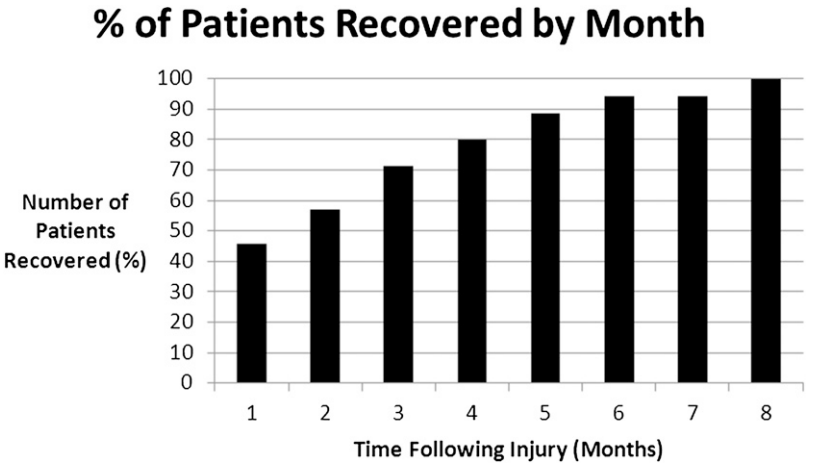

Fig. 2

A bar graph of the number of patients with anterior interosseous nerve recovery at or before each month. (Reprinted, with permission, from: Children's Orthopaedic Center, Los Angeles, California.)

Source of Funding

No external funding was received for this study.

Results

There were 4409 patients treated for supracondylar humeral fractures and thirty-five patients (0.79%) had an isolated anterior interosseous nerve injury, meeting the inclusion criteria. The rates of this injury at each of the three sites were 1.02% (fourteen of 1369 patients) for site 1, 1.73% (sixteen of 924 patients) for site 2, and 0.24% (five of 2116 patients) for site 3. The average patient age was 6.1 years (range, one to twelve years). Of thirty-five patients, 29% (ten patients) had the right arm involved and 71% (twenty-five patients) had the left arm involved, and 65.7% (twenty-three patients) were male and 34.3% (twelve patients) were female. There was one Gartland type-II fracture[8] (3%), thirty-three Gartland type-III fractures (94%), and one Gartland type-IV fracture (3%)[15,19,20]. In thirty-five cases, closed reduction with percutaneous pinning was performed in 97% (thirty-four cases), with 3% (one case) having an open reduction. An open reduction was performed in this patient because of an inability to achieve a satisfactory closed reduction. However, in that case, it also allowed direct visualization confirming that the median nerve was not in the fracture site.

The average time to surgery was 14.6 hours (range, two to thirty-six hours) (Fig. 1). A complete return of anterior interosseous nerve function, as defined by equal strength and joint motion to the unaffected side, occurred in all patients with an average time of forty-nine days (range, two to 224 days). Ninety percent of patients recovered complete anterior interosseous nerve function by 149 days (Fig. 2). There was no significant relationship between time to surgery and time to partial recovery ($p = 0.599$) or time to complete recovery of the nerve injury ($p = 0.668$) for linear regression. There was also no significant difference between patients grouped by delay in surgical time of less than twelve hours (eleven patients) and those grouped by a delay in surgical time of twelve hours or more (twenty-four patients) with regard to partial recovery ($p = 0.873$) and complete recovery ($p = 0.553$).

In our study, antecubital fossa ecchymosis was present in 43% (fifteen patients). The average time to surgery was similar in patients with antecubital fossa ecchymosis (15.6 hours) and those without antecubital fossa ecchymosis (13.9 hours). Patients with and without antecubital fossa ecchymosis had similar average times to return of anterior interosseous nerve function with regard to partial return (32.4 days for patients with antecubital fossa ecchymosis and 36.5 days for those without antecubital fossa ecchymosis) and total return (63.0 days for patients with antecubital fossa ecchymosis and 66.5 days for those without antecubital fossa ecchymosis) (Table I).

Of the thirty-five patients, twenty-eight (80%) received no treatment for their nerve injury other than observation and seven (20%) received either physical therapy or occupational therapy at the discretion of the treating surgeon.

Five patients had reduced elbow flexion or extension at the time of the latest follow-up; two patients had lost 10° of extension, one patient had lost 15° of extension, and the other two patients were not quantified. However, as the patients were not followed for the loss of flexion or extension, it was unclear if this loss was permanent. One patient had a cubitus varus deformity that, at the time of this study, had not yet required surgical correction. No patients developed compartment syndrome.

Discussion

Anterior interosseous nerve injury is the most common type of nerve injury associated with supracondylar humeral fracture[8]. McGraw et al.[10] reported 2.9% (four of 138) of displaced non-articular supracondylar humeral fractures with isolated anterior interosseous nerve injuries. Cramer et al.[7] reported a rate of 5.9% (six of 101) of isolated anterior interosseous nerve injuries in the supracondylar humeral fractures in their study. Lyons et al.[3] reported a rate of 6.2% (thirteen of 210) of isolated anterior interosseous nerve injuries in type-III supracondylar humeral fractures; however, they also reported

that five of their sixteen total anterior interosseous nerve injuries were associated with vascular compromise and they did not delineate how many of the isolated anterior interosseous nerve injuries or the combined anterior interosseous nerve injury with another nerve lesion had vascular compromise.

To our knowledge, this is the largest series to date of isolated anterior interosseous nerve injuries in supracondylar humeral fractures. The rate of isolated anterior interosseous nerve injury in this series was 0.79% (thirty-five of 4409), which is substantially lower than that which has been reported in previous series. The rates of this injury at each of the three sites involved were 1.02% (fourteen of 1369) for site 1, 1.73% (sixteen of 924) for site 2, and 0.24% (five of 2116) for site 3. In our study, Gartland type-II fractures[8] were included, although some of the prior series included only Gartland type-III fractures. Additionally, our study excluded patients who had concomitant nerve injuries and patients who had vascular compromise, open fractures, or associated forearm fractures.

Another factor that might have reduced the overall observed rate of anterior interosseous nerve injuries in this study is the difficulty of diagnosis in an injured and possibly frightened child, particularly with the sensory examination. However, in a recent prospective study of supracondylar humeral fractures, there was 97% agreement between the preoperative and postoperative examinations[21]. Consequently, it is unlikely that this had a meaningful impact on the conclusions of this study.

Our study also excluded cases of concurrent nerve injury or any associated sensory changes. Although technically it may be possible to differentiate between anterior interosseous nerve and median nerve palsies on the basis of the motor examination, based on middle finger proximal interphalangeal flexion, this is often challenging in the pediatric patient because of age, anxiety, and associated swelling[22]. One useful method for conducting a sensory examination without patient feedback is to submerge the area in question in water, or soak in a wet cloth, and observe which areas retain the ability to wrinkle[23]. Areas that no longer have adequate sensory innervation will remain unwrinkled despite being submerged. This technique was used in several instances in which sensory function was in question, but it was not uniformly applied in all cases at all centers. Given the multicenter and retrospective nature of this study, it is possible that some of the patients included in this study, particularly in the younger age groups, had some sensory component and there may have been a small percentage of injuries that were actually median nerve injuries. Although no complications were observed in this series, the authors continue to believe that a median nerve injury carries additional risk due to both the degree of injury and the potential for masking compartment syndrome, particularly if the sensory function is questionable.

The average time to complete resolution of isolated anterior interosseous nerve injury in this study was forty-nine days. The days to recovery were calculated on the basis of the first clinic visit with documentation of a normal examination. It is likely that in many cases the nerve recovered before this documentation, so the time to nerve return is likely overestimated. Of the thirty-five patients, twenty-eight received no treatment for the nerve injury other than observation, and seven received either physical therapy or occupational therapy. It is unclear what effect, if any, therapy has on time to recovery in this study, as the majority of patients who received a recommendation for physical therapy or occupational therapy did not begin until several weeks after their initial injury. Those patients with a physical therapy or occupational therapy recommendation were often patients who were not otherwise having improvement of the nerve injury.

Traditional recommendations have been that supracondylar humeral fractures with nerve involvement be treated urgently. However, the average time to surgery in this study was 14.6 hours (range, two to thirty-six hours). This time to treatment did not appear to have any effect on the time to recovery after the nerve injury for either partial recovery or total recovery. There was no significant relationship between time to surgery and time to recovery of the nerve injury with regard to partial recovery ($p = 0.599$) or complete recovery ($p = 0.668$). When grouped into patients with time to surgery of less than twelve hours and twelve hours or more, there was no difference between groups for either time to partial recovery ($p = 0.873$) or time to complete recovery ($p = 0.553$).

In this study, 43% of patients had antecubital fossa ecchymosis documented. Although some of the authors in our study consider this as a relative indication for urgent operative management, the time to surgery was similar in both groups (15.6 hours for the patients with antecubital fossa ecchymosis compared with 13.9 hours for patients without antecubital fossa ecchymosis) and there was no apparent effect of antecubital ecchymosis on the time to recovery. However, this finding may be attributable to the fact that we had already excluded patients with definitive indications for urgent management.

Overall, our data suggest that isolated anterior interosseous nerve injuries in the presence of a supracondylar humeral fracture do not require urgent surgical management. Standard treatment of the fracture followed by monitoring of nerve function recovery by observation is adequate for most patients. The average time to surgery in this study was longer than we anticipated at 14.6 hours, and no significant correlation between the time to recovery of the anterior interosseous nerve and the time to surgery was seen. However, it is critically important to remember that this series excluded cases with any sensory changes, pulselessness, other nerve injuries, and ipsilateral forearm fractures, which all may require urgent surgery.

In conclusion, all patients in this series had complete resolution of the nerve palsy regardless of the timing of their operative management. The average time to complete return of anterior interosseous nerve function was forty-nine days and 90% of patients had complete resolution within approximately five months. ■

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