Outcomes for pediatric supracondylar humerus fractures treated by orthopaedic surgeons with and without pediatric orthopaedic surgery fellowship training.

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Abstract

This retrospective chart review study evaluated the outcomes of pediatric supracondylar humerus fractures treated by orthopaedic surgeons with and without pediatric orthopaedic fellowship training. The outcomes evaluated included the Flynn criteria\(^1\), radiographic measurements, and complication rates. The radiographic measurements used were the anterior humeral line, ulnohumeral angle, and Baumann’s angle which were used to determine the carrying angle, presence of deformity, and degree of healing accomplished. Patients age zero to sixteen years, treated for a supracondylar humerus fracture between 8/1/2010 – 12/31/2017 with adequate radiographs and documentation in the medical record available were included. It was determined that there was not a large enough sample size to determine significance between outcomes between general orthopaedic surgeons and pediatric fellowship trained orthopaedic surgeons, but the data collected was used to extrapolate results that suggest that there is no difference in outcomes.

Introduction

Pediatric supracondylar humerus fractures most commonly occur in children three to six years old, with more males affected than females\(^2\). This injury is common because the supracondylar part of the humerus is very thin, and most fractures are from children falling and landing on an out-stretched arm\(^3\). The desired outcome of treatment of this injury is to have an elbow able to perform day-to-day movements, no pain, no neurovascular complications, and a normal appearance\(^4\).

Currently, there are very limited data comparing the outcomes between surgeons with and without pediatric orthopaedic fellowship training while treating a pediatric supracondylar humerus fracture, but other studies have shown that this is a common injury in children\(^5\), and is therefore relevant to communities with children. Various studies concerning pediatric supracondylar humerus fractures have evaluated outcomes including range of motion,
appearance, Flynn’s criteria, pain, nerve palsy, time of surgery (day-time or after hours), experience of surgeon, open or closed reduction, and variations in treatments. The Flynn criteria includes an assessment of deformity and function of the elbow. Li et. al. looked at how childhood obesity affected the treatment needed and determined that obese children are four times more likely to need open reduction than non-obese children.

In the pediatric population, supracondylar humerus fractures are a common injury and the treatment for this fracture is taught and evaluated as a Milestone in orthopaedic surgery residency training. Orthopaedic Surgery residency is a five-year training program following medical school. Graduating residents are trained to be able to practice as general orthopaedic surgeons. Many residents choose to complete a fellowship after residency training. Fellowships are typically 1 year programs and provide additional training in a subspecialty area of orthopaedic surgery. A pediatric orthopaedic fellowship provides in depth education on caring for orthopaedic problems specific to children, including fractures and growth disturbances. Supracondylar humerus fractures are often handled on an urgent/emergent basis and, in many practice settings, are cared for by the orthopaedic surgeon on call. If children with a supracondylar humerus fracture must be treated by a pediatric fellowship trained orthopaedic surgeon, patients may be required to travel outside of their community for treatment. This may entail a longer time period between presentation and surgical treatment, additional days of hospitalization, and increased cost.

In communities that do not have a pediatric fellowship trained orthopaedic surgeon available, this study hypothesizes that a pediatric fellowship trained orthopaedic surgeon is not required, and non-pediatric orthopaedic fellowship trained surgeons would have the same outcomes as their fellowship trained counterparts. This study will look at the Flynn criteria and complications during or after the surgery as the primary outcome measures.

Methods
Data was collected from Bronson Methodist Hospital, using eCW and the EPIC charting system. All data was collected and saved in a secure REDCap form during the data collection process. A participant will be included in the study if they are a child treated for a supracondylar humerus fracture, and a participant will be excluded if they do not meet these criteria: males of females age 0 to 16, treated for a supracondylar humerus fracture, adequate radiographs and documentation in the medical record. Participants will be excluded if they meet the exclusion criteria: age > 16 years, not treated for a supracondylar humerus fracture, and incomplete data in the medical record for analysis.

Patients will be identified by an ICD-9/10 code for supracondylar humerus fracture (ICD-10 codes S42.41, S42.411, S42.412, S42.413, S42.414, S42.415, S42.416, S42.42, S42.421, S42.422, S42.423, S42.424, S42.425, S42.426. ICD-9 codes 812.41, 812.51, V54.11, 733.81, 905.2.), or by a CPT code for surgical treatment of supracondylar humerus fracture (CPT 24538, 24545, 24546). Only patients aged 0-16 will have their medical records accessed. Data that is not easily programmatically extracted will be manually extracted into a REDCap database.

Data Elements to be Abstracted: from EPIC: age at presentation (in months), MRN (will be destroyed after manual review), gender, date of injury, date of surgery, time to OR, surgical procedure: CRPP vs open reduction and percutaneous pinning, operative duration. Data to be manually extracted: laterality, hand dominance, fracture pattern, open/closed fracture, treating orthopaedic surgeon with Pediatric fellowship training or not, radiographic parameters: anterior humeral line through capitellum, Baumann’s angle, ulnohumeral angle on final follow up, elbow range of motion, pain, carrying angle, follow up duration, return to OR, complications: nonunion, loss of reduction, revision surgery, infection, nerve or vascular injury.

All data and records generated during this study will be kept confidential in accordance with Institutional policies and HIPAA (if applicable) on subject privacy and that the Investigator
and other site personnel will not use such data and records for any purpose other than conducting the study. Safeguards are described under Data Collection and Management.

No identifiable data will be used for future studies without first obtaining IRB approval or confirmation that IRB approval is not required. When applicable, in accordance with HIPAA, Data Use Agreements (DUAs) will be executed between provider and any recipient researchers (including others at WMED) before sharing a limited dataset.

The anterior humeral line measures sagittal alignment and is measured by determining if the anterior humeral line passes through the capitellum. The ulnohumeral angle is measured from the center point at the heal of the humerus to the angle of the head of the ulna. Baumann’s angle is the angle between the long axis of the humeral shaft and the growth plate of the lateral humeral condyle.

Results

Figure 1. Ages of all patients that had a supracondylar humerus fracture and were included in this study. Minimum age was 5 months, median age was 74 months, the mean was 86.05 months ±45.57 standard deviation, and the maximum was 204 months old.
Figure 2. Comparison of male and female patients included in the study. There were 124 male patients, which was 50.4% of the total patient count, and 122 female patients, which was 49.6% of the total patient account.

Figure 3. Comparison of the side on which the fracture occurred. There were 148 patients that had the fracture of the left side, 60.4% of the patients, and 97 patients had the fracture on the right side, 39.6%.

Figure 4. Comparison of whether the fracture was open or closed (a closed fracture does not break the skin, and open fracture will have a wound present at the fracture site). There were only 4 patients with an open fracture, 1.7% of patients, and 231 patients had a closed fracture, 98.3%.
The Gartland classification describes the severity of the fracture. I Non-displaced (3, 1.5%), II Angulated with intact posterior cortex (90, 46.4%), III Complete displacement but have periostial (medial/lateral) contact (87, 44.8%), IV Periostal disruption with instability in both flexion and extension (11, 5.7%), Flexion type (3, 1.5%).

There were 222 patients treated by closed reduction percutaneous pinning, 92.5%, and 18 patients treated by open reduction percutaneous pinning, 7.5%.
**Figure 7.** Number of patients treated by a pediatric fellowship trained orthopaedic surgeon versus a general orthopaedic surgeon. There were 72 patients treated by a pediatric fellowship trained orthopaedic surgeon, 16.4%, and 366 patients treated by a general orthopaedic surgeon, 83.6%.

![Figure 7](image1)

**Figure 8.** Radiographic Ulnohumeral Angle on final follow up. The negative values are for patients with a Varus angle, where the arm angles towards the midline, and the positive values are for patients with a Valgus angle, where the elbow angles away from the midline. Of the Valgus patients, the highest value was 179 degrees, and the lowest value was 143. For the Varus patients, the highest value was -179 degrees, and the lowest value was -158 degrees.

![Figure 8](image2)

**Figure 9.** Baumann’s angle of 111 of the records. The lowest value was 49 degrees, and the highest value was 99 degrees.

![Figure 9](image3)
Figure 10. Anterior humeral line intersecting the capitellum on final follow up x-rays. There were 100 patients where the anterior humeral line intersects the capitellum, 92.6%, and 8 patients where the anterior humeral line does not intersect the capitellum, 7.4%.

The Flynn criteria were used to determine a limit on an acceptable range of range of motion loss and carrying angle loss.

**Discussion**

This retrospective medical chart review study was not determined to have significant results based on the low number of patients treated by pediatric fellowship trained orthopaedic surgeons. Results can still be estimated with the knowledge that a larger sample number is required to definitively determine if general orthopaedic surgeons have the same outcomes as pediatric fellowship trained orthopaedic surgeons.

Concerning most fields of information that were collected, since this was a retrospective study, all data was not documented equally. Other limitations of this study include that during this time period, there was only one pediatric fellowship trained orthopaedic surgeon practicing at Bronson hospital, which could make the results biased by one technique or lack of diversity. Range of motion was measured differently and at different time points throughout the recovery process, which does not allow for a uniform way to interpret the results. Some patients had their range of motion tested the same day that their cast came off, and had an understandable amount of loss of range of motion. The x-ray measurements for some patients were measured while the pins where still in place, making the results of this measurement also not completely reliable. The pins, in some cases, hindered full range of motion and could skew the expected recovery of the patient. It is assumed that once the pins are removed and the patient has had time to recover and regain muscle once the cast is removed, that most patients would regain their range of motion, but since the data collected was based on the functionality of the patient in life, and not for research purposes, there was little to no follow up much time after the case and pins were removed. For some doctors, it is common practice to see the patient when they come in to the emergency room, perform the surgery that day or the next day, see the patient 1 week after
surgery, and then see the patient 3 weeks after that to remove the cast and pins, and to have that the last meeting between the doctor and patient as long as there are no complications.

Another factor to be aware of is that for each medical record, not all of the same information was filled out in each one. This leads to differences in the total numbers of patients as expressed in the figures. For example, the total number of patients from figure 9, 111 patients is difference from the total number of patients in figure 2, with 246 patients, because doctors were more likely to always note the sex of he patient, and not as likely to measure Baumann’s angle for each patient treated.

Results may still be extrapolated from the data collected. The study covered the expected age range for these injuries to occur with helpful density (Figure 1), and also had an almost exactly even percent of both males and females (Figure 2), to allow for the results to be assumed to not be skewed by age or sex. Figure 3 shows that there is not a great difference between which side the fractures occurred on, and it is expected that with a larger sample size, this difference will be evened out to an almost even percentage of left and right side fractures.

The severity of the fractures treated with determined by two factors, whether the fracture was opened or closed, and the Gartland Classification. Figure 4 shows that the great majority of the fractures were closed, which was anticipated because of the age group of the patients in this study. The Gartland classification ranges from I to a flexion type fracture, with the first classification being the least severe, and the flexion fracture being a rarer type of fracture (Figure 5).

The typical treatment plan for a supracondylar humerus fracture is for the fracture to be reduced, or realigned, using live fluoroscopy and manual manipulation of the elbow. This is usually done without creating an incision to help reduce the invasiveness and likelihood of complications to the procedure. Pins are then inserted through the skin to hold the bones in a reduced orientation to allow for bone growth and healing. Figure 6 demonstrates that 93% of all
the fractures used in this study were reduced in a closed manner. Sometimes fractures that are presented to the emergency room with a wound already visible will be reduced in an open fashion since there is already an opening.

There were 72 patients treated by a pediatric fellowship trained orthopaedic surgeon, which accounts for 16.4% of the total number of patients studied (Figure 7). This number is lower than the number of patients treated by general orthopaedic surgeons because there is only one practicing pediatric fellowship trained orthopaedic surgeon during this time frame, and there are about 6 other surgeons who also treated these fractures during this time frame. It was determined that of all the patients who scored a 1 on the Flynn criteria, which is an unsatisfactory result, one of the 17 patients, one of these patients was treated by a pediatric fellowship trained orthopaedic surgeon, and one of the 12 patients who received a zero for the Flynn criteria, which was a satisfactory result, was treated by a pediatric fellowship trained orthopaedic surgeon.

Figures 8, 9, and 10 show the results of the measurements taken from the x-rays of the healed or healing fractures.

**Conclusion**

This retrospective medical chart review study was not determined to have significant results based on the low number of patients treated by pediatric fellowship trained orthopaedic surgeons. Results may still be extrapolated from the data collected. There were some limitations to this study, including the short date range, number of samples, number of patients treated by a pediatric fellowship trained orthopaedic surgeon, and the inconsistent collection and recording of data. The study population was almost equal in sex, and in the side of fracture. There was a range in the severity of fractured, as demonstrated by the Gartland classification and if the fracture was presented to the emergency room as open or closed. From these results, it is concluded that general orthopaedic surgeons had similar outcomes as pediatric fellowship trained
orthopaedic surgeons, but more research and a larger sample size is required for this result to be significant and proven.

**Further Research**

Studies concerned with the treatment of supracondylar humerus fractures and have used performance improvement questionnaires (PIQs) to determine the most effective treatment plan for this common injury. Jobst et. al. determined that there are still many different treatment plans being utilized, and that there remains opportunity for standardization and cost reduction. In some hospitals, general orthopaedic surgeons who usually treat adults may be hesitant to treat a supracondylar humerus fracture in a child, and will refer the patient to a pediatric fellowship trained orthopaedic surgeon. This hesitancy is not universal, and in many communities the orthopaedic surgeon on call, who may or may not have pediatric fellowship training, will care for the patient.

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