

Research Article

Complications of Supracondylar Humeral Fractures in Children at Level One Trauma Center

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Abstract

Background: Supracondylar humeral fracture is the most common pediatric elbow fracture. The type of the fractures will influence on complications severity. The aim of this study is to discover this association and evaluate it in a level one trauma center.

Methods: The data was retrospectively collected from medical records of patients aged 14 years and below who presented to the emergency department with a supracondylar humeral fracture between 2007 and 2012. The data included mechanism of injury, type of fracture, pre-and post-operative examinations, time from injury to surgery, type of surgery, duration of immobilization and the presence of complications. Assessment of these complications was done preoperatively, postoperatively and at last follow-up. Association between complications and types of fractures was determined using the Fisher exact test.

Results: A total of 125 patients' records were reviewed, 6 cases of type I (4%), 47 types II (38%) and 72 types III (58%). The overall complications rate in the last follow up was higher in type III than in type II (14% vs 4%, respectively), however no statistical significance was found between both types (P-value= 0.16). Stiffness was noted to be the most common complication in type III (n=7) (10%). Other complications associated with type III, were nerve injury and deformity. While in type II, the only complications seen at the last follow up was infection and stiffness, which were equally seen in 1 patient for each complication (2%).

Conclusion: Complication rate significantly changes depending on type of fracture. Type III was more associated with complications compared to type II. Since the complications differ between types of fractures, special attention should be given to each type.

Level of Evidence: Retrospective Cohort Study, Level III.

Keywords: Complication; Elbow; Nerve Injury; Pediatric; Supracondylar Humeral Fracture

Introduction

Upper extremity fractures are responsible for 40% to 50% of all fractures in children, with supracondylar humeral fracture being the most common pediatric elbow fracture [1,2]. This fracture mainly occurs in children above the age of 5 years old [3]. Up to 70% of all Supracondylar fracture cases are caused by a fall on an outstretched arm [3]. Children under the age of three years usually sustain a supracondylar fracture after a fall from a height of less than three feet, like falling from a bed or couch. While Children

older than three years develop this type of fracture after a fall from a height of more than three feet [4]. Although it is more frequent in males than females, Suh S. et al [5] shown that supracondylar fracture affects both genders equally. This type of fracture is thought to occur more in the left elbow [6].

Supracondylar fracture can be classified into three main types according to Gartland Classification [7]. Type I refers to a fracture of the distal part of the humerus with no displacement, while type II refers to an angulated fracture of the distal part of the humerus with an intact posterior cortex, and finally, type III refers to a displaced fracture with no cortical contact [Figure 1]. Several methods of treatment are available ranging from immobilization

in above-elbow cast to closed /open reduction with or without percutaneous Kirschner-wire (K-Wire) fixation. Decision about treatment is usually made according to the type of fracture. Type I is usually treated by cast application for approximately 3 weeks, while closed and open reduction techniques are used in treatment of Type II and Type III supracondylar fracture [8]. There are many complications associated with surgical treatments; such as infections, neurovascular injury and elbow deformity [9].

The aim of the study was to determine the association of complications and different types of supracondylar fracture. Research ethics approval was obtained prior to the commencement of the study.

Materials and Methods

This study is a retrospective cohort design based on chart and X-rays review at a level one trauma center. All pediatric patients aged 14 years and below, who presented to the pediatric emergency room between 2007 and 2012 and were diagnosed to have supracondylar humeral fractures, were included in the study. The minimum follows up in our study was 7 months. All pathological fractures were excluded from the study. The data included mechanism of injury, pre-and post-operative examinations, type of fracture, time from injury to surgery, type of surgery, duration of immobilization and the presence of complications. All radiological films obtained preoperatively, intraoperatively and early postoperatively were reviewed by the senior primary investigator. The data was statistically analyzed using SPSS program version 17.0. The variables were described as percentages and frequencies. Categories were compared using the Chi square test. The complications between groups were also compared using relative risk and a 95% confidence interval. A P-value of <0.05 was considered to be statistically significant.

Results

A total of 125 patients' records were reviewed, 76 of which were male (61%) and 49 were females (39%). Their ages ranged from 2 months to 14.4 years, with a mean age of 5.3 years. We ended up with 6 cases of supracondylar humeral fractures type I (4%) [Figure 2], 47 cases of type II (38%) [Figure 3] and 72 cases of type III (58%) [Figure 4]. Since there were only a few cases of type I compared to type II and III, we excluded them from the complication comparison because it is statistically insignificant. We therefore ended up with a total of 119 patients to include in our study. Falling on an outstretched arm was the most common cause of injury in 92% of the patients (n=115), while the remaining 8% (n=10) were caused by Motor Vehicle Accidents (MVA). Most of the MVA cases were pedestrian accidents 87.5% (n=7). Regarding the site of injury, 59% (n=74) of all injuries were in the left arm and 41% (n=51) were in the right arm. The mean duration time from injury to surgery ranged from 1 to 2 days, with a mean

time being one day. All type III cases were treated as closed reduction and K-wires fixation compared to 72.3% (n=34) in type II. Closed reduction and cast application was the choice of treatment in the remaining 27.7% (n=13) of type II cases. A total of 125 pins were used among the 106 patients who were treated with K-Wires. The lateral to medial pin ratio was 2:0 in 64% of the patients and 2:1 in 24%. The mean time for pin removal was 18 days (Range: 15-30 days); and the mean duration time for last follow up was 9.3 months (Range: 7 - 40 Months). When comparing both types together, the results showed that the overall complications rate was higher in type III than in type II (14% vs 4%, respectively), however no statistical significance was found between both types (P-value= 0.16) [Table 1].



Figure 1: Gartland classification of Supracondylar Humerus Fracture



(a)

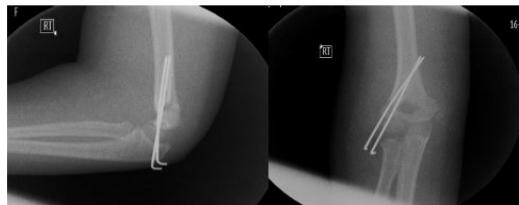


(b)

Figure 2: Type I supracondylar humeral fractures in 5-year-old boy. (a) AP and Lateral X-ray views showed minimally displaced fracture. (b) one-month post cast application showed good fracture healing.



(a)



(b)

Figure 3: Type II supracondylar humeral fractures in 6-year-old girl. (a) AP and Lateral X-ray views showed displaced fracture with intact cortex posteriorly. (b) Fluoroscopy view intra-operatively showed reduced fracture with 2 K-wires fixation.



(a)



(b)



(c)

Figure 4: Type III supracondylar humeral fractures in 8-year-old boy. (a) AP and Lateral X-ray views showed displaced fracture with no cortical contact. (b) Fluoroscopy view intra-operatively showed reduced fracture with 3 K-wires fixation to provide stability. (c) AP and Lateral Elbow X-rays 4 months post-surgery showed good fracture healing.

	Type II=47	Type III=72	P-value
Nerve Injury	0 (0%)	1(1.4%)	>0.99
Stiffness	1 (2.1%)	7 (9.7%)	0.21
Infection	1 (2.1%)	0 (0%)	0.79
Deformity (Cubitus Varus)	0 (0%)	2 (2.8%)	0.73
Re-Displaced Fracture	0(0%)	0(0%)	NA*
Total	2 (4.2%)	10 (13.9%)	0.16

*Not applicable

Table 1: Over all complications at last follow up.

	Pre-op injury		P value	Post op		P value	Last follow up		P value
	Type II =47	Type III =72		Type II= 46	Type III = 67		Type II = 47	Type III = 72	
Nerve injury complications	1 (2.1%)	5 (6.9%)	0.47	0 (0%)	2(3%)	0.7	0%	1(1.4%)	>0.99

Table 2: Nerve injury complications in type II and III supracondylar fractures.

Post-operatively

Post-operative assessment was done after 6 weeks from the date of surgery. Type III fractures showed a higher complication rate post-operatively than type II (5.6% vs 2.1% respectively) with no significant difference again between both groups (P-value = 0.68). Neurovascular injuries were only assessed in those patients whom did not have a nerve injury before the surgery (n=113) and was found in only 2 (1.7%) patients. Both of these patients presented with a type III fracture compared to zero patients from type II, with no significance between both groups (p-value = 0.7). The ulnar nerve being the nerve affected in the first patient and the median nerve in the other. Other complications that were assessed post-operatively included infection and re-displacement of the fracture. One patient in each type of fracture showed signs of infection post-operatively (1.6%) and thus no significant difference was found between both types with a P-value of 0.79. When we looked for re-displaced fractures post-operatively, 3(4.2%) patients from type III showed evidence of re-displacement compared to zero (0%) patients from type II, with no significant difference between both groups (p-value =0.44).

Last Follow Up

All of our patients underwent a physical assessment at least 7 months after the date of surgery. The complications that were assessed then were: neurovascular injuries, infections, stiffness and deformity (Cubitus Varus) [Table 1]. Type III fractures still showed a higher complication rate in the last follow up compared to type II

Pre-operatively

In Pre-Operative physical assessment, the only complication that could be assessed was the neurovascular injury [Table 2], which was found in only 6 (5%) patients from the overall sample (n=119). Five of these patients had type III fractures compared to only one patient with type II, with no significance between both types with a p-value of 0.47. The injured nerve also differed from patient to patient. Among the 5 patients from type III, 3 (60%) of them suffered an injury to the radial nerve and the other 2(40%) patients to the Median nerve, while the patient with a type II fracture suffered an injury to the Median nerve.

(14% vs 4%, respectively), however no statistical significance was found between both types (P-value= 0.16).

All neurovascular injuries caused from the fracture itself or from the surgery (n=8) recovered completely in the last follow up except for one patient with a type III fracture who had a pre-operative radial nerve injury. Out of the two patients who suffered an infection post operatively, the patient with a type II fracture still showed signs of infection in his last follow up, unlike the patient with the type III fracture whose infection subsided. Deformity (Cubitus Varus) was only assessed in the last follow up and was found in only 2 (2.8%) patients with type III, and zero patients in type II without any significance between both groups (p-value=0.73). Finally, stiffness was defined as any loss of range of motion of the elbow of >20 degrees of flexion or extension. It was found to be the most common complication in the last follow up among type III fractures (n=7, 10%). While it was only found in 1(2%) patient with a type II fracture, with a p-value of 0.21.

Discussion

Supracondylar fracture of the humerus is one of the most common injuries in children. It represents about 16% of all pediatric fractures [1-3] and over 60% of fractures of the elbow in children [10]. It usually necessitates early treatment in order to avoid complications, as a result, a routine surgical management for any sort of fracture with displacement is recommended [11]. Oetgen et al. [11] conducted a retrospective study for all patients

who underwent operative fixation of a supracondylar humerus fracture between January 2006 and December 2010 with a total of 752 patients, which concluded that the rate of complication is much higher in type III fracture (19.8%) compared to type II fracture (5.7%) which was statistically significant with a p-value of <0.0001. These findings are similar with our study in which Type III fractures were found to have more complications compared to type II (14% vs 4%, respectively), however no statistical significance was found between both types (P-value= 0.16) due to the limited number of patients and incidence. This issue was also seen Oetgen's article when they compared open fractures, post-operative infections, and ipsilateral forearm fractures between both groups, which also showed a higher incidence in type III but yet no significance due to the overall low incidence of these issues. Other complications that they looked at in their study were, nerve palsy, loss of reduction and the need to return to OR. The highest incidence of complication in their study was attributed to neurovascular injury in both types of fractures. Their study however did not look into stiffness which was considered the highest incidence of complication in our study. In another study by Zamzam M and Bakrman K in 2009 noticed that the time from injury to surgery effects on the prognosis of the fracture. They found a significant relation between delay of surgery more than 24 hours and poor outcomes (p = 0.03) [12]. The complications observed was decreased range of motion, decreased carrying angle, neurological and vascular injuries and finally the need for re-operation. However, all patients in our study had no delay in surgery; all surgeries were done within 24 hours of their presentation.

Nerve Injuries

Evaluation of neurological involvement must be taken carefully in children. If an involvement is noted, a careful evaluation and documentation should be taken by recording the onset, degree and possible progression of the related neurological structures and its supplies and innervations.

Literature states that the most common nerve injury associated with supracondylar humerus fracture is the anterior interosseous nerve [13], which is the branch of the median nerve, with the radial nerve being a close second most common. A paper published in 2013 titled the anatomical basis for anterior interosseous nerve palsy secondary to supracondylar humerus fracture in children concluded that the injury mechanisms leading to selective AIN palsy secondary to supracondylar elbow fracture in children are probably the result of two factors: direct contusion of the posterior aspect of the median nerve, and thereby the AIN fascicles, by the proximal fragment; stretching of AIN in Zone 1, which has less ability to withstand stretching than the median nerve and its other branches because the AIN is fixed in Zone 2 [14]. A study in 2008 mentioned that the incidence of

traumatic and iatrogenic nerve injures in pediatric supracondylar fractures of the distal humerus have been recorded as 12-20% and 2-6%, respectively [15]. They have found that the median nerve, specifically the anterior interosseous nerve accounted for 52% of the injuries and the radial nerve for 32% of the injuries. A study published in 2017 included 220 children hospitalized in the Department of Orthopedic Traumatology due to supracondylar fracture of the humerus in the years 2004–2014. Among these patients 16.81% had suffered acute nerve injuries, with the most injured nerve being the median nerve (68%). In our study among the 8 patients who suffered a nerve injury, 4 patients injured their median nerve (50%), 3 injured the radial nerve (37%) and only 1 patient had an ulnar nerve injury. The fracture itself was the cause of 6 out of the total 8 nerve injuries, while the other 2 injuries (1 median and 1 ulnar) were caused operatively. The literature also mentions that nearly all cases of nerve palsies usually resolve spontaneously and that was the case in our patients. However, only one patient out of the 8 injured in our study did not recover. He had suffered a radial nerve injury pre-operatively due to a type III fracture. Finally, a study titled Deformity and functional outcome after treatment for supracondylar humerus fractures in children resulted a total of 17 nerve injuries among their 139 patients [16]. From the total 17 patients who had a nerve injury, 88% (n=15) of these patients suffered a type III fracture, which was pretty similar to our study's result with 87.5% (n=7) of the total patients with nerve injuries (n=8).

Infection

Pin site infections is always a possible complication when treating patients with supracondylar humerus fractures. The reported frequency of pin site infections varies from 3.6 to 77.0% [17]. A study in 2016 had total of 369 patients that underwent operative reduction, pinning, and casting. Among these 369 only 3 patients (0.81%) developed an infection. Another study published in 2017 looked into the effect of variable pin care management and how it would affect the incidence of infection and its severity. They divided their patients into three groups with 45 patients in each group. Of all the children, 45 children took daily pin care, 45 children took pin care on alternate days and 45 children took weekly pin care. They found no significant difference in the severity of infection or frequency and had a 35.6% overall incidence of infection among their patients. In oetgen [11] only 3 (0.4%) patients from a total of 709 patients developed an infection and they were all type III fractures. However, in our study, out of the 125 pins used among 106 patients, only two patients (1.6%) developed an infection, with no significant difference between the two types of fractures. This variability in incidence of infection could be related to the patient's different backgrounds, type of pins being used, preoperative antibiotic use, pin site care protocols and the duration of pins left in.

Re-displacement

According to Oetgen [11], due to the gradual ossification of the distal humerus, younger patients with a larger percentage of cartilaginous distal humerus may have less stable fixation with percutaneous pins leading to subsequent loss of fracture reduction. They however were not able to determine the cut off age which the risk would decrease but noticed that the majority of the re-displacements were children younger than 8 years old. They also documented a significant increase risk of displacement among type III fractures compared to type II (4% vs 0.3% respectively, P value of 0.003). This result was similar to our findings, since we only had 3 re-displacement (4%) in patients with a type III fracture, compared to no re-displacements at all among type II fractures, however with no significance statistically between both groups (p-value= 0.44).

Deformity

Modern surgical techniques (e.g., Closed Reduction with Percutaneous Pinning) have reduced this frequency of Cubitus Varus from 58 % to approximately 3% in children treated for supracondylar fractures [18]. In our patient's last follow ups, we looked for deformities of Cubitus Varus. It was only found in 2 patients out of the whole sample (1.6%), both of which had suffered a type III fracture. Our result was comparable with a previous study published 2016 which only had three patients (3.2%) with deformities [19].

Stiffness

Decreased range of motion or stiffness is one of the complications of supracondylar fractures. Return of normal functional range of motion of the elbow joint is a very important desired goal in treatment. According to an article published in 2008 the range of motion of the elbow joint gradually recovers over time [20]. Their study showed that 94% of their patients had recovered a normal range of motion in 6 months, which was very similar to our findings of 93% after 7 months. They also claimed that additional improvement of range of motion was observed after a 1 year follow, which increased to 98%. They however showed no difference in the percentage of loss of motion between the two types of fractures after 12 weeks, unlike our patients who showed a higher percentage of loss of motion among type III fractures compared to type II (10% vs 2% respectively) but with a non-significant (p value = 0.21).

Limitations

Since our study is a retrospective cohort study, it is subjected to limitations such as not being able to control exposure or outcome assessments, and instead must rely on others for accurate recordkeeping. Another notable limitation is that due to the limited number of patients and complication incidence, we were unable

statistically to find significance between the two fracture groups, despite the notable trend that suggested that type III fractures may have more complications than type II.

Conclusion

In conclusion, although there has been a report of low complication rates associated with supracondylar fractures, it is still important to know the different complications associated with each type of supracondylar fracture in order to try our best to avoid it. If a complication however is noted, careful documentation should be taken by recording the onset, severity and degree. We also recommend to do a national follow up on the subject in order to increase the number of patients included in the study and to extend the follow up time of these patients, with or without complications, to know the possible long-term complications that might develop and to be able to prove the difference statistically. We also suggest that physiotherapy and other modalities should be considered in patients who show early signs of stiffness, to avoid possible loss of range of motion, especially in patients with type III fractures.

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