

The Cost of Pediatric Distal Humerus Fractures: A TRUVEN Database Study

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Objectives: The purpose of this study was to identify demographic properties, treatment selections, and cost information for pediatric supracondylar humerus, lateral condyle, and medial epicondyle fractures.

Participants: Patients ages 17 years and younger with ICD-9 and ICD-10 diagnosis codes for supracondylar humerus fractures, lateral condyle fractures, and medial epicondyle fractures between the years of 2015 to 2020.

Main Outcomes: Treatment modality and cost of treatment.

Results: A total of 1,133 supracondylar, 154 lateral condyle, and 124 medial epicondyle fractures were identified. Supracondylar fractures had the highest percentage of patients treated with operative intervention at 83%, followed by 78% of lateral condyle and 41% of medial epicondyle fractures. Operative medial epicondyle patients were the oldest, followed by lateral condyle and finally supracondylar. Cost was higher for supracondylar ORIF as compared to CRPP (\$1601.12 [1186.98-2146.63] vs. \$1289.60 [978.75-1748.59] p= .01). Operative fixation of lateral condyle fractures was about \$300 more expensive than for medial epicondyle fractures.

Conclusion: Within this insurance claims database, patients receiving ORIF were not only older on average but also accrued higher costs than CRPP by about \$300. Medial epicondyle fractures tended to be the least expensive operative fixation and lateral condyle fractures the most expensive.

Keywords: Supracondylar humerus fracture, lateral condyle fracture, medial epicondyle fracture, pediatric elbow, TRUVEN

Level of Evidence: Level IV

INTRODUCTION

Distal humerus fractures around the elbow are some of the most common fractures seen in the pediatric population. Three of the most common fracture types are supracondylar (SC), lateral condyle (LC), and medial epicondyle (ME) fractures.¹ Historically, SC are the most common, followed by LC and ME, respectively.¹⁻³

Supracondylar humerus fractures typically occur in children between five to ten years of age and are most often the result of a fall onto an outstretched arm.³⁻⁴ Traditionally, attempts at closed reduction with percutaneous pinning (CRPP) have been the first line of treatment with more invasive open reduction internal fixation (ORIF) techniques being reserved only after closed methods have failed.^{5,6} However, age may be directly proportional to the likelihood of converting to open techniques.^{7,8}

Lateral condyle fractures typically occur in children between four to ten years of age and are the result of a varus or valgus applied force to the extended elbow.^{9,10} Operative treatment is reserved for displaced fractures and consists of either CRPP or ORIF.^{9,10} ME typically present in an older age group between 9-14 years of age.^{1,2,11} Etiology consists of either direct trauma or an avulsion-type injury from an overpull of the flexor-pronator mass, which results in a relatively high rate of nonunion.¹² Operative treatment is controversial due to ambiguous indications and reported outcomes.¹³

With the evolving focus on healthcare costs, there have been recent investigations into the financial impact of treating pediatric distal humerus fractures. In 2021, Gill et al. utilized the Pediatric Health Information System database in order to create a standardized cost for injuries and attributed \$6,600 for total SC care.¹⁴ There is also significant

variability in different treatment pathways, with an almost 17x increase in cost for SC fractures treated as inpatients.¹⁵ There is also evidence that ORIF accrues a larger cost over CRPP for SC fractures.¹⁶ There is a paucity in the literature representing distal humerus fractures other than SC as well as the cost attributed to the isolated surgery in the US.

The purpose of this study was to identify demographic and financial information for the treatment of pediatric distal humerus elbow fractures. Primary outcomes included distinguishing age as an association with injury and treatment modality and determining an interquartile cost range for treatments. We hypothesized SC patients to be on average the youngest, followed by LC and then ME. Further, we hypothesized ORIF to be the treatment of choice in older patients with a higher cost compared to CRPP.

METHODS

Data was obtained from the IBM Truven MarketScan® Commercial and IBM Truven MarketScan Medicare Supplemental databases, which contains de-identified, integrated, person-specific claim data. The database is a conglomerate of three separate patient populations. The first and largest population contains health information from participating large company employer-based health insurance. The second contains Medicare beneficiaries with supplemental insurance provided by their employer. The third includes 11 contributing states' Medicaid health information reported claims. The study period ranged from 2015 to 2020 with patients 17 years and younger with the ICD-9 codes 812.41 and 812.51 and the ICD-10

codes S42.41 and S42.42 for supracondylar humerus fractures; ICD-9 codes 812.42 and 812.52 and ICD-10 code S42.45 for lateral condyle fractures; and ICD-9 codes 812.43 and 812.53 and ICD 10 code S42.44 for medial epicondyle fractures. These selected claims were queried for patient demographics, treatments performed, and procedure cost. All monetary charges linked with the selected CPT code were summed together. Although indistinguishable, these charges represent operative theater utilization, ancillary support staff, anesthesia, implants, medical equipment, and other associated charges.

Statistical Analysis:

Data was organized by injury and treatment type. The normal distribution of continuous variables was assessed with the Kolmogorov-Smirnov test and analyzed with an unpaired t-test. Ordinal data was analyzed with a Chi-Square test. The comparison of proportions test was utilized for percentage analysis. Non-parametric cost data was presented as the median in the interquartile range. Data entries were considered statistically significant if $p < 0.05$.

RESULTS

A total of 1,411 fractures of interest were included. There were 1,133 total supracondylar fractures with average age of 6.76 ± 3.31 years and a slight male predominance at 52%. A total of 939 underwent operative intervention, 54% of whom were male. Operative SC fractures were significantly younger than nonoperative (6.32 ± 2.81 vs. 8.86 ± 4.53 years, respectively, $p < .0001$).

Of the operative SC fractures, CRPP were significantly younger than ORIF (5.97 ± 2.34 vs. 8.47 ± 4.12 years, respectively, $p < .0001$). Operative SC fractures were significantly more expensive than nonoperative ($\$1342.74$ [1012.4-1780.61] vs. $\$233.26$ [90.22-524.33], $p < .0001$). SC CRPP incurred a significantly lower cost than ORIF ($\$1289.60$ [978.75-1748.59] vs. 1601.12 [1186.98-2146.63], respectively, $p = .01$). (Table 1)

Table 1. Supracondylar (SC) Demographics

Treatment	n	Age (years)	Male	Median (USD \$)
All	1133	6.76 ± 3.31	52%	1233.44
Non-op	194	8.86 ± 4.53	54%	233.26
Operative	939	6.32 ± 2.81	52%	1342.74
CRPP	805	5.97 ± 2.34	51%	1289.60
ORIF	134	8.47 ± 4.12	52%	1601.12

There were 154 total lateral condyle fractures with an average age of 7.75 ± 4.2 years, 64% of whom were male. A total of 120 underwent operative intervention, 63% of whom were male. Operative LC fractures were significantly older than nonoperative (9.62 ± 4.91 vs. 7.22 ± 3.81 years, respectively, $p = .009$). Of the operative LC fractures, those undergoing CRPP were younger than those undergoing ORIF (5.76 ± 2.94 vs. 7.6 ± 3.92 years, respectively, $p = .03$). Operative LC fractures incurred a higher cost than nonoperative treatment ($\$1495.94$ [1102.14-2070.26] vs. $\$199.42$ [119.79-522.05], respectively, $p < .0001$). (Table 2)

There were 124 total medial epicondyle fractures with an average age of 11 ± 3.86 years, 47% of whom were male. Of these, 51% underwent operative intervention and 45% of whom were male. Operative ME fractures were significantly

older than nonoperative (12 ± 2.58 vs. 10 ± 4.43 years, respectively, $p = .03$). All but two operative ME fractures were treated with ORIF, so further analysis was not pursued. (Table 3)

Table 2. Lateral Condyle (LC) Demographics

Treatment	n	Age (years)	Male	Median (USD \$)
All	154	7.75 ± 4.2	64%	1352.01
Non-op	34	7.22 ± 3.81	65%	199.42
Operative	120	9.62 ± 4.91	63%	1495.94
CRPP	25	5.76 ± 2.94	80%	1340.00
ORIF	95	7.6 ± 3.92	59%	1614.50

Table 3. Medial Epicondyle Demographics

Treatment	n	Age (years)	Male	Median (USD \$)
All	124	11 ± 3.86	47%	825.00
Non-op	73	10 ± 4.43	48%	275.84
Operative	51	12 ± 2.58	45%	1204.91

When comparing across injury types, there was a statistically significant difference in the percentage of operative fractures between SC and ME (83% vs 41%, respectively, $p < .0001$), and between LC and ME (78 vs 41%, respectively, $p < .0001$). Patients with operative SC were younger than those with LC (6.32 ± 2.81 vs 9.62 ± 4.91 years, respectively, $p < .0001$) and those with ME (6.32 ± 2.81 vs 12 ± 2.58 years, respectively, $p < .0001$). Patients with operative LC were younger than those with ME (9.62 ± 4.91 vs 12 ± 2.58 years, respectively, $p = .001$). There was a statistically significant difference in patient gender distribution between patients with operative SC and LC (52 vs 63% male, respectively, $p = .03$), SC and ME (52 vs 45% male, respectively, $p = .01$) and LC and ME (63 vs. 45% male, respectively, $p = .002$). Operative

LC incurred the highest costs, followed by SC, and lastly ME (\$1495.94 [1102.14-2070.26], \$1342.74 [1012.4-1780.61] and \$1204.91 [946.86-1534.08]). Ranking cost by operative modality produced a similar order with LC ORIF being the most expensive, followed by SC ORIF, LC CRPP and lastly SC CRPP (\$1614.50 [1151.50-2106.03], \$1601.12 [1186.98-2146.63], \$1340.00 [904.18-1879.08], \$1289.60 [978.75-1748.59] Table 1, 2). However; only the comparison between the most expensive operative fracture (LC) and least expensive (ME) showed any statistical significance (p =0.04, Table 4).

Table 4. Operative Treatment Cost Comparison

Type	Percent-Op	Age (years)	Male	Median (USD \$)
SC	83%	6.32 ± 2.81	52%	1342.74
LC	78%	9.62 ± 4.91	63%	1495.94
ME	41%	12 ± 2.58	45%	1204.91

DISCUSSION

Pediatric distal humerus fractures are commonly encountered and therefore warrant continued investigation into current treatment practices. This study identified differences in age between the three injury types as well as treatment modalities. There also was a difference in the percentage of operative fractures between injury types, with ME having the lowest percentage and SC the highest. Operative treatment was more expensive than nonoperative, with ORIF expectedly more expensive than CRPP.

The ossification centers and fusion patterns in the pediatric elbow is predictable and highly studied.¹⁷ The osseous anatomy of the distal humerus in skeletally immature patients presents

with a weak point between the medial and lateral columns through the olecranon fossa.¹⁸ The medial epicondyle is typically the last ossification center to fuse, which occurs around 17 years of age.¹⁷ Our study demonstrates the possible influence of these factors, with SC and LC fractures presenting in a younger population and ME fractures presenting in an older population. Older SC and older LC patients were more likely to undergo an ORIF. Evidence suggests age at the time of injury to be a predictor for conversion from closed to open techniques.¹⁹ Older patients typically weigh more and therefore generate more force through injury. Because of larger patient mass and increased muscle bulk, closed reduction may be a more difficult task in older patients, pushing surgeons to abandon closed management and rely rather on open reduction techniques through direct visualization.

Displaced SC fractures treated nonoperatively have a propensity to progress to malunion, typically cubitus varus, which not only can be aesthetically unappealing, but a source of pain, snapping triceps, and elbow instability.²⁰⁻²² Lateral condyle fractures also have a high nonunion and malunion rate if displaced ≥2 mm; therefore, there is a low threshold to treat both SC and LC fractures operatively.^{3,9,10} Medial epicondyle fractures were less likely to undergo operative intervention in this study. Prior research suggests satisfactory outcomes between operatively and nonoperatively treated ME patients.²³⁻²⁸ Although reported nonunion rates are as high as 90% in nonoperatively and only 7% in operatively managed patients, nonunions are rarely symptomatic.^{11,23-25}

These factors may contribute to the relatively higher percentage of patients with SC and LD fractures undergoing operative treatment, whereas lower rates were observed for those with ME fractures.

Our study demonstrated an overall low variability in costs between the three fracture types. The ORIF group was around \$300 more expensive for SC and LC as compared to their respective CRPP group, and although this database does not publish itemized charges, it likely equates to longer operative time, increased analgesics, tourniquet use, suture, and the possibility of using more expensive screws as opposed to K-wires for implants. Gill et al. published a cost analysis of supracondylar humerus fractures, which includes a wide spectrum of care other than the actual surgery such as laboratory tests, imaging, and room charges.¹⁴ This provides a great tool for understanding the cost to the overall healthcare system; however, it does not isolate the actual operative costs between certain treatment modalities and does not investigate the costs attributed to operative treatment of LC or ME. Vorhies et al. found an increased cost with SC ORIF as compared to CRPP, but simultaneously found longer length of hospital stay for ORIF, likely contributing to this difference.¹⁶ To our knowledge, this study is the first to investigate the cost differences between ORIF and CRPP for both SC and LC. It is also the first to look into the costs of LC and ME.

There were several limitations to this study. The data is retrospective in nature, and there was sparse information for each insurance charge. Operative reports and radiology exams were

unavailable for review. Patient factors such as time from injury, body mass index, mechanism of injury, and patient involvement in athletics were unavailable which may postulate surgical indications. Further, chronologic age was reported rather than bone age, which may be a better metric for this population. Information regarding specific implant types such as screws, plates, or K-wires was not available and directly influences operative costs. Lastly, the database is predicated on appropriate coding reported to the insurance company, which is unvalidated and leaves room for miscoding or omission of codes. However, this insurance claims database allowed us to observe a large cohort of patients without institutional treatment biases commonly encountered in many other retrospective studies.

CONCLUSION

We observed significant age differences between patients presenting with different fracture types: those with SC tended to be the youngest, followed by patients with LC and ME, respectively. Patients undergoing ORIF for SC and LC fractures were older and accrued higher treatment costs compared to patients treated with CRPP. Lateral condyle fracture fixation incurred the highest cost for operative treatment, whereas medial epicondyle fractures tended to incur the lowest cost.

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