

# Surgical Treatment of Supracondylar Humeral Fractures in a Freestanding Ambulatory Surgery Center is as Safe as and Faster and More Cost-Effective Than in a Children's Hospital

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**Background:** Despite an 88% increase in the number of pediatric fractures treated in ambulatory surgery centers (ASCs) over a 10-year period, few studies have compared outcomes of fracture treatment performed in a freestanding ASC compared with those performed in the hospital (HOSP) or hospital outpatient department (HOPD). The purpose of this study was to compare clinical and radiographic outcomes, treatment times, and costs for treatment of Gartland type II supracondylar humeral (SCH) fracture in the ASC, HOSP, and HOPD.

**Methods:** Retrospective review identified pediatric patients with isolated Gartland type II SCH fractures who had closed reduction and percutaneous pinning (CRPP) by board-certified orthopaedic surgeons from January 2012 to September 2016. On the basis of the location of their treatment, patients were divided into 3 groups: HOSP, HOPD, and ASC. All fractures were treated with CRPP under fluoroscopic guidance using 2 parallel or divergent smooth Kirschner wires. Radiographs obtained before and after CRPP and at final follow-up noted the anterior humeral line index (HLI) and Baumann angle. Statistical analysis compared all 3 groups for outcomes, complications, treatment time/efficiency, and charges.

**Results:** Record review identified 231 treated in HOSP, 35 in HOPD, and 50 in ASC. Radiographic outcomes in terms of Baumann angle and HLI did not differ significantly between the groups at any time point except preoperatively when the HLI for

the HOSP patients was lower ( $P=0.02$ ), indicating slightly greater displacement than the other groups. Overall complication rates were not significantly different among the groups, nor were occurrences of individual complications. The mean surgical time was significantly shorter ( $P<0.0001$ ) in ASC patients than in HOPD and HOSP patients, and total charges were significantly lower ( $P<0.001$ ).

**Conclusions:** Gartland type II SCH fractures can be safely treated in a freestanding ASC with excellent clinical and radiographic outcomes equal to those obtained in the HOSP and HOPD; treatment in the ASC also is more efficient and cost-effective.

**Level of Evidence:** Level III—retrospective comparative study.

**Key Words:** supracondylar fractures, pediatric patients, ambulatory surgery center, outcomes, complications, costs

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Over the past decade there has been a dramatic increase in the use of outpatient surgery and freestanding ambulatory surgical centers (ASC) in many specialties, including orthopaedic surgery.<sup>1,2</sup> Compared with those performed in a hospital (HOSP) or hospital outpatient department (HOPD), procedures performed in an ASC take less time, have equal or lower complication rates, are more cost-effective, and are preferred by patients and providers.<sup>1,3–7</sup> Outpatient treatment also minimizes some inherent risks of hospitalization, such as nosocomial infection.<sup>8</sup>

A number of reports have described the effectiveness of ASC-based orthopaedic procedures in adults,<sup>2–6,9–11</sup> including arthroscopy, total joint replacement, hand surgery, and anterior cruciate ligament reconstruction. However, despite an 88% increase in the number of pediatric fractures treated in ASCs over a 10-year period,<sup>12</sup> there are few studies comparing outcomes of pediatric orthopaedic fracture treatment performed in a freestanding ASC compared with those performed in the HOSP or HOPD. The purpose of this study was to compare clinical and radiographic outcomes, treatment times, and costs for treatment of Gartland type II supracondylar

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humeral (SCH) fracture in the ASC, HOSP, and HOPD. We chose Gartland type II SCH fractures because they are common,<sup>13</sup> are generally associated with good outcomes, have low complication rates, and can be safely treated in a delayed manner.<sup>14</sup>

## METHODS

Institutional Review Board (IRB) approval was obtained for a retrospective review of pediatric patients with isolated Gartland type II SCH fractures who had closed reduction and percutaneous pinning (CRPP) performed by board-certified orthopaedic surgeons from January 2012 to September 2016. All consecutive patients aged 2 to 14 years with complete radiographic records were included.

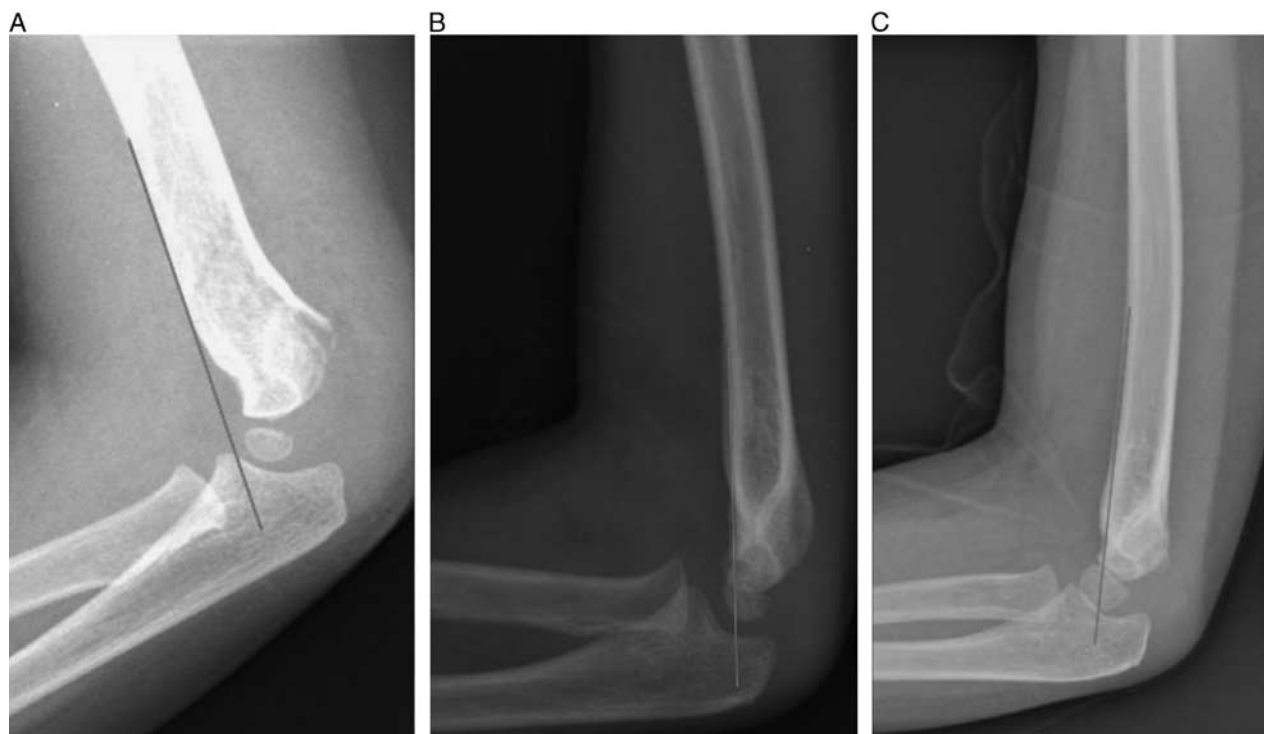
On the basis of the location of their treatment, patients were divided into 3 groups: HOSP, HOPD, and ASC. All HOSP and HOPD procedures were performed at a high-volume level 1 pediatric trauma center, and all ASC patients were treated at a high-volume orthopaedic-only freestanding facility. The ASC, of which the authors have ownership interest, runs from 6:30 AM until 5:00 PM weekdays. HOSP patients were admitted from the emergency room (ER) and treated as soon as the operating room (OR), which includes a dedicated orthopaedic trauma room, became available. Patients in HOPD and ASC groups were evaluated in the ER, discharged in a bivalved cast, and scheduled for elective CRPP. Patients in the HOSP and HOPD groups were treated in the same

operating suite, with the same nursing and anesthesia teams. The decision on treatment location was based on a variety of patient-specific factors including distance from the HOSP/ASC, number of facilities visited before evaluation in the ER, nil per os status, parental preference, and insurance type. The location of treatment was at the discretion of the attending surgeon.

Demographic information obtained included age, weight, height, sex, hand dominance, side of injury, and insurance status. Body mass index (BMI) percentiles relative to children of the same age and sex in the United States were determined using the SAS macro provided by the Centers for Disease Control and Prevention (CDC).<sup>15</sup> Radiographs obtained before and after CRPP and at final follow-up were reviewed, noting the anterior humeral line index (HLI) (Fig. 1) and Baumann angle. Complications, including pin-site infection, malunion, nerve palsy, and vascular injury were recorded.

All fractures were treated with CRPP under fluoroscopic guidance using 2 parallel or divergent smooth Kirschner wires. After pinning, patients were placed in long arm, bivalved casts and either discharged directly home (ASC and HOPD) or from the patient floor (HOSP) according to facility protocol.

Surgical time was defined as the time between the closed reduction maneuver to the time of cast application. Total facility time was the time patients were at the facility in which CRPP was performed. For HOSP patients this



**FIGURE 1.** The anterior humeral line index HLI, measured on a lateral radiograph, indicates the degree of capitellar displacement. A, 0 = humeral line is anterior to the capitellum. B, 1 = humeral line transects the anterior third of the capitellum. C, 2 = humeral line transects the middle third of the capitellum, with acceptable alignment defined as an HLI of 1 or 2. HLI indicates humeral line index.

was the difference between ER admission time and HOSP discharge time. For HOPD and ASC patients, this was time spent in ER (when available) plus the difference between facility arrival and discharge time. As many ASC patients came from other facilities where ER time was not available, a separate comparison excluding ER time was performed.

Charge data for each patient were obtained from the billing records of the surgeons and the corresponding facility. Surgeon fees were constant regardless of facility. Other fees included facility, laboratory/testing, radiology, and materials/implants. Because of the use of different providers at each facility, anesthesia professional fees were not included. All charges were reported in US dollars.

Statistical analysis consisted of comparison of all 3 groups for outcomes, complications, treatment time/efficiency, and charges. To eliminate the effect of overnight admission, a separate subgroup analysis was performed between HOPD and ASC. Surgical outcomes and complications were coded as dichotomous, and surgery duration, length of HOSP stay, and various charges were analyzed as continuous variables. Pearson  $\chi^2$  tests were used for comparing outcomes and complications, and nonparametric Mann-Whitney *U* test also was used, with a *P*-value of  $\leq 0.05$  considered statistically significant. Multiple comparisons were not adjusted.

### RESULTS

Record review identified 330 patients (330 fractures) of whom 14 (4.2%) were excluded because they had flexion type fractures. There were 231 (73%) HOSP patients, 35 (11%) HOPD patients, and 50 (16%) ASC patients. The mean age, sex, hand dominance, side of injury, and BMI percentile of the 3 groups were not significantly different ( $P > 0.05$ ), except for the insurance status ( $P = 0.01$ ) (Table 1). Radiographic outcomes in terms of Baumann angle and HLI did not differ significantly between the groups at any timepoint except preoperatively when the HLI for the HOSP patients was lower ( $P = 0.02$ ), indicating slightly greater displacement than the other groups (Table 1). Overall complication rates were not statistically different ( $P > 0.05$ ) among HOSP (0.9%), HOPD (0%), and ASC (2%) patients, nor were occurrences of individual complications ( $P > 0.05$ ) (Table 2).

The mean surgical time was significantly shorter ( $P < 0.0001$ ) in ASC patients than in HOPD and HOSP patients, and the mean total facility time was significantly longer ( $P < 0.0001$ ) for HOSP patients than for HOPD, and ASC patients. Mean total facility time without ER time also showed significant differences among the 3 groups. HOSP was the longest, followed by HOPD and ASC (Table 3).

There also were significant differences in total charges between the groups, with the ASC having significantly lower charges ( $P < 0.001$ ) than the HOPD or HOSP (Table 3). The mean ASC charges were 27% of the HOSP and 37% of the HOPD charges.

In the subgroup analysis of HOPD and ASC to exclude the effects of HOSP admission, we found no difference

TABLE 1. Patient Demographics

Factors	HOSP	HOPD	ASC	P	
				3-Group Analysis	Subgroup Analysis (HOPD vs. ASC)
Number	231	35	50		
Mean age (y)	5	4.2	5.4	0.06	<b>0.03</b>
Male	126	12	27		
Female	105	23	23		
$\chi^2$ of sex				0.08	0.07
Insurance status	231	35	50		
Public	124	19	17		
Private	87	13	32		
Uninsured	20	3	1		
$\chi^2$ of insurance status				<b>0.013</b>	<b>0.04</b>
Hand dominance	157	7	40		
Right	137	5	35		
Left	20	2	5		
$\chi^2$ of laterality				0.48	0.27
Side of injury	231	35	50		
Right	92	15	16		
Left	139	20	34		
$\chi^2$ of side of injury				0.52	0.31
Mean body mass index	59	47	55	0.18	0.29

ASC indicates ambulatory surgery center; HOPD, hospital outpatient department; HOSP, hospital inpatient.  
 Bold values means statistically significant ( $P < 0.05$ ).

in sex, hand dominance, side of injury, or BMI percentile ( $P > 0.05$ ), but age and insurance status were found to be significantly different ( $P = 0.03$  and  $0.04$ , respectively) (Table 1). We found no differences in complications or radiographic outcomes ( $P > 0.05$ ) (Table 2). ASC patients had significantly shorter mean surgical times, total facility times, and total facility times without ER time ( $P \leq 0.0001$ ) than HOPD patients, with significantly lower charges ( $P < 0.0001$ ) (Table 3).

### DISCUSSION

Increasing numbers of orthopaedic procedures are being performed in the outpatient setting because of increased efficiency, fewer complications, and lower costs;<sup>1-6,9,11,16</sup> however, very few reports describe outpatient pediatric orthopaedic procedures. Recent studies by Kadhim et al<sup>16</sup> and Patrick et al<sup>17</sup> found that pediatric anterior cruciate ligament reconstructions performed in the ASC had shorter OR times and were more efficient in terms of overall workflow than those performed in an inpatient setting.

To determine if these advantages were valid for fracture treatment in pediatric patients, we compared outcomes of SCH fractures in 3 groups of patients: those treated in an ASC, in a HOPD, and in a HOSP inpatient

**TABLE 2.** Radiographic Findings and Complications

Factors	HOSP	HOPD	ASC	P	
				3-Group Analysis	Subgroup Analysis (HOPD vs. ASC)
Number	231	35	50		
Preoperative radiographs					
BA <70 degrees	32	5	2		
BA ≥ 70 degrees	199	30	48		
χ <sup>2</sup> of BA				0.15	0.09
HLI-0	189	27	35		
HLI-1	42	7	15		
HLI-2	0	1	0		
χ <sup>2</sup> of HLI				0.0205	0.31
Postoperative radiographs					
BA <70 degrees	68	5	14		
BA ≥ 70 degrees	163	30	36		
χ <sup>2</sup> of BA				0.17	0.14
HLI-0	0	0	0		
HLI-1	193	30	36		
HLI-2	38	5	14		
χ <sup>2</sup> of HLI				0.13	0.14
Follow-up radiographs					
BA <70 degrees	64	14	21		
BA ≥ 70 degrees	167	21	29		
χ <sup>2</sup> of BA				0.07	0.85
HLI-0	5	1	1		
HLI-1	184	32	36		
HLI-2	42	2	13		
χ <sup>2</sup> of HLI				0.13	0.054
Complications					
P in-site infection	2 (0.9)	0	1	0.62	0.4
Malunion	0	0	0		
Nerve palsy	0	0	0		
Vascular injury	0	0	0		
Other	0	0	0		
Total complications (%)	4 (1.7)	0	1 (2)	0.72	0.4

ASC indicates ambulatory surgery center; BA, Baumann angle; HLI, humeral line index; HOPD, hospital outpatient department; HOSP, hospital inpatient.

setting. SCH fractures were chosen because they are the most common pediatric elbow fracture, and numerous studies have reported their treatment and outcomes, which generally are good. This study was limited to Gartland type II extension-type fractures because of their significantly lower rate of neurovascular injuries and complications compared with type III and flexion-type fractures.<sup>18</sup> In addition, Larson et al<sup>14</sup> has shown that

these fractures can be safely treated in a delayed manner. Our data confirm this: excellent radiographic outcomes and low complication rates were present at any time point, regardless of where the patient was treated.

In terms of efficiency, CRPP was 33% faster when performed in the ASC (20 min) than in the HOSP (30 min). The shorter surgical time in the ASC does not reflect the fact that easier cases were performed in the surgery center. That is one of the reasons we limited our study to type II SCH fractures.<sup>19</sup> Although the anterior humeral line index was lower in the HOSP group than the ASC group, this did not influence treatment location and, while these differences were statistically different, they were most likely not clinically relevant because type II fractures are treated the same way, regardless of the anterior humeral line index. This is consistent with other studies that have shown that procedures performed in orthopaedic-specific ASCs are faster for multiple reasons, including the development of highly specialized, experienced surgical teams with standardized workflows in the ASC compared with the HOSP.<sup>10,20</sup> The members of the surgical teams in the HOSP and HOPD groups had varying levels of orthopaedic experience and training, which may explain in part the faster time in the ASC. This increased efficiency led to less anesthesia exposure and a shorter period of time that the parents were away from the child.

Similar time savings in the ASC were seen in total facility time, although their magnitude was greater. We observed an ~15-hour decrease in total facility time between the HOSP and HOPD groups, which was expected given the fact that the HOSP time included time in the ER, admission to the HOSP, and waiting until an OR became available. By comparing HOPD to ASC times and eliminating those variables, we found a 62% shorter total treatment time in the ASC (4.6 h) compared with the HOPD (12 h). As ER time can vary widely and many ASC patients had missing ER time, total facility times without ER times were compared, which showed similar trends. HOSP total facility time without ER time was 14 hours longer than that of HOPD. Moreover, ASCs showed 66% shorter treatment time than HOPDs. The findings are similar to those of Merrill and Laur<sup>7</sup> and are most likely due to increased efficiencies in administrative functions, room turnover, and patient flow in a single-purpose ASC compared with a large institution such as a full service children's HOSP where more complex admission, documentation, care protocols, and patient flow may exist.<sup>7,16,20,21</sup>

**TABLE 3.** Times and Charges

Factors	HOSP	HOPD	ASC	P	
				3-Group Analysis	Subgroup Analysis (HOPD vs. ASC)
Surgery time (min)	30	29	20	<0.0001	<0.0001
Total facility time (h)	27	12	4.6	<0.0001	<0.0001
Total facility time without ER time (h)	24	10	3.4	<0.0001	<0.0001
Charge (US dollars)	\$17,705.15	\$13,148.33	\$4,843.76	<0.001	<0.0001

ASC indicates ambulatory surgery center; ER, emergency room; HOPD, hospital outpatient department; HOSP, hospital inpatient.

We found that, in terms of charges, this procedure in the ASC was 73% cheaper than in the HOSP and 63% cheaper than in the HOPD. These findings are similar to those in a study by the US Government Accountability Office in which they reported that procedures performed in an ASC cost 84% less than those performed in the HOPD setting.<sup>22</sup> The difference among the facilities is based solely on the facility costs, because the surgeon professional fees were the same at all locations. The dramatic savings of the ASC protocol compared with the HOSP is not surprising given the cost of admitting a patient to the HOSP before surgery, which at our facility averaged \$800 per night. The 63% difference between the HOPD and ASC is multifactorial and most likely reflects the decreased overhead and increased efficiencies associated with operating an ASC compared with an HOPD. Fabricant et al<sup>23</sup> recently reviewed 1021 primarily sports-related surgical procedures and found that cost savings ranged from 17% to 43% for 7 of 8 orthopaedic procedures performed in an ASC compared with HOSP. They found that 80% of the cost savings was due to faster surgical time (64 min/case), of which 73% was due to surgical factors and 20% due to supply utilization.

If the mean charges at the HOPD (\$13,148.33) are subtracted from the mean charges at the HOSP (\$17,705.15), the estimated mean charge difference (\$4,556.82) is related to the preoperative HOSP admission. Over this 4.75-year timeframe, if the 231 HOSP and 35 HOPD cases had been performed in the ASC, the charge savings would have been \$3.26 million dollars. We realize that it is not realistic to assume that all these patients, for a variety of factors, could be treated in the ASC; however, if 71 patients or ~one-third of the HOSP patients had been treated in the ASC, the charge savings would have been ~\$1 million. These findings correlate with the study by Raikin et al,<sup>24</sup> who stated that over \$367 million of excess charge occur annually in the United States due to routine HOSP admission of patients with ankle fractures. Because of the retrospective nature of this study, we had to use charge data rather than true cost, which may not reflect the exact amount paid by patients and third-party payers. Moreover, we were not able to calculate the indirect costs to families associated with increased facility time in the HOSP and HOPD groups. This must be considered because treatment in the HOPD or ASC does require a second trip to a facility for the CRPP to be performed, and this may not be cost and/or time effective if, for example, a patient lives several hours away from the treatment facility. Further prospective study is necessary to better understand these factors.

Another limitation of this study is the lack of randomization of the patients to each group. The ASC patients were slightly older (5.4 y) than those treated at HOPDs (4.2 y); however, this age difference was clinically irrelevant in terms of treatment and outcome. We also found that the fractures in the HOSP group had a slightly lower preoperative HLI (more angulated), which again is likely not clinically relevant since these were all type II fractures. The facility was chosen for factors unrelated to

the injury itself, including distance the family lived from the HOSP, number of health care providers seen before presentation, nil per os status at the time of evaluation at our center, OR availability and insurance status. In our state (Tennessee) there are multiple Medicaid plans, of which we accept the 2 largest by volume in our ASC. We do not accept the Medicaid plans in our ASC from the adjoining states (<30 min away) Mississippi and Arkansas, which most likely led to the significantly greater percentage of Medicaid patients being treated in the HOSP setting. In our analysis, most likely because of the nature of type II supracondylar fractures, there was no effect on outcomes based on insurance status. Further study is underway to develop an algorithm to determine the optimal treatment facility.

It is important to note that these findings are applicable to only type II SCH fractures, where generally good outcomes and low complication rates can be expected, and should not be extrapolated to all supracondylar fracture types. The treatment of a type III supracondylar fracture in an ASC, for example, must be carefully considered based on the higher risk of vascular injury that may require vascular repair, which could be difficult or impossible in an ASC. At our institution, type III supracondylar fractures, especially those with neurovascular compromise, are treated by the orthopaedic surgeon (board certified) on-call, who may not be a pediatric orthopaedic surgeon. Type II supracondylar fractures, such as in this study, are treated in a semiurgent manner by fellowship-trained board-certified pediatric orthopaedic surgeons, regardless of location.

Our study showed that Gartland type II SCH fractures can be safely treated in a freestanding ASC with excellent clinical and radiographic outcomes that are equal to those obtained in the HOSP and HOPD. In addition, treatment of these injuries in a freestanding ASC is faster and more cost-effective for patients, families, third-party payers, and health care systems. Further studies looking at different fracture types, as well as patient/family satisfaction scores and true direct and indirect costs, are necessary and underway. The treatment of each patient, however, should be based on his or her unique injury with a goal of providing the safest environment for obtaining the best possible outcome, regardless of speed and cost.

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