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Abstract

Background: It is not known if the adult literature on midshaft clavicle fracture treatment with open reduction internal fixation (ORIF) has influenced injury management in adolescents. **Purpose:** We sought to longitudinally evaluate the rates of operative management of adolescent midshaft clavicle fractures in the state of Florida. **Methods:** We conducted a retrospective review of data from the following Healthcare Cost and Utilization Project databases: the State Inpatient Database, the State Ambulatory Surgery and Services Database, and the State Emergency Department Database. Patients in Florida ages 10 to 18 years with midshaft clavicle fractures between 2005 and 2014 were identified along with data on age, sex, race/ethnicity, insurance type, treatment, and income percentile. We reviewed the data to identify trends in the rates of operative management of midshaft clavicle fractures. We then compared the rates of operative management between the first 3 years and the most recent 3 years (2005–2007 vs 2012–2014). Various demographic and socioeconomic factors were compared between patients treated with and without surgery. Descriptive statistics as well as univariate and multivariate analyses were performed. **Results:** There were 4297 midshaft clavicle fractures in adolescents identified between 2005 and 2014, and 338 (7.8%) of these fractures underwent operative management. There was a significant increase in the rate of operative management; it increased from 4.3% (n = 59) of the 1373 clavicle fractures that occurred between 2005 and 2007 to 11.2% (n = 130) of the 1164 clavicle fractures that occurred between 2012 and 2014. Patients with commercial insurance and patients who were older were more likely to undergo ORIF. Patients with Medicaid were more likely to undergo ORIF between 2012 and 2014 compared with patients with Medicaid between 2005 and 2007. **Conclusions:** Operative management rates of adolescent midshaft clavicle fractures have significantly increased in Florida over a decade; additional research is needed to understand these findings.

Keywords

adolescent, clavicle fracture, operative trends

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Introduction

Clavicle fractures represent up to 15% of fractures seen in the pediatric population, but treatment in adolescent patients remains controversial [2]. Historically, displaced closed midshaft clavicle fractures were treated with nonoperative management, such as a sling or a figure of 8 brace [11,15]. However, over the last 2 decades, evidence has emerged that suggests superior outcomes with open reduction internal fixation (ORIF) of displaced fractures [3,10,13]. Specifically, a study by the Canadian Orthopedic Trauma Society (COTS) showed fewer nonunions and improved patient-reported outcome measures (PROMs) in operatively managed midshaft clavicle fractures [3]. Although

this study significantly influenced recent clinical practice, it excluded patients younger than age 16.

To our knowledge, there are limited studies in the adolescent population with a similar level of evidence [4].

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Nonetheless, it has been suggested that orthopedic surgeons have changed their management of clavicle fractures in this population based on results reported in the adult literature [14,18]. The extent to which practice patterns and management of clavicle fractures in adolescents have changed over the past decade has yet to be investigated and quantified. It is also unknown if there are significant demographic or socioeconomic differences in adolescent patients treated with or without surgery.

The purpose of this study was to evaluate the rates of operative management of midshaft clavicle fractures in adolescent patients in Florida using a population database. In addition, this study aimed to identify differences in demographic and socioeconomic factors that may influence the decision to treat clavicle fractures with or without surgery. We hypothesized that the rate of operative management in adolescents has increased, similar to the trend seen in adults with midshaft clavicle fractures [16].

Methods

This study is a retrospective review of a population database. To determine rates of operative management of adolescent midshaft clavicle fractures, we conducted a review of the State Inpatient Database (SID), the State Ambulatory Surgery and Services Database (SASD), and the State Emergency Department Database (SEDD). These databases, maintained by Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality (AHRQ), provide publicly available all-payer statewide data related to inpatient discharge records, ambulatory surgery, and other outpatient services from hospital-owned facilities, as well as discharge information for hospital-affiliated emergency department visits that do not result in hospitalizations [5–9]. Data for this study were obtained from the Florida SID, SASD, and SEDD. This state was chosen due to the availability of data over consecutive years for all 3 databases. This study was exempt from Institutional Review Board oversight.

International Classification of Diseases, 9th Revision Clinical Modification (ICD-9 CM) diagnosis codes, and the Current Procedural Terminology (CPT) codes were used to identify adolescent patients with a midshaft clavicle fracture during the study period and to determine if the patient was treated operatively versus nonoperatively. This study included patients 10 to 18 years of age who had a midshaft clavicle fracture and underwent either an ORIF (ICD-9-CM 79.39 or CPT: 23515) or closed treatment (ICD-9-CM 810.02 or CPT: 23500) from January 1, 2005, to December 31, 2014. Patients with open midshaft clavicle fractures (ICD-9 code: 810.12, CPT codes 11010, 11011, 11012) were excluded. Data collected included age,

sex, race and ethnicity, payer source, income percentile, and type of health care facility.

We reviewed the data to identify any trends in the rates of operative management of midshaft clavicle fractures between 2005 and 2014. We then compared the rates of operative management between the oldest and most recent cohorts (2005–2007 vs 2012–2014). In addition, we compared factors between patients treated operatively and nonoperatively to identify any significant differences. Descriptive statistics were performed including *t* test and χ^2 analysis to determine statistical significance of operative and nonoperative management rates. Multivariate logistic regression was performed to determine variables associated with greater likelihood of surgical treatment [17]. A significance level of .05 was used to determine statistical significance. Bonferroni method was used to adjust for multiple comparisons to remove false positive results during multivariate analysis [1]. Statistical analysis was performed using SAS Studio statistical software and Microsoft Office Excel 2020.

Results

Overall, 4297 adolescent clavicle fractures were analyzed between 2005 and 2014. The study cohort consisted of 82.8% ($n = 3557$) male and 17.2% ($n = 740$) female patients, and the mean age at time of injury was 14.3 ± 2.3 years (range: 10–18 years). In total, 7.9% ($n = 338$) of adolescent patients underwent ORIF, and 92.1% ($n = 3959$) of patients were managed nonoperatively. During the study period, there was a significant increase in operative management; it increased from 4.3% ($n = 59$) of the 1373 clavicle fractures that occurred between 2005 and 2007 to 11.2% ($n = 130$) of the 1164 clavicle fractures that occurred between 2012 and 2014 ($P < .01$; Fig. 1).

Over the study period, there were significant differences in race and ethnicity, payer type, and age between patients who underwent operative and nonoperative management. Specifically, significantly more white patients underwent operative management than did patients who identified as black or Hispanic ($P < .01$), even after taking Florida's race and ethnicity demographics into account [18]. In addition, operatively treated patients more commonly had commercial insurance ($P < .01$) and were significantly older than patients treated nonoperatively (16.0 ± 1.7 vs 14.1 ± 2.3 years, $P < .01$; Table 1). There were no significant differences in sex, income percentile, or hospital type in patients treated with or without surgery ($P > .05$). In the multivariate analysis, increasing age and payer type remained significant. Specifically, increasing age by 1 year increased the odds of undergoing operative management by 54%, odds ratio (OR) = 1.54 (1.44–1.64), $P < .01$, and self-pay patients had significantly lower odds of undergoing operative

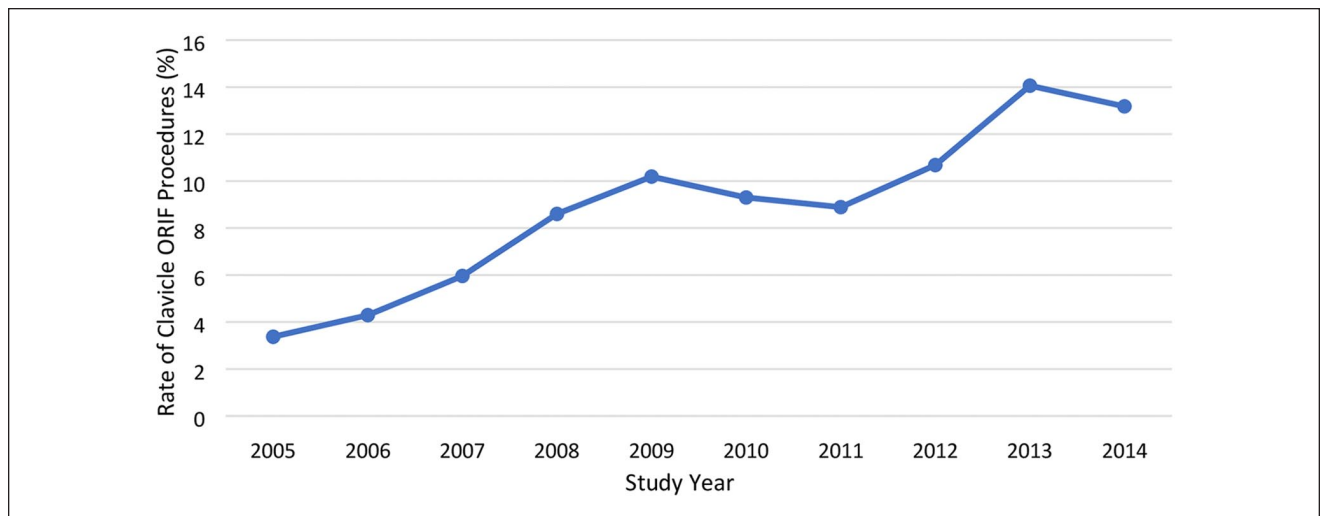


Fig. 1. Annual rate of adolescent clavicle fractures managed operatively from 2005 to 2014.

Table 1. Adolescent fracture cohort univariate analysis: surgery versus nonsurgery (2005–2014).

Predictor variables	Surgery		Nonsurgery		P
	Cohort proportion (%)	Cohort total (n)	Cohort proportion (%)	Cohort total (n)	
Sex					
Male	0.82	277	0.83	3280	.68
Female	0.18	61	0.17	679	
Race/ethnicity					
White	0.80	272	0.71	2801	<.01
Hispanic	0.13	43	0.16	642	
Black	0.07	23	0.13	516	
Payer type					
Commercial	0.62	209	0.47	1875	<.01
Medicaid	0.25	85	0.33	1299	
Self-pay	0.05	17	0.13	519	
Other	0.08	27	0.07	266	
Median income quartile (%)					
0–25th	0.21	71	0.24	946	.66
26th–50th	0.26	87	0.24	946	
51st–75th	0.23	78	0.23	891	
76th–100th	0.30	102	0.30	1176	
Hospital type					
Community	0.80	271	0.84	3320	.60
County	0.14	49	0.14	574	
Academic	0.05	18	0.04	165	
Age (years)					
Mean	16.0 ± 1.7	338	14.1 ± 2.3	3959	<.01

management compared with patients with commercial insurance, OR = 0.32 (0.19–0.53), $P < .01$ (Table 2). Similar trends were noted for patients who identified as

black and patients with Medicaid; however, these results did not remain significant after using the Bonferroni method adjusting for multiple comparisons.

Table 2. Adolescent fracture cohort multivariate analysis (2005–2014).

Predictor variables	Odds ratio	95% confidence intervals	P value
Sex			
Female vs male	1.05	0.77–1.42	.78
Race/ethnicity			
Hispanic vs white	0.79	0.55–1.12	.18
Black vs white	0.57	0.36–0.89	.02
Payer type			
Medicaid vs Commercial	0.71	0.53–0.95	.02
Self-pay vs Commercial	0.32	0.19–0.53	<.01
Other vs Commercial	1.04	0.66–1.62	.88
Median income quartile (%)			
0–25th vs 26th–50th	0.85	0.61–1.20	.36
51st–75th vs 26th–50th	1.02	0.73–1.42	.92
76th–100th vs 26th–50th	1.02	0.75–1.40	.89
Hospital type			
County vs community	0.87	0.63–1.22	.43
Academic vs community	0.98	0.58–1.67	.95
Age	1.54	1.44–1.64	<.01

Table 3. Adolescent fracture surgical subgroup univariate analysis (2005–2007 vs 2012–2014).

Predictor variables	2005–2007		2012–2014		P value
	Cohort proportion (%)	Cohort total (n)	Cohort proportion (%)	Cohort total (n)	
Sex					
Male	0.86	51	0.81	105	.34
Female	0.14	8	0.19	25	
Race/ethnicity					
White	0.83	49	0.72	94	.16
Hispanic	0.08	5	0.19	25	
Black	0.08	5	0.08	11	
Payer type					
Commercial	0.73	43	0.49	64	<.01
Medicaid	0.12	7	0.36	47	
Self-pay	0.07	4	0.02	3	
Other	0.08	5	0.12	16	
Median income quartile (%)					
0–25th	0.20	12	0.21	27	.48
26th–50th	0.34	20	0.25	33	
51st–75th	0.25	15	0.24	31	
76th–100th	0.20	12	0.30	39	
Hospital type					
Community	0.85	50	0.80	104	.71
County	0.12	7	0.15	19	
Academic	0.03	2	0.05	7	
Age					
Mean	16.2 ± 1.5	59	16.0 ± 1.7	130	.44

Subgroup univariate analysis for adolescents who underwent operative management between 2005 and 2007 ($n = 59$) and 2012 and 2014 ($n = 130$) demonstrated a significant difference in payer type. Specifically, there was a significant increase in the proportion of patients with

Medicaid insurance and a decrease in patients with commercial insurance treated with surgery between 2012 and 2014 compared with the previous cohort ($P < .01$; Table 3). This finding was significant in the multivariate analysis, as well, OR = 4.30 (1.71–10.82), $P < .01$ (Table 4).

Table 4. Adolescent fracture surgical subgroup multivariate analysis (2005–2007 vs 2012–2014).

Predictor variables	Odds ratio	95% confidence intervals	P value
Sex			
Female vs male	1.76	0.70–4.44	.23
Race/ethnicity			
Hispanic vs white	2.38	0.80–7.10	.12
Black vs white	1.07	0.29–3.98	.92
Payer type			
Medicaid vs Commercial	4.30	1.71–10.82	<.01
Self-pay vs Commercial	0.61	0.11–3.34	.57
Other vs Commercial	2.06	0.67–6.35	.21
Median income quartile (%)			
0–25th vs 26th–50th	1.40	0.54–3.64	.49
51st–75th vs 26th–50th	1.16	0.46–2.92	.75
76th–100th vs 26th–50th	1.73	0.68–4.40	.25
Hospital type			
County vs Community	1.78	0.65–4.85	.26
Academic vs Community	2.04	0.37–11.34	.41
Age	0.95	0.76–1.19	.64

Discussion

There is growing evidence supporting the superiority of operative management of displaced clavicle fractures in adults, but few studies investigate the rates and management of clavicle fractures in adolescent patients. In this study, we found a significant increase in the rate of operative management of clavicle fractures in adolescents in Florida between 2005 and 2014. Notably, rates of operative management significantly differed by patient age, patient race or ethnicity, and payer type. Specifically, operatively treated adolescents were more likely to be older, identify as white, and have commercial health insurance.

This study has several limitations. First, as a database study, radiographic parameters of injury, such as the degree of fracture displacement, were not included. However, this study identifies various demographic, socioeconomic, and geographic factors that are relevant to surgeons, researchers, and patients. Second, only Florida was included in the dataset, as data from other states up to 2015 were incomplete. This is comparable with previous studies that have used Florida as a comprehensive dataset. However, all institutions in Florida were included, which may improve the generalizability of our findings. Last, data since 2015 were not included due to incomplete data entry in HCUP. To our knowledge, this study covers the most recent operative trends in the management of adolescent clavicle fractures. Future studies are needed to validate these findings and further explore recent trends.

This increase in operative management in adolescent patients is similar to trends noted in adults. Schairer et al [16] found a 290% increase in operatively managed clavicle fractures in adults from 2005 to 2010 subsequent to the publication of the COTS study. In a multicenter study that

enrolled 545 pediatric patients from 2013 to 2016, Ellis et al [4] noted that 32% of all completely displaced clavicle fractures underwent ORIF. In an analysis of PearlDiver data, Yang et al [19] also found a nearly 2-fold increase in operatively managed adolescent clavicle fractures from 2007 to 2011. While the 127% increase in the number of cases in this study is not as high as previously reported, this is still a significant increase. In addition, our study includes data up to 2015, which may suggest that enthusiasm for operative management may have tapered. The overall trend is still significantly high, despite the lack of prospective comparison studies showing improved outcomes in adolescents [14].

To our knowledge, this is the first study to show significant demographic and socioeconomic differences in adolescent patients treated with and without surgery for clavicle fractures. However, the findings are consistent with previous studies that have shown that older patients are more likely to undergo ORIF and that these patients are also more likely to identify as white and have private insurance [16,18]. It has been hypothesized that the difference in the use of surgery could potentially stem from education level, availability of social resources, patient expectations, trust in providers, and referral patterns [19].

The increase in rates of operative management is partially explained by an increase in the number of patients with Medicaid who are now being treated with surgery. This finding likely reflects shifting provider opinion on how to treat displaced midshaft clavicle fractures. In general, previous studies have shown that patients with a higher socioeconomic level use operative management at a higher rate. For instance, in a cohort of 98,349 Swedish patients, Nordenvall et al [12] found that patients with high socioeconomic status were significantly more likely to undergo anterior cruciate ligament surgery. In our study, even though

patients with commercial insurance comprise the greatest proportion of those treated with surgery in 2005–2007 and 2012–2014, we also detected a significant increase in the proportion of patients with Medicaid insurance treated with surgery over time. Controlling for other factors, this finding suggests a paradigm shift in provider opinion favoring operative management for adolescent patients.

Few studies have compared outcomes after operative and nonoperative treatment of midshaft clavicle fractures in adolescents, but there remains a trend toward operative management. We found that rates of operative management of adolescents with midshaft clavicle fractures in Florida differed significantly based on patient age, patient race or ethnicity, and payer type. Additional studies are needed to investigate and justify the increase in rates of operative management of midshaft clavicle fractures in adolescents, as well as explore the disparities in health care use and management.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Ishaan Swarup, MD, reports a relationship with Orthopediatrics Consulting, outside the submitted work. The other authors declared no potential conflicts of interest.

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Human/Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent

Informed consent was waived from all patients included in this study.

Level of Evidence

Level III, retrospective database review.

Required Author Forms

Disclosure forms provided by the authors are available with the online version of this article as supplemental material.

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