

# Incidence of Readmission Following Pediatric Hand Surgery: An Analysis of 6600 Patients

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## Abstract

**Background.** Quality in surgical outcomes is frequently assessed by the 30-day readmission rate. There are limited data available in the published literature regarding readmission rates following pediatric hand surgery. This study aims to identify factors associated with an increased risk of readmission following hand surgery in a pediatric population.

**Methods.** The 2012-2017 National Surgical Quality Improvement Project – Pediatric (NSQIP-P) databases were queried for pediatric patients who underwent procedures with hand-specific current procedural terminology (CPT) codes. The primary outcome was readmission.

**Results.** A total of 6600 pediatric patients were identified and included in the analysis. There were 45 patients who were readmitted in the study cohort, giving an overall readmission rate of 0.68%. The median time to readmission was 12 (IQR 5-20) days. On univariate analysis, factors associated with readmission included younger age, smaller size, prematurity, higher American Society of Anesthesiologists (ASA) class, inpatient admission at index operation, and longer anesthesia and operative times. Complex syndactyly repair was also associated with higher readmission rates. On multivariate analysis, ASA class 3 or 4 and inpatient surgery remained significant predictors of readmission.

**Conclusions.** Overall, pediatric hand surgery is associated with a very low risk of 30-day readmission. Higher ASA class and inpatient surgery increase patients' risk for readmission. In particular, complex syndactyly repair is associated with a higher risk of readmission than other hand procedures. This information is useful in surgical planning and preoperative counseling of parents.

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**Keywords:** quality improvement; pediatric hand surgery; readmission

## Introduction

There has been increasing pressure on health care entities to demonstrate quality of care. The 30-day readmission rate following a surgical procedure has been identified as an important surrogate for health care quality. Consequently, understanding risks associated with readmission is relevant for patient counseling, risk stratification, and risk reduction. The Centers for Medicare & Medicaid services implemented a Hospital Readmissions Reduction Program in 2012, assigning a ratio to “standardize” unplanned readmissions and compare hospitals using this metric.<sup>1</sup> Whereas adult hand surgery has been associated with a low readmission rate, few studies address the risk factors for readmission in the pediatric population.<sup>2-7</sup>

The American College of Surgeons (ACS) National Surgical Quality Improvement Program – Pediatric (NSQIP-P) main-

tains a prospective database from 50 children's hospitals in the United States. These databases have been used to assess 30-day complications and readmissions in multiple disciplines within pediatric surgery.<sup>8-14</sup> An analysis of the NSQIP-P database is able to provide more complete data regarding readmissions following pediatric hand procedures.

This study aims to identify factors associated with an increased risk of 30-day readmission following hand surgery in the pediatric population. Our hypothesis is that pediatric hand procedures are safe procedures with low readmission rates.

## Methods and Materials

The ACS NSQIP-P databases are a case-mix-adjusted repository of pediatric surgical cases from a variety of subspecialties that contain aggregate data on 30-day complications following

TABLE 1. PATIENT DEMOGRAPHICS

Variable, no. (%)	All patients (N = 6600)	Readmission		
		No (n = 6555)	Yes (n = 45)	P value
No. of patients	6600 (100)	6555 (99.3)	45 (0.7)	-
Male sex	3730 (56.5)	3702 (99.2)	28 (0.8)	.44
Race/ethnicity				.29
White	3465 (52.5)	3441 (99.3)	24 (0.7)	
Black	952 (14.4)	944 (99.2)	8 (0.8)	
Hispanic	932 (14.1)	922 (98.9)	10 (1.1)	
Asian	297 (4.5)	296 (99.7)	1 (0.3)	
Other	46 (0.7)	46 (100)	0 (0)	
Unknown/not reported	908 (13.8)	906 (99.8)	2 (0.2)	
Age, mean $\pm$ SD, months	38.4 $\pm$ 36.2	38.4 $\pm$ 36.2	31.9 $\pm$ 34.4	.04
Weight, mean $\pm$ SD, lbs	34.6 $\pm$ 24.6	34.6 $\pm$ 24.6	30.3 $\pm$ 20.4	.01
Preterm				<.01
Yes	507 (7.7)	498 (98.2)	9 (1.8)	
No	5160 (78.2)	5127 (99.4)	33 (0.6)	
Not reported	933 (14.1)	930 (99.7)	3 (0.3)	
ASA class				<.001
I	4368 (66.2)	4351 (99.6)	17 (0.4)	
II	1910 (28.9)	1893 (99.1)	17 (0.9)	
III	309 (4.7)	300 (97.1)	9 (2.9)	
IV	13 (0.2)	11 (84.6)	2 (15.4)	

lbs, pounds; ASA, American Society of Anesthesiologists Physical Status

surgical procedures for pediatric patients (ages 0-18 years). Data are abstracted by trained surgical clinical reviewers from more than 50 participating children's hospitals, and outcomes are assessed for 30 days following the procedure. Data acquisition and maintenance have been described in detail elsewhere.<sup>15</sup> The ACS NSQIP-P is a de-identified database compliant with the Health Insurance Portability and Accountability Act (HIPAA) and is therefore exempt from institutional review board review.

The 2012-2017 NSQIP-P databases were queried for pediatric patients who underwent procedures with hand-specific Current Procedural Terminology (CPT) codes. CPT codes 26010-26989 are associated with procedures on the hand and fingers and were queried in the NSQIP-P databases. Within this range referring to hand-specific procedures, 6 codes were identified in the databases. Patient demographics, operative details, readmission, and complication data were extracted. Variables assessed included sex, race, age, weight, gestational age at birth, American Society of Anesthesiologists (ASA) classification, inpatient or outpatient surgery, emergent or

elective surgery, specialty performing the surgery, wound classification, anesthesia and operative times, any unplanned readmission, time to readmission, reason for readmission, reoperation, the presence of any complication, and wound complication. Incomplete charts (those not containing weight or ASA classification) were excluded. ASA classification was used as a surrogate for medical comorbidities.

The primary outcome assessed was unplanned readmission. Secondary outcomes included reasons for readmission and wound complications. Univariate analyses were performed using Fisher's exact test, Wilcoxon rank-sum test, Chi-square, and analysis of variance as appropriate to assess the incidence and risk factors for readmission. Variables significant at a level of  $P < .20$  were used to create a bidirectional, stepwise logistic regression model. Secondary outcomes were assessed with univariate analyses only. Statistical analysis was performed using STATA version 14 (College Station, TX). Statistical significance was defined as  $P < .05$ .

TABLE 2. OPERATIVE DETAILS\*

Variable, no. (%)	All patients (N = 6600)	Readmission		P value
		No (n = 6555)	Yes (n = 45)	
<b>CPT code</b>				<.01
Tendon sheath incision (26055)	3139 (47.6)	3128 (99.6)	11 (0.4)	
Syndactyly repair with flaps (26560)	265 (4.0)	264 (99.6)	1 (0.4)	
Syndactyly repair with flaps and grafts (26561)	1013 (15.3)	1001 (98.8)	12 (1.2)	
Complex syndactyly repair (26562)	298 (4.5)	293 (98.3)	5 (1.7)	
Polydactyly repair (26587)	1735 (26.3)	1719 (99.1)	16 (0.9)	
Phalangeal fracture treatment (26727)	150 (2.3)	150 (100)	0 (0)	
<b>Hospital setting</b>				<.01
Inpatient	240 (3.6)	231 (96.3)	9 (3.7)	
Outpatient	6360 (96.4)	6324 (99.4)	36 (0.6)	
<b>Case type</b>				1
Elective	6557 (99.3)	6512 (99.3)	45 (0.7)	
Emergent	23 (0.3)	23 (100)	0 (0)	
Urgent	20 (0.3)	20 (100)	0 (0)	
<b>Surgical specialty</b>				.27
Orthopedic surgery	4271 (64.7)	4246 (99.4)	25 (0.6)	
Plastic surgery	2195 (33.3)	2175 (99.1)	20 (0.9)	
Other surgical specialty	134 (2)	134 (100)	0 (0)	
<b>Wound class</b>				.59
Clean	6472 (98.1)	6428 (99.3)	44 (0.7)	
Clean/contaminated	116 (1.8)	115 (99.1)	1 (0.9)	
Contaminated	10 (0.2)	10 (100)	0 (0)	
Dirty	2 (<0.1)	2 (100)	0 (0)	
<b>Anesthesia time, mean ± SD, minutes</b>	100.3 ± 77.6	99.9 ± 77.2	158.3 ± 109.9	<.01
<b>Operative time, mean ± SD, minutes</b>	57.9 ± 63.2	57.5 ± 62.8	106.2 ± 96.3	<.01

## Results

In the 2012-2017 databases, there were 6688 patients who underwent hand-specific procedures. Eighty-eight patients were excluded for incomplete data, leaving 6600 patients available for analysis. The characteristics of the cohort are shown in **Table 1**. Of the 181 procedural codes that were reported by the NSQIP-P, 6 hand-specific CPT codes were identified as the primary billing procedure (**Table 2**), including “tendon sheath incision” (26055), “syndactyly repair with flaps” (26560), “syndactyly repair with flaps and grafts” (26561), “complex syndactyly repair” (26562), “polydactyly repair” (26587), and “phalangeal fracture treatment” (26727). The most performed hand procedure was “tendon sheath incision” (26055), which accounted for 47.6% of procedures, followed by “polydactyly repair” (26587), which accounted for

26.3% of the procedures. Of the patients undergoing hand procedures, 64.7% received their care by Orthopedic Surgery, with Plastic Surgery and “Other” surgical specialty accounting for 33.3% and 2% of cases, respectively.

Of the study cohort, 45 were readmitted, giving an overall readmission rate of 0.68%. The median time to readmission was 12 days. On univariate analysis (**Table 1**), patient factors that were associated with readmission included younger age (31.9 vs 38.4 months,  $P = .04$ ), smaller size (30.3 vs 34.6 pounds,  $P = .01$ ), prematurity (20.0% vs 7.6%,  $P < .01$ ), and an ASA class of 2 or greater ( $P < .01$ ). Significant operative factors (**Table 2**) included inpatient admission at index operation (20.0% vs 3.5%,  $P < .01$ ) and longer anesthesia (158.3 vs 99.9 minutes,  $P < .01$ ) and operative times (106.2 vs 57.5 minutes,  $P < .01$ ). CPT code was identified on initial frequency testing to be significantly associated

**TABLE 3. MULTIVARIATE ANALYSIS\***

	Odds ratio	95% confidence interval	P value
<b>Preterm birth</b>			
No	Ref	Ref	Ref
Yes	2.18	0.96-4.51	<.05
Unknown	0.62	0.15-1.76	.44
<b>ASA class</b>			
I	Ref	Ref	Ref
II	1.70	0.84-3.45	.13
III	3.95	1.57-9.34	<.01
IV	25.80	3.47-118.14	<.01
<b>Hospital setting</b>			
Outpatient	Ref	Ref	Ref
Inpatient	2.95	1.19-6.68	.01
<b>Operative time</b>	1.00	1.00-1.01	.02

Ref, referent group  
 \*Based on a bidirectional, step-wise logistic regression model, 6600 patients with complete data, using univariate variables significant at a level of  $P < 0.20$

**TABLE 4. READMISSION ANALYSIS\***

Variable, no. (%)	
<b>Unplanned readmission</b>	
Yes	40 (88.9)
No	5 (11.1)
<b>Time to readmission, median (IQR), days</b>	12 (5, 20)
<b>Related readmission</b>	
Yes	16 (35.6)
No	24 (53.3)
Not reported	5 (11.1)
<b>Suspected reason for Readmission</b>	
Superficial incisional SSI	6 (13.3)
Wound disruption	2 (4.4)
Bleeding requiring transfusion	1 (2.2)
Pneumonia	1 (2.2)
Other ICD code	6 (13.3)
Not reported	29 (64.4)

with readmission ( $P < .01$ ); however, post-hoc analysis failed to demonstrate significant differences on pairwise comparisons.

On multivariate analysis (**Table 3**), patient level factors associated with readmission included ASA class 3 (OR 3.95, 95% CI 1.57-9.34) or class 4 (OR 25.80, 95% CI 3.47-118.14) and prematurity (OR 2.18, 95% CI 0.96-4.51). Inpatient surgery had an odds ratio of being readmitted of 2.95 (95% CI 1.19-6.68). Increased operative time had a statistically significant but clinically unimportant effect on the odds of being readmitted (OR 1.00, 95% CI 1.00-1.01).

The NSQIP-P databases capture the reported reasons for readmission (**Table 4**). “Unplanned readmission” accounted for 40 of the 45 (88.9%) readmissions. Among patients who were readmitted, 16 (35.6%) were readmitted for a reason related to the prior surgery, including 8 related to a wound complication and 1 for significant bleeding. Increased anesthesia time was a significant predictor of reoperation (100.2 vs 142.8 minutes,  $P = .03$ ).

Significant predictors of wound complications are reported in **Table 5**. One hundred twenty-four (1.9%) patients experienced a wound complication. The procedure most associated with wound complications was “complex syndactyly repair” (26562, 4.7%), and the least associated procedure was “phalangeal fracture treatment” (26727, 0.7%). The significant patient factors that predicted wound complications included younger age (28.9 vs 38.5 months,  $P < .01$ ) and lower weight (29.4 vs 34.6 pounds,  $P < .01$ ). Increased anesthesia and operative times were also associated with readmission (124.6 vs 99.8 min,  $P < .01$ ; 80.8 vs 57.4 min,  $P <$

.01, respectively). Six (4.8%) patients with a wound complication required reoperation.

## Discussion

This study leverages 6 years of multi-institutional, aggregated data of 6600 patients from the NSQIP-P to quantify the risk of readmission for pediatric hand surgery. Overall, we found a 0.68% readmission rate. Pediatric hand surgery, for both congenital and traumatic indications, is safe and associated with a very low risk of 30-day readmission and a low complication profile.

The ACS NSQIP-P was piloted in 2008 and now collects 94 data points for 30-day outcomes for most pediatric surgical subspecialties.<sup>15</sup> Several publications have used the adult or pediatric NSQIP database to assess 30-day outcomes within hand surgery, which are summarized in **Table 6**. Three prior studies have assessed the readmission and complication rates of pediatric patients undergoing upper extremity surgery. Thibaudeau and colleagues<sup>16</sup> queried the 2012-2014 NSQIP-P databases for all upper extremity procedures and found a 0.78% readmission rate. McQuillan and colleagues<sup>17</sup> examined the same databases for procedures related to congenital hand differences and found a readmission rate of 0.30%. That group furthermore described an increased risk of complications among patients undergoing “Repair of syndactyly each web space; complex, involving bone, nails, etc” (CPT code 25452).<sup>17</sup> This outcome mirrors the finding in our study, with procedures associated with this CPT code result in higher rates of readmission. Chouairi et al<sup>18</sup> assessed CPT codes related to syndactyly reconstruction specifically, using

TABLE 5. WOUND COMPLICATIONS

Variable, no. (%)	All patients (N = 6600)	Wound Complication		P value
		No (n = 6476)	Yes (n = 124)	
No. of patients	6600 (100)	6476 (98.1)	124 (1.9)	-
Wound complication				-
Superficial incisional SSI	80 (1.2)	-	80 (64.5)	
Deep incisional SSI	5 (<0.1)	-	5 (4.0)	
Superficial wound disruption/dehiscence	43 (0.7)	-	43 (34.7)	
Age, mean ± SD, months	38.4 ± 36.2	38.5 ± 36.3	28.9 ± 27.8	<.01
Weight, mean ± SD, lbs	34.6 ± 24.6	34.6 ± 24.7	29.4 ± 17.2	<.01
Preterm				.04
Yes	507 (7.7)	420 (82.8)	87 (17.2)	
No	5160 (78.2)	5150 (99.8)	10 (0.2)	
Not reported	933 (14.1)	906 (97.1)	27 (2.9)	
Current procedural terminology code				<.01
26055	3139 (47.6)	3100 (98.8)	39 (1.2)	
26560	265 (4.0)	255 (96.2)	10 (3.8)	
26561	1013 (15.3)	986 (97.3)	27 (2.7)	
26562	298 (4.5)	284 (95.3)	14 (4.7)	
26587	1735 (26.3)	1702 (98.1)	33 (1.9)	
26727	150 (2.3)	149 (99.3)	1 (0.7)	
Hospital setting				<.01
Inpatient	240 (3.6)	227 (94.6)	13 (5.4)	
Outpatient	6360 (96.4)	6249 (98.3)	111 (1.7)	
Anesthesia Time, mean ± SD, minutes	100.3 ± 77.6	99.8 ± 77.3	124.6 ± 87.6	<.01
Operative Time, mean ± SD, minutes	57.9 ± 63.2	57.4 ± 62.9	80.8 ± 75.7	<.01
Reoperation	14 (0.2)	8 (57.1)	6 (42.9)	<.01

the 2012-2016 databases. In addition to comparing complication rates between simple and complex syndactyly, they published readmission rates of 0.8% and 2.1%, respectively.<sup>18</sup> The overwhelming majority of complications in this study were related to surgical site complications. Our study adds to these previous studies the combined experience of traumatic and congenital hand surgeries over 6 years. Overall, the reported rates of readmission are low, and pediatric hand surgery remains very safe. However, future quality improvement efforts should be aimed at decreased surgical site complications.

The findings of the present study compare favorably with similar studies conducted using the adult NSQIP databases.<sup>2-7</sup> Two studies have looked at hand-specific CPT codes in adults using the 2006-2011 and 2011-2014 NSQIP databases.<sup>2,4</sup> Between 2006 and 2011, the adult NSQIP databases included 10 646 patients; however, the overall readmission rate was not reported. Subse-

quently, the 2011-2014 databases included 23 613 patients who underwent outpatient hand surgery, with a 0.88% readmission rate.<sup>2</sup> The 2011-2015 study found that patient medical factors contributed significantly to the risk of readmission, similar to findings in the pediatric population. Noureldin et al<sup>5</sup> conducted a similar study looking at unplanned readmissions for hand- and elbow-specific CPT codes and found a 1.2% unplanned readmission rate. The readmitted patients were more likely higher ASA class and a lower preoperative functional status.<sup>5</sup> Several studies have assessed the safety of specific procedures within upper extremity surgery. Studies on peripheral nerve surgery and corrective osteotomies of the forearm demonstrate readmission rates around 2%.<sup>3,7</sup> Recently, Shah and colleagues<sup>6</sup> assessed 11 years' worth of carpometacarpal arthroplasty cases and demonstrated a far lower readmission rate of 0.27%.

The present study identified several specific factors that

TABLE 6. NATIONAL SURGICAL QUALITY IMPROVEMENT PROJECT STUDIES

	NSQIP-P years	Inclusion	Patients	Readmission rate	Publication year	Number of CPT codes
<b>Pediatric</b>						
Chouairi	2012-2016	Syndactyly CPTs	956		2019	3
Goodenough	2012-2017	Hand-specific CPTs	6600	0.68%	2020	6
McQuillan	2012-2014	Congenital hand cases	1656	0.30%	2017	4
Thibaudeau	2012-2014	All upper extremity procedures	12459	0.78%	2016	7
<b>Adult</b>						
Donato	2011-2014	Hand-specific CPTs	23613	0.88%	2017	208
Hu	2005-2014	Peripheral nerve surgery	2351	1.95%	2016	
Lipira	2006-2011	Hand-specific CPTs	10646		2015	208
Noureldin	2012-2013	Hand- and elbow-specific CPTs	14106	1.20%	2017	407
Shah	2005-2015	CMC arthroplasty	3344	0.27%	2019	
Shrouder-Henry	2005-2013	Corrective osteotomy of ulna or radius	362	2%	2019	

NSQIP- P, National Surgical Quality Improvement Program – Pediatric

were associated with readmission. The collective NSQIP-P data suggests an increased complication profile associated with complex syndactyly repair. The hallmark of complex syndactyly is abnormal skeletal or cartilaginous attachments, most commonly manifested as side-to-side fusion at the distal phalangeal tuft. These abnormalities also correlate with anomalies of the neurovascular bundles, placing these structures at risk during reconstruction.<sup>19</sup> In addition, syndromic patients who can have higher anesthetic and perioperative risks may fall under this CPT code. Additionally, surgeries associated with an inpatient stay were 3 times more likely to be readmitted. McQuillan et al's study<sup>17</sup> focused specifically on congenital hand differences and did not find an association between admission status and subsequent readmission. This difference in these findings may be accounted for by the addition of patients undergoing tendon sheath incision and fracture fixation, which together constituted 49.9% of the present cohort. With respect to trauma specifically, some literature suggests that pediatric hand trauma in general is associated with a higher complication rate, but the collective administrative data in the NSQIP-P databases suggests that treatment of pediatric hand trauma is very safe.<sup>20</sup> In addition, case urgency was not associated with readmission. Finally, the findings of this multivariate model support the idea that the overall health of a child is a better predictor of readmission than the surgery itself.

The NSQIP-P databases solicits comments regarding the association between a procedure and subsequent readmission, although this information is variably available. In the present

cohort, the readmission was considered to be related to the prior procedure about half of the time, with the other half representing medical problems unrelated to surgery. This finding suggests that readmissions due to technical or wound complications are exceptionally rare in pediatric hand surgery. Among the stated reasons for readmission, surgical site infection (SSI) was the most frequently cited. The present study revealed wound complications as the main surgical cause for readmission in the pediatric hand population, consistent with other studies in both pediatric and adult upper extremity surgery.<sup>2</sup> Specifically, variables suggestive of more significant medical problems, such as readmission, were all factors contributing to an increased risk of SSI.

## Limitations

This study was limited by several factors. Many of the readmission statistics did not include the reason for readmission, which would have offered more insight into risk factors of readmission. Also, the low readmission rate resulted in a small sample size from which to glean information regarding complications, limiting the ability to correlate readmission and complications with potential causes. In addition, the NSQIP-P database has been criticized for inaccurate data extraction when compared with departmentally collected data.<sup>21</sup> Finally, retrospective, administrative data have inherent limitations when applied to clinical outcomes, as they lack granularity to assess patients at a detailed level. Future studies may include prospective examination of the impact of tourniquet use and wound care education interventions in the postoperative period.

## Conclusions

Overall, pediatric hand surgery is associated with a very low rate of 30-day readmission. Higher ASA class and inpatient surgery increase this rate for patients. Complex syndactyly repair is associated with a higher risk of readmission than other hand procedures. This information is useful for surgical planning, postoperative care and appointments, preoperative optimization of expectations, counseling of parents, and nutritional optimization of the pediatric patient.

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