Original Clinical Article

JOURNAL OF CHILDREN'S ORTHOPAEDICS

Journal of Children's Orthopaedics
2022, Vol. 16(2) 104–110

DOI: 10.1177/18632521221087174
journals.sagepub.com/home/cho

Anxiety surrounding supracondylar humerus pin removal in children

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Abstract

Purpose: The purpose of this study was to quantify the anxiety experienced by patients undergoing pin removal in clinic following closed reduction and percutaneous pinning for supracondylar humerus fractures.

Methods: We prospectively enrolled 53 patients (3–8 years) treated for supracondylar humerus fracture with closed reduction and percutaneous pinning between July 2018 and February 2020. Demographic and injury data were recorded. Heart rate and the Face, Legs, Activity, Cry, and Consolability scale were measured immediately before pin removal and after pin removal, and crossover control values were obtained at the subsequent follow-up clinic visit.

Results: All patients experienced anxiety immediately prior to pin removal (95% confidence interval, 94%–100%) with a median Face, Legs, Activity, Cry, and Consolability score of 7 (interquartile range, 6–8). In addition, 98% of subjects experienced an elevated heart rate (95% confidence interval, 88%–100%). Patients experienced a median 73% reduction in Face, Legs, Activity, Cry, and Consolability score and mean 21% reduction in heart rate from prior to pin removal to after pin removal ($p < 0.001$). All 45 patients who completed their follow-up visit had a control Face, Legs, Activity, Cry, and Consolability score of 0 and a mean control heart rate of 89.7 bpm. Twenty-five of these 45 subjects (56%) had an elevated control heart rate for their age and sex. Mean heart rate prior to pin removal was 36% higher than control heart rate. There were no sex differences detected in Face, Legs, Activity, Cry, and Consolability scores or heart rate.

Conclusions: Pediatric patients experience high levels of anxiety when undergoing pin removal following closed reduction and percutaneous pinning for supracondylar humerus fractures. This is an area of clinical practice where intervention may be warranted to decrease patient anxiety.

Level of evidence: II

Keywords: Pin removal, anxiety, supracondylar, pediatrics, heart rate, Face, Legs, Activity, Cry, and Consolability, fracture, trauma, implant

Introduction

Supracondylar humerus (SCH) fractures are one of the most common pediatric injuries.[1–5] These fractures are reported as the second most common pediatric fracture, constituting about 18% of all pediatric fractures and approximately 60% of all elbow fractures.[1,3,5] The median age of injury is between 3 and 8 years old, peaking at 5–6 years old.[1,3] The widely accepted treatment for displaced SCH fractures is closed reduction and percutaneous pinning (CRPP),[4,6–10] using stainless steel pins that are left exposed out of the skin, with pin removal occurring 3–4 weeks post-surgery in outpatient clinics.[11]

To our knowledge, no studies have quantified a patient's physiological and behavioral response during the pin removal procedure in clinic. However, there have been several in-depth investigations of these responses during cast removal procedures, where heart rate (HR) is used as a psychological indicator of anxiety.[12–14] In 1997, Merkel et al.[15] developed the Face, Legs, Activity, Cry, and

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Date received: 13 January 2022; accepted: 19 February 2022

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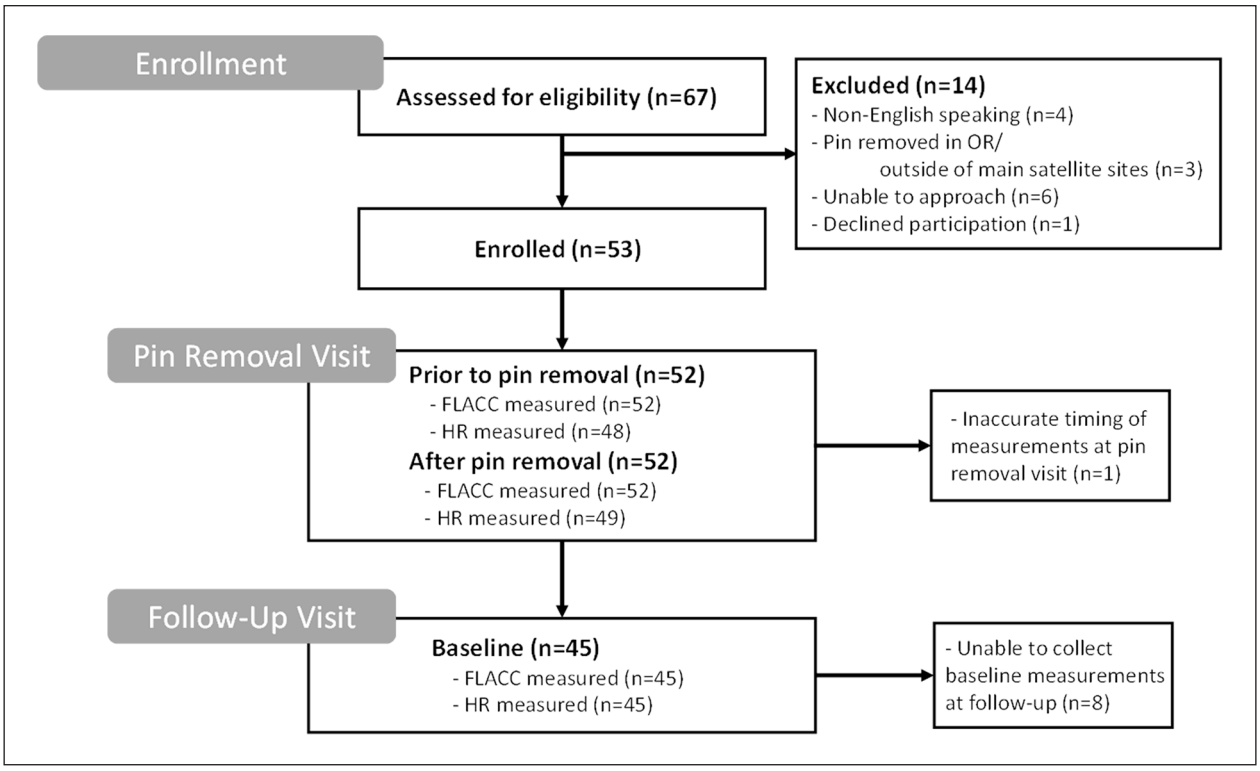

Figure 1. Consort diagram detailing enrollment and collected patient measures.

Consolability (FLACC) scale that resulted in a valid and reliable tool now in wide use to quantify pain behaviors in children. The FLACC scale is also sensitive to non-painful medical management (i.e. during the non-painful restraint phase prior to nasogastric tube insertion), and thus, it can be considered a composite of pain and distress (anxiety).[16] This scale has been used as a behavioral measure during a study examining anxiety during cast removal.[14]

Anxiety in the medical setting has been linked to future adverse effects for children.[17–19] Previous publications have shown that patients with anxiety in the perioperative setting have increased postoperative pain, maladaptive behavior, and long-term anxiety with future medical visits.[17,18] Preoperative anxiety in children also has been reported to have similar negative effects on behavior.[20,21] It is plausible that an anxiety-provoking procedure, such as pin removal, would have similar effects.

The primary purpose of this study was to quantify anxiety experienced by patients undergoing non-anesthetic and non-analgesic pin removal in clinic following CRPP for SCH fractures. Our secondary aim was to determine whether there were any differences in the proportion of patients experiencing an anxiety response across age and sex. We hypothesized that greater than 75% of patients would experience an anxiety response when undergoing pin removal and that younger patients would have higher levels of anxiety. We did not expect to detect any differences between sexes.

Methods

After institutional review board's approval, we prospectively screened all patients between 3 and 8 years old who presented to our tertiary children's hospital with a displaced SCH fractures. Sixty-seven patients presented to our hospital between 24 July 2018 and 29 February 2020, and received CRPP treatment for an SCH fracture by the five physician co-investigators. Fourteen of these patients were excluded because they either had non-English-speaking parents (4), documented history of an anxiety disorder, pins removed in the operative room (1) or at an outpatient clinic outside of our two main satellite sites (2), missed during the screening process or a researcher was not present to consent (5), restricted research operations due to the Covid-19 pandemic (1), or declined participation (1). A total of 53 patients were consented to participate in this study (Figure 1). Demographic (age at pin removal, sex, height, weight, race, and hand dominance) and injury (laterality, mechanism of injury) data were recorded from patients' medical records.

On the day of the pin removal, patients first presented to the cast room for cast removal. Radiographs were obtained out of cast to confirm proper healing and then patients were seen by the provider in our orthopedic clinic for pin removal. Patient HR was used as a physiological correlate of anxiety,[12–14] while FLACC score was used as a behavioral correlate of anxiety.[16] The FLACC

score is measured by observing a patient's facial expression, leg movements, crying severity, and effort needed to console the patient on a scale from 0 to 2.[15,16] The sum of these five scores generate a total score ranging from 0 to 10 (0 = no pain/anxiety and 10 = maximum pain/anxiety).[15,16] For example, a patient with an FLACC score of 2 may have grimaced and whimpered before the pin removal, but laid quietly, with their legs relaxed, and required no touching or hugging from a guardian. A patient with an FLACC score of 7 may have had a quivering chin, sobbed, had tense leg and body movements, but required no touching or hugging from a guardian. HR, via a pulse oximeter, and FLACC scores were collected by the research staff immediately prior to the first pin being removed and at least 2 min after all pins were removed and the elbow was bandaged. Patient HR and FLACC scores were measured once at each time point. A single cohort crossover design was used in which patients served as their own controls via HR and FLACC scores captured when the patient returned to clinic for a range of motion check, approximately 4 weeks after pin removal. Because patients could only be enrolled after sustaining an operative fracture, we believed that collecting control HR and FLACC scores would be most appropriate at the subsequent clinic visit as no anxiety-provoking procedure was performed.

Patient and injury characteristics were summarized for the cohort. The FLACC score was summarized for control values, prior to pin removal, and after pin removal for all subjects by median and interquartile range (IQR, 25th–75th percentiles). HR, measured in beats per minute (bpm), was summarized for control values, prior to pin removal, and after pin removal for all subjects by mean and standard deviation (SD). The primary outcome was the proportion of patients that exhibited an anxiety response defined as an FLACC score greater than 0 prior to pin removal. Ideally, a one-side test with a null hypothesis that the proportion of patients with a non-zero FLACC score was less than or equal to 75% compared to an alternative hypothesis that greater than 75% of subjects had non-zero FLACC score response was considered for primary analysis. However, at the completion of the study, 100% of subjects had a non-zero FLACC score response prior to pin removal. Thus, the rule of three was utilized to estimate a 95% confidence interval (CI) for the proportion of patients with an anxiety response.[22] The rule of three indicates that when all subjects in the sample experience the event, one can estimate a 95% CI as $[1-3/n, 1]$, where n is the number of subjects in the sample.

The proportion of patients that had an elevated HR immediately prior to pin removal, defined as a HR in excess of the upper 95% normal limit for their age and sex,[23] was calculated. A two-sided 95% CI was computed around the estimated proportion of patients with an elevated HR prior to pin removal.

Table 1. Cohort summary ($n = 53$).

Characteristic	Freq.	(%)
Age (*years; mean* (*SD*))	5.9	±1.43
Sex (*% male*)	26	(49%)
BMI percentile (*median* (*IQR*); *N = 36*)	57	(44–85)
BMI percentile category		
Healthy weight	26	(49%)
Overweight	10	(19%)
Unknown	17	(32%)
Race		
White	43	(81%)
Black	2	(4%)
Asian	1	(2%)
American Indian	1	(2%)
More than one race	3	(6%)
Other/unknown	3	(6%)
Ethnicity		
Hispanic	5	(9%)
Not Hispanic	48	(91%)
Dominant hand (% right)	43	(81%)
Injured side (% right)	22	(42%)
History of fracture	12	(23%)
Mechanism of injury		
Fall from height	30	(57%)
Fall from standing	12	(23%)
Motor vehicle accident	1	(2%)
Sport	3	(6%)
Other	7	(13%)

SD: standard deviation; BMI: body mass index.

Secondary analysis included quantifying the change in FLACC score and HR from immediately prior to pin removal to after pin removal as well as between both prior to and after pin removal with control measurements. Changes in FLACC score were compared using the Wilcoxon signed rank test and changes in HR were compared using the paired Student's t test. A Holm–Bonferroni correction was used for multiple comparisons. Subgroup analysis was conducted to assess for any differences in FLACC score or HR response across patient sexes and across patient age groups dichotomized by patients 6 years and younger versus those older than 6 years. The Spearman and Pearson correlation coefficients were analyzed for continuous age as well. The p values less than 0.05 were considered significant.

Results

Fifty-three participants (49% male) underwent pin removal for an SCH fracture at a mean age of 5.9 years (range, 3.2–8.9 years) (Table 1). The most common mechanism of injury was fall from height (30/53, 57%). All patients in the cohort experienced an anxiety response immediately prior to pin removal (95% CI, 94–100%). Forty-five of the

Table 2. Outcome summary by time point.

Outcome	Control ($n=45$)		Prior to pin removal ($n=52$)		After pin removal ($n=52$)		p^a	p^b	p^c
	Median	(IQR)	Median	(IQR)	Median	(IQR)			
FLACC scale score	0	(0–0)	7	(6–8)	2	(0–3)	<0.001	<0.001	<0.001
FLACC >0 (*freq.* (%))	0	(0%)	52	(100%)	8	(15%)	–	–	–
Outcome	Control ($n=45$)		Prior to pin removal ($n=48$)		After pin removal ($n=49$)		p^a	p^b	p^c
	Mean	±SD	Mean	±SD	Mean	±SD			
Heart rate (*bpm*)	89.7	±12.97	119.4	±18.0	94.1	±17.22	<0.001	0.20	<0.001
Elevated HR (*freq.* (%))	25	(56%)	47	(98%)	30	(61%)	<0.001	0.52	<0.001

IQR: interquartile range; FLACC: Face, Legs, Activity, Cry, and Consolability; SD: standard deviation; HR: heart rate.
[a]*p* values are based on tests in the change in outcome from prior to pin removal to after pin removal.
[b]*p* values are based on tests in the change in outcome between control and after pin removal.
[c]*p* values are based on tests in the change in outcome between control and prior pin removal.

53 patients completed their subsequent follow-up clinic visit for control measurements.

FLACC

All patients demonstrated an anxiety response (100%; 95% CI, 94–100%) with a median FLACC score of 7 (IQR, 6–8) immediately prior to pin removal (Table 2). The median FLACC score for subjects after pin removal was 2 (IQR, 0–3). There was a median 73% reduction in FLACC score from prior to pin removal to after all pins were removed ($p<0.001$). All patients had an FLACC score of 0 for their control value at their second postoperative visit.

Heart rate

Ninety-eight percent of subjects experienced a HR in excess of the upper 95% normal limit for their age and sex (95% CI, 88%–100%) (Table 2). From prior to pin removal to after, subjects experienced a mean 21% reduction in HR (95% CI, 0.17–0.25; $p<0.001$). The mean HR for subjects with control measurements was 89.7 bpm (SD, 12.97). Twenty-five of the 45 patients (56%) recorded an elevated control HR for their age and sex. Prior to pin removal, patients experienced a mean 36% increase in HR compared to control values (95% CI, 0.25–0.47; $p<0.001$).

Age and sex

No differences were detected in FLACC scores or HR across patient sex for any time point in the study (Table 3). There was also no significant correlation between patient age and FLACC score or HR at any time point during the study. When stratified by ages less than 6 versus greater than 6 years, there were no differences detected in FLACC scores or HR at any time point in the study.

Discussion

Pediatric patients with displaced SCH fractures are typically treated with CRPP and pins are removed around 3–4 weeks post-surgery in clinic, without anesthesia.[4,6–11] While intuitively obvious that this would be an anxiety-provoking procedure, the degree of anxiety that young patients experience to having pins removed has not been quantified. The primary purpose of this study was to quantify the anxiety experienced by patients undergoing pin removal following CRPP for SCH fractures.

In this study of the 53 subjects, all patients demonstrated an anxiety response immediately prior to pin removal with a median FLACC score of 7, and 98% of subjects experienced an elevated HR. Following the pin removal, there was a median 73% reduction in FLACC score and mean 21% reduction in HR. In the 45 patients who were seen at follow-up for control measurements, all 45 had an FLACC score of 0 and there was a mean 36% decrease in HR compared to prior to pin removal. However, 25 of the 45 patients (56%) with control HR recorded experienced an elevated HR compared to normal for their age, the significance of which is unclear. Two possible explanations would be these patients had elevated HR solely due to being at a physician's office or these patients recall their prior clinic experience. No differences were detected across age or sex.

Pin removal in clinic, without anesthesia, provoked a high anxiety response in children. The median score of 7 on the FLACC score immediately prior to pin removal was much higher in this study than in a prior investigation of anxiety during cast removal in

Table 3. Outcomes by sex and age groups.

FLACC scale score	Females ($n=27$)		Males ($n=26$)		p
	Median	(IQR)	Median	(IQR)	
Control	0	(0–0)	0	(0–0)	–
Prior to pin removal	8	(6–8)	7	(6–7)	0.08
After pin removal	2	(1–3)	1	(0–4)	0.20
Heart rate (*bpm*)	Mean	SD	Mean	SD	p
Control	91.6	±10.47	87.8	±15.17	0.34
Prior to pin removal	122.3	±16.07	116.5	±19.64	0.26
After pin removal	97.2	±16.83	91.0	±17.38	0.21
FLACC scale score	Age ≤ 6 ($n=30$)		Age > 6 ($n=23$)		p
	Median	(IQR)	Median	(IQR)	
Control	0	(0–0)	0	(0–0)	–
Prior to pin removal	7	(6–8)	7	(5–8)	0.36
After pin removal	2	(1–4)	1	(0–3)	0.12
Heart rate (*bpm*)	Mean	SD	Mean	SD	p
Control	90.8	±13.82	88.3	±11.92	0.51
Prior to pin removal	121.0	±17.45	117.4	±18.92	0.51
After pin removal	94.6	±17.08	93.5	±17.80	0.82

FLACC: Face, Legs, Activity, Cry, and Consolability; IQR: interquartile range; SD: standard deviation.

children, which found a median score of 2 on the same scale.[14] Our results compare with the published scores for intravenous line insertion, nasogastric tube insertion, and metered dose inhaler application, suggesting a highly anxiety-provoking experience.[16] It is clear that pin removal may be an anxiety producing experience for the child, and may lead or add to long-term anxiety with physician visits in the future.[17,18]

This study is not without its limitations. The FLACC score has been demonstrated to have good validity, reliability, and reproducibility.[24] We did not perform a reliability study when recording the FLACC score, introducing the possibility of variability in scoring across staff. In addition, there were a number of patients in which distraction techniques were utilized by the parents (consisting of iPads, headphones, videos, etc.) to facilitate pin removal. Distraction techniques were not quantified during our investigation but rather observed by the study team therefore introducing some heterogeneity. Future studies should collect data on these techniques and perform subgroup analysis to determine their effect on patient's anxiety levels based off whether the patient had some form of distraction or not. It was felt that preventing the utilization of these techniques by parents to standardize the pin removal process was neither practical nor ethical. Also, the FLACC score was obtained after removal of cast, but before pin removal, so that, it is possible the FLACC score was affected by the cast removal process. We suggest future studies to measure HR and FLACC score before and after cast removal. In addition, because patients could only be enrolled after sustaining an operative fracture, control measurements were taken at the second postoperative visit to most closely approximate their pre-injury state. Of course, these measurements were obtained during a clinic visit which may not approximate the patient's true baseline state. These control measurements may be influenced by post-traumatic stress from the patient's prior visit.

This study highlights an area of clinical practice where an intervention may be developed and studied in an attempt to decrease patient anxiety. There are many options that could be considered in trying to reduce anxiety. In our study, the HR and FLACC score are recorded just before pin removal. This occurs following check in, cast removal, elbow X-rays out of cast which may require arm manipulation, and return to clinic awaiting pin removal. This process could take up to an hour of time, potentially escalating anxiety. Some authors feel that obtaining an X-ray prior to pin removal is unnecessary, as it does not commonly affect clinic management.[6,25,26] Therefore, removing pins immediately following cast removal and prior to X-ray may decrease the overall time waiting for pin removal and decrease patient anxiety. We would formally study other interventions, such as headphones, virtual reality headsets, tablet/phone devices

containing video capabilities, patient's anatomical position during removal (lying down vs sitting upright), utilizing a dedicated child life therapist, or any other intervention in an effort to reduce the time and amount of anxiety that the patients experience.

In conclusion, pediatric patients experience high levels of anxiety when undergoing pin removal in clinic, without anesthesia, following CRPP for displaced SCH fractures. Ultimately, the findings presented here can provide the groundwork for future research in techniques to minimize anxiety for the pediatric patient having to undergo pin removal.

Author contributions

Ryan M. Sanborn contributed to data acquisition, assistance with data interpretation, first draft and critical revisions of the work, final approval of the work, and agreement to be accountable for all aspects of the work. Andrea S. Bauer contributed to conception of the work, critical drafting and review of the work, final approval of the work, and agreement to be accountable for all aspects of the work. Patricia E. Miller contributed to analysis of the data for the work, critical drafting and review of the work, final approval of the work, and agreement to be accountable for all aspects of the work. Dennis E. Kramer contributed to conception of the work, critical drafting and review of the work, final approval of the work, and agreement to be accountable for all aspects of the work. Collin J. May contributed to conception of the work, critical drafting and review of the work, final approval of the work, and agreement to be accountable for all aspects of the work. Carley B. Vuillermin contributed to conception of the work, critical drafting and review of the work, final approval of the work, agreement to be accountable for all aspects of the work. Yi-Meng Yen contributed to conception and design of the work, critical drafting and review of the work, final approval of the work, agreement to be accountable for all aspects of the work.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

This study involved human participants and was performed in accordance with the Helsinki declaration. Institutional review board's approval was granted.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Informed consent

Informed consent was obtained from all human subjects that met inclusion/exclusion criteria.

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