Journal of the Pediatric Orthopaedic Society of North America 10 (2025) 100141

Contents lists available at ScienceDirect

Journal of the Pediatric Orthopaedic Society of North America

journal homepage: www.jposna.com

Original Research

Differences in Treatment of Supracondylar Humerus Fractures Requiring Transfer Between Facilities

Shrey Nihalani, BS, BA [*]; Harrison Reeves, BS; Pearce Lane, MD; Mack Padgett, MD; Gerald Mcgwin, PhD; Michael J. Conklin, MD; Kevin A. Williams, MD

Children's Hospital of Alabama, University of Alabama at Birmingham, Birmingham, AL, USA

ARTICLE INFO

Keywords:
Delay
Timing
Transfer
Supracondylar humerus fracture

ABSTRACT

Purpose: The current study aims to elucidate the differences in the timing of the management of operative supracondylar humerus fractures (SCHF) based on whether or not the patient is transferred between facilities.
Methods: This was a prospective cohort study of patients with surgically treated SCHF conducted at a level I pediatric trauma center. The management of these fractures was compared based on their presenting facility (pediatric trauma center versus another facility). Primary outcomes were time to orthopaedic consult, time to surgery, need for open reduction, and operative times. Secondary outcomes include the need for repeat imaging, transfer time, transfer vehicle, and transfer distance.
Results: A total of 146 (78 female) patients with an average age of 5.70 (±2.12) years were included in the study. Time from initial presentation to orthopaedic consult ($P < 0.001$) and time from initial presentation to surgery ($P = 0.006$) was shorter for Children's hospital patients compared to outside facility patients. Repeat radiographs were more common when patients presented to outside facilities compared to children's hospital ($P < 0.001$). Operative times were the same for both groups (31 min children's hospital, 32 min outside facility). Patients arriving from the outside facility via ambulance traveled further in comparison to those arriving via private vehicle ($P = 0.009$) but had a shorter time to operation ($P = 0.002$).
Conclusions: Efficient processes and collaboration between healthcare facilities to ensure timely and effective care for pediatric patients with SCHF are essential. Patients from outside facilities experienced longer times to orthopaedic consult and surgery while having similar baseline characteristics.
Key Concepts:

(1) Patients arriving from outside facilities had an overall longer time to orthopaedic consult and definitive fixation.
(2) There was no difference in the need for open reduction or the operative time based on the patient's presenting facility.
(3) Transferred patients often underwent repeat imaging prior to consult.

Level of Evidence: II

Introduction

Supracondylar humerus fractures (SCHF) are one of the most common injuries in the pediatric population, consisting of 55%–80% of pediatric elbow injuries [1]. Furthermore, they are the most common operatively treated pediatric orthopaedic injury. Depending on the severity of injury, displaced SCHF can be treated with closed or open reduction with the aim of restoring and maintaining alignment, preserving function, and decreasing complications [2]. Severe complications of SCHF include nerve palsy, compartment syndrome, and Volkmann ischemic contracture [3,4]. Timely management of SCHF is imperative to avoid some common complications but can be difficult to accomplish when treatment facilities are not immediately accessible to the patient [5]. If an orthopaedic surgeon adept with pinning SCHF is not available at the presenting facility, the patient will require transfer, whether by private vehicle or ambulance, to an institution where the injury can be appropriately managed. A delay in the time to presentation not only jeopardizes timely care but also serves as a potential indicator of

* Corresponding author: University of Alabama at Birmingham, 1600 7th Ave South, Birmingham, AL 35233, USA.
E-mail address: shreynihalani@gmail.com (S. Nihalani).

https://doi.org/10.1016/j.jposna.2024.100141
Received 17 June 2024; Received in revised form 28 October 2024; Accepted 28 October 2024
Available online 9 December 2024

healthcare disparity [6]. To date, prior studies on supracondylar humerus fractures have not investigated the impact that the presenting facility may have on time to presentation and the impact on definitive management. This study sought to determine if there were significant differences in management and time to treatment based on the facility of presentation. We hypothesize that there will be a delay in time to an orthopaedics consult and operative treatment and increased conversion to open reduction for the patients who initially presented to an outside facility.

Materials and methods

Study design

The current study is a prospective cohort study with approval from the Institutional Review Board. Weekly operative reports were used to prospectively collect data for skeletally immature patients who were treated surgically for a SCHF at a standalone children's hospital with a level I trauma center. All patients had SCHF fractures fixed with a pin construct following reduction. The presenting facility was defined as the location where the patient first received medical evaluation (ie outside clinic, outside hospital, children's hospital). The treating facility is defined as the children's hospital where surgical treatment took place. To be included in the study, patients had to have sustained a displaced SCHF that was surgically treated. Patients with inadequate or inaccessible documentation, other concomitant fractures, or SCHF treated non-operatively were excluded.

Patients treated by six different surgeons at a single academic institution over the course of one year, from October 2022 to October 2023, were included. Two pediatric fellowship-trained orthopaedic surgeons reviewed radiographs. The modified Gartland classification was used to classify injuries [7].

Electronic medical records (EMR) and imaging archives were reviewed for demographic information and injury patterns. Time of injury was categorized into time blocks of 6 a.m.–2 p.m. (morning), 2 p.m.–10 p.m. (afternoon), and 10 p.m.–6 a.m. (night). Time of injury was based upon the time noted by the patient/parents in recorded documents. Time of presentation was based on the arrival time noted in the EMR or based on the time imaging was performed for outside hospitals. If the patient required transfer, the transferring attending would typically call either the children's emergency department (ED) or the orthopaedic resident on call prior to initiation and ED to ED transfer. Time to orthopaedic consult was defined as the time of injury to the start of orthopaedic consult based on the initiation of a consult note in the EMR by the consultant. Time to surgery was defined as the time of injury to operative start time noted on EMR documentation. Transfer time, transfer distance, transfer vehicle, time from presentation to orthopaedic consult, time from presentation to surgery, presence of open injury, neurovascular compromise, number of pins, use of a medial pin, need for open reduction, and operative time were ascertained based on EMR documentation. Neurovascular compromise was defined as the presence of nerve palsy or decreased/absent pulses.

Statistical analysis

Descriptive statistics, chi-square, Fisher exact, and Kruskal–Wallis tests were used to determine the relationship between variables. Analysis was performed using SPSS software (Armonk, NY). An alpha value of 0.05 was used to define statistical significance for all tests.

Results

There were 172 patients with operatively treated SCHF over 365 days; however, 26 were excluded from the study due to inaccessible records from an outside facility. Of the 146 included in the study, there were 68 males and 78 females. The average age of patients was 5.70 ($\pm$2.12) years, all of which were skeletally immature (range 1–13 years of age). One hundred White patients comprised the majority of the cohort (68.5%) followed by Black (20.5%), Hispanic (7.5%), and multiracial patients (3.4%). Forty-three patients initially presented at the treating hospital and 103 at an outside facility. There were 40 Gartland type 2 fractures and 106 type 3 fractures. Closed reduction and pinning were performed in 83.6% while 16.4% underwent open reduction. Two pins were used in 50.7%, three pins in 46.6%, and four pins in 2.7%. Medial pins were used in 27.3% of cases. Median time from presentation to orthopaedic consult for all patients was 323 min (IQR: 211-415) and median time from presentation to surgery for all patients was 895 min (IQR: 665-1103).

There was no significant difference in median time to orthopaedic consult between patients presenting during the morning, afternoon, and night time blocks. However, median time to surgery was different between morning (1166 min) (IQR: 530-1304), afternoon (939 min) (IQR: 758-1100), and night (687 min) (IQR: 610-841) ($P = 0.016$). The majority of patients who initially presented to the treating hospital (74.4%) and outside facilities (69.9%) had injuries that occurred during the afternoon ($P = 0.816$) (Table 1). Patients also presented to their respective facilities (hospital 79.1%; outside facility 76.7%) primarily in the afternoon ($P = 0.553$). An orthopaedic consult most often occurred during the afternoon if the patient initially presented to the treating hospital (65.1%) compared with a night consultation if the patient initially presented at an outside facility (57.3%) ($P = 0.002$).

Patients were more likely to arrive at the children's hospital via private vehicle (children's hospital 81.4%; outside facility 52.4%) versus emergency transfer ($P < 0.001$). The median transfer time and distance from the outside facility was 158.5 min (IQR: 112-245) and 67 miles (IQR: 41-99), respectively. The median time from initial presentation to orthopaedic consult was 151 min (IQR: 96-244) for patients presenting to the children's hospital and 369 min (IQR: 280-462) for patients presenting to an outside facility ($P < 0.001$). The median time from initial presentation to surgery was 847 min (IQR: 326-1018) for children's hospital patients compared to 957 min (IQR: 744-1144) for outside facility patients ($P = 0.006$) (Fig. 1).

The median time to orthopaedic consult when a patient from an outside hospital arrived at the children's hospital via private vehicle was

Table 1.
Timing of fracture compared with presenting facility.

	Hospital (*N*) (%)	Outside facility (*N*) (%)	*P*-value
Time of injury			0.816*
6 a.m.–2 p.m.	10 (23.3)	27 (26.2)	
2 p.m.–10 p.m.	32 (74.4)	72 (69.9)	
10 p.m.–6 a.m.	1 (2.3)	4 (3.6)	
Time of presentation			0.553*
6 a.m.–2 p.m.	6 (13.9)	11 (10.7)	
2 p.m.–10 p.m.	34 (79.1)	79 (76.7)	
10 p.m.–6 a.m.	3 (7.0)	13 (12.6)	
Time of orthopaedic consult			**0.002***
6 a.m.–2 p.m.	2 (4.7)	10 (9.7)	
2 p.m.–10 p.m.	28 (65.1)	34 (33.0)	
10 p.m.–6 a.m.	13 (30.2)	59 (57.3)	
Transfer vehicle			**<0.001**†
Private	35 (81.4)	54 (52.4)	
Emergency transfer	8 (18.6)	49 (47.6)	

Bold values indicate statistical significance.
* *Chi-square test.*
† *Fisher's Exact test.*

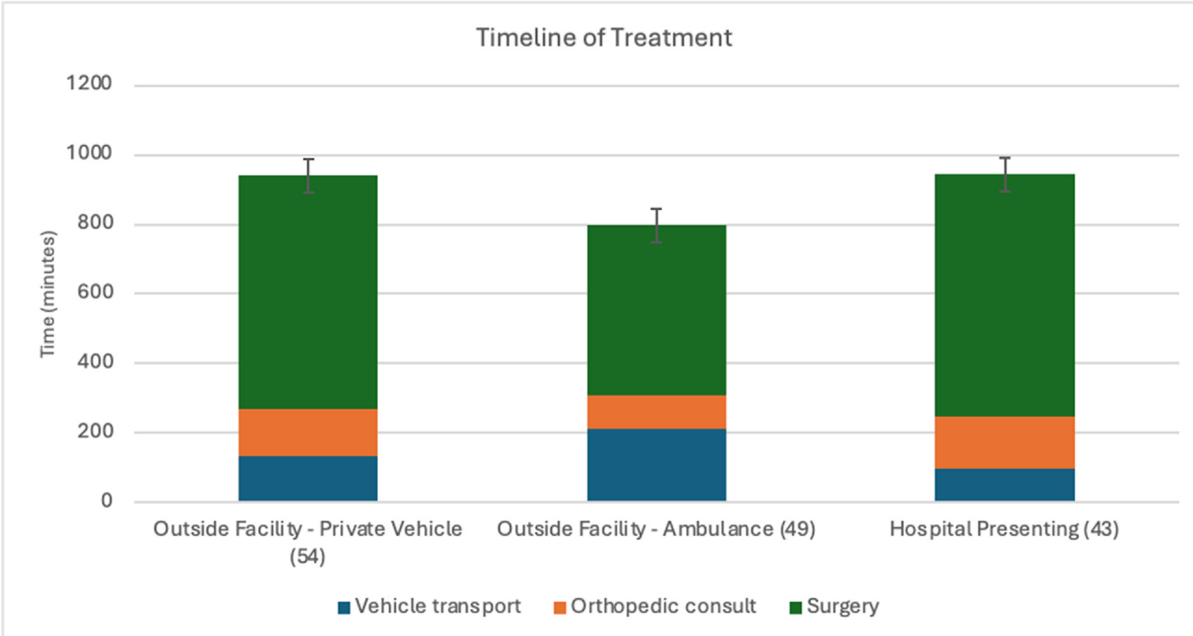

Figure 1. Timeline to treatment for displaced supracondylar humerus fracture of patients from different presentation facilities and modes of transport based on median times for each group. Zero on the x-axis represents patient time of injury. Dark blue represents the overall travel time to the children's hospital. Orange represents time of patient arrival at hospital to completion of orthopaedic consult. Green represents time from consult completion to patient arrival into the operating room.

266 min (IQR: 175-396) compared to 351 min (IQR: 275-485) for ambulance transport ($P = 0.037$). Additionally, patients arriving from the outside hospital via ambulance traveled further in comparison to those arriving via private vehicle (85 miles (IQR: 56-140) vs 58 miles (IQR: 21-77), $P = 0.009$). The median time to operation was 973 min (IQR: 808-1157) for patients transported via private vehicle compared to a median time of 824 min (IQR: 524-1009) for patients transported via ambulance ($P = 0.002$). Patients transported via ambulance more frequently had Gartland 3 fractures (43/49) compared to patients transported via private vehicle (29/54) ($P < 0.001$).

Table 2.
Injury characteristics of surgically treated fractures.

	Hospital (*N*) (%)	Outside facility (*N*) (%)	*P*-value
Need for repeat films	3 (7.0)	32 (31.1)	**<0.001***
Type of injury			0.207*
Open	2 (4.7)	1 (0.8)	
Closed	41 (95.3)	102 (99.0)	
Neurovascular compromise	8 (18.6)	18 (17.5)	1.000*
Gartland classification			1.000*
2	12 (27.9)	28 (27.2)	
3/4	31 (72.1)	75 (72.8)	
Direction of injury			0.732*
Extension	39 (90.7)	96 (93.2)	
Flexion	4 (9.3)	7 (6.8)	
Type of reduction			0.632*
Open	8 (18.6)	16 (15.5)	
Closed	35 (81.4)	87 (84.5)	

Bold values indicate statistical significance.
* *Fisher's Exact test.*

The need for repeat radiographs was more common when patients presented to outside facilities (31.1%) compared with patients presenting to children's hospital (7.0%) ($P < 0.001$) (Table 2). Closed fractures were more common when presenting to an outside facility (99.0%) than children's hospital (95.3%), but this was not statistically significant ($P = 0.21$). Neurovascular compromise was present in 18.6% of patients when presenting to the children's hospital compared to 16.5% of patients when presenting at an outside facility ($P = 1.00$). Of the 24 patients with neurovascular compromise, only one patient had a type II fracture. Seven patients had decreased or nonpalpable pulses, while 15 had nerve palsies, and two patients had both decreased pulses and nerve palsies. Anterior interosseous nerve (AIN) palsies were most common with seven patients affected, followed by radial nerve palsies in six patients, ulnar nerve palsies in three patients, and median nerve palsies in two patients.

The percentage of patients with a Gartland type III fracture was similar between those presenting at the children's hospital (72.1%) and outside facility (72.8%) ($P = 1.00$). The percentage of patients with extension-type fractures was similar for patients presenting to the Children's hospital (90.7%) and the outside facility (93.2%) ($P = 0.732$). The percentage of patients undergoing closed reduction was similar for those presenting to the children's hospital (81.4%) and the outside facility (84.5%) ($P = 0.632$). The mean blood loss was 3.3 ($\pm$5.2) mL and mean length of stay was 0.9 ($\pm$0.5) days. The mean number of pins used was similar for those presenting to the outside facility (2.5 $\pm$ 0.6) and the children's hospital (2.6 $\pm$ 0.6) ($P = 0.389$). There was no significant difference in the use of medial pins for the two groups ($P = 0.417$).

When comparing Gartland type II (300 min (IQR: 197-384)) and III (330 min (IQR: 212-450)) fractures, there were no differences in time to orthopaedic consult ($P = 0.333$). When comparing Gartland type with time to surgery, there was a significant difference for Gartland type II (1004 min (IQR: 835-1157) vs type III (884 min (IQR: 524-1088) respectively, $P = 0.017$).

Operative times compared based on the initial presenting facility were not different ($P = 0.58$). Patients presenting to the children's hospital averaged 31 min (IQR 22-41) compared to outside facility 32 min (IQR 24-43). When comparing the severity of fracture and operative time, Gartland type II operations (23 min (IQR: 20-26.5)) were shorter than Gartland type III operations (35 min (IQR: 29-50)) ($P < 0.001$). Also, patients who arrived at the children's hospital via private vehicle had a shorter operative time (29 min (IQR: 22-38.3)) when compared to ambulance transfers (37 min (IQR: 29-49.5)) ($P = 0.005$).

Discussion

The current study was undertaken to establish a temporal relationship in the surgical treatment of displaced SCHF based on the presenting facility and the mode of transport. In a group of 146 prospectively enrolled patients, a pattern was clearly established. Those who initially presented to an outside facility had a longer median time to orthopaedic consult and median time to surgery. Also, those traveling from outside facility to the children's hospital via private vehicle received orthopaedic consult sooner than those traveling by ambulance. Those traveling by ambulances were more likely to have Gartland type III fractures than those traveling by private vehicle. Lastly, repeat radiographs were more commonly obtained when patients arrived from an outside facility. Understanding these issues is the first step in facilitating timely access to definitive surgical treatment.

In an effort to determine if fracture severity was similar between those presenting to an outside facility and those presenting to children's hospital, we assessed the Gartland classification, need for a medial pin, number of pins, need for open reduction, and operative times. There was no significant difference in any of these parameters between groups.

Our cohort's average time to surgery was 15 h, which is within the acceptable time frame to treat as described by Larson et al. [8] Undue delay in treatment should be avoided, but factors outside of the surgeon's control may ultimately affect time to surgery.

The need for repeat imaging was statistically significant when presenting from an outside facility ($P < 0.001$). Repeat imaging was obtained either due to inadequate imaging or, more commonly, inability to access radiographs from the outside hospital. Frequently, images were ordered by children's hospital emergency providers prior to orthopaedic consultation. The medical decision-making for repeat imaging, however, is not consistently documented in the EMR and provides an opportunity for future investigation. In a study investigating repeat imaging in children being transferred to a trauma center, Mangus et al. found a 43% rate of repeat imaging similar to our rate of 31.1% [9]. Other studies have reported rates as high as 91% [10]. In 10% of cases, inadequate imaging was cited as the reason for repeat imaging, highlighting a deficiency in proper training or capacity for image acquisition at nonpediatric hospitals [11]. Obtaining appropriate imaging at initial presentation and ensuring their availability at the treating institution prevents unnecessary radiation exposure, cost, and facilitates the timely administration of care.

An interesting finding in the current study is that those patients arriving at the children's hospital in the morning had the longest median time to surgery compared to other time blocks. Though the current study is not granular enough to determine the causes for this, it is likely due to a lack of operating room availability. As operating room staffing tapers in the mid-afternoon, availability for nonemergent procedures decreases. Historically, treating SCHF without impending skin or neurovascular compromise has met resistance from our institution's OR administrators if the procedure were to begin in the afternoon. A recent publication noted that hospital staffing inefficiencies have persisted since the COVID-19 pandemic [12]. Kym et al. found a significant reduction in surgery wait time with a dedicated orthopaedic trauma operating room [13]. We have used data from the current study to work with the hospital administration to ensure an early operating room start time for orthopaedic trauma and hope to provide other pediatric orthopaedic surgeons with a basis to advocate for a dedicated orthopaedic trauma room as well.

Interestingly, in the current study, there was a statistically significant difference in time to orthopaedic consult when the patient arrived at the treating hospital by ambulance compared to private vehicle ($P = 0.037$) with patients arriving by private vehicle receiving orthopaedic consult sooner. Mechas et al. found no difference in outcomes or time to surgery for type II SCHF that were transported via ambulance compared to private vehicle, while noting increased cost with ambulance transfer [14]. There was no difference in the use of a medial pin or need for open reduction in the current study between children transported per private vehicle versus ambulance. However, children transported per private vehicles had shorter operating times than those transported per ambulance and were more likely to be Gartland type II than type III injuries. This study further supports the concept that type II SCHF fractures can be safely and efficiently transported by private vehicle.

The current study has helped us to understand barriers to timely treatment (ie repeat imaging, transfer between facilities) in the preoperative management and transport of children with operative SCHFs. This can result in improved safety in patients with neurovascular compromise and improved satisfaction and lower costs in those not requiring emergent treatment. Orthopaedic patients discharged the same day of surgery tend to be satisfied and have lower costs than those admitted [15,16].

The current study has limitations. First, patient-reported outcome measures were not reported for this study. Secondly, the reason for ordering repeat imaging could not be consistently determined. Thirdly, precise reporting of presentation time and location relied upon the precision of the documentation, which presents inherent opportunities for inaccuracies. Additionally, many patients had to be excluded due to inaccessible or incomplete records from outside facilities. As hospital systems continue to integrate EMR systems, consistent documentation will likely be more accessible. Lastly, these findings may not be generalizable to all institutions. Ours is a moderately large state with a single level I children's hospital situated approximately in the center of the state where ground travel times can exceed 4 h.

Conclusions

Our prospective analysis of the timing of treatment in displaced SCHF found areas of inefficiencies that have the potential to lead to delays in care. Patients were frequently transferred via ambulance, resulting in longer time to orthopaedic consult. Furthermore, mode of transportation had no impact on the construct or approach required to sufficiently stabilize the fracture. Improving education on orthogonal imaging, transfer policies, and communication between providers may reduce inefficiencies in the treatment of SCHF.

Author contributions

Shrey Nihalani: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Harrison Reeves:** Writing – original draft, Investigation, Data curation. **Pearce Lane:** Writing – review & editing, Writing – original draft, Supervision, Data curation, Conceptualization. **Mack Padgett:** Formal analysis, Data curation. **Gerald Mcgwin:** Writing – review & editing, Formal analysis. **Michael J. Conklin:** Writing – review & editing, Writing – original draft, Conceptualization. **Kevin A. Williams:** Writing – review & editing, Writing – original draft, Conceptualization.

Consent for publication

The author(s) declare that no patient consent was necessary as no images or identifying information are included in the article.

Ethics approval and consent

Ethical approval for this study was obtained from University of Alabama at Birmingham IRB (IRB-300006500).

Funding

No funding was received for this work.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to acknowledge Dr. Gerald McGwin for his assistance in statistical review.

References

[1] Choi PD, Melikian R, Skaggs DL. Risk factors for vascular repair and compartment syndrome in the pulseless supracondylar humerus fracture in children. J Pediatr Orthop 2010 Jan 1;30(1):50–6.

[2] Brubacher JW, Dodds SD. Pediatric supracondylar fractures of the distal humerus. Cur Rev Muscul Med 2008 Dec;1:190–6.

[3] Armstrong DG, MacNeille R, Lehman EB, Hennrikus WL. Compartment syndrome in children with a supracondylar fracture: not everyone has risk factors. J Orthop Trauma 2021 Aug 1;35(8):e298–303.

[4] Wilks DJ, Ye X, Biggins R, Wang KK, Wade RG, McCombe D. Median nerve palsy in pediatric supracondylar humerus fractures recovers faster with open than closed reduction. J Pediatr Orthop 2023 Aug 1;43(7):407–13.

[5] Yildirim AO, Unal VS, Oken OF, Gulcek M, Ozsular M, Ucaner A. Timing of surgical treatment for type III supracondylar humerus fractures in pediatric patients. J Child Orthop 2009 Aug;3(4):265–9.

[6] Arant KR, Modest JM, Gil JA, Cruz Jr AI. What's new in pediatric orthopaedic health care disparities? J Pediatr Orthop 2022 Oct 1;42(9):e954–9.

[7] Leitch KK, Kay RM, Femino JD, Tolo VT, Storer SK, Skaggs DL. Treatment of multidirectionally unstable supracondylar humeral fractures in children: a modified Gartland type-IV fracture. JBJS 2006 May 1;88(5):980–5.

[8] Larson AN, Garg S, Weller A, Fletcher ND, Schiller JR, Kwon M, et al. Operative treatment of type II supracondylar humerus fractures: does time to surgery affect complications? J Pediatr Orthop 2014 Jun 1;34(4):382–7.

[9] Mangus CW, Klein BL, Miller M, Stewart D, Ryan LM. Repeat radiographic imaging in patients with long bone fractures transferred to a pediatric trauma center. J Invest Med 2019 Jan;67(1):59–62.

[10] Chwals WJ, Robinson AV, Sivit CJ, Alaedeen D, Fitzenrider E, Cizmar L. Computed tomography before transfer to a level I pediatric trauma center risks duplication with associated increased radiation exposure. J Pediatr Surg 2008 Dec 1;43(12):2268–72.

[11] Reginelli A, Russo A, Turrizziani F, Picascia R, Micheletti E, Galeazzi V, et al. Imaging of pediatric foot disorders. Acta Biomed: Atenei Parmensis 2018;89(Suppl 1):34.

[12] Reichert M, Sartelli M, Weigand MA, Hecker M, Oppelt PU, Noll J, et al. Two years later: is the SARS-CoV-2 pandemic still having an impact on emergency surgery? An international cross-sectional survey among WSES members. World J Emerg Surg 2022 Jun 16;17(1):34.

[13] Kym D, Kaur J, Pham NS, Klein E, Langner JL, Wang E, et al. Effectiveness of an early operating room start time in managing pediatric trauma. World J Orthoped 2023 Jul 7;14(7):516.

[14] Mechas C, Mayer R, Iwinski H, Riley SA, Talwalkar V, Prusick V, et al. The costs of interfacility transfers for nonurgent pediatric supracondylar fractures. J Pediatr Orthop 2022 Aug 1;42(7):e727–31.

[15] Levy HJ, Mashoof AA. Outpatient open Bankart repair. Am J Sports Med 2000 May;28(3):377–9.

[16] Hall-Burton DM, Hudson ME, Grudziak JS, Cunningham S, Boretsky K, Boretsky KR. Regional anesthesia is cost-effective in preventing unanticipated hospital admission in pediatric patients having anterior cruciate ligament reconstruction. Reg Anesth Pain Med 2016 Jul 1;41(4):527–31.