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Protocolized management of isolated linear skull fractures at a level 1 pediatric trauma center

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OBJECTIVE Isolated linear skull fractures without intracranial findings rarely require urgent neurosurgical intervention. A multidisciplinary fracture management protocol based on antiemetic usage was implemented at our American College of Surgeons–verified level 1 pediatric trauma center on July 1, 2019. This study evaluated protocol safety and efficacy.

METHODS Children younger than 18 years with an ICD-10 code for linear skull fracture without acute intracranial abnormality on head CT were compared before and after protocol implementation. The preprotocol cohort was defined as children who presented between July 1, 2015, and December 31, 2017; the postprotocol cohort was defined as those who presented between July 1, 2019, and July 1, 2020.

RESULTS The preprotocol and postprotocol cohorts included 162 and 82 children, respectively. Overall, 57% were male, and the median (interquartile range) age was 9.1 (4.8–25.0) months. The cohorts did not differ significantly in terms of sex ($p = 0.1$) or age ($p = 0.8$). Falls were the most common mechanism of injury (193 patients [79%]). After protocol implementation, there was a relative increase in patients who fell from a height > 3 feet (10% to 29%, $p < 0.001$) and those with no reported injury mechanism (12% to 16%, $p < 0.001$). The neurosurgery department was consulted for 86% and 44% of preprotocol and postprotocol cases, respectively ($p < 0.001$). Trauma consultations and consultations for abusive head trauma did not significantly change ($p = 0.2$ and $p = 0.1$, respectively). Admission rate significantly decreased (52% to 38%, $p = 0.04$), and the 72-hour emergency department revisit rate trended down but was not statistically significant (2.8/year to 1/year, $p = 0.2$). No deaths occurred, and no inpatient neurosurgical procedures were performed.

CONCLUSIONS Protocolization of isolated linear skull fracture management is safe and feasible at a high-volume level 1 pediatric trauma center. Neurosurgical consultation can be prioritized for select patients. Further investigation into criteria for admission, need for interfacility transfers, and healthcare costs is warranted.

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KEYWORDS linear skull fracture; children; protocol; quality improvement; traumatic brain injury; trauma; TBI

Isolated linear skull fractures in children are an increasingly common diagnosis[1] and frequent reason for interfacility transfer for neurosurgical evaluation.[2] Pediatric traumatic brain injury (TBI) is on the rise.[3] Interestingly, the proportion of patients with severe pediatric TBI has declined, while there has been a marked increase in mild TBI.[4] Classified as a sequela of mild TBI, isolated linear skull fractures have also witnessed a substantial increase that many believe is related to enhanced screening criteria,[5] as well as advanced imaging capabilities with the advent of thin-cut and 3D CT sequences.[6–8] Although such fractures are a common diagnosis for transfer and admission, studies have shown that children rarely (if ever) need urgent surgical evaluation or intervention.[9,10] As such, these findings call into question the utility of emergent neurosurgical consultation and need for neurosurgery follow-up.[11–13]

Standardization of the management of children with isolated linear skull fractures is not a new concept to pediatric care. Many physicians believe these children have historically been overtreated, overtriaged, and overtransferred.[11,12,14–16] Protocols have been successfully piloted

ABBREVIATIONS CARE = Child Protection and Well Being; ED = emergency department; IQR = interquartile range; NAT = nonaccidental trauma; TBI = traumatic brain injury.

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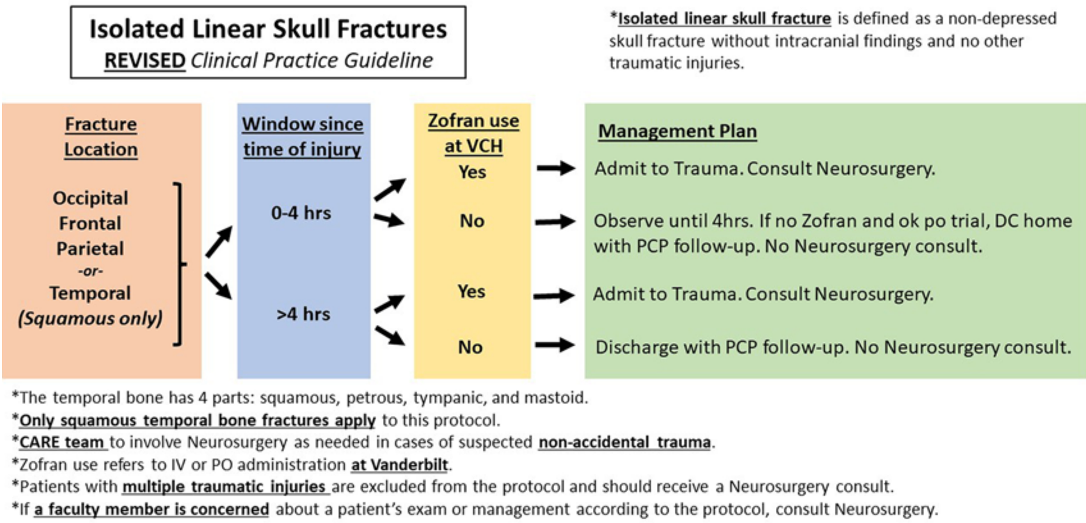

FIG. 1. Pediatric linear skull fracture management protocol. DC = discharge; IV = intravenous; PCP = primary care provider; PO = per os; VCH = Vanderbilt Children's Hospital. Figure is available in color online only.

at other level 1 pediatric trauma centers such as Boston Children's Hospital[17] and Primary Children's Hospital in Salt Lake City.[18] The reported outcomes indicated the safety and efficacy of their unique protocols,[17,18] as well as a consistent role for neurosurgery. Our study sought to challenge the status quo of urgent pediatric neurosurgical consultation for patients with linear skull fractures without intracranial pathology.

We implemented a quality improvement protocol at our pediatric level 1 trauma center that sought to standardize neurosurgical consultations for children with an isolated linear skull fracture (Fig. 1). An isolated linear skull fracture was defined as a nondepressed fracture of the cranial vault without acute intracranial findings on head CT. The primary factors involved in the protocol were fracture location, time from presentation, and antiemetic usage. These 3 factors were chosen because a previous study at our institution assessed the risk factors for emergency department (ED) revisits and need for admission.[19] The purpose of this study was to assess the safety and efficacy of a multidisciplinary fracture management protocol at a major pediatric trauma center. Prior to implementation of this protocol, most patients were evaluated by the pediatric neurosurgical team in the ED (140/162 patients [86%]) and were often admitted for observation (84/162 [52%]). We hypothesized that the protocol would decrease unnecessary hospital admissions without changes in patient mortality or ED revisits within 72 hours after time of injury.

Methods

Patient Population

Children younger than 18 years of age who presented to Monroe Carell Jr. Children's Hospital at Vanderbilt with an isolated linear skull fracture on head CT were included in the study. The study patients were retrospectively identified on the basis of their ICD-10 code and divided into preprotocol and postprotocol implementation cohorts. A linear skull fracture protocol was implemented at Vanderbilt on July 1, 2019. Patients were divided into preprotocol and postprotocol cohorts. The preprotocol cohort was identified as children who presented between July 1, 2015, and December 31, 2017. The postimplementation cohort was identified as children who presented within 1 year after protocol implementation (July 1, 2019, to July 1, 2020). Patients were excluded from the study if they presented with additional traumatic injuries, intracranial hemorrhage, pneumocephalus, skull base fracture, or depressed or displaced skull fracture. The study was deemed exempt by the Vanderbilt University Institutional Review Board.

Skull Fracture Management Protocol

The skull fracture management protocol referenced in this study is shown in Fig. 1. This evidence-based protocol was created after a retrospective analysis of patients who presented with isolated linear skull fractures at our institution showed associations of fracture location and antiemetic usage with ED revisits.[19] It was created in a multidisciplinary fashion by colleagues at the departments of pediatric trauma, neurosurgery, and otolaryngology, as well as the ED. It is the first iteration of the protocol at our institution and was used throughout the duration of the study period.

All children included in the study underwent head CT that demonstrated an isolated linear skull fracture. The initial decision to obtain intracranial imaging of a child who presented after a traumatic mechanism of injury was made by the pediatric emergency medicine physician, who was guided by the externally validated algorithm outlined by the Pediatric Emergency Care Applied Research Network (PECARN) group (see Fig. 3 of their 2009 *Lancet* study).[20] Children are stratified into low, moderate, or high risk for clinically significant brain injury on the basis of age, mechanism of injury, and presenting signs/symptoms. They then undergo imaging and observation for a period of time.[5]

The caveat to the aforementioned protocol is concern for nonaccidental trauma (NAT). For any cases without a reported mechanism of injury or concerning findings on physical examination (such as bruising in a nonmobile child or atypical patterns of injury), a social work consultation is placed in the ED. The child undergoes head CT, a skeletal survey, and laboratory evaluations to assess for intraabdominal injury in the setting of concern for NAT. The decision to admit or discharge a child with the question of NAT is made as a joint decision between the social workers, the department of child services, and ED physicians. If all workup has negative findings and the patient has a safe discharge plan generated by the department of child services, then the child could be discharged from the ED.

Study Variables

Data were stored using an online REDCap database.[21,22] The same variables were collected for the preprotocol and postprotocol cohorts. The variables of interest included age at the time of presentation (in years), sex, race, mechanism of injury, loss of consciousness, presentation on a weekday or weekend, and time from initial injury to ED presentation. Mechanism of injury was categorized as fall less than 3 feet (lower than the average countertop), fall greater than 3 feet, no reported mechanism, and other, which included motor vehicle collisions, all-terrain vehicle injuries, etc. Symptoms of nausea/vomiting and ondansetron use were documented separately because prior research indicated that these are unique markers of ED revisit in this patient population.[19] Fracture location was also documented within the skull as parietal, temporal, frontal, or occipital. Fracture location spanning the venous sinuses was not measured, and venous imaging was not routinely pursued given the low incidence of clinically significant thrombosis in patients with nondisplaced skull fractures.[23] The predominant fracture location was listed for fractures that spanned multiple bones. Documentation of concern for NAT or Child Protection and Well Being (CARE) team consultation and pediatric trauma surgery consultation were also included. Primary outcomes assessed safety and included death and 72-hour ED revisits. Secondary outcomes assessed efficacy and included inpatient admissions and neurosurgical consultation.

An additional subgroup analysis of the postprotocol cohort was performed that assessed hospital length of stay (in hours), vomiting while inpatient, ondansetron administration while inpatient, and discharge disposition. This information was not reliably documented in the preprotocol analysis and thus was not compared between the preprotocol and postprotocol cohorts.

Statistical Analysis

The SPSS software platform (IBM Corp.) was used for the statistical analysis. In univariable analysis, the Pearson's chi-square test and Fisher's exact test were performed to identify categorical and continuous variables, respectively, that were significantly different between before and after protocol implementation. Multivariable analysis was not indicated because this study was specifically designed to compare each variable between the preprotocol and postprotocol cohorts and not the effect of a variable on a particular outcome. Statistical significance was set a priori at $p < 0.05$.

Results

Patient Characteristics

Two hundred forty-four patients were identified for this study, including 162 and 82 children in the preprotocol and postprotocol cohorts, respectively. Most children were White (159 [65%]) and male (138 [57%]), and the median (interquartile range [IQR]) age was 9.1 (4.8–25.0) months (Table 1). The preprotocol and postprotocol cohorts did not differ significantly in terms of race, sex, or age.

Overall, the most common mechanism of injury was a fall from a height less than 3 feet (152 patients [62%]), followed by a fall from greater than 3 feet (41 [17%]) and no reported mechanism of injury (32 [13%]). Postprotocol patients more frequently fell from heights greater than 3 feet than the preprotocol patients (24 [29%] vs 17 [10%], respectively; $p < 0.001$). Most patients had no documented loss of consciousness (197 [81%]) or associated nausea/vomiting (184 [75%]). The most common fracture location was the parietal bone (150 [61%]), followed by the occipital bone (68 [28%]). Most children presented within 6 hours of time of injury (122 [50%]), but several also presented later. Twenty-four percent of patients presented more than 24 hours after time of injury (59 [24%]). The proportion of patients with concern for NAT did not significantly change but did trend upward (from 22 [14%] patients in the preprotocol cohort to 18 [22%] in the postprotocol cohort, $p = 0.095$).

Outcome Analysis

With respect to the primary outcome, there were no documented patient deaths or neurosurgical procedures in the preprotocol or postprotocol cohorts. The ED revisit rate did not significantly change; however, it was lower in the postprotocol cohort (1 patient [1%]) than the preprotocol cohort (7 [4%]; $p = 0.2$) (Fig. 2). After protocol implementation, the 1 patient who returned to the ED within 72 hours after initial ED discharge was admitted for an additional episode of vomiting. The patient was observed overnight after re-presentation, and no further vomiting was documented and no antiemetics were administered while inpatient.

With respect to secondary outcomes, the proportions of patients who required neurosurgical consultation significantly decreased from 86% of preprotocol patients (n = 140) to 44% of postprotocol patients (n = 36; $p < 0.001$) (Fig. 3). Hospital admission rates significantly decreased from 52% (n = 84) to 38% (n = 31; $p = 0.038$). The frequency of pediatric trauma surgery consultations remained unchanged.

Inpatient Admissions

A total of 115 children in our study cohort were admitted to the hospital. Overall, 69% of patients who were admitted were discharged the following day (n = 84); however, this significantly reduced after protocol implementa-

TABLE 1. Characteristics of the preprotocol and postprotocol cohorts

Characteristic	Total (n = 244)	Preprotocol (n = 162)	Postprotocol (n = 82)	Test Statistic (X value)	p Value
Age, yrs	0.76 (0.40–2.08)	0.77 (0.41–1.81)	0.75 (0.40–2.41)	0.05*	0.821
Sex					
Male	138 (57)	86 (53)	52 (63)	2.36	0.124
Female	106 (43)	76 (47)	30 (37)		
Race					
White	159 (65)	105 (65)	54 (66)	3.81	0.149
African American	33 (14)	18 (11)	15 (18)		
Other	52 (21)	39 (24)	13 (16)		
Mechanism of injury					
Fall <3 feet	152 (62)	110 (68)	42 (51)	17.3	**<0.001**
Fall >3 feet	41 (17)	17 (10)	24 (29)		
None	32 (13)	19 (12)	13 (16)		
Other	19 (8)	16 (10)	3 (4)		
Loss of consciousness					
Yes	11 (5)	7 (4)	4 (5)	1.41	0.494
No	197 (81)	128 (79)	69 (84)		
Unknown	36 (15)	27 (17)	9 (11)		
Fracture location					
Parietal	150 (61)	100 (62)	50 (61)	1.4	0.706
Temporal	11 (5)	8 (5)	3 (4)		
Frontal	15 (6)	8 (5)	7 (9)		
Occipital	68 (28)	46 (28)	22 (27)		
Nausea/vomiting					
Yes	60 (25)	35 (22)	25 (30)	2.32	0.128
No	184 (75)	127 (78)	57 (70)		
Ondansetron					
Yes	38 (16)	20 (12)	18 (22)	3.82	0.051
No	206 (84)	142 (88)	64 (78)		
Day of presentation					
Weekend	103 (42)	69 (43)	34 (41)	0.03	0.866
Weekday	141 (58)	93 (57)	48 (59)		
Time from injury to presentation, hrs					
<6	122 (50)	82 (51)	40 (49)	1.69	0.430
6–24	63 (26)	38 (23)	25 (30)		
>24	59 (24)	42 (26)	17 (21)		
Neurosurgery consultation					
Yes	176 (72)	140 (86)	36 (44)	49	**<0.001**
No	68 (28)	22 (14)	46 (56)		
Trauma consultation					
Yes	118 (48)	83 (51)	35 (43)	1.59	0.207
No	129 (52)	79 (49)	47 (57)		
Concern for NAT					
Yes	40 (16)	22 (14)	18 (22)	2.78	0.095
No	204 (84)	140 (86)	64 (78)		
Admitted to hospital					
Yes	115 (47)	84 (52)	31 (38)	4.31	**0.038**
No	129 (53)	78 (48)	51 (62)		
ED revisit					
Yes	8 (3)	7 (4)	1 (1)	1.65	0.199

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TABLE 1. Characteristics of the preprotocol and postprotocol cohorts

Characteristic	Total (n = 244)	Preprotocol (n = 162)	Postprotocol (n = 82)	Test Statistic (X value)	p Value
ED revisit (*continued*)					
No	236 (97)	155 (96)	81 (99)		
Death					
Yes	0 (0)	0 (0)	0 (0)		
No	244 (100)	162 (100)	82 (100)		
Neurosurgical intervention					
Yes	0 (0)	0 (0)	0 (0)		
No	244 (100)	162 (100)	82 (100)		

Values are shown as number (%) or median (IQR) unless indicated otherwise. Boldface type indicates statistical significance (p < 0.05).
* F value is shown.

tion, while the number of same-day admissions increased (p = 0.02). Of the 31 patients admitted after protocol implementation, the median (IQR) length of stay was 20 (14–26) hours. Only 4 patients vomited or received ondansetron while inpatient (13%). All patients were discharged home from the hospital. No patients needed neurosurgical follow-up.

Discussion

Protocolizing the management of isolated linear skull fractures in children at a level 1 pediatric trauma center can be both safe and effective. We conducted a retrospective analysis of a quality improvement initiative that standardized the management of children with this diagnosis at a single pediatric academic medical center.

With respect to protocol safety, there were no documented patient deaths during admission or within 72 hours after discharge. No neurosurgical procedures were performed. With respect to protocol efficacy, the hospital admission rate significantly decreased (from 52% to 38%, p = 0.038) (Fig. 2), the neurosurgery consultation rate decreased (from 86% to 44% of patients, p < 0.001) (Fig. 3), and the 72-hour ED revisit rate trended down (from 4% to 1%, p = 0.2). There were no significant changes to the role of pediatric trauma surgery in patient evaluation. As such, this protocol presents a safe and efficacious outline for standardized linear skull fracture management at a major pediatric trauma center.

The data in this study corroborate those found in other published studies[12] but also add several new pieces of information. Mechanism of injury with a relatively low velocity (e.g., falling) was associated with linear skull fractures.[24] There were few motor vehicle collisions or all-terrain vehicle crashes because these more severe mechanisms of injury often result in more severe TBI, such as intracranial hemorrhage or a displaced skull fracture.[24] With the increase in ED discharges, we closely monitored cases of NAT to ensure that no significant decrease occurred after protocol implementation. Conversely, there was an increase in cases of NAT over the study period, which may allude to heightened provider suspicion.[25]

An important observation noted in this study is the reduced need for admission without an increase in ED revisits. The reasons for admission vary, but admission is most commonly for nausea and vomiting after head in-

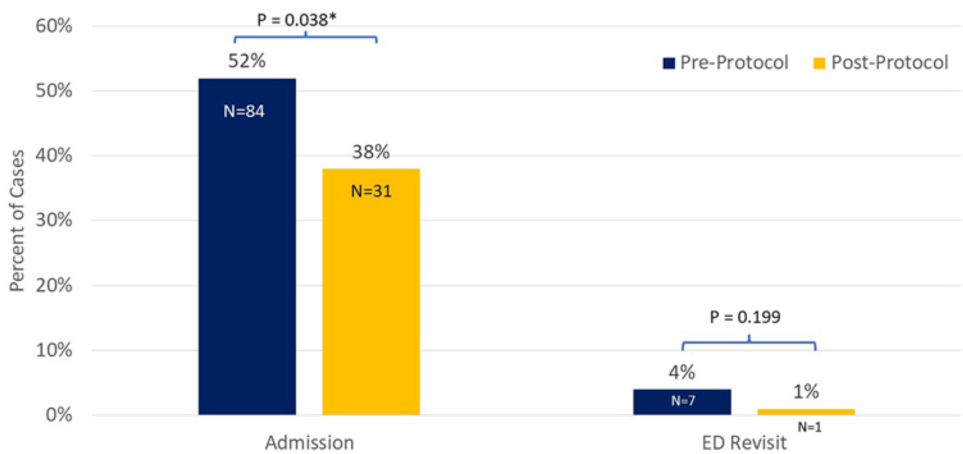

FIG. 2. Inpatient admissions and ED revisits for the preprotocol and postprotocol cohorts. *p < 0.05. Figure is available in color online only.

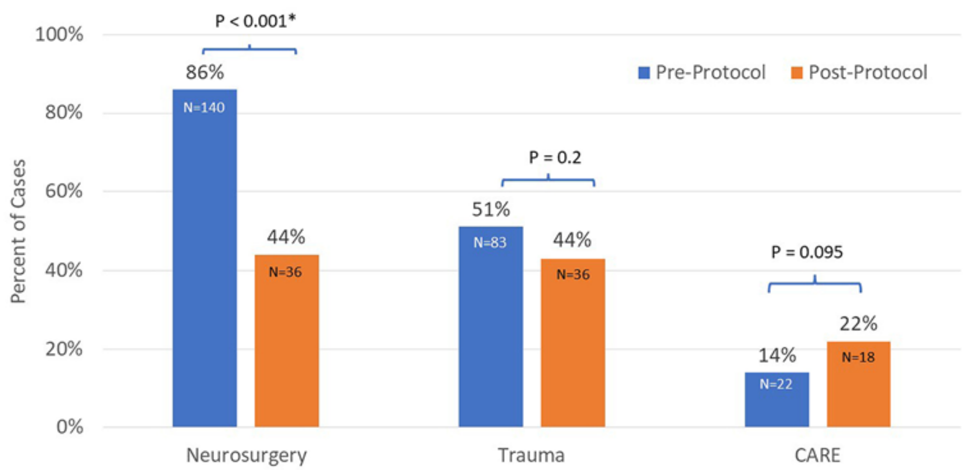

FIG. 3. Preprotocol versus postprotocol consultations to the neurosurgery, trauma surgery, and CARE teams. Figure is available in color online only.

jury. When the 31 admitted patients in the postprotocol cohort were analyzed further, it was apparent that only 4 (13%) vomited while inpatient or received antiemetics. These data suggest that patients are still being overadmitted and that the protocol could be revised further to promote discharge from the ED. Overall, this study presents a representative sample of children with isolated linear skull fractures seen at a pediatric level 1 trauma center and demonstrates the utility of a protocolized approach to patient care.

The wide variability in the management of children with isolated linear skull fractures in the United States has been well documented in the literature.[26] Several champions in pediatrics,[12] pediatric surgery,[11,14] and neurosurgery[15,16] have advocated for ED discharge and/or reducing the need for interfacility transfer. Protocols have been suggested and tested at both Boston Children's Hospital[17] and Primary Children's Hospital in Salt Lake City;[18] however, these protocols have not been widely circulated and indicate a consistent role for neurosurgery. In advocating for universal neurosurgical presence, local ED providers default to patient transfer to a major tertiary care center to achieve this perceived necessity. Given the 0% neurosurgical procedure rate and 0% mortality rate according to the current data, the role of urgent neurosurgical evaluation is called into question.[8] It should be emphasized that these findings refer to patients with isolated linear skull fractures with no acute intracranial findings and not patients with depressed fractures of the cranial vault or skull base, which portray a more severe source of trauma.[27] The pediatric neurosurgery team in this study tried to identify scenarios in which neurosurgery would continue to have an important presence for these patients and their families. The collaborative team at this institution included clinicians from the departments of pediatric emergency medicine, pediatric surgery, pediatric neurosurgery, and pediatric otolaryngology to create a multidisciplinary management protocol that integrated these considerations. The response was favorable, and the data were promising.

This study brings up the topic of a refined role for pediatric neurosurgery in TBI management. It is important to emphasize that the focus of this study was very narrow. We included patients with isolated linear skull fractures and without a referral to concussion management or severe TBI. Neurosurgery needs to have a continued role in the care of these children with linear skull fractures, but perhaps the focus should shift toward as-needed consultation rather than in primary triage and evaluation. In this era of telehealth, electronic medical records, and the 21st Century Cures Act that facilitates patient access to health records, remote neurosurgery consultation should be offered to (and billable for) physicians in local EDs.[28] Local EDs should continue to transfer a patient if the evaluating provider feels uncomfortable with managing the child. For children who are not evaluated by the neurosurgery department as part of their initial ED presentation, our center provides standard discharge guidelines for linear skull fractures and our clinic line is available if parents wish to pursue follow-up. Routine follow-up imaging is not performed, and follow-up appointments are not routinely scheduled; however, parents have access to an open line of communication to neurosurgery. Parent education materials include the remote possibility of a growing skull fracture should swelling worsen over the course of months. We emphasize that this is a rare subacute condition typically associated with a more severe skull fracture.[13,29] The role of neurosurgery in linear skull fracture management is constantly evolving and the results of this study and management protocol continue to support that role for internal reevaluation.

Limitations

Although this study offers strong support for standardizing management of isolated linear skull fractures in children, there were several limitations. First, this was a retrospective quality improvement study that was implemented at a single center in the southeast United States. We refer to the regional variability in skull fracture management, and thus a truly representative sample would include tertiary children's hospitals from across the country. Second, although the concept of reducing interfacility transfer has been brought up, this hypothesis was not tested in this study. To ensure similar outcomes, the next step would be to monitor the outcomes of patients managed in local EDs with imaging read by local radiologists. Thirdly, this study included a short follow-up period of peri-injury management. Long-term monitoring of outcomes and increasing the sample size would also further define the incidence of peri-injury morbidity, need for follow-up, and possibility of long-term issues such as growing skull fracture in this patient population.

Conclusions

Protocolization of isolated linear skull fracture management is safe and feasible at a high-volume level 1 pediatric trauma center. Neurosurgical consultation can be prioritized for select patients and does not necessarily serve a central role in the management of these children. Further investigation into criteria for admission, need for interfacility transfer, and healthcare costs is warranted because this protocol serves as an example and could be further refined as the population at risk for ED revisits is further clarified.

Acknowledgments

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References

1. Schneier AJ, Shields BJ, Hostetler SG, Xiang H, Smith GA. Incidence of pediatric traumatic brain injury and associated hospital resource utilization in the United States. *Pediatrics*. 2006;118(2):483-492.
2. White IK, Pestereva E, Shaikh KA, Fulkerson DH. Transfer of children with isolated linear skull fractures: is it worth the cost? *J Neurosurg Pediatr*. 2016;17(5):602-606.
3. Centers for Disease Control and Prevention. TBI-related emergency department visits, hospitalizations, and deaths. Accessed June 8, 2022. https://cdc.gov/traumaticbraininjury/data/tbi-edhd.html
4. Coulter IC, Forsyth RJ. Paediatric traumatic brain injury. *Curr Opin Pediatr*. 2019;31(6):769-774.
5. Babl FE, Borland ML, Phillips N, et al. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. *Lancet*. 2017; 389(10087):2393-2402.
6. Thiam DW, Yap SH, Chong SL. Clinical decision rules for paediatric minor head injury: are CT scans a necessary evil? *Ann Acad Med Singap*. 2015;44(9):335-341.
7. Orman G, Wagner MW, Seeburg D, et al. Pediatric skull fracture diagnosis: should 3D CT reconstructions be added as routine imaging? *J Neurosurg Pediatr*. 2015;16(4):426-431.
8. Tang AR, Reynolds RA, Dallas J, et al. Admission trends in pediatric isolated linear skull fracture across the United States. *J Neurosurg Pediatr*. 2021;28(2):183-195.
9. Williams DC, Russell WS, Andrews AL, Simpson KN, Basco WT Jr, Teufel RJ II. Management of pediatric isolated skull fractures: a decision tree and cost analysis on emergency department disposition strategies. *Pediatr Emerg Care*. 2018;34(6):403-408.
10. Tavarez MM, Atabaki SM, Teach SJ. Acute evaluation of pediatric patients with minor traumatic brain injury. *Curr Opin Pediatr*. 2012;24(3):307-313.
11. Snyder CW, Kauffman JD, Pracht EE, Danielson PD, Ciesla DJ, Chandler NM. Risk factors for avoidable transfer to a pediatric trauma center among patients 2 years and older. *J Trauma Acute Care Surg*. 2019;86(1):92-96.
12. Powell EC, Atabaki SM, Wootton-Gorges S, et al. Isolated linear skull fractures in children with blunt head trauma. *Pediatrics*. 2015;135(4):e851-e857.
13. Northam W, Chandran A, Quinsey C, Abumoussa A, Flores A, Elton S. Pediatric nonoperative skull fractures: delayed complications and factors associated with clinic and imaging utilization. *J Neurosurg Pediatr*. 2019;24(5):489-497.
14. Rollins MD, Barnhart DC, Greenberg RA, et al. Neurologically intact children with an isolated skull fracture may be safely discharged after brief observation. *J Pediatr Surg*. 2011;46(7):1342-1346.
15. Reuveni-Salzman A, Rosenthal G, Poznanski O, Shoshan Y, Benifla M. Evaluation of the necessity of hospitalization in children with an isolated linear skull fracture (ISF). *Childs Nerv Syst*. 2016;32(9):1669-1674.
16. Mackel CE, Morel BC, Winer JL, et al. Secondary overtriage of pediatric neurosurgical trauma at a Level I pediatric trauma center. *J Neurosurg Pediatr*. 2018;22(4):375-383.
17. Lyons TW, Stack AM, Monuteaux MC, et al. A QI Initiative to reduce hospitalization for children with isolated skull fractures. *Pediatrics*. 2016;137(6):e20153370.
18. Metzger RR, Smith J, Wells M, et al. Impact of newly adopted guidelines for management of children with isolated skull fracture. *J Pediatr Surg*. 2014;49(12):1856-1860.
19. Dallas J, Mercer E, Reynolds RA, Wellons JC, Shannon CN, Bonfield CM. Should ondansetron use be a reason to admit children with isolated, nondisplaced, linear skull fractures? *J Neurosurg Pediatr*. 2020;25(3):284-290.
20. Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009; 374(9696):1160-1170.
21. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381.
22. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208.
23. Hersh DS, Shimony N, Groves ML, et al. Pediatric cerebral venous sinus thrombosis or compression in the setting of skull fractures from blunt head trauma. *J Neurosurg Pediatr*. 2018;21(3):258-269.
24. Stephens S, Campbell R, Chaseling R, Ma N. Traumatic brain injuries in a paediatric neurosurgical unit: a Queensland experience. *J Clin Neurosci*. 2019;70:27-32.
25. Riney LC, Frey TM, Fain ET, Duma EM, Bennett BL, Murtagh Kurowski E. Standardizing the evaluation of nonaccidental trauma in a large pediatric emergency department. *Pediatrics*. 2018;141(1):e20171994.
26. Mannix R, Monuteaux MC, Schutzman SA, Meehan WP III, Nigrovic LE, Neuman MI. Isolated skull fractures: trends in management in US pediatric emergency departments. *Ann Emerg Med*. 2013;62(4):327-331.
27. Tunik MG, Powell EC, Mahajan P, et al. Clinical presentations and outcomes of children with basilar skull fractures after blunt head trauma. *Ann Emerg Med*. 2016;68(4):431-440.e1.
28. Rodriguez JA, Clark CR, Bates DW. Digital health equity as a necessity in the 21st Century Cures Act era. *JAMA*. 2020; 323(23):2381-2382.
29. Lopez J, Chen J, Purvis T, et al. Pediatric skull fracture characteristics associated with the development of leptomeningeal cysts in young children after trauma: a single

institution's experience. *Plast Reconstr Surg*. 2020;145(5): 953e-962e.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Reynolds, Vance, Lovvorn, Hanson, Shannon, Bonfield. Acquisition of data: Reynolds, Ahluwalia. Analysis and interpretation of data: Reynolds, Ahluwalia. Drafting the article: Reynolds, Kelly, Ahluwalia. Critically revising the article: Reynolds, Kelly, Ahluwalia, Vance, Lovvorn, Hanson, Shannon, Bonfield. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Reynolds. Statistical analysis: Zhao. Administrative/technical/material support: Reynolds. Study supervision: Lovvorn, Hanson, Shannon, Bonfield.

Supplemental Information

Previous Presentations

This work was presented virtually at the AANS/CNS Joint Pediatric Neurosurgery Section, December 2020.

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