

Functional outcome of supracondylar elbow fractures in children: a 3- to 5-year follow-up

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Background: Long-term functional outcomes of supracondylar elbow fractures (SCEF) have not been well documented in the literature. We retrospectively evaluated functional outcomes of pediatric SCEF using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Methods: We retrospectively reviewed the outcomes of patients who presented to our tertiary care pediatric emergency department with SCEF between January 2005 and December 2009. We reviewed their charts to assess several clinical parameters, including age, sex, Gartland classification of SCEF, weight, comorbidities, treatment intervention, physiotherapy and the extremity involved. The DASH questionnaire was administered in 2012. We performed a multiple linear regression analysis to determine the significance of these clinical parameters as they related to the DASH score for functional outcome.

Results: We included 94 patients with SCEF in our review. Pediatric SCEF had good functional outcomes based on the DASH questionnaire (mean score 0.77 ± 2.10). We obtained the following DASH scores: 0.45 ± 2.20 for type I, 1.09 ± 1.70 for type II and 1.43 ± 2.40 for type III fractures. There was no statistical difference in functional outcome, regardless of sex ($p = 0.07$), age at injury ($p = 0.96$), fracture type ($p = 0.14$), weight ($p = 0.59$), right/left extremity ($p = 0.26$) or surgery ($p = 0.52$).

Conclusion: Our results demonstrate that good functional outcomes can be expected with pediatric SCEF based on the DASH questionnaire, regardless of age at injury, sex, weight, right/left extremity or surgical/nonsurgical intervention, provided satisfactory reduction is achieved and maintained.

Contexte : Les répercussions fonctionnelles à long terme des fractures du coude supracondyliennes (FCSC) n'ont pas été bien documentées dans la littérature. Nous avons évalué de manière rétrospective les résultats fonctionnels des FCSC pédiatriques à l'aide du questionnaire DASH (Disabilities of the Arm, Shoulder and Hand).

Méthodes : Nous avons passé en revue rétrospectivement les résultats chez les patients amenés pour une FCSC au service d'urgence pédiatrique de notre établissement de soins tertiaires entre janvier 2005 et décembre 2009. Nous avons examiné leurs dossiers pour évaluer plusieurs paramètres cliniques, dont l'âge, le sexe, la classification de Gartland pour les FCSC, le poids, les comorbidités, l'intervention thérapeutique, la physiothérapie et la latéralité du membre affecté. Le questionnaire DASH a été administré en 2012. Nous avons procédé à une analyse de régression linéaire multiple pour déterminer la signification de ces paramètres cliniques en regard du score DASH d'évaluation fonctionnelle.

Résultats : Nous avons inclus 94 patients ayant subi une FCSC dans notre analyse. La FCSC pédiatrique évolue bien au plan fonctionnel selon le questionnaire DASH (score moyen $0,77 \pm 2,10$). Nous avons obtenu les scores DASH suivants : $0,45 \pm 2,20$ pour les fractures de type I, $1,09 \pm 1,70$ pour les fractures de type II et $1,43 \pm 2,40$ pour les fractures de type III. On n'a noté aucune différence statistique quant aux résultats fonctionnels, indépendamment du sexe ($p = 0,07$), de l'âge au moment de la fracture ($p = 0,96$), du type de fracture ($p = 0,14$), du poids ($p = 0,59$), de la latéralité ($p = 0,26$) ou de la chirurgie ($p = 0,52$).

Conclusion : Nos observations démontrent qu'on peut s'attendre à de bons résultats fonctionnels dans les cas de FCSC en se fondant sur le questionnaire DASH, indépendamment de l'âge au moment de la fracture, du sexe, du poids, de la latéralité ou de l'intervention chirurgicale ou non chirurgicale, à la condition d'obtenir et de maintenir une réduction satisfaisante.

Pediatric supracondylar elbow fractures (SCEF) are a common occurrence in children. These fractures are commonly extra-articular, unlike adult SCEF. Return of elbow motion after treatment of supracondylar humeral fracture in children has been well documented in the literature.¹ However, the return of elbow range of motion and function is usually measured as an objective parameter, such as a return of normal range of arc motion in the sagittal plane (flexion and extension).¹ Long-term functional outcome using standardized tools has not been well documented in the literature. One study analyzed the correlation between the values of a modified Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and change of elbow function after SCEF of the humerus.² However, the study addressed only flexion SCEF, which represents a small percentage of pediatric SCEF. The authors concluded that the value of a modified DASH questionnaire correlates with objective indicators of elbow function after flexion SCEF in children. A standardized functional outcome tool, such as the well-validated DASH questionnaire, has been instrumental in measuring functional disability.

Bot and colleagues³ evaluated the clinimetric quality of 16 self-administered shoulder disability questionnaires, including DASH, the Shoulder Pain and Disability Index and the American Shoulder and Elbow Surgeons Standardised Shoulder Assessment Form. For clinimetric purposes, the DASH questionnaire received the best ratings.³ Thus, we chose the DASH questionnaire, as it is a region-specific standardized functional outcome tool that is well validated has been important in measuring functional disability.

The purpose of the present study was to provide a retrospective, longitudinal evaluation of functional outcome in a large population of children treated for pediatric SCEF, using the DASH for standardized measure of outcome. A secondary goal was to determine whether factors such as age at injury, sex, weight, right or left extremity, Gartland fracture type and surgical versus nonsurgical intervention could predict long-term functional outcomes.

METHODS

We retrospectively reviewed the cases of children with SCEF who presented to our tertiary care pediatric emergency department between January 2005 and December 2009. We reviewed their charts for several parameters, including age, sex, classification of fracture severity, weight, comorbidities, operative or nonoperative treatment intervention, postoperative physiotherapy and associated nerve injury. A DASH questionnaire was administered in 2012 by the parents of the patients with the child present; if they were old enough, the patients completed

the questionnaire themselves under a parent's supervision. We chose to remove the sex-related question to make the questionnaire more age appropriate. The optional work module was not used, but the optional sports/performing arts module was.

The DASH score is scaled between 0 and 100. Higher scores indicate worse function, and lower scores indicate better function relating to upper-extremity disability.

Our inclusion criteria for joining the study were isolated extension SCEF in patients younger than 13 years at the time of injury, closed injury and consent to join the study (obtained from parents). The exclusion criteria were polytrauma, flexion type SCEF, ipsilateral injury requiring surgery, iatrogenic neurologic injury, reinjury to the same elbow within the study period, metabolic bone disease, condyle, epicondyle fractures and transphyseal fractures that had been reported as SCEF. We chose to exclude the flexion type SCEF owing to the small number (1.2%) of patients with this condition.

Three fellowship-trained pediatric orthopedic surgeons independently reviewed the radiographs and grouped the patients according to the Gartland classification,⁴ which is widely used in the literature. In the Gartland classification system, type I fractures are essentially nondisplaced. Type II fractures are displaced with a variable amount of angulation, but more importantly, the posterior cortex of the humerus is intact. Type III fractures are completely displaced, with no cortical continuity (Fig. 1). A κ value for interobserver agreement was then calculated.

The pediatric orthopedic surgeons in our tertiary care centre treated patients either operatively or nonoperatively based on the degree of angulation and displacement (displacement of the anterior humeral line [Fig. 2] and alteration of the Baumann angle [Fig. 3]).

The anterior humeral line should intersect the middle third of the capitellum on lateral radiographs. A Baumann angle within 5° of the uninjured side was considered acceptable. This was the radiographic measure of coronal plane deformity. The normal physiologic tilt of the capitellum on the humerus is about 30° anteriorly; reduction was not required if this physiologic angulation was 20° or more and if the anterior humeral line intersected the middle third of the capitellum on lateral radiographs in extension type SCEF. Type I fractures were treated nonoperatively. Type II fractures were treated operatively or nonoperatively depending on the amount of angulation and displacement. Type II fractures that failed closed reduction based on the radiographic parameters mentioned previously were treated operatively. All type III fractures were treated operatively. Patients who were managed operatively underwent closed reduction and percutaneous pinning using Kirschner wires under fluoroscopy. If reduction could not be obtained with closed reduction, open reduction and percutaneous pinning was performed.

Patients were seen by the pediatric orthopedic surgeons for scheduled follow-up visits. They were seen

10–14 days postoperatively for a cast change, wound check and radiographs to ensure displacement had not occurred. Displacement was measured using the anterior humeral line and the relationship with the capitellum. Alignment was considered acceptable if the anterior humeral line intersected the middle third of the capitellum on lateral radiographs. Patients were seen for pin removal and cast change at 4 weeks postoperative and again for final cast removal, radiographs and range of motion check at 6 weeks postoperative. At the 3-month follow-up, patients were seen to assess the need for physiotherapy and to check range of motion.

The patients who received closed reduction or who sustained a nondisplaced or minimally displaced SCEF

not requiring closed reduction were casted and seen in clinic at 2 weeks postinjury for a cast check and radiographs and at 4 weeks for cast removal, radiographs and range of motion check.

Three fellowship-trained pediatric orthopedic surgeons followed all patients to ensure fracture healing, as seen radiographically. One of us (A.I.) independently reviewed all the radiographs to ensure that reductions were maintained and that fractures had healed.

Statistical analysis

Mean DASH scores were then calculated based on sex, right or left extremity, weight, intervention (operative v.

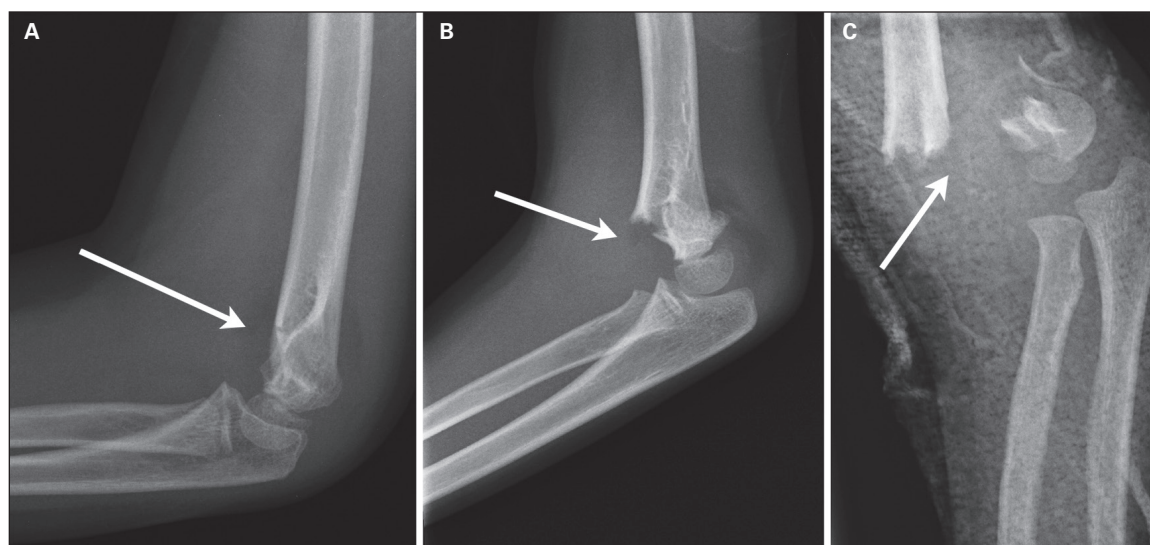


Fig. 1. Types of supracondylar fractures. **A)** type I supracondylar fracture with a posterior fat pad sign, **B)** type II supracondylar fracture with an intact posterior hinge, **C)** type III supracondylar fracture with no cortical continuity. Arrows delineate fracture lines.

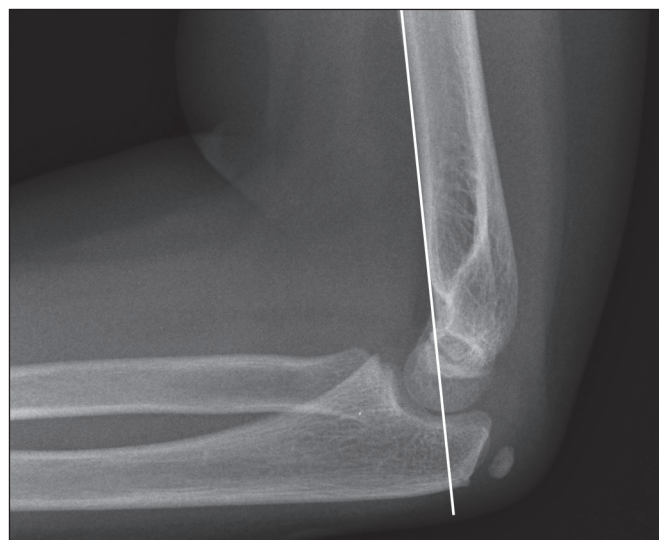


Fig. 2. Anterior humeral line, drawn in line with the anterior humeral shaft, should intersect the middle of capitellum.

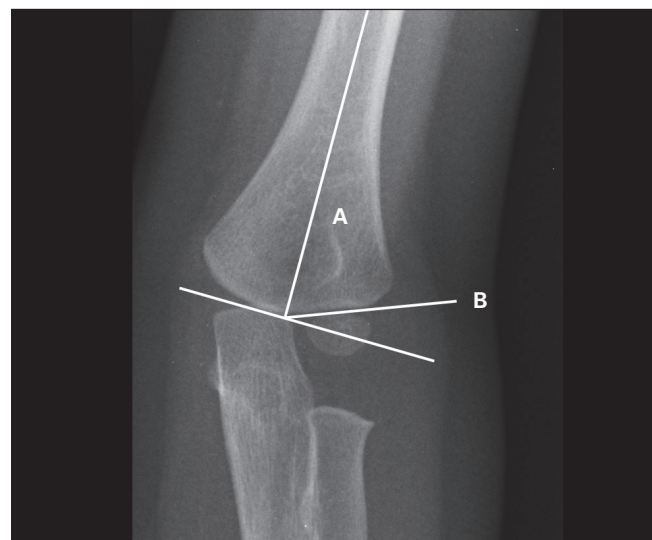


Fig. 3. Baumann angle: **(A)** Angle between long axis of humeral shaft and **(B)** growth plate of lateral humeral condyle.

nonoperative) and age at time of injury. A multiple linear regression analysis was then performed, and we considered results to be significant at $p < 0.05$.

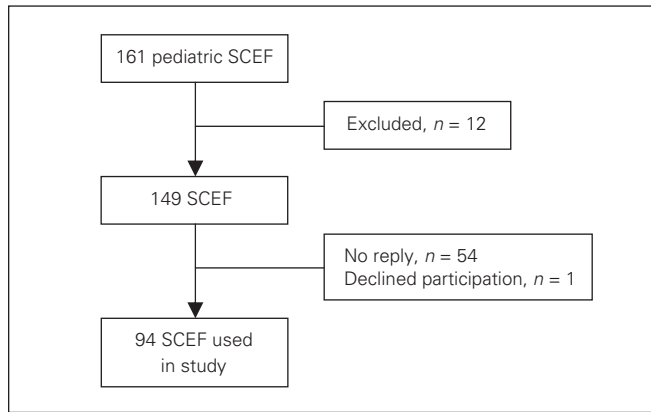


Fig. 4. Enrolment of eligible patients. SCEF = supracondylar elbow fractures.

Table 1. Distribution of supracondylar elbow fracture

Type	Group; no. (%)	
	Study group	No reply
1	53 (56.4)	32 (58.2)
2	26 (27.7)	14 (25.5)
3	15 (15.9)	9 (16.3)
Total	94	55

Table 2. Patient demographics

Characteristic	Group; no. (%)		
	Type 1, n = 53	Type 2, n = 26	Type 3, n = 15
Sex			
Male	29 (55)	16 (62)	9 (60)
Female	24 (45)	10 (28)	6 (40)
Extremity			
Right elbow	18 (34)	11 (42)	7 (47)
Left elbow	35 (66)	15 (58)	8 (53)
Weight, kg			
≤ 15	9 (17)	3 (12)	1 (7)
16–30	34 (64)	19 (73)	9 (60)
31–45	8 (15)	4 (15)	2 (13)
> 45	2 (4)	0 (0)	3 (20)
Intervention			
Operative	0 (0)	11 (42)	13 (87)
Nonoperative	53 (100)	15 (58)	2 (13)
Age at injury, mo			
< 30	2 (4)	1 (4)	0 (0)
31–60	21 (39)	6 (23)	4 (27)
61–90	17 (32)	12 (46)	5 (33)
91–120	10 (19)	6 (23)	3 (20)
> 120	3 (6)	1 (4)	3 (20)
Mean age, mo	70	74	83

RESULTS

A total of 158 patients with 161 SCEF were eligible to participate in our study. Ten patients were excluded, as they did not meet the inclusion criteria. Fifty-four patients did not respond because they had moved away or changed phone numbers without providing an update in the medical record system, and 1 patient declined participation, leaving 94 patients for analysis (Fig. 4). Patients who did not reply or declined participation had a similar distribution in terms of type of SCEF compared with our study group (Table 1).

Of the 94 patients included in the study (Table 2), 54 (57%) were male and 40 (43%) were female. We subdivided patients by fracture type: 53 (56.4%) had type I, 26 (27.7%) had type II and 15 (15.9%) had type III fractures; 2 (2.1%) had flexion type SCEF. Patients were further subdivided by sex, right or left extremity, weight, intervention (operative v. nonoperative) and age at time of injury (Table 2). There was a higher incidence of SCEF in boys (57%) than in girls, and the left elbow was more commonly injured than the right elbow (61.7%). The mean age of patients with type I SCEF was 70 months, type II was 74 months, type III was 83 months and Flexion type SCEF was 73.5 months (Table 2).

A multiple linear regression analysis was performed to determine the significance of the clinical parameters as they related to the DASH score for functional outcome. There was no statistical difference in functional outcome using the DASH score regardless of sex ($p = 0.07$), age at injury ($p =$

Table 3. Mean dash scores and standard deviation

Characteristic	Group; mean ± SD		
	Type I, n = 58	Type II, n = 18	Type III, n = 16
Sex			
Male	0.03 ± 0.17	0.78 ± 1.28	1.69 ± 2.42
Female	0.96 ± 3.22	1.57 ± 2.19	1.04 ± 2.55
Extremity			
Right elbow	0.81 ± 3.21	0.76 ± 1.26	2.17 ± 2.57
Left elbow	0.27 ± 1.46	1.32 ± 1.96	0.78 ± 2.21
Weight, kg			
≤ 15	0.11 ± 0.32	1.98 ± 1.93	6.25*
16–30	0.65 ± 2.72	0.90 ± 1.64	0.80 ± 2.07
31–45	—	1.29 ± 2.05	—
> 45	0.45 ± 0.63	—	2.68 ± 2.36
Intervention			
Operative	—	1.39 ± 1.99	0.83 ± 1.91
Nonoperative	0.45 ± 2.20	0.86 ± 1.48	5.35 ± 1.27
Age at injury, mo			
≤ 30	—	—	—
31–60	0.70 ± 2.97	0.66 ± 1.02	1.56 ± 3.13
61–90	0.51 ± 2.09	1.21 ± 1.63	1.44 ± 2.72
91–120	0.09 ± 0.28	1.66 ± 2.58	—
> 120	—	0.86*	2.68 ± 2.36

SD = standard deviation.
*There was only 1 patient in this category, so the SD could not be calculated.

0.96), type of fracture ($p = 0.14$), weight ($p = 0.59$), right or left extremity ($p = 0.26$) or surgery ($p = 0.52$; Tables 3 and 4).

Using the optional module (sports/performing arts), there was no statistical difference in functional outcome regardless of sex ($p = 0.33$), age at injury ($p = 0.90$, type of fracture ($p = 0.62$), weight ($p = 0.99$), or right or left extremity ($p = 0.28$; Table 5).

Our interobserver agreement to indicate the reproducibility of the classification was calculated using weighted Fleiss κ , with κ representing the proportion of agreement among the orthopedic surgeons beyond that expected by chance. A value of 0 indicates what would be expected by chance and a value of 1 indicates perfect agreement. A value less than 0 is an indication that agreement is less than what is expected by chance.⁵ Our calculated κ score was 0.76, which represents good interobserver reliability (Table 6).

DISCUSSION

Supracondylar elbow fractures are common in children. The Gartland classification has been widely used for classification of pediatric SCEF. Ideally, a fracture classifica-

tion system should be both prognostic and provide a guide to clinical management. Our study demonstrated no statistical difference in functional outcomes across all pediatric SCEF despite Gartland classification. There were no significant differences between other parameters, such as sex, right or left extremity, weight, intervention (operative v. nonoperative) and age at time of injury and their correlation with functional outcomes. These types of fractures, regardless of several parameters, tend to have good functional outcomes based on the DASH score, provided that satisfactory reduction is maintained by either surgical or nonsurgical (cast) means and that the technique of reduction and subsequent treatment course is uncomplicated.

The pediatric orthopedic surgeons at our institution still use the Gartland classification; however, for clinical decision making, degree of displacement is used. For example, not all Gartland type II SCEF were treated operatively; based on degree of displacement/intersection of the anterior humeral line and capitellum (Fig. 3) and the Baumann angle (Fig. 4) as well as on failure of closed reduction, patients were treated operatively or nonoperatively. There was no significant difference in DASH scores ($p = 0.52$) between patients treated operatively and those treated nonoperatively. This does not mean that surgery is not important in the management of pediatric SCEF; adequate reduction is important to the functional outcome. Inadequate reduction can lead to potential functional long-term problems.⁶ Garland type II SCEF is not an indication for surgery. The degree of displacement should guide management, as SCEF tend to do well if adequate reduction is obtained and maintained and if it follows an uncomplicated course. A study by Heal and colleagues⁷ further supports this, as they also conclude that pediatric SCEF should be treated based on the degree of displacement rather than the Gartland classification.

In the same study, based on a calculated κ score of 0.54, Heal and colleagues⁷ concluded that there was a moderate interobserver agreement with the Gartland classification, with poor agreement over type I extension SCEF, fair to moderate agreement with type II and good to very good agreement with type III using κ scores. Our interobserver agreement to indicate the reproducibility of the classification was calculated using weighted Fleiss κ , which represents the proportion of agreement among the orthopedic surgeons beyond that expected by chance. In contrast to Heal and colleagues,⁷ our calculated score was 0.76, which indicates substantial or good agreement among the orthopedic surgeons, bearing in mind that the calculated κ scores could also be due to chance.

Our study showed no statistical difference in the functional outcome based on the Gartland classification. Pediatric SCEF, if treated appropriately based on degree of displacement and adequacy/maintenance of closed reduction tend to do well despite the classification of fracture with little to no functional limitation of day-

Table 4. Multiple linear regression analysis

Model	<i>p</i> value
Constant	0.25
Class	0.16
Sex	0.07
Weight	0.59
Age	0.96
Operative v. nonoperative	0.52
Right or left extremity	0.26

Table 5. Multiple linear regression analysis of sports/performing arts module

Model	<i>p</i> value
Constant	0.48
Class	0.62
Sex	0.33
Weight	0.99
Age	0.90
Right or left extremity	0.28

Table 6. Interpretation of κ , Landis and Koch (1997)

κ	Strength of agreement
< 0	Poor
0.01–0.20	Slight
0.21–0.40	Fair
0.41–0.60	Moderate
0.61–0.80	Substantial/good
0.81–1.00	Almost perfect

to-day activities or associated pain. In the sports/performing arts module, there was also no statistical difference in mean DASH score among the groups (Table 4), regardless of age, weight, right or left extremity, sex, intervention (operative v. nonoperative) or Gartland classification of severity. These patients also tend to function well with no significant limitation in sports or performing arts (Table 5).

Spencer and colleagues¹ demonstrated the effect of age and severity of fracture (determined by those requiring operative intervention) on the recovery of elbow motion, with patients older than 5 years demonstrating a 3%–9% lower relative arc of motion at the follow-up points than younger patients and a slower recovery in motion in those who had more severe fractures requiring surgical intervention. We studied whether there were any functional differences between these groups using the DASH questionnaire and found that despite the findings of Spencer and colleagues,¹ there was no statistical difference in functional outcome regardless of age or operative or nonoperative intervention ($p = 0.52$) based on multiple linear regression analysis.

Limitations

The limitations of our study include the fact that it was retrospective and, in some cases, the parents filled out the DASH questionnaire based on their perceptions of their children's functioning. Another limitation is the validity of this questionnaire in this age group. Although the DASH questionnaire has not yet been formally validated in this age group, multiple studies have used the DASH questionnaire in pediatric populations.^{8–11} There is also a possibility for skewed data given that 54 patients did not respond and 1 declined participation. Thus, given our small sample size, there is a chance that we missed the difference in DASH scores among the groups. We did not perform a subgroup analysis on the fractures treated with open reduction, as the numbers would be small and we would have therefore been unable to make firm statistical conclusions; however, this was not the primary focus of our study and represents a potential future area of research. Despite the small number at follow-up, we reviewed the charts of all 149 patients who were eligible for participation in the study to identify any adverse outcomes or the need for further therapy or intervention. There were none identified from our chart review. We also reviewed the surgeon's notes at subsequent follow-ups.

To our knowledge, our study is the first to attempt to identify risk factors for poor functional outcomes using a standardized measure of outcome in a large group of children with all types of extension SCEF. Our study further provides a longitudinal evaluation of functional outcome in a large population of children treated for pediatric SCEF fracture using the DASH for standardized measure of outcome.

CONCLUSION

Return of range of motion after an isolated pediatric SCEF has been well documented in the literature. We found that overall, most parents and patients reported no functional interference with normal social activities, sports or performing arts, activities of daily living (including self-care), and no functionally limiting symptoms, regardless of age at injury, sex, weight, right or left extremity, operative or nonoperative intervention or Gartland classification, provided that satisfactory reduction is maintained by either surgical or nonsurgical (cast) means and that the means of reduction and treatment course are not complicated. Perhaps adequate reduction is more important than simply treatment of fracture type.

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Competing interests: None declared.

Contributors: All authors designed the study. A.D. Isa acquired the data, which all authors analyzed. A.D. Isa and A. Furey wrote the article, which all authors reviewed and approved for publication.

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