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ORIGINAL ARTICLE • UPPER LIMB - PAEDIATRICS

Screw fixation for supracondylar humerus fractures in children: a report of seventeen cases

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Abstract

Purpose Supracondylar fractures in the pediatric population are common. For years, K-wires have been the preferred method of surgical fixation. However, fixation with K-wires alone may lead to multiple complications. This study reports the results of surgical care of supracondylar humerus fractures using screw fixation with K-wires or screw fixation alone.

Methods This study retrospectively reviewed all patients with supracondylar humerus fractures treated with screw fixation between 2007 and 2013. Patients treated only with smooth wires, or having a displaced medial epicondyle, or presenting with lateral condyle fractures were excluded from the study. Flynn's criteria were used to determine the outcome.

Results Seventeen patients who met inclusion criteria formed the study group. All patients were followed until union, resolution of complications, and return to preinjury activity level. Satisfactory outcome was reported in 70.6% of patients with less than 15° loss of either flexion or extension. Mean time to union was 6.5 weeks (range 3.3–12.1 weeks). Screw fixation alone had a shorter mean time to union (5.5 weeks) than compared screw fixation with K-wires group (6.9 weeks). Full range of motion following surgical invention was associated with Flynn's criteria (p value = 0.044).

Conclusion Screw fixation for pediatric supracondylar fractures is a viable option to achieve healing and early motion in highly unstable fractures as well as fractures which require (1) increased stability, (2) maintenance of stability during wound checks in the immediate postoperative period and after discontinuation of the cast, or (3) if further exploration like associated vascular injury is warranted.

Keywords Supracondylar fracture · Screw fixation · Distal humeral fractures · Kirschner wires

Introduction

The distal humerus makes up approximately 85% of all elbow fractures in children [1]. For years, smooth Kirschner wires (K-wires) have been the preferred method of surgical fixation. However, fixation with K-wires alone may lead to complications including loss of fixation, lateral prominence, and infection around wire fixation [2]. Utilization of screw fixation alone or concomitantly with K-wires may improve outcomes of elbow fractures in the child, as anatomical and stable reduction is essential to achieving successful outcomes. Screw fixation has been hypothesized to allow improved healing in addition to allowing continued fixation after termination of supplemental casting [3]. Few publications exist for using screw fixation in lateral condyle fractures and the displaced medial epicondyle; however, to our knowledge, there are no reports about using screws in supracondylar (SC) fractures. The working hypothesis of this study was that screw fixation might be a viable alternative to the typical K-wire fixation for SC humerus fractures in children. The goal of this study was to report the experiences of using screws as a method of fixation for SC fractures in children.

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Patients and methods

This retrospective study was approved by the institutional review board (IRB). The study included all patients treated with screw fixation for the supracondylar (SC) humerus fracture between 2007 and 2013. Medical records and radiographs were reviewed for all patients. Flynn's criteria [4] were used to determine the outcome. A total of seventeen patients met the inclusion criteria. The SC fractures were classified using the Gartland classification. All patients in this study required operative treatment based on the degree of displacement and pertinent fracture classification.

Surgical technique

Younger patients were placed supine on a flattop table, with fluoroscopy on the opposite side. A hand table was used for older children with the fluoroscopy coming parallel to the table. All seventeen patients received a trial of closed reduction internal fixation (CRIF). Open reduction internal fixation (ORIF) was pursued if closed reduction failed. A lateral approach to the elbow was utilized for open reduction in irreducible fractures. For patients with vascular compromise, the anterior transverse approach was used. One/two or three 4.0–4.5 cannulated screws (Depuy Synthes©) with or without washers were used to fix the lateral column. After reduction was achieved, a 1.6-mm K-wire was used for initial fracture stabilization. The wire was positioned through the center of the capitellum and through the olecranon fossa. The screws were then positioned outside the olecranon fossa through the lateral column to avoid blocking of elbow extension after discontinuation of the cast. The number of screws utilized was dependent on the fracture stability and the available anatomical corridors. A long-arm cast in neutral forearm rotation was applied following reduction. Cast and pin removal were performed at three weeks postoperatively where active or assisted active elbow range of motion (ROM) is encouraged (Fig. 1).

Statistical data analysis

Demographic and clinic characteristics were evaluated to determine association with Flynn outcome (satisfactory vs. unsatisfactory) by Fisher's exact test. Time to union was treated as a dependent variable measuring the improvement of healing. Mean time to union was calculated for two groups: screw fixation alone or screw fixation with K-wires. The two-sample *t* test was used to compare the means of two groups. Mean time to union of the two groups was also compared to clinical variables to examine differences in time to union by each variable (e.g., *Flynn outcome* or *Number of wires* as an independent variable). A two-way ANOVA was conducted to test significant differences between categorical variables. *All analyses were done using R statistical software* [5].

Results

Demographic and clinical characteristics are summarized in Table 1. Ten fractures were treated with closed reduction percutaneous fixation, and seven required open reduction internal fixation. Different fixation constructs were used: screw fixation only (5/17) or screw fixation with the addition of Kirschner wires (12/17). This difference in operative management was left to the discretion of the attending surgeon and was based on fracture pattern and patient presentation. Two patients required vascular exploration and repair. Hardware was removed in 15/17 patients in the SC group at an average of 16.4 weeks after surgery (range 4–30 weeks). Mean time to union for all 17 patients was 6.5 weeks (range 3.3–12.1 weeks). Time to union with screw fixation alone (5.5 weeks) was shorter than screw and K-wire fixation (6.9 weeks).

The overall complication rate was 11.8% (2/17). One patient (5.9%) presented with loss of reduction and was subsequently treated with revision internal fixation. Another patient (5.9%) developed a superficial infection around the pin, which resolved after pin removal. None of the patients developed growth disturbances of the distal humerus during the follow-up period. There were also no refractures reported after screw removal.

Time to union with screw fixation alone was shorter when compared to screw and K-wire fixation (5.5 weeks vs. 6.9 weeks). However, these differences were not statistically significant. Mean time to union was not found to be significantly associated with any clinical variables evaluated in this study, including Flynn outcome.

Table 2 discusses demographic and clinical characteristics by Flynn outcome. Satisfactory outcomes for patients with full range of motion (ROM) were higher in comparison with the patients with $> 15°$ lack of extension/flexion. This association was found to be statistically significant (p value $= 0.044$) and implies that full ROM patients are more satisfied than those with the lack of extension/flexion. No other clinical or demographic variable was found to be statistically associated with Flynn outcome.

Discussion

Supracondylar (SC) and lateral condyle (LC) fractures are the most common elbow fractures in children [6]. The current preferred method of treatment for SC fractures is

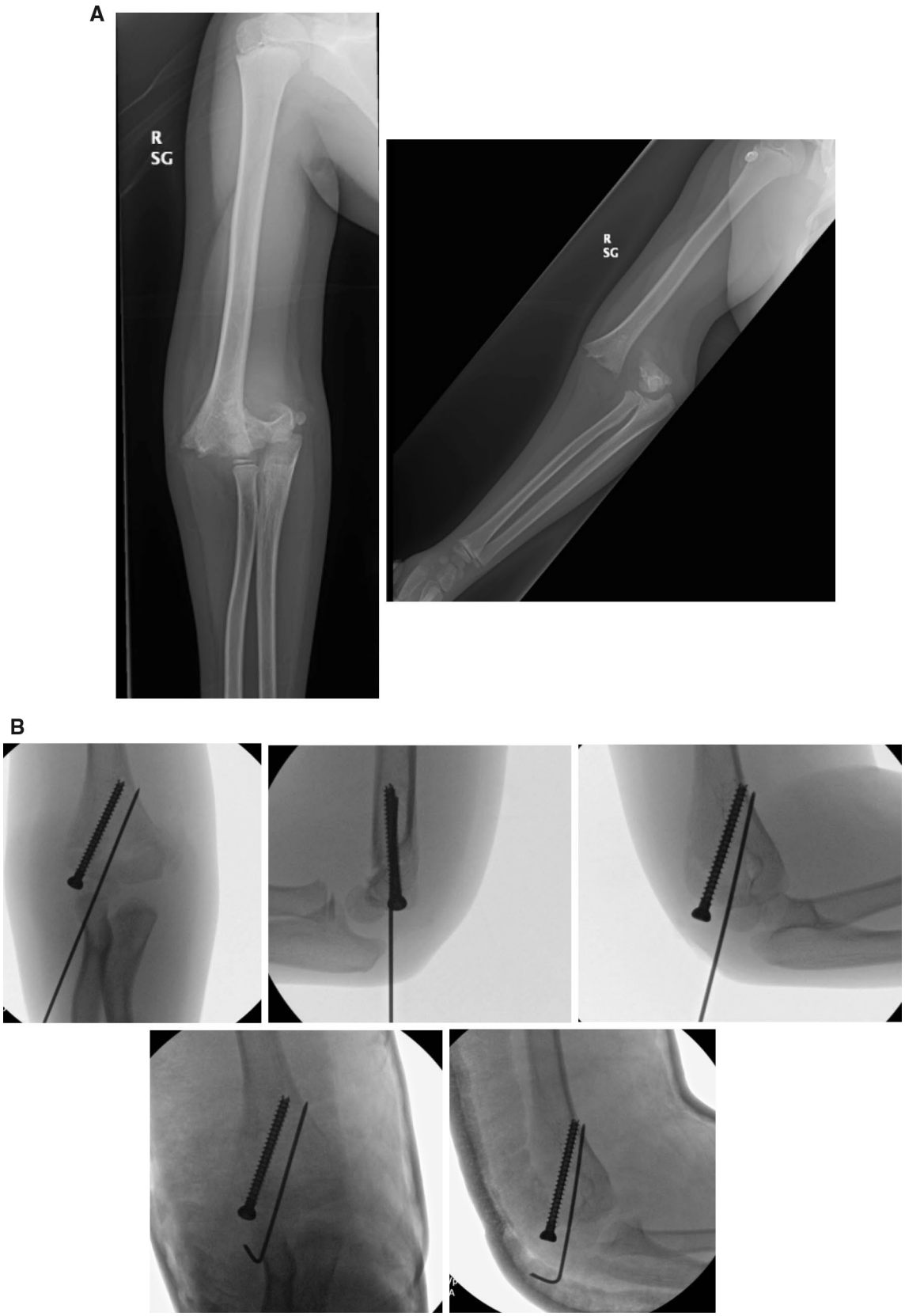

Fig. 1 Case example of a 7-year-old male. **a** Anteroposterior and lateral injury radiographs of a Gartland type III supracondylar fracture. **b** Intraoperative fluoroscopic images. **c** Three-week follow-up anteroposterior and lateral radiographs after pin removal. **d** Anteroposterior and lateral radiographs showing acceptable union at 6-month final follow-up

Fig. 1 (continued)

closed reduction and percutaneous pinning with Kirschner wires (K-wires) [7–9]. Open reduction may be warranted when the fracture is open, closed reduction cannot be achieved, or there is vascular compromise to the limb [10]. Unfortunately, studies discussing the efficacy and results of screw fixation in the setting of SC fractures are sparse. The current study investigates utilization of screw fixation as the method of treatment for SC fractures. This study reports 17 patients with SC fractures with minimal complications associated with screw fixation.

By comparison, there is general agreement that LC fractures should be treated with ORIF with screw fixation. Screws have been advocated for internal fixation as it can provide compression and earlier mobilization of the joint and have been associated with decreased risks of fixation loss, infection, and growth disturbances [11, 12]. Under

Table 1 Descriptive of the categorical variables, $n = 17$

Variable (s)	Frequency, *n*	Percent, %
Gender		
Female	8	47.06
Male	9	52.94
Reduction technique		
ORIF	7	41.18
CRIF	10	58.82
Fixation method		
Screw only	5	29.41
Screw and K-wires	12	70.59
Revision surgery		
Yes	1	5.88
No	16	94.12
Range of motion (ROM)		
Full ROM	7	41.18
Lack of extension/flexion/both	10	58.82
Intra OP complication		
No	17	100.00
Post OP complication		
Yes	2	11.76
No	15	88.24
Flynn outcome		
Satisfactory	12	70.59
Unsatisfactory	5	29.41

Table 2 Contingency tables of the demographic and clinical characteristics by *Flynn outcome*

Variable (s)	Frequency of Flynn outcome		*p* value[a]
	Satisfactory	Unsatisfactory	
	12	5	
Gender			
Female	5	3	0.620
Male	7	2	
Reduction technique			
ORIF	4	3	0.593
CRIF	8	2	
Number of screw			
One	8	2	0.593
More than two	4	3	
Number of wire			
0 (i.e., screw fixation alone)	3	2	0.600
More than one	9	3	
Revision surgery			
Yes	1	0	1.000
No	11	5	
Range of motion (ROM)			
Full ROM	7	0	**0.044**
Lack of extension/flexion/both	5	5	
Post OP complication			
Yes	1	1	0.515
No	11	4	

Bold value indicates statistical significance in ROM in screw only group compared to other methods of fixation

[a]*p* values for Fisher's exact test for categorical variables

tension, screw fixation is biomechanically superior to K-wire fixation in terms of stiffness and maximum force required for displacement [3]. Furthermore, screw fixation allows for earlier return of ROM and improved healing after termination of supplemental casting [3]. Gilbert et al. compared 43 patients treated with K-wire fixation against 41 patients with screw fixation and found fewer complications, improved ROM, and decreased time to union in the screw fixation group [13]. The compressive properties of screw fixation have also been demonstrated to decrease lateral bony overgrowth in comparison with K-wire fixation, a potential complication in LC fractures [14, 15]. This success in treating LC fractures with screw fixation was hoped to be replicated in the present study investigating SC fractures with screw fixation.

Due to proximity to the distal epiphysis of the humerus, growth arrest is of concern in the management of SC fractures. It has been demonstrated in the literature that temporary pinning of the epiphysis does not necessarily cause physeal growth disruption and that growth deformities following SC fractures can be mitigated with proper reduction and fixation during the initial management [16, 17].

Although K-wires may be a simpler mode of fixation, duration of immobilization necessary for proper healing and risk of wire migration often lead to suboptimal outcomes. In contrast, screw fixation can apply compression and start early ROM, while fixation is still in place [18]. All fractures in the current study were treated with screws under compression and have a lateral bony overgrowth incidence of 0% (0/17). We attributed the nonexistence of this complication to the compression forces of the screw providing fracture stabilization, whereas K-wires may promote bone callus formation. Further studies should be conducted to conclude whether or not screw fixation can decrease the incidence of this complication.

Postoperative loss of reduction is a complication of great concern in SC fracture management. Davis et al. reported that 7% (4/60) of patients with type III SC humerus fractures displaced postoperatively [19]. Fifty-two of these patients were treated with crossed K-wires, where one fracture displaced postoperatively (2%). Seven fractures were treated with two or three lateral K-wires, and two (28%) had early postoperative displacement ($p < 0.04$). Inadequate fixation with K-wires may be the cause of postoperative

displacement. The necessity for proper technique is critical when using pin fixation, as technical errors are a major cause of loss of fixation and subsequent poor outcome [20]. The postoperative loss of fixation seen in this study was 5.9% (1/17), comprising favorably to K-wire fixation. Secondary displacement is also a concern with the pinning technique with rates ranging from 1.9 to 9% [21]. Our study had no instances of secondary displacement.

Furthermore, in comparison with K-wires, screw fixation may decrease risk of infection. Infections following management of SC fractures are most commonly associated with the pin tract, with rare incidence of deep infection or osteomyelitis [22, 23]. Pin tract infection associated with SC fractures has been reported to range from < 1 to 6.6% [14, 22, 24]. Alam et al. [25] reported that 7.7% of patients treated for SC fractures developed pin site infection, all of which completely resolved with oral antibiotics and removal of pins. Another study reported that 3.8% of patients developed superficial infection around unburied K-wires and were treated with a course of oral antibiotics [26]. Our series has an infection rate of 5.9% (1/17) and was associated with the K-wire placement.

Baumann angle was utilized to assess control of reduction with the normal range between 9 and 26 degrees in the pediatric population [27]. In our study, the mean Baumann angle was 16.4, indicating that screw fixation can be used to achieve proper control of reduction in SC fractures. Cubitus varus deformity has been a reported complication of distal humeral fractures in the literature [26, 28]. The varus deformity is due to the defect of the distal humeral epiphysis growth plate [29]. In a review of 35 papers using K-wire fixation for SC fractures, 4.5% of patients experienced a change of carrying angle greater than 10 degrees or cubitus varus greater than 5 degrees. Cubitus varus has been reported to be as high as 6.6% using K-wires for SC fractures [30]. In our series, there were no cases of cubitus varus in the SC group. Our results support the hypothesis that screw fixation alone or in conjunction with K-wires may reduce the incidence of cubitus varus.

In this study, all seventeen patients achieved union with minimal complications. The main limitation of this study was its retrospective nature and small sample size. Nonetheless, this case series elucidates the pros and cons of using screw fixation for SC fractures in the pediatric patient.

Conclusion

Screw fixation for pediatric supracondylar fractures is a viable option to achieve healing and early motion in highly unstable fractures as well as fractures which require (1) increased stability, (2) maintenance of stability during wound checks in the immediate postoperative period and after discontinuation of the cast, or (3) if further exploration like associated vascular injury is warranted.

Compliance with ethical standards

Conflict of interest All authors have no relevant conflicts of interest to disclose. There was no pharmaceutical or industry support for this investigation.

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