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A prospective randomised non-blinded comparison of conventional and Dorgan's crossed pins for paediatric supracondylar humeral fractures

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ABSTRACT

Background: Closed reduction and percutaneous pinning are the preferred treatment of displaced supracondylar humeral fractures in children. The purpose of this study is to evaluate the non-standard Dorgan's method and compare its results with those of the standard percutaneous cross pinning method in treatment of unstable or irreducible Gartland type II and III supracondylar humeral fractures in children.

Patients and methods: This was a prospective evaluation of 138 consecutive patients with Gartland type II or III extension supracondylar humeral fractures referred to University Children's Hospital during a four-year period. The patients were randomized into two groups: the first group, comprised of 71 patients, was treated with standard pin configuration and the second group, comprised of 67 patients, underwent Dorgan's method. The study included 88 boys and 50 girls aged 1.5–11.4 years (mean 6.5 ± 2). At initial presentation 8.7% (n-12) fractures were classified as Gartland type IIa, 25.4% (n-35) as Gartland type IIb and 65.9% (n-91) as Gartland type III.

Results: Flynn's criteria were used to evaluate the results. An excellent clinical outcome was reported in about 90% of patients (n-90) treated with standard pin configuration and 89.5% (n-60) of patients treated with Dorgan's method. There were no statistically significant differences in outcomes between the groups in terms of their gender, age, fracture types, function and cosmetics. Neurological lesions were observed in 9.9% of patients (n = 7) who were treated using the standard configuration Kirschner pins, while in those treated by Dorgan's method neurological complications were not observed. However, the procedure time was longer (mean 36.54 ± 5.65 min) and radiation exposure significantly higher (mean 10.19 ± 2.70 exposures) in the group that was treated using Dorgan's method, compared to the conventional method (mean 28.66 ± 3.76 min and 7.54 ± 1.63 exposures).

Conclusion: Two laterally inserted crossed pins provide adequate stability with good functional and cosmetic outcome for most unstable paediatric supracondylar humeral fractures with no risk of iatrogenic ulnar nerve injury.

Introduction

Closed reduction with percutaneous fixation is the method of choice in the treatment of displaced supracondylar fractures in children. There are different methods of pinning. Many authors,

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such as Swenson and Flynn, report using two pins, inserted medially and laterally through the medial and lateral epicondyles [1,2]. Supporters of this technique argue that its advantage is that it offers better biomechanical stability for the reduction of fractures, although there is a possibility of injury to the ulnar nerve in 2–8% of cases during the medial placement of the pin. Arino et al. recommended inserting the two pins through the lateral epicondyles to avoid ulnar nerve injury [3]. Biomechanically, fixation provided by two parallel lateral pins is less secure. Dorgan's method, insertion of two lateral crossed pins, provides a biomechanically stable fixation while avoiding the risk of ulnar nerve injury [4]. This method was named after Dr. John Dorgan, consultant orthopaedic surgeon, Alder Hey Children's Hospital, Liverpool, who came up with this lateral cross pinning technique.

The aim of the present study is to evaluate and compare the results of standard percutaneous cross pinning and lateral cross pinning method in treatment of unstable or irreducible type II and III supracondylar humeral fractures in children.

Patients and methods

Between February 2010 and April 2014, we prospectively identified 138 consecutive patients aged 1.5–11.4 years (mean 6.5 ± 2), admitted to the emergency department of the University Children's Hospital with extension-type displaced supracondylar humeral fractures. Skilled senior paediatric orthopaedic surgeons treated all the admitted patients. They were randomized by random number generator using R software environment where odd numbers were assigned to Dorgan's method of fixation while even numbers were assigned to conventional cross pinning technique.

Demographic information, clinical data and radiological findings were recorded upon admission. Information regarding the type of treatment, the time between the presentation and the referral to the definitive treatment, and procedure were recorded immediately after surgery. Treatment outcome was evaluated after the removal of the cast and wires and during the follow-up period. Antibiotic prophylaxis was given in case of all patients 30–60 min before surgery. Patients with Gartland type I fracture (non-displaced), patients with open fractures, patients that required open reduction and cases with serious neurovascular complications demanding other specific operative management were excluded.

There were 71 patients treated with standard percutaneous pinning (Group A, n-71) and 67 patients treated with Dorgan's method (Group B, n-67). Closed reduction and percutaneous pinning were done under general anaesthetic. In the first group of patients (Group A), after satisfactory reduction was obtained and confirmed by a C-arm, Kirschner pins were placed with elbow hyperflexion and forearm pronation to maintain good fragment position. First Kirchner pin was inserted into the bone using a cordless drill, always through the lateral part of ossified capitulum, passed through growth zones, then the fracture site and the medial pillar, to engage the opposite cortex. Insertion of the medial Kirschner pin was done after lateral pin placement. Kirchner pin was placed through the medial epicondyle, more horizontally than laterally, passed transversely through the medial pillar humeral fracture site and the lateral pillar, while ensuring that it engaged the opposite cortex (Fig. 1).

In the second group of patients (Group B), the first Kirchner pin was introduced through the lateral condyle across the fracture and into the medial cortex. The second pin was introduced through the lateral cortex, proximal to the fracture line, and was then driven across the fracture and into the medial condyle (Fig. 2). The pins had to cross above the fracture line.

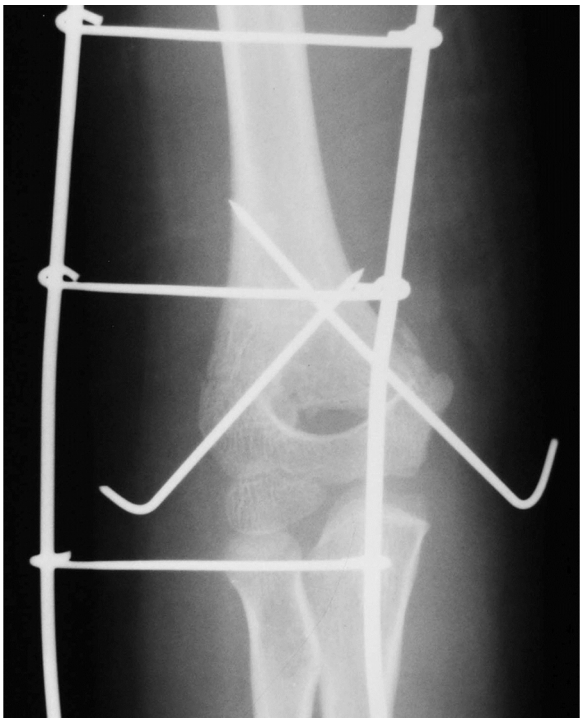

Fig. 1. Kirschner wires configuration using conventional percutaneous pinning.

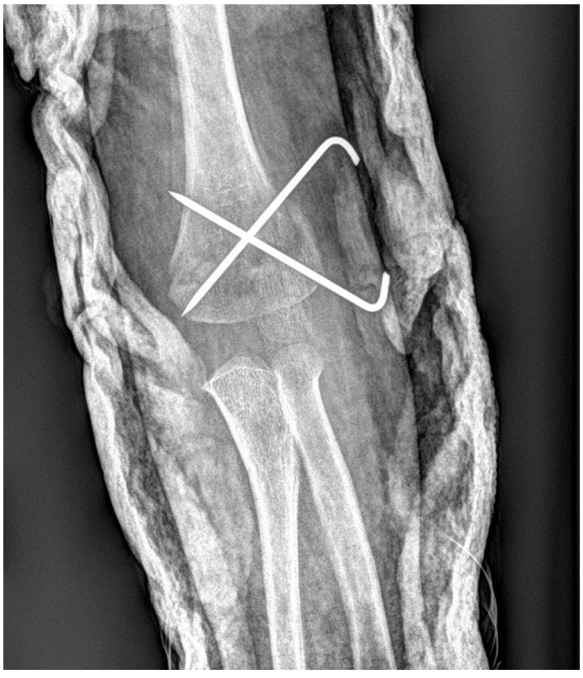

Fig. 2. Kirschner wires configuration using Dorgan's method of fixation.

After placing Kirschner pins under image intensifier control, to check if the reduction was successful and confirm the achieved fracture stabilization, the pins were bent at a 90° angle and then intersected. Plaster splint was placed with the elbow in 60–90-degree flexion.

Radiographic evaluation was performed four weeks after the procedure when the plaster cast and K-wires were removed, including antero-posterior and lateral views of the entire upper extremity, in order to estimate the reduction outcome.

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Evaluation was based on the range of movement of elbow joint in both arms (functional) and the difference in 'carrying angle' (cosmetic) between the affected and unaffected arms, as well as a neurologic examination. Treatment outcomes were classified according to two Flynn's criteria, the "functional" and the "cosmetic" one, which are defined by motion loss in degrees and the loss of carrying angle in degrees, respectively. The carrying angle of the elbow is defined as the angle formed by the long axis of the arm and the long axis of the forearm in the frontal plane. The carrying angle was measured with a goniometer and compared with that of the unaffected opposite extremity.

Measures of central tendency and variability measures were used to describe the data. The following tests were used: Student's *t* test, chi-square test, Mann-Whitney *U* test, and Fisher's exact test.

The study was approved by the local research ethics committee, and informed consent was obtained from all patients included into the study.

Results

We identified and treated 138 patients with extension-type supracondylar fractures over a four-year period. The average time from the elbow fracture to clinical evaluation was 11.2 ± 2.3 (8.9–13.5 months). There were no statistically significant differences between the study groups of patients regarding the follow-up period. Two groups of patients were observed: Group A, with 71 patients treated with standard percutaneous pinning and Group B, 67 patients treated with Dorgan's method. Demographic data are presented in Table 1. There were no statistically significant differences between the two study groups of patients in terms of patients' age ($p = 0.645$), gender ($p = 0.922$), injured arm ($p = 0.641$), manner of sustaining the injury or type of fractures.

The mean time from injury to therapeutic procedure was 6.35 ± 4.64 h. According to Flynn's modified classification system, the functional result was excellent in 90% (n-64) and good in 10% (n-7) of the patients treated using the standard method whereas the result was excellent in 89.5% (n-60) and good in 10.5% (n-7) of the patients treated with Dorgan's method. There was no significant difference between the two groups ($p = 0.909$). The cosmetics result was excellent in 90% (n-64), good in 5.6% (n-4) and poor in 4.4% (n-3) of the patients treated with the standard method while it was excellent in 89.5% (n-60), good in 4.5% (n-3) and poor in 6% (n-4) of the patients treated with Dorgan's method. There was no significant difference between the two groups ($p = 0.917$). The complete treatment outcome data is shown in Tables 2 and 3. According to Flynn's criteria there were no significant differences in the success of treatment between the two study groups and there were no patients with poor treatment outcomes ($p = 0.937$).

Dorgan's method was more time demanding (mean 36.54 ± 5.65 min) in comparison with standard crossed pinning technique (mean 28.66 ± 3.76 min) with a significant difference ($p = 0.001$). Moreover, Dorgan's method required more image intensifier expositions (mean 10.19 ± 2.70) compared to conventional method (mean 7.54 ± 1.63), also with a significant difference ($p = 0.001$).

Vascular complications were observed in 4 patients treated with the standard treatment and 4 patients treated with Dorgan's method, in whom radial pulse was absent before and after surgery. However, these patients had a satisfactory collateral circulation with no signs of ischemia and therefore did not need additional surgery.

Neurological complications, such as ulnar nerve lesion, were detected in 9.9% (n-7) of the patients treated with standard procedures. Sensory loss in the little and medial half of the ring finger was observed in four patients, while motor function loss of flexor carpi ulnaris and the weakness of long flexor tendon function to ring and little fingers occurred in two patients. In four patients sensory function recovered spontaneously within three months after injury, while motor function returned after 2–5 months (mean 5 months). Nerve function was completely restored in all patients. Neurological complications were not observed in the patients treated by Dorgan's method.

Extensive formation of granulation tissue around Kirschner pins was observed in 22% (n-15) while pin site infection occurred in 4.4% (n-3) of patients treated with Dorgan's method. Patients with minor pin-site infection were treated with oral antibiotics and did not require early removal of the wire. Patients who developed excessive granulation tissue around the wire were managed successfully with topical silver nitrate.

Table 1
Clinical characteristics of children with displaced supracondylar fractures based on the type of therapy.

Patients characteristics		Group 1 (n = 71)	Group 2 (n = 67)	p
Age, (years)		6.7 ± 1.6	6.5 ± 1.85	0.645
Gender, n (%)	Male	45 (63.4)	43 (64)	0.922
	Female	26 (36.6)	24 (36)	
Arm, n (%)	Left	42 (59)	37 (55)	0.641
	Right	29 (41)	30 (45)	
Fracture Type, n (%)				
Gartland IIa		6 (8.5)	6 (9)	NS
Gartland IIb		15 (21)	20 (30)	NS
Gartland III		50 (70.5)	41 (61)	NS

Discussion

Displaced supracondylar fractures of the humerus are the most common fractures in children. Most orthopaedic surgeons now accept closed reduction and pinning as the initial treatment of choice for most displaced supracondylar humerus fractures in children. Nevertheless, many issues are still open to discussion for a number of reasons, including the pinning technique used for fixation (the number and configuration of pins), the effect of delaying operative treatment, etc. [5].

Currently accepted techniques of Kirschner pins fixation are two parallel pins inserted through the lateral condyle across the fracture, engaging the medial cortex, or two crossed pins, one inserted laterally and the other through the medial condyle [6]. The advantage of crossed fixation is good biomechanical stabilization, while unilateral fixation, being biomechanically weaker, results in less biomechanical stability [7]. On the other hand, the possibility of injury to the ulnar nerve was significantly higher in cross configuration pins. The frequency of iatrogenic ulnar nerve injuries occurring during the placement of pins in the medial position ranges from 1.4 to 15.6% [8]. Because of the possibility of iatrogenic injury to the ulnar nerve in crossed pin configuration, many authors favour the lateral configuration of pins, highlighting that there was no statistically significant difference in clinical and radiographic outcomes between patients treated with lateral entry pinning compared to those treated with crossed pinning, with the former method bringing less risk for iatrogenic ulnar nerve injury [9–11].

In a large retrospective study, which included 345 patients, Skaggs concluded that the fixation with diverging lateral pins is safe and effective for both Gartland type II and Gartland type III (unstable) supracondylar fractures of the humerus in children [12]. The exclusive use of lateral pins prevents iatrogenic injury to the ulnar nerve. Skaggs observed iatrogenic ulnar nerve injury in 6 (4%) patients of the 145 patients treated by cross pinning [13]. Boyd and Aronson reported ulnar nerve injury in two out of seventy-one patients treated with crossed pins [14].

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Table 2
Functional and cosmetic outcomes according to Flynn's criteria.

Outcomes		Standard N (%)	Dorgan N (%)
Functional loss of range of motion (degrees)	E (0–5)	64 (90)	60 (89.5)
	G (6–10)	7 (10)	7 (10.5)
	F (11–15)	0	0
	P (> 15)	0	0
Cosmetic difference in carrying angle (degrees)	E (0–5)	64 (90)	60 (89.5)
	G (6–10)	4 (5.6)	3 (4.5)
	F (11–15)	3 (4.4)	4 (6)
	P (> 15)	0	0

p = 0.909 p = 0.917.
E-Excellent, G-Good, F-Fair, P-Poor.

Table 3
Total outcomes according to Flynn's criteria.

Mode of treatment	Treatment outcome				Total
	E (0–5)	G (6–10)	F(11–15)	P (> 15)	
Standard percutaneous cross pinning	61 (85.9%)	7 (9.9%)	3 (4.2%)	0	71 (100%)
Dorgan	56 (83.6%)	7 (10.4%)	4 (6.0%)	0	67 (100%)
Total	117 (84.8%)	14 (10.1%)	7 (5.1%)	0	138 (100%)

p = 0.937.
E-Excellent, G-Good, F-Fair, P-Poor.

Dorgan's fixation methods showed that insertion of two lateral cross pins will provide a biomechanically stable fixation, while avoiding the risk of injuring the ulnar nerve [4]. In our study, which included 67 patients treated with Dorgan's method, no loss of reduction or iatrogenic ulnar nerve injury were observed. The results of treatment of our patients are similar to the results reported by most authors.

In a series of 20 patients treated with Dorgan's method, Shannon observed no fracture redislocation, nor any iatrogenic injury to the ulnar nerve. The only complication that occurred in these 20 patients treated by this method was an insignificant infection and excessive formation of granulation tissue around K-wires insertion sites. Shannon concluded that cross pinning from the lateral side represented a useful option in the treatment of type II and III supracondylar fractures of the humerus. This method provides biomechanical advantages of cross pinning while avoiding the risk of iatrogenic ulnar nerve injury [4].

In a retrospective study, which included 43 patients treated by lateral cross pinning method, Queally noted that stability achieved with this method was the same as the one achieved by crossed configuration pins. The author observed no fragment redislocation and no injuries to the ulnar nerve in 43 patients treated with this method [15].

Altay, in a comparative study of 25 patients treated with conventional cross pinning and 26 patients treated with Dorgan's method, observed no significant differences in the results of treatment between these two treatment methods [16]. Although there was nosignificant difference between groups, 9.9% of iatrogenic ulnar nerve injuries were noted in group 1 postoperatively, probably due to medial pinning, and none in group 2. The ulnar nerve injuries resolved within 2–3 months without any treatment. Minor pin tract infection developed in 5.6% (n-4) of the patients, but was managed successfully with proper oral antibiotics and did not require early removal of the pin.

El-Adl achieved satisfactory functional results in all 70 patients in his retrospective study, while 91.4% of patients had satisfactory and 8.6% unsatisfactory cosmetic results. There was no iatrogenic neurological injury either for the ulnar or for the radial nerves [17].

Disadvantages of inserting pins in a lateral configuration are minimal, but it is technically more difficult to perform this procedure than the standard cross configuration procedure. Sometimes it is necessary to place a third pin in order to achieve better fracture stabilization. One of the potential complications of this method is the possibility of injury to the radial nerve at the point of entry of the proximal pin. At this level, the radial nerve is located in front of the lateral part of the intermuscular septum. Nerve injury can be prevented by inserting pins posterolaterally [18].

The complications that occurred in our patients were not specific to this method of treatment, and consisted mainly of problems due to pin exposure, concretely pin tract infection in 4.4% (n-3) of the patients and formation of excessive granulation tissue in 22% (n-15) of the patients. Complications were successfully treated without long-term sequelae. Shannon noticed that these complications related to entry points of the wires, as pin site infection and excessive granulation tissue, were not serious, and burying the wires deep into the skin eliminated these concerns but required anaesthesia for their removal [4].

In his series of 20 patients, Shannon observed infected pins in 5% (n-1) of patients, and excessive formation of granulation tissue in 25% (n-5) of patients [4]. El-Adl concluded that the most frequently occurring complications were minor pin tract infections in 8.6% (n-6) of patients, deep infection in 2.85% (n-2) of patients, and excessive granulation tissue formation, mostly around the proximal pin, which suffered by 45.7% (n-32) of patients [17]. Queally reported pin site infection in 7% (n-3) of patients and excessive formation of granulation tissue in 14% (n-6) of patients [15]. Altay observed minor pin tract infection in 7.8% (n-8) of patients [16].

Pin tract infections were managed successfully with proper oral antibiotics, and did not require early removal of the pins. Excessive granulation tissue formation is cured successfully ether by spontaneous resolution or by a topical treatment with silver nitrate.

Conclusion

The majority of orthopaedic surgeons accept closed reduction and percutaneous pinning as the initial treatment for a displaced

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supracondylar fracture of the humerus in children. Both methods of percutaneous pinning, Dorgan's and the standard percutaneous cross pinning, give a good probability of a successful outcome. Dorgan's method is as good as the conventional method of cross pinning in terms of biomechanical stability, with no risk of injury to the ulnar nerve. This is a suitable option for the treatment of supracondylar fractures of the humerus in children.

Conflicts of interest

All authors declare no financial or other conflict of interest.

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