Percutaneous lateral cross-pinning of paediatric supracondylar humeral fractures

Mohamad Osman, Emad Abd Al-Hadi

Department of Orthopedics, Zagazig University Hospital, Zagazig, Egypt

Correspondence to Mohamad Osman, MD, Department of Orthopedics, Zagazig University Hospital, Zagazig, Egypt
Tel: +20 122 768 7689;
e-mail: prof.osman@yahoo.com

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Introduction
The currently accepted treatment for displaced supracondylar humeral fractures in children is closed reduction and fixation with percutaneous Kirschner wires. The aim of this study was to study the results of a cross-wiring technique, achieved solely from the lateral side, in an effort to reduce the risk of ulnar nerve injury.

Patients and methods
Thirty-two cases of displaced supracondylar humeral fractures were treated by the closed reduction and lateral cross-pinning technique. The mean age of the patients was 6 years (range; 4–12). All fractures were of the extension type (Gartland's types II and III).

Results
The mean follow-up period was 12 months (range; 9–20 months). Using the cosmetic and functional criteria of Flynn and colleagues, cosmetically, 93.8% of the cases achieved a satisfactory outcome and 6.2% achieved fair results with mild cubitus varus. Functionally, 87.5% of the cases achieved satisfactory results and 12.5% achieved unsatisfactory results. Radiologically, all fractures united. The humeral shaft-condylar angle was normal in 90.7% and Baumann's angle was normal in all except two cases. There was no case of secondary displacement. Most complications were mild pin-site problems. There were no iatrogenic nerve injuries.

Conclusion
The lateral cross-pinning technique offers fracture stability and ulnar nerve safety. It could be considered as a viable option for treating displaced supracondylar fractures in children.

Keywords:
closed reduction, crossed-pin fixation, lateral cross-pinning, supracondylar humeral fractures in children

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Introduction

Fractures around the elbow joint represent ~10% of all paediatric orthopaedic injuries, and supracondylar humeral fractures account for 50–70% of all elbow fractures [1,2]. Closed reduction with percutaneous pin fixation is now widely accepted and has become the treatment of choice for displaced supracondylar paediatric humeral fractures [2–4].

Controversy exists about the optimal K-wire configuration in the fixation of Gartland's type II and III fractures [3–5]. Two principal configurations have appeared in the literature: crossed pins (medial and lateral) and two lateral pins [3,5,6].

The classic medial–lateral cross-wire technique involves the placement of two ascending K-wires, one inserted through the lateral condyle and another through the medial condyle [2,7]. With this technique, the ulnar nerve may be injured by the medial wire as it is passed through the medial condyle. Ulnar nerve injury rates of up to 6–8% have been reported [8–10]. To avoid ulnar nerve injury, two parallel K-wires may be placed through the lateral cortex as an alternative method of fixation. Avoiding placement of a medial K-wire protects the ulnar nerve. However, this configuration is thought to be biomechanically less stable than the cross-wire configuration.[7,11]

To achieve stability and avoid ulnar nerve injury, a modified version of the cross-wire technique, lateral crossed pin fixation with ascending and descending K-wires (Dorgan's lateral cross-wiring), has been proposed, where cross-wire fixation is achieved solely from the lateral side [7,12–14].

The aim of the present study was to evaluate the results of the percutaneous lateral cross-wiring technique in the treatment of Gartland's type II and III supracondylar humeral fractures in children.

Patients and methods

During the period from June 2006 to July 2008, 32 cases of displaced supracondylar humeral fractures had been treated at our institution by the closed reduction and lateral cross-pinning technique.

The mean age of the patients was 6 years (range; 4–11). The mean age of the boys was 17 years (53%), whereas that of the girls was 15 years (47%). The mechanisms of injury were fall on a flat surface in 16 cases, fall from a height in 11 cases and road traffic accidents in five cases. All fractures were of the extension type. Twelve fractures (37.5%) were Gartland's type II, whereas 20 (62.5%) fractures were Gartland's type III [15]. Injuries were closed in all except four cases who had Guistilo type I open fractures [16]. The radial pulse was absent on first presentation in three cases and was restored on closed reduction. Anterior interosseous nerve deficit was present on first presentation in three cases (9.4%). Associated fractures included ipsilateral clavicle in two, ipsilateral distal radius in one, contralateral tibia in one and contralateral femur in one case. Twenty cases arrived to our hospital in the first day after injury, whereas 12 cases were referred to us 2–3 days after injury. Exclusion criteria included flexion-type fractures, Guistilo type II or III open fractures, injuries that required open reduction and internal fixation (ORIF) or vascular repair and delayed cases.

The operative technique

Under general anaesthesia, the patient was positioned supine with the affected arm on a radiolucent short arm board.

Closed reduction was performed in the following sequential steps:

(a) With countertraction on the humerus, forearm traction was applied with the elbow in about 20° of flexion to avoid the possibility of tethering neurovascular structures over an anteriorly displaced proximal fragment.
(b) The forearm was pronated or supinated to rotate the distal fragment into the correct rotational alignment with the proximal fragment.
(c) The distal fragment was translated to correct medial or lateral displacement.
(d) While maintaining traction and precise forearm rotation, the elbow was flexed gently.
(e) The posterior displacement of the distal fragment was corrected by placing gentle pressure on the olecranon as the elbow was maximally flexed.
(f) The elbow was flexed maximally and the forearm pronated to lock the posterior and medial soft-tissue hinges.

In the most common posteromedially displaced fracture, with a medially intact periosteum, pronation may assist in reduction by placing the medial periosteum in tension and closing down the open lateral column. However, the opposite situation exists with a posterolaterally displaced fracture, and pronation may thus be counterproductive in this situation [12].

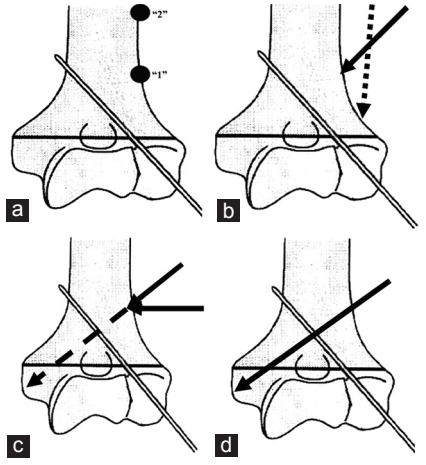
The reduction was then checked by fluoroscopic images in anteroposterior (AP), lateral and oblique planes. If difficulty was encountered in maintaining reduction when rotating the image for a lateral view, moving the C-arm instead of the patient's arm was considered.

Once a satisfactory reduction had been obtained, two 1.6-mm K-wires were used to stabilize the fracture. These wires were passed under fluoroscopic guidance with the elbow held in a flexed position to maintain the initial reduction. The first wire was introduced through the lateral condyle in a retrograde direction (ascending) across the fracture and into the medial cortex. The second wire was introduced through the lateral cortex, proximal to the fracture line, and driven in an antegrade direction (descending) across the fracture line into the medial condyle (Fig. 1). The medial condyle should not be penetrated. The wires must cross above the fracture line. Occasionally, the second wire may skid down the lateral cortex during introduction. To avoid this, the wire was directed perpendicular to the cortex until the cortex was penetrated, pulled back and then redirected towards the medial condyle (Figs. 2 and 3).

Using fluoroscopy, the fracture stability was tested.

The wires were then bent, cut and left outside the skin, facilitating their removal.

Figure 1



(a) The point of entry should be in the metaphyseal part '1' and not in the diaphyseal part '2' of the humerus. (b) The second wire may skid down the lateral cortex during introduction. (c) The wire is directed at right angles to the cortex until it has penetrated, and then pulled back, and the trajectory is readjusted. (d) The second wire is introduced through the lateral cortex, proximal to the fracture line, and is driven across the fracture into the medial condyle. Wires must cross above the fracture line [14].

The pulse and capillary perfusion of the hand were evaluated after reduction, after fixation and then postoperatively [7,12].

Postoperative care and follow-up

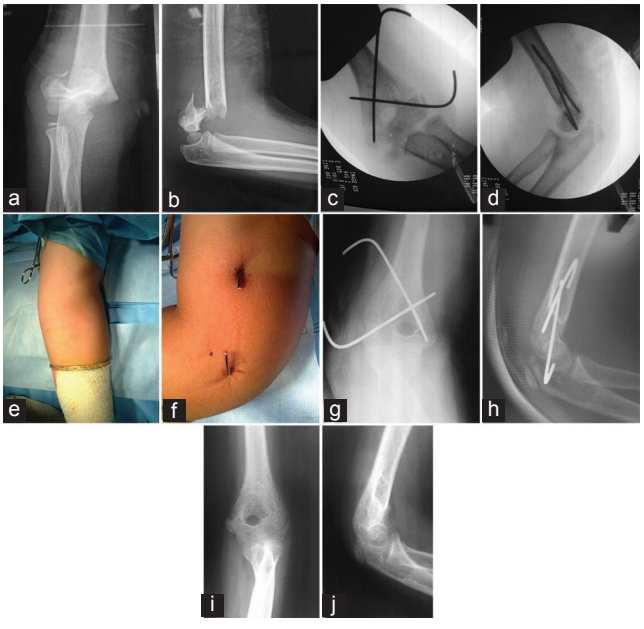
Patients were then immobilized in an above-elbow backslab for 4 weeks. Immediate postoperative neurovascular assessment was performed. AP and lateral radiographs were obtained to assess fracture reduction. At 4 weeks postoperatively, patients attended the outpatient clinic for the removal of the K-wires after AP, and lateral radiographs confirmed reasonable radiological union. A collar-and-cuff sling was then placed for a further 2 weeks. At 6 weeks postoperatively, the sling was discarded and physiotherapy was commenced.

Clinical evaluation was performed using Flynn's cosmetic and functional criteria [17]. Radiographic evaluation was performed using the humeral shaft-condylar angle in the lateral view and Baumann's angle in the AP view [2]

Results

The mean follow-up period was 12 months (range, 9–20 months).

Figure 2



A boy with Gartland's type III supracondylar fracture. Final satisfactory clinical and radiologic outcomes. (a, b) Preoperative radiographs. (c, d) Intraoperative fluoroscopic views. (e, f) Intraoperative photos. (g, h) Postoperative views. (i, j) Final radiographs.

Clinical results

Clinical outcomes at the final follow-up were evaluated using the cosmetic and functional criteria of Flynn *et al.* [17] (Table 1). Cosmetically, 30 patients (93.8%) achieved a satisfactory outcome and two patients (6.2%) achieved a fair result. Functionally, 28 patients (87.5%) achieved satisfactory results and four patients (12.5%) achieved unsatisfactory results (Table 2).

Radiologic results

All fractures had united.

The humeral shaft-condylar angle was normal (30°–40°) in 29 cases (90.7%). It was less than 30° in one case (3.1%) with a resultant loss of full flexion, and two cases (6.2%) had an angle greater than 40° with a resultant loss of full extension. The mean Baumann's angle was 17°.

According to the criteria outlined by Skaggs *et al.* [6], no patient had a loss of reduction (either mild or major)

Table 1 The cosmetic and functional criteria of Flynn *et al.* [17]

Rating	Cosmetic factor (carrying angle loss) (deg.)	Functional factor (loss of motion) (deg.)
Excellent	0–5	0–5
Good	6–10	6–10
Fair	11–15	11–15
Poor	>15	>15

Table 2 Clinical results

Rating	Cosmetic outcome (number of patients)	Functional outcome (number of patients)
Excellent	14	13
Good	16	15
Fair	2	3
Poor	–	1

Figure 3

A girl with Gartland's type III supracondylar fracture. Final satisfactory clinical and radiologic results. (a, b) Preoperative radiographs. (c, d) Before wire removal. (e, f) After wire removal (united fracture).

as the change in Baumann's angle was less than 6° in all patients. The mean Baumann's angle at the final follow-up was 17°, which was not significantly different from the angle measured at the time of fixation.

Heterotopic ossification did not occur in any case.

Complications and problems

(1) Pin problems: Eight patients (25%) developed mild pin-site infections, which were treated with a course of oral antibiotics with no need for premature removal of the wire in any case. Thirteen patients (40.6%) developed excessive granulation tissue at the pin sites, especially around the proximal wire, which was treated with topical silver nitrate.
(2) Mild cubitus varus deformity occurred in two patients (6.3%), in whom the reduction quality was unsatisfactory.
(3) Regarding neurological examination, the three patients who had presented with anterior interosseous nerve deficit at the time of injury had recovered from this deficit within 3 months of their injuries. There was no case of iatrogenic ulnar or radial nerve injury.
(4) No iatrogenic vascular injury was noted.

Discussion

Although closed reduction and percutaneous K-wire stabilization is the currently accepted treatment of displaced supracondylar fractures of the humerus in children, there is still argument on the optimal configuration of these K-wires regarding the fracture stability and ulnar nerve safety [7,18,19].

In the present series, a modified version of the cross-wire technique, performed solely from the lateral side, was studied.

In the present study, using Flynn's score [17], 93.8% of the patients achieved a satisfactory cosmetic outcome and two patients (6.2%) achieved fair results with mild cubitus varus. Functionally, 28 patients (87.5%) achieved satisfactory results and four patients (12.5%) achieved unsatisfactory results (three fair and one poor). Radiologically, the humeral shaft-condylar angle was normal in all except in three cases (9.4%) with resultant loss of full ROM, and Baumann's angle was normal in all except in two cases (6.2%) with mild cubitus varus due to malreduction (but no secondary loss of reduction occurred in any case).

A similar series from Kallio *et al.* [5] achieved 90% excellent or good cosmetic results; yet, 10% were rated as poor.

In the 20 cases of Shannon *et al.* [13], all children had a full range of elbow motion compared with their normal side, and the mean carrying angle of the injured elbow was 15° (range, 10–20°). There were no intraoperative complications, including ulnar nerve injuries. All complications were related to K-wires.

Another similar series from Eberhardt *et al.* [7] achieved 93% good to excellent functional results. Their cosmetic results were 93% excellent and 7% good, with no poor results. Radiologically, 87% of their cases had a normal humeral shaft condylar angle. There was no case of secondary displacement.

There were no significant complications in the present series other than mild cubitus varus in two cases. Most complications were related to proud wires, in the form of mild infection and excess granulation tissue. These problems, although important, are not serious, and removal of wires was easy. Burying the wires deep into the skin eliminates these concerns, but it requires a second anesthetic for their removal [7,13]. In a series with lateral cross-pinning with proud wires, the pin complication rate was 30% [13]. In a similar series from El-Adl *et al.* [14], cubitus varus deformity was noted in six patients (8.6%). They related it to unsatisfactory reduction of the fracture before pinning.

In agreement with others [7,12], all fractures in the present study were immobilized with a long arm splint for 4 weeks before mobilization was permitted. There was no secondary displacement of the fracture after percutaneous pinning with this protocol.

Stability studies had demonstrated that crossed pins provided the best stability. Using an adult human cadaver model, Zionts *et al.* [18] measured the resistance to rotation of the distal fragment of simulated supracondylar fractures fixed with four different pin configurations. They found that the crossed-wire configuration, placed from the medial and the lateral condyles, was the most stable arrangement. They promoted the use of the crossed-pin configuration, but mentioned that with significant swelling, the two lateral parallel pins could be considered as an inferior but acceptable option. More recently, Lee *et al.* [19] using a saw-bone model, found that two 'divergent' lateral pins were comparable to cross-wires in extension, varus and valgus loading, but were inferior in axial rotation testing.

Although Dorgan's technique does not include supporting biomechanical data, the crossed-wire configuration obtained by inserting both wires from the lateral side is similar to that obtained by the traditional medial and lateral technique [7,12–14].

An important point was the possible difficulty of introduction and oblique direction of the proximal lateral pin. However, truely, this is not so difficult. The periosteum is typically thick in this age group, and so, even with an oblique approach, the pin easily enters the cortex and can then be advanced toward the medial condyle as it traverses the fracture site [7]. Occasionally, the proximal wire may skid down the lateral cortex during introduction. To avoid this, the wire was directed perpendicular to the cortex until the cortex was penetrated, pulled back, and then redirected towards the medial condyle.

There might be a theoretical risk that the proximal lateral pin can injure the ulnar nerve when drilling through the bony area of the medial condyle. The descending pin should not perforate the medial condyle to avoid ulnar nerve injury. This could be verified by fluoroscopy. Regarding this point, like all exclusive lateral-pinning techniques, it is advantageous over the traditional medial/lateral cross-wiring, which had a reported incidence of iatrogenic ulnar nerve injury ranging from 2 to 8% [7–10,12,14].

Another potential complication exclusive to this technique is the risk of radial nerve injury at the site of the proximal wire entry. However, this pin does not appear to produce an increased risk to the radial nerve. There is a distance of greater than 2 cm between the radial nerve in this area on the lateral side and the pin introduction point, provided that the entry is metaphyseal or metadiaphyseal and not higher in the diaphysis. Also, at this level, the radial nerve is anterior to the lateral intermuscular septum. It can be avoided by entering the skin slightly posterior to the midcoronal plane [7,12,13].

Conclusion

The lateral cross-pinning technique of paediatric supracondylar humeral fractures is similar to the conventional cross-wire technique in terms of the fracture stability, but superior in terms of ulnar nerve safety. Also, it is similar to other lateral entry techniques in avoiding ulnar nerve injury, but it is superior in achieving fracture stability. It could be considered as a viable option for treating displaced supracondylar fractures in children.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Arino VL, Lluch EE, Ramirez AM, Ferrer J, Rodriguez L, Baixauli F. Percutaneous fixation of supracondylar fractures of the humerus in children. J Bone Joint Surg Am 1977; 59:914–916.

2 Wilkins KE. Supracondylar fractures: what's new? J Pediatr Orthop B 1997; 6:110–116.

3 Mehserle WL, Meehan PL. Treatment of the displaced supracondylar fracture of the humerus (type III) with closed reduction and percutaneous cross-pin fixation. J Pediatr Orthop 1991; 11:705–711.

4 Mazda K, Boggione C, Fitoussi F, Pennecot GF. Systematic pinning of displaced extension-type supracondylar fractures of the humerus in children. A prospective study of 116 consecutive patients. J Bone Joint Surg Br 2001; 83:888–893.

5 Kallio PE, Foster BK, Paterson DC. Difficult supracondylar elbow fractures in children: analysis of percutaneous pinning technique. J Pediatr Orthop1992; 12:11–15.

6 Skaggs DL, Hale JM, Bassett J. Operative treatment of supracondylar fractures of the humerus in children. The consequence of pin placement. J Bone Joint Surg Am 2001; 83:735–740.

7 Eberhardt O, Fernandez F, Ilchmann T, Parsch K. Cross pinning of supracondylar fractures from a lateral approach. Stabilization achieved with safety. J Child Orthop 2007; 1:127–133.

8 Brown IC, Zinar DM. Traumatic and iatrogenic neurological complications after supracondylar fractures of the humerus in children. J Pediatr Orthop 1995; 15:440–443.

9 Rasool MN. Ulnar nerve injury after K-wire fixation of supracondylar humerus fractures in children. J Pediatr Orthop 1998; 18:686–690.

10 Royce RO, Dutkowsky JP, Kasser JR. Neurologic complications after K-wire fixation of supracondylar humerus fractures in children. J Pediatr Orthop 1991; 11:191–194.

11 Fowles JV, Kassab MT. Displaced supracondylar fractures of the elbow in children. A report on the fixation of extension and flexion fractures by two lateral percutaneous pins. J Bone Joint Surg Br 1974; 56:490–500.

12 Queally JM, Paramanathan N, Walsh JC, Cathal J Moran CJ, Fintan J, *et al*. Dorgan's lateral cross-wiring of supracondylar fractures of the humerus in children: a retrospective review. Injury 2010; 41:568–571.

13 Shannon FJ, Mohan P, Chacko J, D'Souza LG. Dorgan's percutaneous lateral cross wiring of supracondylar fractures of the humerus in children. J Pediatr Orthop 2004; 24:376–379.

14 El-Adl WA, El-Said MA, Boghdady GW, Ali AM. Results of treatment of displaced supracondylar humeral fractures in children by percutaneous lateral cross-wiring technique. Strategies Trauma Limb Reconstr 2008; 3:1–7.

15 Gartland JJ. Management of supracondylar fractures of the humerus in children. Surg Gynecol Obstet 1959; 109:145–154.

16 Guistilo RB. *The fracture classification manual*. St Louis: Mosby; 1991.

17 Flynn JC, Matthews JG, Benoit RL. Blind pinning of displaced supracondylar fractures of the humerus in children. Sixteen years experience with long-term follow up. J Bone Joint Surg Am 1974; 56:263–272.

18 Zionts LE, McKellop HA, Hathaway R. Torsional strength of pin configurations used to fix supracondylar fractures of the humerus in children. J Bone Joint Surg Am 1994; 76:253–256.

19 Lee SS, Mahar AT, Miesen D, Newton PO. Displaced pediatric supracondylar humerus fractures: biomechanical analysis of percutaneous pinning techniques. J Pediatr Orthop 2002; 22:440–443.