Eur J Orthop Surg Traumatol (2015) 25:297–303
DOI 10.1007/s00590-014-1494-0

ORIGINAL ARTICLE

# A new joystick technique for unsuccessful closed reduction of supracondylar humeral fractures: minimum trauma

**Serdar Hakan Basaran · Ersin Ercin · Mustafa Gokhan Bilgili · Alkan Bayrak · Huseyin Cumen · Mustafa Cevdet Avkan**

Received: 24 October 2013 / Accepted: 8 June 2014 / Published online: 21 June 2014


**Abstract**
*Background* The purpose of this study was to compare operation duration, radiological and functional results of the open reduction with either posterior or lateral approach and closed reduction with joystick method in unsuccessful closed reduction of displaced (Gartland type III) supracondylar humeral fractures.
*Methods* Between February 2010 and August 2011, 37 patients who were not obtained satisfactory reduction with classic closed reduction attempts for three times in operating room were included in this study. Patients were treated with three different surgical methods. Group I have 13 patients who had joystick and lateral K-wire-assisted closed reduction, group II have 12 patients who had open reduction by lateral approach, and group III have 12 patients who had open reduction by posterior approach. In final follow-up, AP and lateral radiographs of both elbows were taken and bilateral Baumann angles, lateral humerocapitellar angles, carrying angles, and elbow range of motion were measured. These angles and operation times compared between the groups. The functional and cosmetic outcome of surgery was evaluated by criteria of Flynn et al.
*Results* There was no statistical significance difference between Baumann angles, lateral humerocapitellar angles, and carrying angles of fractured and uninjured sides in between three groups (respectively, $p = 0.761$, $p = 0.354$, $p = 0.750$). In group I, operation duration is shorter than the other groups. Functional scoring showed that in group I and group II, all patients have satisfactory results; however, in group III, three patients (25 %) had poor results. In the perspective of cosmetic results, all three groups have satisfactory results.
*Conclusions* When classical closed reduction fail, lateral joystick and K-wire-assisted reduction is a useful way to make and maintain the reduction. Functional and radiological results are as good as lateral and posterior open approaches. Short operation time is an advantage. This method reduces the risk of complications due to repeated closed reduction and open reduction in unsuccessful closed reduction in pediatric supracondylar humeral fractures.
*Level of evidence* Level III.

**Keywords** Child · Supracondylar humeral fractures · Severe displacement · Closed and open reduction · Percutaneous pinning

S. H. Basaran (✉)
Department of Orthopaedic and Traumatology, Faculty of Medicine, Karabuk University, Karabuk, Turkey
e-mail: drserdarhakan@gmail.com

E. Ercin · M. G. Bilgili · A. Bayrak · H. Cumen · M. C. Avkan
Orthopaedic and Traumatology Clinic, Bakırkoy Dr. Sadi Konuk Research and Training Hospital, Istanbul, Turkey
e-mail: ersine@hotmail.com

M. G. Bilgili
e-mail: mgbilgili@yahoo.com

A. Bayrak
e-mail: drqueum@gmail.com

H. Cumen
e-mail: huseyints61@hotmail.com

M. C. Avkan
e-mail: cevdetavkan@hotmail.com

## Introduction

Pediatric supracondylar fractures are the second most common fracture in all pediatric fractures [1, 2]. At childhood, they are the most common fractures in elbow

region [3]. These fractures are most often seen between ages of four and seven [1, 2]. Accounting for 97–99 % of these fractures is extension type [4]. Reduction is difficult due to anatomy of the region and swelling.

Stable fractures require only simple external immobilization, whereas unstable displaced fractures require surgical intervention [4–6]. The aim of treatment of these fractures is to achieve anatomic reduction and stable fixation, and good functional and cosmetic results. Surgical treatment consists of open or closed reduction with K-wire fixation. Treatment of these fractures with closed reduction and percutaneous fixation with cross K-wires is widely accepted and has successful results [6–10].

In this study, we compared operation duration, radiological, and functional results of the open reduction with either posterior or lateral approach and closed reduction with joystick method in unsuccessful closed reduction of displaced (Gartland type III) supracondylar humeral fractures.

## Materials and methods

Between February 2010 and August 2011, 239 pediatric patients with acute supracondylar humeral fractures were admitted in our emergency department. Of these fractures, 52 (21.7 %) were classified as Gartland type I, 33 (13.8 %) were classified as type II, and 154 (64.5 %) were classified as type III. Patients who had <6 months follow-up period, patients undergoing initial treatment at another center, patients treated with primary open reduction, revision cases, open fractures, patients with neurovascular injuries in admission, divergent or parallel K-wire fixed cases were excluded from study. Thirty-seven (40.6 %) of 91 patients were not obtained satisfactory reduction with classic closed reduction attempts for three times in operating room. These 37 patients had Gartland type III fractures and were included study. Patients were treated with three different surgical methods and were divided into three groups. All fractures were fixed with cross K-wire. Surgeon's preferences determined methods of operation. The study was performed retrospectively by reviewing the hospital records.

Group I have 13 patients who had joystick and lateral K-wire-assisted closed reduction, group II have 12 patients who had open reduction by lateral approach, and group III have 12 patients who had open reduction by posterior approach. The demographic distributions of patients were given in Table 1. In all three groups were similar respect to gender, side, and follow-up period (Table 1). Group II was younger than the other groups ($p < 0.001$), but group I and III were similar respect to age ($p = 0.422$).

### Surgical technique

In group I, after unsuccessful attempts of closed reduction with fluoroscopic control under general anesthesia, a 5 mm incision was made just distal to the deltoid muscle attachment. In accordance with the patient's age, 2.5 or 3 mm K-wire was placed as double cortex, perpendicular to the long axis of the humerus. After classic closed reduction manipulation, distal fragment of fracture was usually internal rotation. Proximal fragment using joystick K-wire was fitted to distal fragment. When accurate reduction in AP view and partial reduction in lateral view achieved, a 1.2 mm soft K-wire was placed from lateral as double cortex. While the distal assisted K-wire was maintaining to reduction in coronal plane, accurate reduction was achieved using joystick K-wire in lateral view. Then, second 1.6 or 2 mm K-wire was placed from lateral to the far cortex. Another K-wire was placed from medial with 1 cm medial mini-incision in elbow flexion more than 90°, while reduction was maintaining with lateral K-wires and joystick K-wire. Joystick K-wire was removed after fixation, the other K-wires bent outside to skin. Operative stages are shown in Fig. 1.

**Table 1** Demographics of patients

| | Group I ($n = 13$) | | Group II ($n = 12$) | | Group III ($n = 12$) | | $p$ |
|---|---|---|---|---|---|---|---|
| | Mean ± SD | % | Mean ± SD | % | Mean ± SD | % | |
| Age | 7.8 ± 2.3 | | 3.7 ± 1.7 | | 7 ± 2.8 | | 0.001* |
| Operation duration (min) | 63.4 ± 26 | | 85 ± 30.3 | | 82 ± 17.8 | | 0.092* |
| Follow-up (months) | 9 ± 4.1 | | 8.1 ± 2.6 | | 7.5 ± 2.5 | | 0.868* |
| Gender | | | | | | | |
| Boy | 12 | 92.3 | 11 | 91.7 | 8 | 66.7 | 0.275** |
| Girl | 1 | 7.7 | 1 | 8.3 | 4 | 33.3 | |
| Side | | | | | | | |
| Right | 6 | 46.2 | 4 | 33.3 | 8 | 66.7 | 0.276** |
| Left | 7 | 53.8 | 8 | 66.7 | 4 | 33.3 | |

* Kruskal–Wallis test

** Fisher's exact test

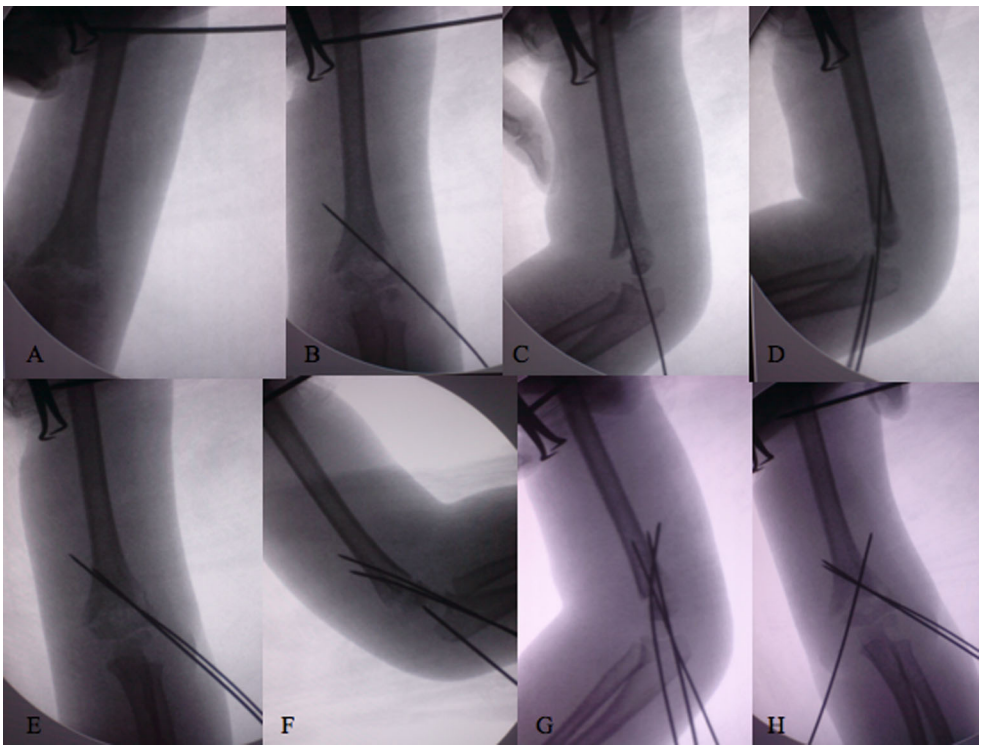


**Fig. 1** Respectively stages of fluoroscopic views of joystick and lateral K-wire assisted closed reduction and fixation. Placing joystick K-wire (**a**) and assisted K-wire (**b**, **c**). Bending of assisted K-wire after full reduction in lateral view (**d**). Placing of lateral and medial K-wires after accurate reduction in both views (**e**–**h**)

In group II and III, after attempts of closed reduction with classical method for three times, open reduction with lateral approach lateral approach between ekstensör carpi radialis, triceps and brachialis, and cross K-wire fixation done for group II. Open reduction with posterior triceps split approach and cross K-wire fixation done for group III.

In all cases, the quality of the reduction was controlled by fluoroscopy. Long arm splint was applied with 90° elbow flexion and neutral forearm position. All patients monitored 1 day in hospital concerning edema, circulation problems and neurological deficit. First, second, and fourth weeks of follow-up, clinical and radiological examinations were performed. Active motion was allowed by removing splint and K-wires in 4th week. AP and lateral radiographs of both elbows were taken at last control.

In last control, bilateral Baumann angles and lateral humerocapitellar angles were measured. Carrying angles and elbow range of motion were measured by goniometer. These angles and operation times compared between the groups. Cosmetic and functional assessment of patients in all groups was evaluated by criteria of Flynn et al. [11].

### Statistical analysis

IBM SPSS Statistic Version 20.0 software was used for statistical analysis. In evaluation of the data descriptive statistical methods (mean, standard deviation) and in analyzing of independent groups of quantitative data showing no normal distribution, Mann–Whitney $U$ test and Kruskal–Wallis test were used. For crude analysis of independent groups of qualitative data, Fisher's exact test was used. About, 95 % confidence interval significance at $p < 0.05$ was accepted.

## Results

Difference between Baumann angles, lateral humerocapitellar angles and carrying angles of fractured and uninjured sides are listed in Table 2. Between group I and group II and between group I and group III, Baumann angles differences are $p = 0.473$, $p = 0.639$, respectively, lateral humerocapitellar angles differences are $p = 0.175$, $p = 0.978$, respectively, carrying angles differences are $p = 0.736$, $p = 0.416$, respectively. There was no significant difference.

Operation time between three groups were no significant difference ($p = 0{,}092$) but between group I and II and between group I and III have meaningfully differences (respectively, $p = 0.0076$, $p = 0.0051$).

Table 3 describes the cases according to criteria of Flynn et al. [11]. Excellent, good and fair results

**Table 2** Difference between angles of fractured and uninjured sides

| | Group I Mean ± SD | Group II Mean ± SD | Group III Mean ± SD | *p* |
|---|---|---|---|---|
| Baumann angle | 4.3 ± 2.8 | 6.2 ± 5.3 | 5.5 ± 4.2 | 0.761 |
| Humerocapitellar angle | 6 ± 4.6 | 12.2 ± 9.8 | 8 ± 7.8 | 0.354 |
| Carrying angle | 2 ± 2.1 | 3 ± 3.6 | 2.5 ± 2 | 0.750 |

Kruskal–Wallis Test

**Table 3** Distribution of cases according to criteria of Flynn et al. [11]

| | Flynn functional | | | | | Flynn cosmetic | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poor | Fair | Good | Excellent | *n* (%) | Fair | Good | Excellent | *n* (%) |
| Group I | | 1 (7.7 %) | 5 (38.5 %) | 7 (53.8 %) | 13 (100 %) | | 1 (7.7 %) | 12 (92.3 %) | 13 (100 %) |
| Group II | | | 7 (58.3 %) | 5 (41.7 %) | 12 (100 %) | 1 (8.3 %) | 2 (16.7 %) | 9 (75 %) | 12 (100 %) |
| Group III | 3 (25 %) | 1 (8.3 %) | 3 (25 %) | 5 (41.7 %) | 12 (100 %) | | 2 (16.7 %) | 10 (83.3 %) | 12 (100 %) |

considered satisfactory. Functional scoring in our cases showed that in group I and group II all patients have satisfactory results; however, in group III, three patients (25 %) had poor results. In the perspective of cosmetic results, all three groups have satisfactory results. There was no neurovascular injury in our cases. Only one patient in group II had pin infection, one patient in group III had superficial wound infection. Both patients had fully recovered after antibiotic treatment and removal of K-wires.

## Discussion

Supracondylar fractures are common fractures accounting for 17.9 % of all pediatric fractures [2]. They are the most commonly surgically treated fractures during childhood [4]. Anatomic reduction, stable fixation, providing full range of motion, and good cosmetic appearance are surgical goals of these fractures. As a fast and easy method closed reduction and percutaneous pining is accepted by many authors [4–13]. However, in soft tissue interposition, severely displaced fractures, very edematous extremities closed reduction may not be achieved [14–16].

Usually, open reduction is the chosen method for open fractures, accompanying neurovascular injuries and irreducible fractures with closed methods [4, 7, 17]. Posterior triceps split approach have the advantage of visualizing both colons and easier anatomical reduction [9]. But it has the disadvantage of muscle fibrosis and range of motion deficit because of muscle weakness [4, 9]. Lateral and medial approaches visualize one colon and anterior portion of distal humerus, reduction of other colon is checked by palpation when using these approaches [8, 18].

Advantages of closed reduction and percutaneous fixation are shorter operation time, less infection risk and no opening fracture site; however, disadvantages of this technique are; needs more experience, fluoroscopy usage, risk of iatrogenic nerve injuries and not able to visualizing quality of reduction directly [11, 19–21]. Also aggressive and repeated reduction attempts may lead to neuropraxia, elbow stiffness, and myositis ossificans [13, 15]. By using joystick and lateral K-wire-assisted closed reduction and cross K-wire fixation method, we think that the complications related with repeated manipulation and open approaches can be avoided. Main advantage of this technique is single reduction manipulation. While joystick K-wire supplies necessary rotation to proximal fragment, lateral K-wire keeps fracture reducted position in the coronal plane, also in lateral view accurate reduction can be achieved by using these two wires.

Kazımoglu et al. [13] and Kaewpornsawan [8] in their studies compared primary open lateral approach and closed reduction. They found no differences in Flynn cosmetic and functional results. Aktekin et al. [9] found better cosmetic and functional scores with closed reduction group comparing posterior approach group. Ozkoc et al. [10] mentioned better functional results with closed reduction than primary open posterior approach. They stated no differences in cosmetic scores. All groups in our study had the similar results for Flynn cosmetic criteria. There were not any poor result in group I and group II according to functional results. In group III, three patients had more than 15° range of motion deficit and had poor result. In one of these patients, there was triceps fibrosis and the other two patients had elbow stiffness.

Method of K-wire fixation is controversial. Biomechanical studies imply the most stable fixation as medial and lateral cross K-wire fixation [22]. Some authors state the importance of additional medial K-wire after fixation with two lateral K-wire [7, 12, 23]. But there is the risk of ulnar nerve injury with additional medial K-wire fixation.

Ulnar nerve injuries are the most common iatrogenic nerve injuries in supracondylar fractures [7, 20]. To reduce the risk of ulnar nerve injuries we used a mini-incision on medial side and bend the elbow <90° during medial pin placement as stated in previous studies [6, 7, 12, 23]. This technique allows placement of the medial pin safely and reduction of fractures does not deteriorate during medial pin placement.

During closed reduction it is difficult to maintain reduction before fixation especially in severely displaced and swollen elbows. Besides these situations this new technique may be useful patients whom can not be treated with open reduction due to soft tissue problems (Fig. 2). Also during surgery rotation of elbow for fluoroscopic lateral view control a cause displacement of the fracture side. Joystick and lateral K-wire assisted closed reduction is an effective way to maintain reduction during fluoroscopic visualization. There is a risk of iatrogenic radial nerve deficit, but with careful application and proper placement (distal to the lateral deltoid insertion) this risk can be reduced.

Lee and Kim [24] described pin leverage technique after three unsuccessful closed reduction attempts in patients with Gartland type III fractures and edema. In this technique, they used a Steinmann pin applied from posterior to the fracture line for reduction and they had good results, but this technique was not useful for multifragmented fractures. Parmaksizoglu et al. [25] described joystick pin reduction technique in failed closed reduction cases. After fixation of proximal fragment below deltoid muscle insertion, distal fragment can easily manipulated to correct coronal tilt, translation and rotation. They had good results according to Flynn criteria at the ratio of 95.6 %. Novais et al. [26] in their retrospective study had used a joystick K-wire through capitellum to establish reduction in multi-directional unstable fractures. Li et al. [27] compared closed reduction with minimally invasive mosquito forceps assisted reduction. They found similar functional results. In none of cases treated with joystick technique, open reduction was not applied as similar with the literature [25–27]. In addition, we used joystick technique in two patients with multifragmented fractures (Fig. 3). Both of them had successful results as radiologic and functionally. Another advantage of this technique allows better cosmesis due to its no incision scar compared to open reduction.

In our study, we calculated the time of operation as starting and ending of duration of anesthesia as the study of Lee and Kim [24]. We found shorter operation time in joystick and lateral K-wire assisted closed reduction group than open reduction groups. Weaknesses of our study are short follow-up period, small number of cases and its retrospective nature. However, patients of group II were younger than group I and group III. We believe that this finding was due to lateral approach tendency of surgeons in younger children in the present study.

## Conclusion

As a conclusion, when classical closed reduction fail, lateral joystick and K-wire-assisted reduction is a useful way to make and maintain the reduction. Functional and radiological results are as good as lateral and posterior open approaches. Short operation time is an advantage. This technique is also useful in multifragmented fractures. This method reduces the risk of complications due to repeated closed reduction attempts such as neuropraxia, elbow stiffness and myositis ossificans and risks of open

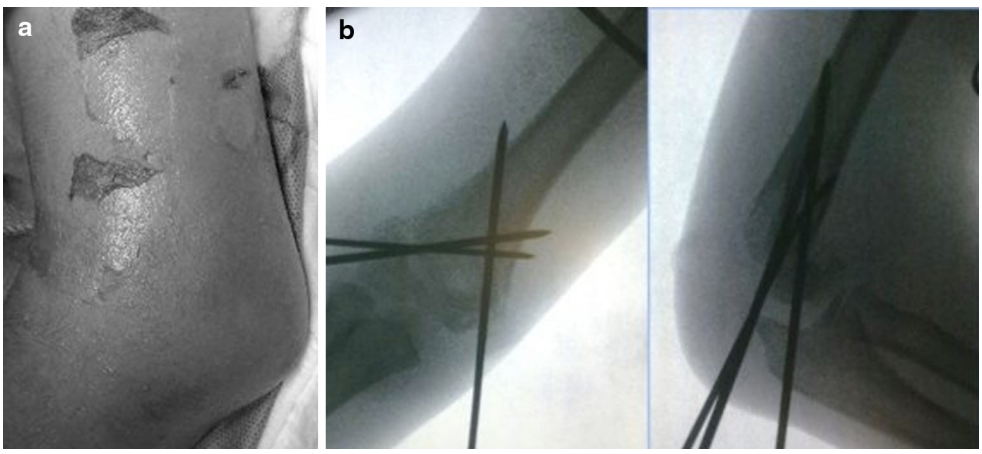


**Fig. 2** Preoperative photograph of the supracondylar humeral fracture with severe edema and soft tissue problem (**a**). Intraoperative fluoroscopic images of after joystick and assisted lateral K-wires reduction and fixation (**b**)

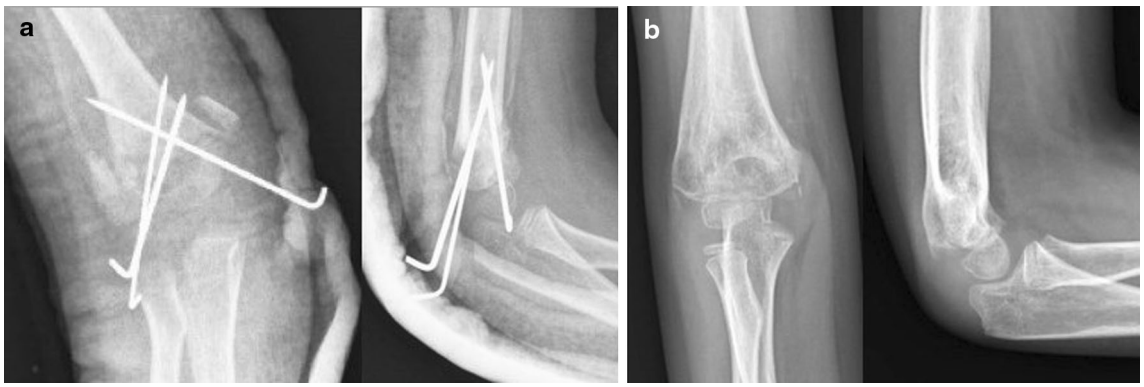


**Fig. 3** Third week direct radiographies of multifragmanted supracondylar humerus fracture maintaining reduction and showing callus formation (**a**). In 1 year follow-up radiographies, fracture totally remodeled (**b**)

reduction such as triceps fibrosis, joint stiffness and unsightly scarring in unsuccessful closed reduction in pediatric supracondylar humeral fractures.

**Conflict of interest** None.

## References


1. Cheng JC, Shen WY (1993) Limb fracture pattern in different pediatric age groups: a study of 3,350 children. J Orthop Trauma 7:15–22
2. Cheng JC, Ng BK, Ying SY, Lam PK (1999) A 10-year study of the changes in the pattern and treatment of 6,493 fractures. J Pediatr Orthop 19:344–350
3. Houshian S, Mehdi B, Larsen MS (2001) The epidemiology of elbow fracture in children: analysis of 355 fractures, with special reference to supracondylar humerus fractures. J Orthop Sci 6:312–315
4. Omid R, Choi PD, Skaggs DL (2008) Supracondylar humeral fractures in children. J Bone Joint Surg Am 90:1121–1132
5. Brubacher JW, Dodds SD (2008) Pediatric supracondylar fractures of the distal humerus. Curr Rev Musculoskelet Med 1:190–196
6. O'Hara LJ, Barlow JW, Clarke NM (2000) Displaced supracondylar fractures of the humerus in children. Audit changes practice. J Bone Joint Surg Br 82:204–210
7. Zamzam MM, Bakarman KA (2009) Treatment of displaced supracondylar humeral fractures among children: crossed versus lateral pinning. Injury 40:625–630
8. Kaewpornsawan K (2001) Comparison between closed reduction with percutaneous pinning and open reduction with pinning in children with closed totally displaced supracondylar humeral fractures: a randomized controlled trial. J Pediatr Orthop B 10:131–137
9. Aktekin CN, Toprak A, Ozturk AM, Altay M, Ozkurt B, Tabak AY (2008) Open reduction via posterior triceps sparing approach in comparison with closed treatment of posteromedial displaced Gartland type III supracondylar humerus fractures. J Pediatr Orthop B 17:171–178
10. Ozkoc G, Gonc U, Kayaalp A, Teker K, Peker TT (2004) Displaced supracondylar humeral fractures in children: open reduction vs. closed reduction and pinning. Arch Orthop Trauma Surg 124:547–551
11. Flynn JC, Matthews JG, Benoit RL (1974) Blind pinning of displaced supracondylar fractures of the humerus in children. Sixteen years' experience with long-term follow-up. J Bone Joint Surg Am 56:263–272
12. Karapinar L, Oztürk H, Altay T, Köse B (2005) Closed reduction and percutaneous pinning with three Kirschner wires in children with type III displaced supracondylar fractures of the humerus. Acta Orthop Traumatol Turc 39:23–29
13. Kazimoglu C, Cetin M, Sener M, Aguş H, Kalanderer O (2009) Operative management of type III extension supracondylar fractures in children. Int Orthop 33:1089–1094
14. Steinman S, Bastrom TP, Newton PO, Mubarak SJ (2007) Beware of ulnar nerve entrapment in flexion-type supracondylar humerus fractures. J Child Orthop 1:177–180
15. Pretell-Mazzini J, Rodriguez-Martin J, Andres-Esteban EM (2010) Does open reduction and pinning affect outcome in severely displaced supracondylar humeral fractures in children? A systematic review. Strateg Trauma Limb Reconstr 5:57–64
16. Mulpuri K, Wilkins K (2012) The treatment of displaced supracondylar humerus fractures: evidence-based guideline. J Pediatr Orthop 32(suppl 2):S143–S152
17. Oh CW, Park BC, Kim PT, Park IH, Kyung HS, Ihn JC (2003) Completely displaced supracondylar humerus fractures in children: results of open reduction versus closed reduction. J Orthop Sci 8:137–141
18. Fu D, Xiao B, Yang S, Li J (2011) Open reduction and bioabsorbable pin fixation for late presenting irreducible supracondylar humeral fracture in children. Int Orthop 35:725–730
19. Esen E, Doğramaci Y, Gültekin S, Görmeli G, Yildirim A, Kanatli U, Bölükbaşi S (2009) Comparison of radiation exposure times in the treatment of pediatric supracondylar humeral fractures with open–closed reduction and internal fixation. Acta Orthop Traumatol Turc 43:400–405
20. Kalenderer O, Reisoglu A, Surer L, Agus H (2008) How should one treat iatrogenic ulnar injury after closed reduction and percutaneous pinning of paediatric supracondylar humeral fractures? Injury 39:463–466
21. Padman M, Warwick AM, Fernandes JA, Flowers MJ, Davies AG, Bell MJ (2010) Closed reduction and stabilization of supracondylar fractures of the humerus in children: the crucial factor of surgical experience. J Pediatr Orthop B 19:298–303
22. Larson L, Firoozbakhsh K, Passarelli R, Bosch P (2006) Biomechanical analysis of pinning techniques for pediatric supracondylar humerus fractures. J Pediatr Orthop 26:573–578
23. Eidelman M, Hos N, Katzman A, Bialik V (2007) Prevention of ulnar nerve injury during fixation of supracondylar fractures in

children by 'flexion-extension cross-pinning' technique. J Pediatr Orthop B 16:221–224
24. Lee HY, Kim SJ (2007) Treatment of displaced supracondylar fractures of the humerus in children by a pin leverage technique. J Bone Joint Surg Br 89:646–650
25. Parmaksizoglu AS, Ozkaya U, Bilgili F, Sayin E, Kabukcuoglu Y (2009) Closed reduction of the pediatric supracondylar humerus fractures: the "joystick" method. Arch Orthop Trauma Surg 129:1225–1231
26. Novais EN, Andrade MA, Gomes DC (2013) The use of a joystick technique facilitates closed reduction and percutaneous fixation of multidirectionally unstable supracondylar humeral fractures in children. J Pediatr Orthop 33:14–19
27. Li YA, Lee PC, Chia WT et al (2009) Prospective analysis of a new minimally invasive technique for paediatric Gartland type III supracondylar fracture of the humerus. Injury 40:1302–1307