Original Article

Outcomes of Closed Reduction Percutaneous Pinning in Paediatric Supracondylar Humerus Fractures using "Arm Board" Technique

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Abstract

Introduction: Closed reduction percutaneous pinning (CRPP) is the standard treatment for displaced supracondylar fractures of humerus (SCH) in children. The purpose of our study is to analyze the functional outcomes of percutaneous Kirschner wire fixation of SCH fractures in paediatric population using a novel "arm board" technique.

Materials and Methods: A prospective study was carried out between October 2015 to and October 2017 which included 71 patients of SCH fracture. Outcome evaluation was performed using Flynn's score and Skagg's grading. Age, gender, type of fracture, position of k-wires, and time to surgery were also recorded. All patients were followed up for a minimum period of one 1 year.

Results: About 90% were graded as excellent, 8.5% good, and 1.5% fair, according to Flynn's score. By Skagg's grading there was no loss of reduction in any patient. There were no significant differences in the outcomes based on age, gender, type of fracture, position of k-wires, and time to surgery.

Conclusion: Good functional outcomes can be achieved with the "arm board" technique irrespective of age, gender, type of fracture, and duration between injury and procedure, if satisfactory reduction of the fracture can be achieved. Our technique uses a simple, locally fabricated radiolucent arm board that can be adapted to any standard operating table. It is a novel and innovative method that is safe, effective and can be easily replicated by orthopedic surgeons managing paediatric fractures.

Level of evidence: Therapeutic, Level III.

Keywords: "Arm board" technique, closed reduction percutaneous pinning, paediatric, supracondylar humerus fracture.

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Introduction

Supracondylar fractures of the humerus are among the most commonly encountered pediatric fractures. It is the most common elbow fracture in children [1, 2] comprising 17% of all pediatric fractures and second in frequency only to forearm fractures. The current standard of care for displaced supracondylar fractures of the humerus in children is closed reduction and percutaneous pinning (CRPP). Numerous techniques for CRPP have been reported in literature by various authors [3, 4, 5, 6, 7, 8]. Perceiving the shortcomings of existing techniques, the senior author devised a method of positioning the upper limb and image intensifier that simplifies fracture reduction, fixation, and obtaining

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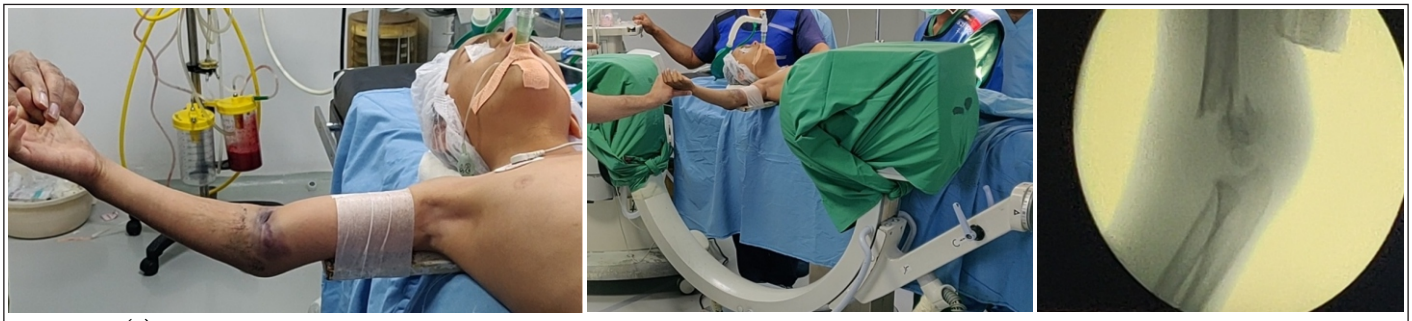

Figure 1: (a) Position of the patient at the edge of the table with arm abducted at 90° and the proximal fragment stabilized with adhesive tape over the radiolucent board, (b) position of the C-arm parallel to the table, (c) C-arm image of the fracture before the reduction.

intraoperative radiographs; potentially obviating the necessity for a surgical assistant.

The purpose of this study was to evaluate the outcomes of percutaneous k-wire fixation in supracondylar fractures of humerus (SCH) fractures in pediatric population with arm board technique and assess the demographic factors affecting the fracture pattern.

Materials and Methods

This study was approved by the Institutional Ethical Review Board and written informed consent was taken from the parents of all children participating in the study. Seventy-one patients between 0 and 16 years of age who underwent treatment for Gartland [15] extension-type SCH fracture between October 2015 and October 2017 were assessed for eligibility. Exclusion criteria were pathological fractures, congenital abnormalities, and open fractures. All operations were performed by the same pediatric orthopedic surgeon. All clinical and radiographic data were collected and patients were followed up for a minimum of 1 year. Pre-operative and post-operative clinical status was assessed using the Flynn's Score [16]. The effect of age, gender, type of fracture, position of k wires, and time to surgery was other variables measured.

Surgical technique [17]

Under general anesthesia and supine position with the affected limb abducted to 90°, the arm was positioned on a specially fabricated, length-adjustable radiolucent arm board (length: 3 feet, thickness: 1 inch, and width: 3 inches). The board was adjusted to support the arm proximal to the fracture site. The proximal arm was fixed to the board with a broad hypoallergenic adhesive tape to stabilize the proximal fragment (Fig. 1a). The distal fragment was kept free for ease of reduction and pinning. The image intensifier was positioned parallel to the foot end of the table on the same side as the injured limb while the monitor was positioned on the contralateral side for easy visualization of the images (Fig. 1b). The elbow was extended and c-arm was used to check if the fracture was out to length (Fig. 1c). To achieve reduction, the surgeon grasps the forearm, applies gentle longitudinal traction followed by flexion of the distal fragment by thumb pressure (Fig. 2a and b). An assistant was required only in case of difficult reduction or medial pinning. Coronal malalignment, translation and rotational displacements were sequentially corrected and the elbow was flexed to 120° (Fig. 2c). The reduction was confirmed in anteroposterior (AP) and lateral views by rotating the c-arm 180° without moving the limb (Fig. 2d). The limb was held in this position, prepared and draped with a pediatric O-sheet (Fig. 2e). Following draping, the reduction was confirmed with the C-arm and where necessary, the reduction maneuver was repeated. The 1st lateral pin (1.6 mm Kirschner wire for a smaller child; 2.0 mm for a bigger child) was the olecranon fossa pin with 4-cortex purchase passing from the lateral condyle across the olecranon fossa to engage the medial cortex (Fig. 3a and b). After the 1st pin, the c-arm was rotated 180° to visualize the fixation in AP, medial and lateral oblique views (Fig. 3c). The 2nd pin was the lateral pillar pin placed parallel to or divergent from the first pin and was bicortical (Fig. 3d). After the 2nd pin, the laxity of the adhesive tape allows checking the stability of the fracture with imaging by gently

Figure 2: Reduction of the displaced fracture with puckering skin. (a) Longitudinal traction, (b) milking method, (c) 120° Flexion of the distal fragment, (d) post reduction C-arm image, (e) shows the elbow kept free for the ease of access and draped with pediatric O-sheet and position of the C-arm.

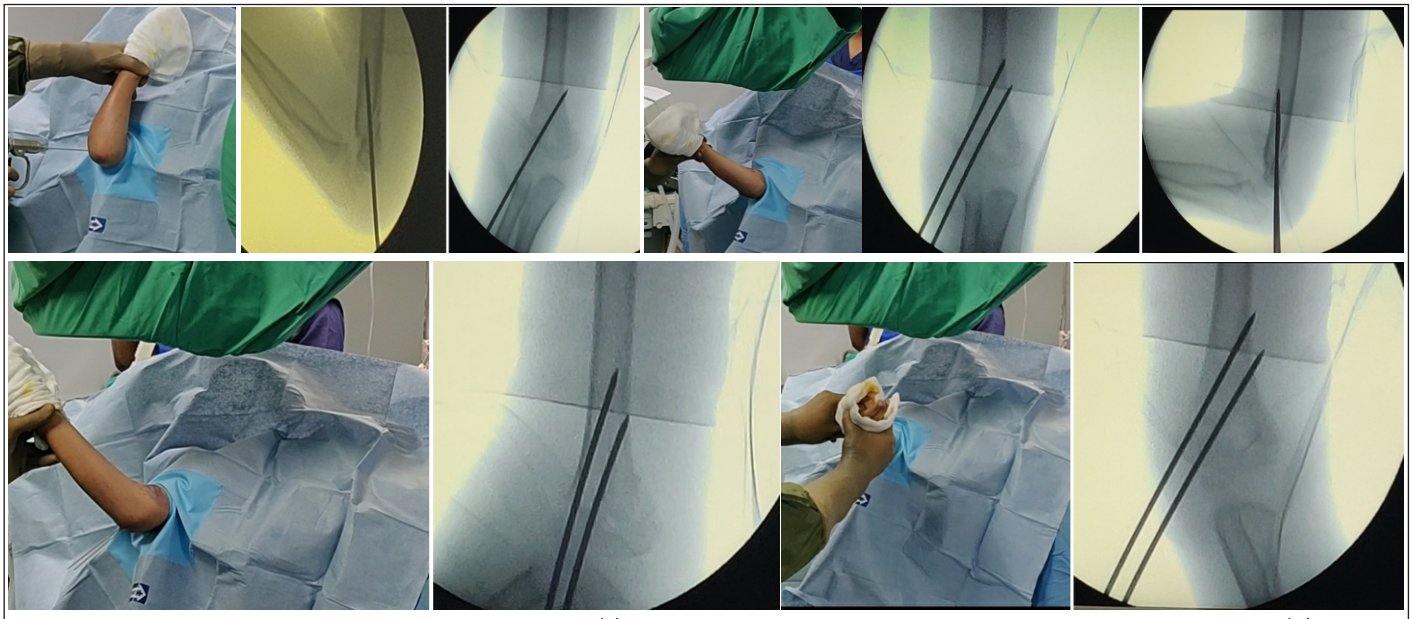

Figure 3: Technique of lateral percutaneous pinning. (a) No assistance was required during pinning to hold the arm, (b) AP and Lateral view of olecranon fossa pin, (c) C-arm was rotated without moving the limb to obtain AP, medial and lateral oblique views, (d) shows C-arm image of the fixation in the AP and lateral views, (e) external rotation of the arm and C-arm image for medial column view and internal rotation of the arm and C-arm image for lateral column view.

rotating the shoulder externally and internally (Fig. 3e). If the stability was unsatisfactory as occurs usually in comminuted fractures, a third k-wire was then added parallel to the first two pins laterally or in a cross-fashion medially. A medial pin may be indicated in cases of medial oblique fractures where there was a larger medial fragment or in cases of rotational instability. For medial entry pins, the ulnar nerve was palpated by gently rolling it between the finger and the bone (Fig. 4a). By pushing it posteriorly with the thumb and the elbow in extended position, the pin was driven from the medial epicondyle in an anteromedial to posterolateral direction to engage the lateral cortex (Fig. 4b and c). The wires were bent to about 100° and cut about 2 cm from the skin. Sterile gauze and iodine ointment were applied around the pins; padding was applied from the axilla to the metacarpo-phalangeal joints followed by above-elbow fiberglass cast with the forearm in neutral rotation and the elbow in 90° flexion. The cast was bivalved on the operation table if there was considerable pre-operative swelling.

Post-operative care

The cast and pins were removed without anesthesia in the outpatient department at 3 weeks. For the older child, pin and cast removal was done at 4 weeks. Active elbow range of motion exercises was then commenced. Patients were further followed up to 12 months for assessment of final functional outcome.

Radiographic evaluation

Standard AP and lateral radiographs of elbow were taken at each follow-up. At 12 months, radiographs of unaffected elbow were also taken to assess the degree of loss of reduction by

Figure 4: Percutaneous technique of medial Pinning, (a) medial epicondyle was palpated with thumb and the other thumb locates the ulnar nerve, (b) with the arm in slight extension and thumb pushing the ulnar nerve posteriorly, the medial pin was inserted percutaneously, (c) anteromedial to posterolateral direction of medial pin avoids injuring the ulnar nerve which was located posterior to the medial epicondyle.

Figure 5: 5Y, male, with left supracondylar humerus fracture treated with closed reduction k wire and above elbow cast. (a) Pre-op, (b) post-op, (c) at 1 year, (d) opposite elbow, (e) clinical pictures in extension, (f) left lateral, (g) right lateral, (h) supination, (i) mid-prone, (j) pronation.

Table 1: Flynn's score

Results	Rating	Cosmetic factor: loss of carrying angle (degrees)	Functional factor: Loss of motion (degrees)
Satisfactory	Excellent	0–5	0–5
	Good	6–10	6–10
	Fair	11–15	11–15
Unsatisfactory	Poor	>15	>15

change in Baumann angle [18], defined as the angle between a line parallel to the longitudinal axis of the humeral shaft and a line drawn along the lateral epicondyle on an AP radiograph. Gartland [15] and Bahk et al. [19] classifications were used to classify the fracture for analysis.

Statistical analysis

Data analysis was done using SPSS version 20:0 by an independent statistician. Carrying angle [20], passive range of motion, and Baumann angle [18] were calculated for the normal and affected limbs at 1 year and the Flynn's score was also calculated (Table 1) (Fig. 5a, b, c, d, e, f, g, h, i, j). Loss of reduction was calculated by Skagg's grading [21]. Statistical significance was determined using Chi-square test variables. $P < 0.05$ was considered as significant.

Results

The mean age was 6.2 ± 2.68 years (range, 1–14 years) at the time of surgery. There were 24 girls and 47 boys. The mean follow-up period was 16 months (range, 12–24 months). Closed reduction was achieved in all patients. The mean Baumann angle at final follow-up was 75.23 ± 3.25^0 (range, 68–82^0). The mean pronation was 76.14 ± 2.76^0 (range, 72–84^0), the mean supination was 81.13 ± 3.13^0 (range, 75–88^0), mean flexion was 138.8 ± 3.81^0 (range, 122–146^0), and extension was −0.3 ± 1.16^0 (range, −6–0^0). Cross k-wiring was required in 4.76% of Gartland Type 2, 12.50% of Type 3, and 23.08% of Type 4 fractures ($P = 0.0001$). As per the Bahk classification, the need for cross k wires was 40% in patients with medial oblique fractures ($P = 0.372$).

Of the 71 cases, 64 (90.14%) were graded as excellent, 6 (8.45%) were graded as good, 1 (1.41%) graded as fair, and none had poor outcomes by Flynn's criteria (Table 2). Sixty-four (90.14%) patients had overall excellent results irrespective of the age group ($P = 0.518$). As per the Bahk classification (Table 3), transverse type was the most common comprising 52 cases (73.24%) and represented the largest number of cases with an excellent result ($P = 0.182$). Lateral pinning showed excellent results in 41 cases while in cross pinning this was seen in seven cases ($P = 0.908$). About 89.36% patients operated within 24 h had excellent result while 90.9% patients operated between 1 and 5 days had excellent results ($P = 0.949$).

One patient had a pre-operative anterior interosseous nerve palsy (Gartland Type 4 fracture) while one patient had a preoperative ulnar nerve palsy (Type 3 fracture) both of which recovered completely within 3 months of fixation. Two patients with Type 4 fractures had a "pink pulseless" hand at presentation; underwent routine management and had satisfactory outcome. Two patients developed refracture at 1 year in the same limb. There was no incidence of cubitus varus or valgus deformity.

Discussion

Numerous techniques have been employed for the management of supracondylar humerus fracture in children. Mubarak and Davids [3] used bed linen wrapped around the

patient's body with counter traction provided by the anesthetist. Tolo et al. [4] recommended use of an extra assistant for providing counter traction against the axilla of the patient while the surgeon applies traction. Many surgeons use "elbow on the tube" technique, that is, the receiver arm of the image intensifier as a table [5]. However, this practice necessitates rotation of the limb to obtain a lateral view which could result in loss of fracture reduction. The expensive c-arm receiver can be damaged by sharp objects or power instruments during the procedure. Jayakumar and Ramachandran [6] used "elbow on the table" technique, that is, a typical radiolucent arm board with a tiny folded towel underneath the child's elbow. Guler et al. [7] reported a shorter duration of anesthesia in supine position as compared to prone while fixing SCHF; however, they used conventional technique and needed an extra surgical assistant for reducing the fracture. Vuillermin et al. [8] positioned the affected arm on the fluoroscopic detector or hand-table.

Considering the shortcomings, we modified our technique to ease intraoperative difficulties. Our technique permits free movement of the c-arm which enables visualization of the fracture fixation in multiple planes, namely, AP, lateral, medial, and lateral oblique. It can also be used to convert the procedure to open reduction if required by sliding the arm board to support the forearm and provide unhindered access to the elbow through the anterior approach.

Functional improvements were measured using two different scoring systems which were Flynn's Criteria and Skagg's grading. The outcomes reported in the present study are comparable with those described in the literature [11, 22, 23, 24, 25].

We also studied the effect of age, gender, fracture type, position of k wires, and time to surgery on functional outcome. We found that the outcome was excellent in around 90% cases in all age groups and comparable outcomes between sexes.

The requirement for a medial pin increased with Gartland grade; 12.5% of patients with Type 3 fracture and 23% in Type 4 fractures ($P < 0.05$). Crossed k-wires were required more often in medial oblique fractures, that is, 40% cases compared to 10.6% in transverse type.

Our results concur with Gopinathan et al. [27] that there was no difference in the Baumann angles and outcome according to Flynn's criteria with regard to wire configuration (divergent or parallel). Danielsson and Pettersson [28] noted loss of reduction when only one pin was used.

Table 2: Functional outcome as per Gartland Classification

Gartland type	Treatment received			Flynns score			Total
	CR	CRPP+Lateral pin	CRPP+Crossed pin	Excellent	Fair	Good	
Type 1	5 (100%)	0	0	5 (100%)	0	0	5
Type 2	11 (52.38%)	9 (42.86%)	1 (4.76%)	20 (95.24%)	0	1 (4.76%)	21
Type 3	0	28 (87.5%)	4 (12.5%)	27 (84.37%)	1 (3.12%)	4 (12.5%)	32
Type 4	0	10 (76.92%)	3 (23.08%)	12 (92.30%)	0	1 (7.69%)	13
Total	16	47	8	64	1	6	71
Row%	22.54%	66.20%	11.27%	90.14%	1.41%	8.45%	100.00%

CR: Closed reduction, CRPP: Closed reduction percutaneous pinning

Table 3: Functional outcome as per Bahk Classification

Bahk type	Treatment received			Flynns score			total
	CR	CRPP+Lateral PIN	CRPP+Crossed PIN	Excellent	Fair	Good	
Lateral oblique	4 (28.6%)	10 (71.4%)	0	11 (78.57%)	1 (7.14%)	2 (14.28%)	14
Medial oblique	2 (40%)	1 (20%)	2 (40%)	4 (80%)	0	1 (20%)	5
Transverse	10 (21.3%)	37 (78.7%)	5 (10.6%)	49 (94.23%)	0	3 (5.76)	52
Total	16	48	7	64	1	6	71
Row%	22.5	67.6	9.9	90.14	1.41	8.45	100

CR: Closed reduction, CRPP: Closed reduction percutaneous pinning

Han et al. [29] concluded that delay in surgery, regardless of whether it was closed or open, for more than 12 h after injury does not influence the perioperative complications and clinical results for displaced supracondylar humeral fractures in children. Iyengar et al. 30] found no difference in the final outcome between early and delayed reduction and pinning of Gartland type III fractures. We observed that the duration between injury and definitive procedure had no significance ($P > 0.05$).

There are certain limitations in our study. The number of cases included in the study is small. The follow-up period is 1-year. This is a single surgeon prospective study at a tertiary care hospital. Further studies employing the technique described above will validate whether the method is reproducible and universally applicable in pediatric supracondylar humerus fractures.

Conclusion

Arm board technique uses a simple, locally fabricated radiolucent arm board that can be adapted to any standard operating table especially in developing countries where the resources are limited. It is a novel and innovative method that is safe, effective and can be easily replicated by orthopedic surgeons involved in managing paediatric fractures. Increase in fracture severity tends to have unstable fractures sometimes requiring more than 2 k-wires and/or cross k-wire configuration to maintain acceptable reduction. Technique can also be used in difficult situation requiring the procedure to be converted to open.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil; **Source of support:** None

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