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ORIGINAL ARTICLE

Close Reduction Technique for Severely Displaced Radial Neck Fractures in Children

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Abstract

Introduction Radial neck fractures account for 5–10% of paediatric elbow trauma. Radial neck fractures have been classified by Judet into five types (I–IVb). There is a global agreement to reduce radial neck fractures with angulation more than 30° (Type III, IVa and IVb). Various maneuvers have been described but none of them uniformly achieved complete reduction in severely displaced radial neck fractures (Type IVa and Type IVb Judet). In this case series, we are presenting our experience with close reduction of ten severely displaced paediatric radial neck fractures to achieve complete anatomical reduction.
Methods We attempted close reduction in ten consecutive children with average age of 8.59 ± 1.68 years (range, 6–12 years) who presented with severely displaced radial neck fracture (Type IVa and IVb Judet). There were five girls. All patients had close injuries and presented to us within 24–48 h. One of the patients had associated undisplaced lateral condyle fracture. We have excluded two patients with associated elbow dislocation. Close reduction was performed within 48 h of initial injury.
Results We were able to obtain complete anatomical reduction in all of our patients with this technique. None of the patients required fixation of fracture. At 1 year of follow-up, (12 ± 2.07 months, range 9–16 months) all patients demonstrated almost full range of elbow and forearm motion. Final radiographs revealed complete union without any evidence of avascular necrosis.
Conclusion This technique offers an option of close reduction for the most severely displaced radial neck fractures, which were otherwise being treated by surgical intervention.

Keywords Radial neck fracture · Severe · Close reduction · Judet IV

Introduction

Radial neck fractures account for 5–10% of paediatric elbow trauma and 1% of total childhood fractures [1, 2]. In 90% of proximal radial fractures, the fracture line comprises of radial neck or physis [3, 4]. The management of radial neck fractures is based on fracture angulation, displacement and skeletal maturity. There is a consensus in the literature to reduce radial neck fractures with angulation more than 30° whereas fractures with less than 30° of angulation can be immobilized as they can remodel well [7, 19].

Treatment methods for displaced radial neck fractures include closed reduction, percutaneous pin-assisted

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reduction, elastic stable intra-medullary nailing (metaizeau technique) and open reduction with or without internal fixation [2, 5–9, 11, 12]. Various maneuvers have been described for close reduction of displaced radial neck fractures but these are mostly successful in fractures with incomplete translation and angulation less than 60° [5–10, 11, 12]. Severely displaced fractures frequently pose a challenge to closed reduction and may require operative intervention. There are potential complications with surgical intervention including the risk of nerve injury with percutaneous reduction techniques and the risks for avascular necrosis, premature epiphyseal fusion, and heterotopic ossification with open reduction [13, 14, 15]. While treating radial neck fractures, achieving anatomically acceptable reduction is of paramount importance to avoid forearm rotational restriction [16]. The purpose of our study is to report on a modified technique of closed reduction for severely displaced paediatric radial neck fractures.

Materials and Methods

Radial neck fractures have been classified by Judet into five types (I–IVb) depending on the angulation and displacement of the proximal fragment (Fig. 1) [17]. Between 2017 and 2018, we performed close reduction in ten consecutive patients (Table 1) who presented at our centre with completely displaced radial neck fracture. We classified the fracture based on Judet classification. Five were type IVa and five were type IVb. In all the cases, mechanism of injury was fall while playing on an outstretched hand with extended elbow and supinated forearm. Average age of our patients was 8.59 ± 1.68 years (range, 6–12 years). There were five girls and five boys who sustained close

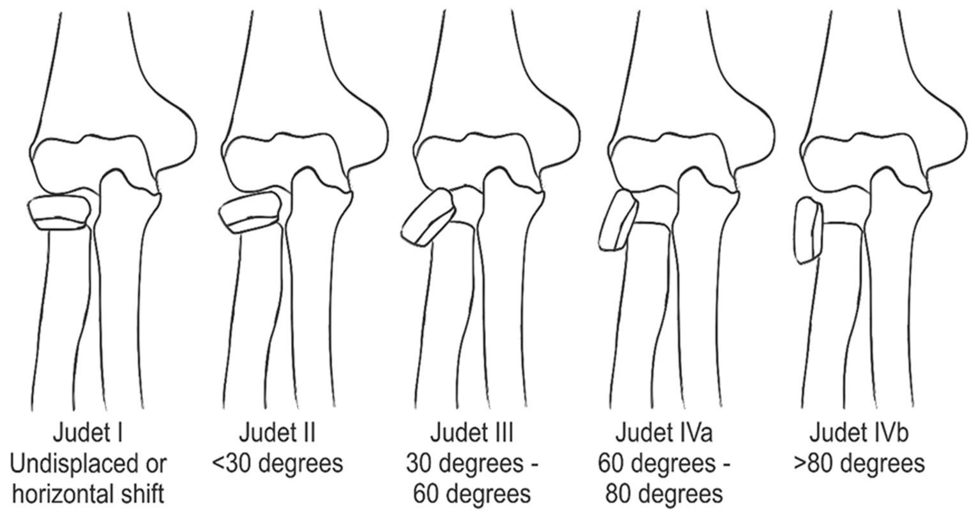

Fig. 1 Diagrammatic description of Judet classification of radial neck fractures

Table 1 Description of the patients

Sl. no.	Age (yrs)	Sex	Site involved	Associated injuries	Radial head angulation (Judet Type)	Final follow-up (in months)	ROM at final follow-up			
							F	E	P	S
1	8	F	Right elbow	None	87° (Type IVb)	20	140	0	70	80
2	12	F	Left elbow	Undisplaced lateral condyle fracture	70° (Type IVa)	20	130	5	70	85
3	6	F	Right elbow	None	72° (Type IVa)	18	135	0	60	80
4	7.5	M	Right elbow	None	67° (Type IVa)	16	140	10	70	75
5	9.5	M	Right elbow	None	82° (Type IVb)	15	130	5	65	80
6	8.4	F	Left elbow	None	77° (Type IVa)	15	140	−5	70	85
7	9	M	Right elbow	None	82° (Type IVb)	15	125	0	60	80
8	10	M	Right elbow	None	83° (Type IVb)	14	130	0	70	80
9	7	F	Right elbow	None	68° (Type IVa)	14	140	−10	60	75
10	8.5	M	Right elbow	None	85° (Type IVb)	13	125	10	60	70

Sl. no. serial number, *yrs* years, *F* female, *M* male, *F* flexion, *E* extension, *P* pronation, *S* supination

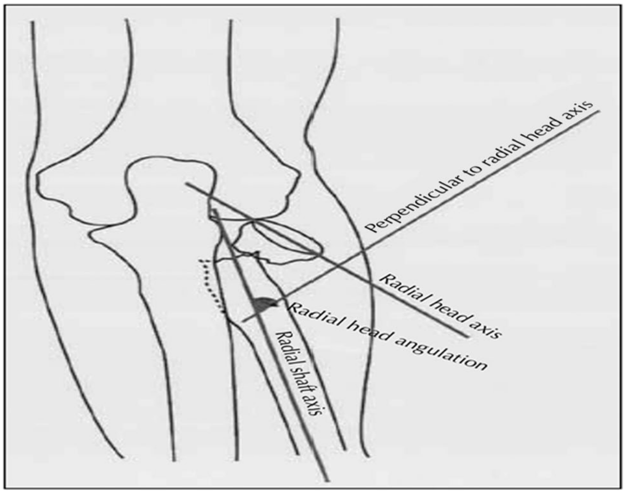

Fig. 2 Measurement of radial head angulation

injury over the elbow. One patient had associated undisplaced lateral condyle fracture and elbow instability. None of them had distal neuro-vascular deficit. All the patients presented within 24–48 h of injury and close reduction was performed within 48 h of injury. We have excluded two patients with posterior elbow dislocation and convergent elbow dislocation, respectively.

To assess the radial head angulation, we first drew the radial shaft axis and the radial head axis on an AP radiograph. A perpendicular is then drawn to the radial head axis. The angle subtended between this line and the radial shaft axis was calculated as radial head angulation [15] (Fig. 2). The average angulation of radial head was 77.3 ± 7.48° (range, 67°–87°) in this series.

Technique (Fig. 3; Video 1)

Close reduction was executed under general anaesthesia and muscle relaxation with fluoroscopic control. The affected limb was kept in elbow extension and full supination. Under image intensifier, degree of forearm rotation was identified to localise maximum angular displacement. It is the position in which the radial head epiphysis appears to be a long, thin rectangle on the anteroposterior (AP) view [8]. In this position, longitudinal traction was applied to the forearm with varus stress at the elbow joint to distract the lateral side of the joint. Pressure was applied with the thumb over the displaced radial head fragment [6]. With this manuver, we were able to obtain partial reduction of radial head. After this, the elbow was pronated and flexed simultaneously with sustained pressure over the radial head to obtain further correction. We believe, this is the most critical step of the technique as we were able to obtain complete anatomical reduction in all of our cases with this final maneuver. Reduction was then checked in full range of flexion and extension, keeping the forearm in

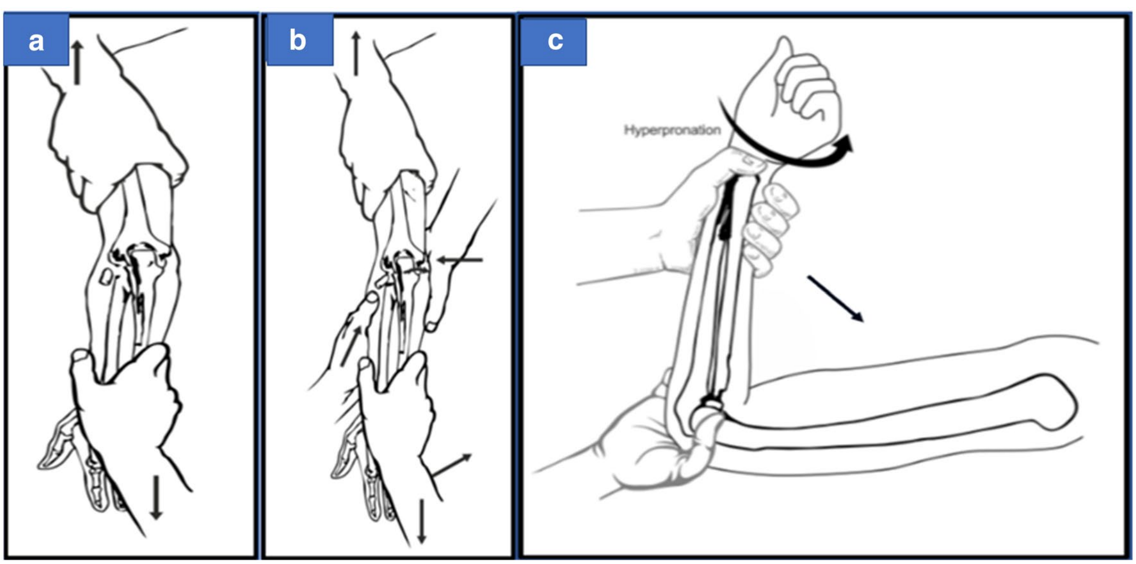

Fig. 3 Diagrammatic description of close reduction technique. **a** Forearm is gently supinated to get a complete profile image of radial head (position of maximal radial angulation and then traction is applied. **b** Varus stress is applied at the elbow (medical aspect) by the assistant and thumb pressure is applied at the radial head along postero-lateral aspect of elbow. This results in partial reduction of the radial head. **c** Now elbow is maximally flexed and pronated continuous pressure over the radial head. This final step anatomically reduces the radial head and hyper pronating the forearm locks it in the corrected position. Above elbow cast is applied in 90° elbow flexion and mid-prone position of the forearm

mid-prone position. We found that the fracture had the tendency to displace in supination and so we immobilized the extremity in the mid-prone position and 90° elbow flexion. None of the patients required k-wire or nail fixation, once complete reduction was achieved. Gradual active exercises were begun after 3 weeks of immobilization. Patients were followed at 1, 3 and 12 months.

Results

In all the cases, we were able to obtain complete reduction with this technique. There was no displacement during subsequent follow-up in any of our patients. At an average follow-up of 16 months (16 ± 2.07 months, range 9–16 months), all patients demonstrated full range of elbow and forearm motion (average flexion-133.5°, extension-1.5°, pronation-78°, supination-79°). Final radiographs revealed complete anatomical union without any evidence of avascular necrosis or heterotopic ossification (Figs. 4, 5, 6).

Discussion

Radial neck fracture in children is caused by fall on an outstretched hand. In this position, a valgus force causes impaction of lateral column, compressing the radial head against

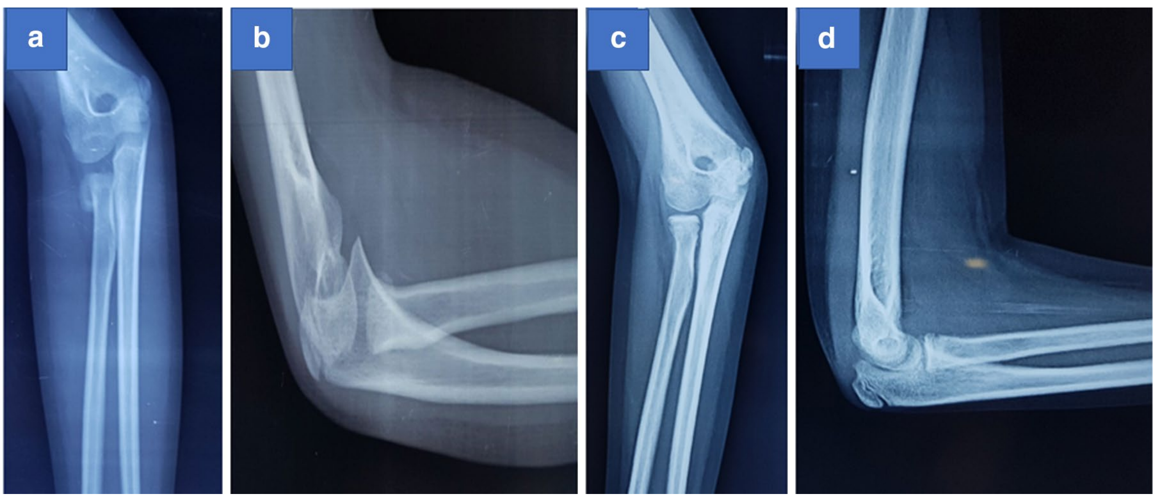

Fig. 4 **a** Pre-operative AP view of patient 1 showing radial head displacement angle is 87° (Judet Type IVb). **b** Lateral view showing complete displacement of radial head. **c** One year post-operative AP view demonstrating anatomic reduction. **d** One year post-operative lateral view

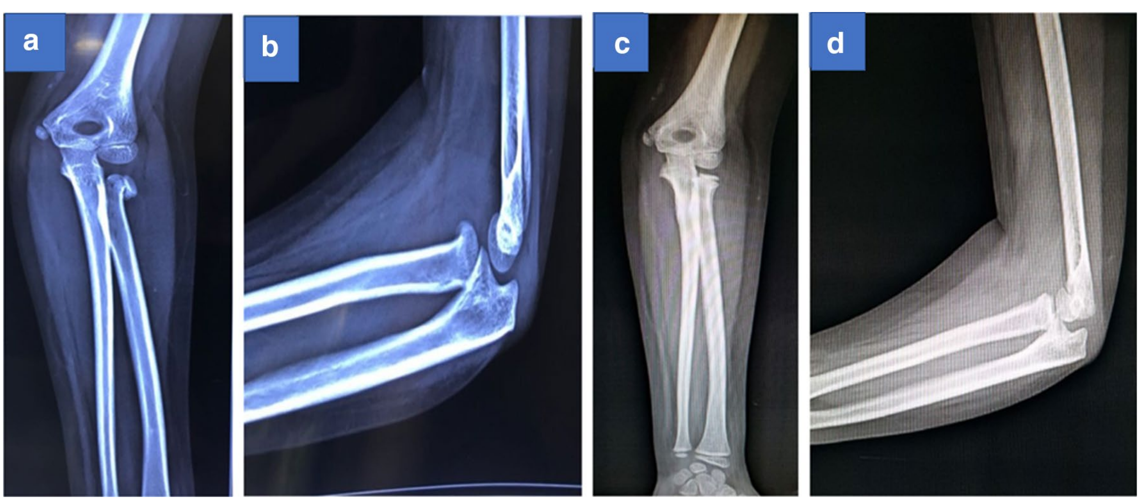

Fig. 5 **a** Pre-operative AP view of patient 3. Radial displacement angle is 72° coinciding with Judet IVa. **b** Lateral view of the same elbow. **c** Fracture was reduced by close method. One year post-operative AP view of elbow. **d** Lateral view showing anatomic reduction without signs of avascular necrosis or growth arrest

Table 2 Various published close reduction techniques for displaced radial neck fractures

Sl. no.	Name of the technique	Year of publication	Position of elbow	Mean age (yrs)	No of patients	Angulation	Results
1	Kaufman or Israeli	1989	90° flexion	8.5	10	< 60°	Eight anatomically reduced, two accepted with 10° angulation
2	Nehar-Torch	2003	Extended	7	4	> 60° (maximum angulation 72°)	Near normal reduction in all
3	Monson	2009	90° flexion	9.5	6	27°–76°	All anatomically reduced except one (20° angulation)
4	Augustithis and Huntley	2015	Extended		5	30°–60°	Successful

Sl. no. serial number, *yrs* years

the capitulum leading to fracture and displacement of radial neck [18].

The proximal radio-ulnar joint has an exacting congruence. The rotational axis lies directly in the centre of the radial neck. Any deviation of the centre of the radial head from its alignment with the centre of the radial neck changes the arc of rotation of the head. This displaced radial head rotates with a "cam effect" instead of rotating smoothly in a pure circle [16]. Residual angulation of more than 30° disrupts the congruity of the proximal radio ulnar joint and results in subsequent loss of supination and pronation [7, 19].

To our knowledge, six techniques [5–10] have been described till date for close reduction of displaced radial neck fractures (Table 2). Most of these techniques work on decompressing the lateral column by applying traction in extension or flexion at elbow and reducing the fracture by pressing either the proximal or the distal fragments. Only one of these techniques have been described for near anatomical reduction of severely displaced fractures of radial neck [8]. A detailed description of all these techniques has already been mentioned in the literature. We attempted these techniques in our cases, but we were unable to achieve anatomical reduction by applying any of them independently. So, we tried a combination of them as described above and were able to obtain 100% reduction in all the cases.

Capsular ligament and lateral collateral ligament complex are the key components to achieve close reduction in isolated radial neck fractures [20]. Rotating the extremity to visualize the radial head in full profile brings it in the pre-fracture position before attempting reduction.

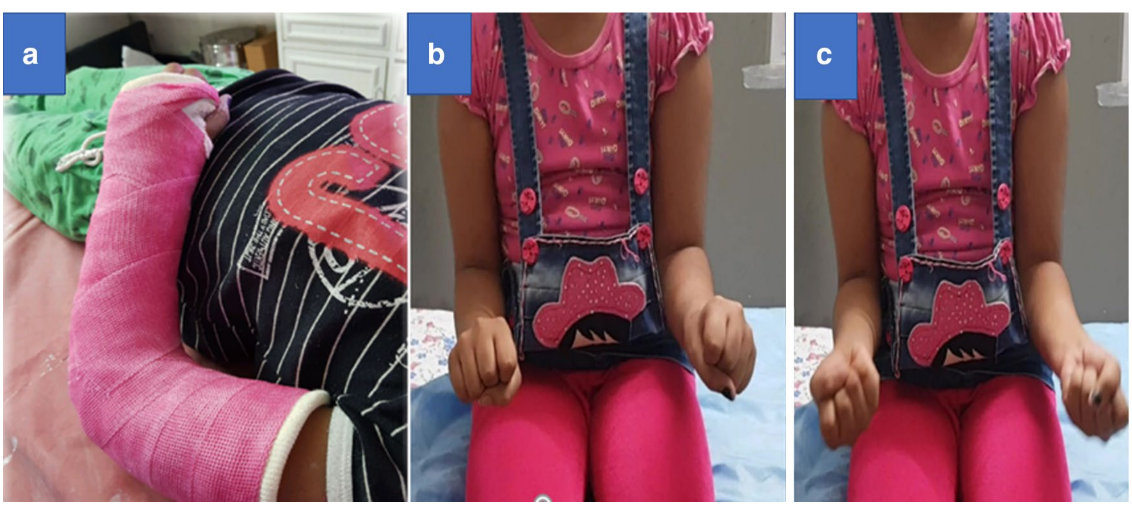

Fig. 6 **a** Position of post reduction cast given to patient 3 in mid-prone position. **b**, **c** One year follow-up clinical pictures of patient 3 showing near normal prono-supination

Varus force to the elbow along with longitudinal traction distracts the space between capitellum and shaft of radius. Constant pressure over radial head at this point partially reduces the radial head. Flexion of the elbow in pronation leads to obliteration of posterior capsule and lateral collateral ligament complex. This biomechanical ligamentotaxis leads to anatomic reduction of radial head. Stability of reduction can be checked under image intensifier in full range of flexion and extension while keeping forearm in pronation. The role of ligamentotaxis by lateral collateral ligament complex can be further emphasized by the fact that radial head has a tendency to re-translate laterally on supination of the forearm. Since the reduction was stable in mid-prone position, we could avoid either k-wire or nail fixation of these fractures. We were unsuccessful in reducing two severely displaced radial neck fractures associated with elbow dislocation. This might be due to disturbed/torn ligament structures which are the key components to provide close reduction through ligamentotaxis. These patients were excluded from the study.

This study has a few limitations. More number of patients will help in delineating the generalised applicability of this method. The follow-up of this study is relatively short to comment on the incidence of premature epiphyseal fusion.

Conclusion

Severely displaced radial neck fractures (Judet Type IV) are conventionally treated by surgical intervention. None of the existing techniques have independently treated this fracture pattern with closed reduction and uniformly achieved complete anatomical reduction. The method described here has given anatomical reduction consistently in all isolated severely displaced radial neck fractures.

Author Contributions MMS, GG, QR: study design. MMS, GG: performed measurements. VB: statistical analysis. MMS, QR, VB, KKW: manuscript preparation.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standard statement All procedures performed on human participants in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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