The Functional Results of Surgical Percutaneous Joystick Reduction Therapy for Isolated Severely Angulated Radial Neck Fracture in Children

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ABSTRACT

Background: Radial neck fractures in children account for 5 to 10% of all elbow fractures in children. They are extra-articular fractures of the radius proximal to the bicipital tuberosity. The physis is typically involved as a Salter-Harris I or II pattern. Alternatively, the fracture sometimes is extraphyseal, through the metaphysis. In children there is considerable potential for remodeling after these fractures. Up to 30° of radial head tilt and up to 3 mm of transverse displacement are acceptable. Many modalities of treatment are available regarding Surgical &Non-Surgical treatments.

Objectives: To evaluate the functional outcome after surgical percutaneous joystick reduction therapy of severely angulated radial neck fracture in children.

Type of the study: A prospective study.

Methods: During the period between February/2012 and May/2015, we made a prospective study of (18) patients suffered from O'Brien type II&III radial neck fracture with severe angulation that require surgery seen at Al-Kindy Teaching Hospitals. However, we select a group of children who had more than 30° of Radial head angulation really cannot treated by conservative method. Angulated radial neck fractures in children reduced with a percutaneous Kirschner wire. We select of surgical procedure after failure of thumbing intraoperatively. The primary indication for surgery was changing type II&III to typeI which can go on in manage conservatively.

Results: All the (18) patients treated with percutaneous pinning techniques were followed-up, clinically and radiographically evaluated pre-surgery, post-surgery and finally (6) months after surgery. The mean angulation of the fractures was 64° (30° - 90°) before reduction and 10°(0° - 22°) after reduction. Mean fracture displacement after reduction in all cases was less than 3 mm. Range of Motion (ROM) in flexion, extension, pronation and supination was the functional parameter in our study as graded by (the grading system of Steele). We obtained an outcome of excellent results in 15 patient (83%), good results in 3 patients (17%) and we have no fair or poor results.

Conclusions Percutaneous Joystick Reduction Techniqueusing K-wire in children with radial neck fractures is a safe, short, easy procedure requires only good technical measures, minimally invasive in nature with minimal hospitalization time, has a minimal morbidity and complication rates, it is recommended surgical treatment that can achieve recovery of normal radial neck angulation, elbow motion and yielding excellent results.

Keywords: Radial neck - elbow fractures in children – closed reduction – percutaneous joystick – pediatric forearm injuries.

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Fractures of the radial neck in children are usually seen after the appearance of the proximal radial epiphysis at about the age of (5) years(1). The most common **mechanism** of radial neck fractures is a valgus and axial force to the elbow caused by a fall on an outstretched hand(2).**Clinically** there is usually pain, tenderness, and swelling over the lateral aspect of the elbow and decreased forearm rotation (pronation/supination)(3).The treatment of radial neck fractures in children varies according to the displacement, angulation, and skeletal maturity.

Radial head angulationwas defined as the angle between the perpendicular line of the axis of the displaced radial epiphysis and the axis of the radial shaft(1).In our study we follow O'Brein classification for radial neck fractures…According to the grouping standard of **O'Brien** about fracture Angulation:

Type I: Less than 30°. Type II: 30° to 60°. Type III: More than 60°(4)(5).The remodelling capacity of bone healing depends on the proximity of fracture to the physis; favourable results appear if the fracture is close to the physis(6). Most fractures are undisplaced or minimally displaced (O'Brien type I fractures) and can be treated with closed reduction and casting with good outcome(7). The more severely angulated and displaced fractures (O'Brien type II&IIIfractures)have been variously treated by: closed reduction, closed Percutaneous Joystick Reduction,open reduction, or open reduction with internal fixation, but the precise indications for each are not clear(2). The radial neck is extra-articular and has a normal 15 degrees of valgus angulation on anteroposterior(AP)and 5 degrees on lateral radiographic views(8). The surgeon must beware of injury tothe posterior interosseous nerve as it travels distally anterior to the radial head and neck(5). Normal Ranges of Movements: are variable with different references but generally:

Elbow Extension = 0°-5°.Elbow Flexion = 140°-150°. Forearm Pronation = 80°-90°.Forearm Supination = 80°-90°(9) (2).

In our study we follow a standard of (0°)Extension,(150°)Flexion,(90°)Pronation and (85°) Supination. Normal Carrying Angle in children (5-15yr.) is about:Male= 7.Female= 8°. This degrees increase with age till reach about 15 yr. old(10). In a previous retrospective studiesthey found that open reduction of radial neck fractures generally had a poor result.They also found that open reduction with internal fixation was even worse(11). Severely displaced or angulated fractures often have poorer outcomes, even after open reduction. **Complications** include: pain, decreased range of motion, cubitus valgus, radio-ulnar synostosis, heterotopic ossification, radial head overgrowth, premature physeal closure, avascular necrosis, malunion and non-union.

Risk factors associated with poor outcome include: age, radial neck angulation, associated injury, open reduction and internal fixation(1). The proximal radial epiphysis is mainly supplied by periosteal blood vessels running from distal to proximal; The radial head and its blood supply can be damaged by the original trauma and/or by surgical trauma, such as open reduction or forceful manipulations and may lead to avascular necrosis of the radial head or physeal closure(12). Percutaneous means of reduction of these fractures in children has been described previously by(Feray1969;Angelov1981; Pesudo, Aracil and Barcelo1982) but the technique is not widely known or used(2).

The present study is a retrospective analysisof this methodregarding the clinical and radiological outcomes of percutaneous pinning in a consecutive cohort of children.We follow the **Grading System of Steele**as afunctional parameter(Table.1)(13). The contralateral upper limb of the child is better to be without history of fracture or severe injury to help us in comparison of X-Rays and movements (The uninjured elbows served as controls)(14).

Grade	Loss of flexion-extension	Pronation	Supination	Increased carrying angle
Excellent	0° to 5°	75° to 90°	70° to 85°	0° to 5°
Good	6° to 10°	60° to 74°	55° to 69°	6° to 10°
Fair	11° to 15°	45° to 59°	40° to 54°	11° to 15°
Poor	>15°	<45°	<40°	>15°

Table (1): Steele Scores for clinical results of management of radial neck fractures.

Closed Reduction (PattersonTechnique)/ (Thumbing):

.With the elbow extended and forearm supinated,Varus stress is applied to the elbow by an assistant .The surgeon reduces the fragment with lateral digital pressure.

Surgical Technique of Percutaneous Reduction:

.If closed reduction fails, a Kirschner wire can be used to directly push the radial head in to anatomic position.

.The surgeon must beware of the posterior interosseous nerve. The radial head can be protected by pronating the forearm and by using a posterolateral pin approach.

PUSH TECHNIQUE:

.The end of a large Kirschner wire, 0.062 inch or larger, is percutaneously inserted through the skin distal to the fracture and just off the lateral border of the ulna through a 2_mm incision.With the fluoroscopic guidance the pin is placed against posterolateral aspect of the proximal fragment and the radial head is pushed in to place.

.Axial traction and rotation of the forearm can dislodge an impacted fracture and assist in the reduction(5).

Methods: During the period between February/2012and May/2015, a (18) patients suffered from O'Brien type II&III radial neck fracture sufficiently severe to require surgery were seen at the Emergency Unit of Al-Kindy Teaching Hospitals.

All cases including (13) boys and (5) girls, the range of age was from (6) to (12) years old, the average age was about(8.5) years old. (11) Rt. And (7) Lt.Elbows.

The diagnosis of the type of fracture depends on X-Ray…

In (2) elbows the fracture line was entirely metaphyseal and in (16) it was epiphyseal: (3) Salter-Harris type I and(13) type II separations.

However, we select a group of children who had more than (30°) really not treated by any conservative method. All patients had normal contralateral upper limb and this help us in comparison of X-Rays and movements.

We inform the family before surgery that if we fail in closed method we will change it to open reduction surgery. All cases are managed within the first 2 days of injury,all cases were treated with percutaneous joystick reduction in the theatre after failure of thumbing reductionand all cases had no internal fixation.

3 groups of patients excluded from the study:

A) 5 cases had failed percutaneous reduction ends with open reduction &internal fixation.B) 3 cases lost from follow-up.C) 5 cases end with success of Thumbing.

All reductions were performed by same Surgeon in Al-Kindy Teaching Hospital.

The procedure took about up (7-11) minutes, the average time was (9) minutes.

Results of all 18 patientstreated with percutaneousjoystick pinningtechniques were followed-up,clinically and radiographically evaluated.

Procedure: The injured elbow is screened using an image intensifier with magnification facilities. Under general anesthesia the extended elbow is screened in the anteroposterior plane through the range of forearm rotation.

The position of maximum angulation and displacement of the fracture is then recorded. Displacement of the fracture is measured from the same view using dividers to measure the width of the uncovered radial metaphysis and the total width of the metaphysis, then expressing the ratio as a percentage.Trial of Thumbing done first, if success then we do a slab to the patient, if failed, then:

The elbow is prepared and draped free, using the image intensifier as the operating surface. A 15 cm long smooth Kirschner wire in a T-handled chuck is used for the reduction. The diameter of the wire is 1.5to 2 mm, selected according to the patient's size. The entry for the wire, chosen on a lateral view, is through a lateral skin puncture in the mid-axial line, made as far proximally as possible so as to avoid the posterior interosseous nerve. The point is advanced into the fracture under screening and far enough to push the head and reduce it(Fig.1).Another magnified view is taken and the postoperative angulation and displacement are recorded. The stability of the reduction and the range of forearm rotation are checked under the image intensifier.

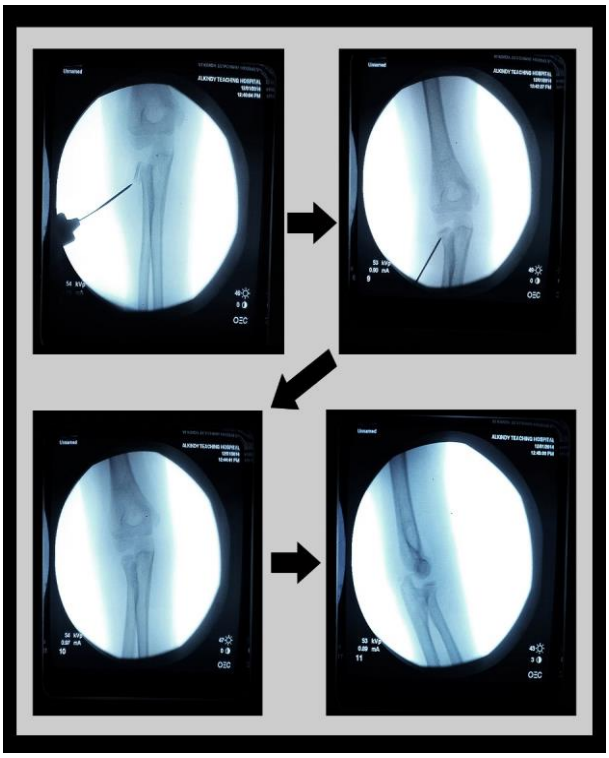


Figure (1): Intraoperative reduction of severely angulated radial neck fracture by Percutaneous Wiring, with serial screen monitor photos for stages of reduction.

Post-Operative Care: The arm is held in a long-arm back slab cast at 90° flexion and neutral rotation for (3) weeks before starting active mobilization.

Hospitalizationis based on the concept of (Day-Care Procedure), putting the patient when discharge in the same day of surgery on simple oral antibioticfor only 2 days and simple oral analgesic for 5 days.

Follow-Up:Follow-up cases range from 6-9 month with mean of about (7) month at the Outpatient Unit. Patients were reviewed every week at first month and checked every 2 weeks following three months, and lastly at six-month for evaluation.

Results: All the X-rays after operations showed accepted anatomical reduction.

The mean angulation of the fractures was 64°(30°- 90°) before reduction and 10°(0°-22°) after reduction. Mean fracture displacement was 60% (20% to 100%) before reduction and 8% (0% to 15%) after reduction and all are less than (3) mm.

At final follow-up, radiological evaluation revealed that residual angulation and displacement of all fractures had undergone healing in excellent or good alignment.

Range of Motion (ROM) in flexion, extension, pronation and pronation was the functional parameter in our study(Fig.2).

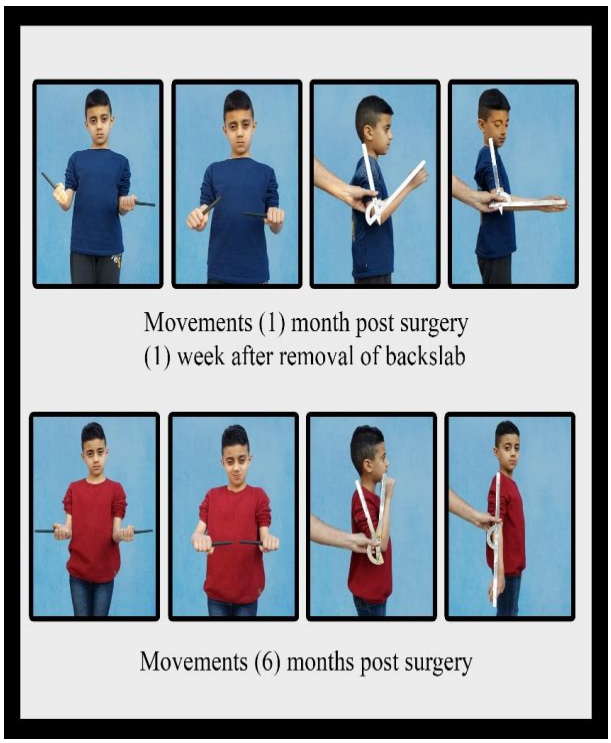


Figure (2): Movements (Supination- Pronation- Flexion-Extension) in a child with Rt. Sided severely angulated fracture neck radius treated by Percutaneous Reduction.

Upper Raw= (1) month post-surgery Lower Raw= (6) months post-surgery.

We used a Goniometer to record forearm rotation, elbow flexion-extension and the carrying angles of both arms.

At the final follow-up examination, the carrying angle of the elbows was symmetrical in 83% (15/18 cases) of patients and it had increased non- significantly in 3 patients compared to the contralateral limb.

There were no iatrogenic nerve injuries or infections.No patients developed other complications. The only ''minor'' complication observed was represented by one case of asymptomatic enlargements of the radial head.

All radial head does not re-displaced after surgery, gets good anatomical reduction and good bone healing(Fig.3).No patients underwent a second surgery after reduction.

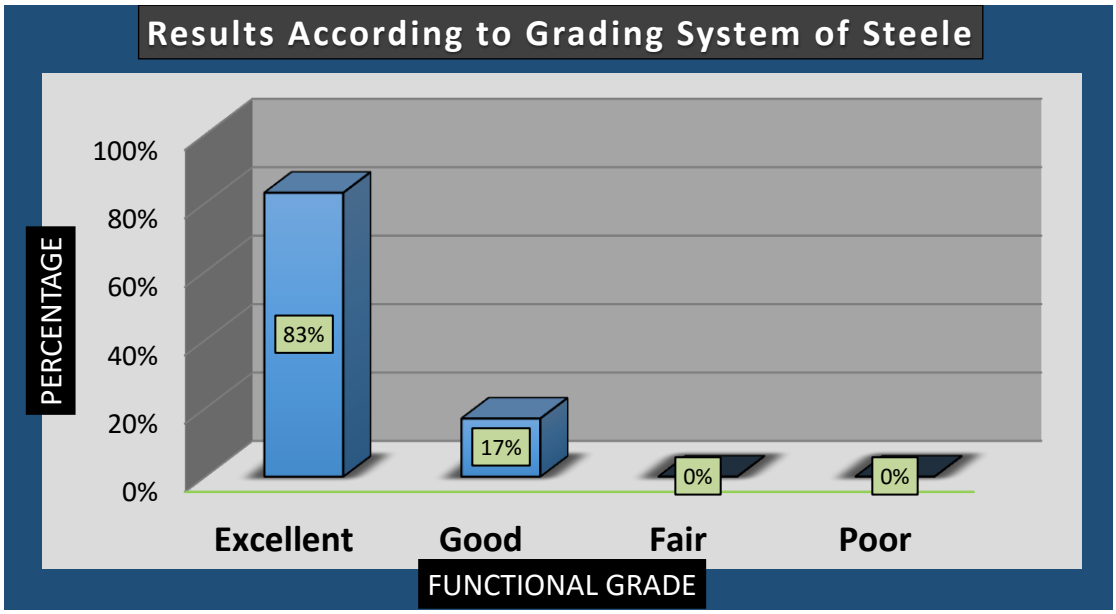
Figure (3): X-ray of patient with fracture neck radius (1) month after reduction by percutaneous pinning shows excellent alignment &union.

The final follow-up examination was done after (6) months from the surgical procedures.
According to the grading system of Steele. Excellent results were achieved by the time of final follow-up evaluation in 15cases (83%), Good results in 3cases(17%) andno cases ofFair or Poor results(0%) - (Table 2) & (Graph 1).

Case	Sex	Age (years)	Angle	Follow-up (months)	X-Ray Post-operative angulation	Flexion deficit	Extension deficit	Pronation deficit	Supination deficit	Increased carrying angle	Clinical results
1	M	8	48°	7	0°	0°	0°	0°	0°	0°	Excellent
2	F	12	64°	9	8°	0°	0°	0°	0°	0°	Excellent
3	M	6	78°	6	18°	0°	4°	0°	0°	2°	Excellent
4	M	10	70°	6	12°	0°	0°	0°	0°	0°	Excellent
5	F	7	54°	6	8°	0°	5°	0°	0°	0°	Excellent
6	M	8	64°	9	5°	0°	3°	0°	5°	3°	Excellent
7	M	11	30°	6	8°	5°	5°	0°	0°	0°	Excellent
8	M	10	58°	7	3°	0°	0°	0°	0°	0°	Excellent
9	F	12	78°	6	22°	7°	10°	15°	12°	8°	Good
10	M	6	74°	7	20°	0°	0°	5°	5°	4°	Excellent
11	F	10	56°	8	12°	5°	0°	0°	0°	0°	Excellent
12	M	8	70°	6	6°	10°	5°	15°	5°	0°	Excellent
13	M	6	45°	8	15°	0°	0°	0°	0°	0°	Excellent

Case	Sex	Age (years)	Angle	Follow-up (months)	X-Ray Post-operative angulation	Flexion deficit	Extension deficit	Pronation deficit	Supination deficit	Increased carrying angle	Clinical results
14	F	12	62°	8	16°	12°	15°	18°	15°	10°	Good
15	M	9	82°	6	0°	3°	0°	0°	0°	0°	Excellent
16	M	7	68°	7	7°	0°	3°	0°	0°	0°	Excellent
17	M	10	64°	6	10°	3°	13°	10°	15°	8°	Good
18	M	7	90°	7	6°	0°	0°	0°	0°	0°	Excellent

Table (2): Table of Results of all patients of the study regarding Radiological and Functional Data gained (6) months after Percutaneous Pinning.



Graph1: Results in percentage (%) according to **the grading system of Steele.**

Discussion: There are marked controversies found in the literatures with respect to what should be considered an acceptable reduction or how much initial displacement is acceptable when deciding operative or non-operative management(15). All conservatively treated fractures with angulation up to (45°) can be accepted as seen byCreasman, Zaleske& Ehrlich in their study(2). VockeAK&Von Laer L. On follow-up radiographs, all conservatively treated fractures with angulation up to (50°) had corrected themselves spontaneously.

The high complication rate after open reduction and the poor functional results and inconvenience for the pediatric patient makes conservative treatment of radial neck fractures in children preferable(16).

Steele and Graham obtained a satisfactory radial head reduction by percutaneous Kirschner wire in 33 of 36 patients(17),And this goes withour study.

Also show that cases with failure of closed reduction seems to have interposition of the capsule or annular ligament between the head and the neck(17),And this is also what do we see with cases of failure during our study which ends with open reduction and internal fixation. Older children tend to sustain more severe fractures and have poorer outcomes. Skeletal maturity confers a poor prognosis. This could be due to:

(1)The higher energy involved in the injuries in older children. (2) In addition, younger children's bones are more cartilaginous and hence more cushioned. The energy from the trauma is more effectively absorbed,

resulting in less severe fractures. (3) The bone also has greater remodeling potential and hence can achieve better outcomes(1),So in our study allgood results group (less than Excellent) are found in higher ages: 12, 12 & 10 years of age respectively. Children generally recover their elbow range of motion well and do not require physiotherapy(3),in our study we advise parentsto avoidphysiotherapy, we advise only for active movements. Wang Sun et.al use Percutaneous joystick reduction and fixationwith wire was advanced to the far cortex of the radius and penetrated into the far cortex to maintain the reduction status(Metaizeau),and have good effect for O'Brien II, III pediatric radial neck fracture(18). Bernstein SM& McKeever P.in their study on (18) children treated with a Steinmann pin after failing closed reduction. Reduction was successfully accomplished for (15) patients. (3) Patients failing percutaneous pin reduction(19).During our study, we fail in percutaneous pin reduction in (5) cases. Francesco et.al in their study shows that complication relative to internal fixation to the fragment blood supply and particular surface was avoided without loss of reduction(20),so in our study all fractures were stable after reduction and also we avoid putting fixation.

Conclusion: In Conclusion from this study, surgical percutaneous Joystick technique to treat a severely angulated radial neck fracture in children is the first line of management after failure of conservative methods of reduction.

Percutaneous joystick reduction technique is a simple,easy to masterand reliable method to treat severely angulated radial neck fractures in children, which provides good functional results and has a limited risk of complications.

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