Research Article

Outcome of Transcapitellar K-wire Fixation for Radial Neck Fractures

Ali A. Ali **
(M.B.Ch.B., F.I.B.M.S(ortho), C.A.B.S(ortho))

Date Submitted:20/1/2014
Date Accepted: 8/4/2014

Address for Correspondence:
***** Lecturer/Orthopedic Surgeon at Al-Mustansiriya University, College of Medicine, department of Surgery
(aliaziz76@yahoo.com).

Abstract

Background: Fractures of the radial neck are mainly seen in children and require meticulous management to avoid elbow disabilities. Age, grade of the fracture and association with other elbow injuries affect the surgical approach to be used for treatment.
Aim: This study was performed to detect the outcome of using transcapitellar K-wire fixation for treatment of radial neck fractures.
Patients & Methods: Twelve patients with displaced (Broberg-Morrey II, III & IV) radial neck fractures were included. Eight patients (Group A) were children below skeletal maturity (10-18 years) and four patients were over 18 years of age (Group B) who achieved full skeletal maturity. Kaplan's approach for open reduction and internal fixation using K-wires was used, and the patients were followed up for 6 months. Each patient was assessed for outcome according to predefined criteria ranging from excellent to good, fair and poor.
Results: In group A, two patients had excellent outcome, one patient had fair outcome and the rest had good outcome. In group B, two patients had good outcome while the other two had fair outcome; however, none of the patients had poor outcome. Valgus deformity of >10ºand elbow stiffness of >20º developed in three patients, with stiffness mainly affecting supination & extension. Of the patients with fair outcome, one developed implant failure due to poor compliance, while another patient developed neuropraxia of the posterior interosseous nerve that resolved spontaneously.
Conclusion: Several surgical methods have been proposed for treatment of radial neck fractures with variable results and outcomes. While open reduction and K-wire fixation may not be the first line of these methods, it remains a safe method and provides advantages like short operative time, no exposure to image intensifier, less blood loss and less risk of neurovascular injury. However, for optimal results with minimal complications, the procedure requires early intervention, good patient compliance and prolonged follow-up.

Key words: ***Radial neck fractures, K-wire.***

INTRODUCTION

The proximal radial end represents the head, neck, and tuberosity. The head is cylindrical with a shallow fovea on its upper surface for articulation with the capitulum of the humerus. The radial head is smooth; and broad medially for articulation with the ulna and it is surrounded by the annular ligament. The head is attached to a smooth, and constricted neck, on the back of which is the insertion of part of the Supinator [(1)]. The ossification center of the proximal radial end appears at 3-5 years of age and fuses with the shaft at the age 18-20 years [(2)].

The radiocapitellar joint makes up the lateral articulation of the elbow with the radial head acting as an important secondary valgus stabilizer of the elbow. It is also important in maintaining axial stability of the forearm [(3)]. A 57%-60% of the force applied to the forearm crosses the radio-capitular joint while 40%-43% crosses the ulnar-trochlear joint [(4)].

Radial neck fractures are uncommon and account for 8% of all elbow fractures in children and only 4% of all fractures in adults [5]. The mechanism of injury involves a fall on the outstretched hand with the elbow extended and the forearm supinated. The resulting valgus force compresses the capitulum against the radial head. The fracture may also be associated with a posterior dislocation of the elbow [6].

Many authors have disputed controversies regarding radial neck fractures management [7]. The type of management depends on the fracture grade and time of presentation. Open reduction allows anatomical reduction of the fracture, but also carries a higher incidence of complications [8].

Radial neck fractures have a 20%-60% complication rate related to the severity of the initial injury and the aggressiveness of the treatment plan. Complications include: pain, loss of motion, nonunion/malunion (cubitus valgus), avascular necrosis of the radial head, radioulnar synostosis and posterior interosseous nerve injury [9].

Aim of the study

This study determines the practicality and the outcome of using K-wire fixation in the treatment of radial neck fractures of different grades and at different ages.

PATIENTS AND METHODS

The study was conducted at Al-Yarmouk Teaching Hospital and Iraqi Red Crescent Hospital (Baghdad) over a period of 16 months (from August 2011 to December 2012). Twelve patients (10 males, 2 females) who attended the hospitals for displaced radial neck fractures were enrolled in the study.

The patients were divided into two age groups in relation to skeletal maturity; Group A patients (n=8) were 10-18 years of age (mean age=14.5 years) & Group B patients (n=4) were >18 years (skeletally mature) with a mean age of 22.6 years. After clinical examination, two-view radiographs (AP and Lateral) were taken for the injured elbow for grading purposes. The fracture was graded according to Broberg-Morrey classification [10] (table 1); depending on degree of the radial head or neck angulation and translation (figure 1). Three patients of group A had grade II fracture; the remaining patients of group A and two patients of group B had grade III fracture and the rest of group B patients had grade IV fracture. All grades required surgical intervention that was performed within 48-72 hours of presentation.

Table (1): Broberg-Morrey classification for radial head or neck fractures [10].

Classification grade	Clinical description
Type I	fracture of the radial head or neck with displacement of < 2mm.
Type II	fracture of the radial head or neck with displacement of ≥ 2 mm.
Type III	comminuted fracture of the radial head or neck.
Type IV	dislocation of the elbow, whatever the type of the fracture.

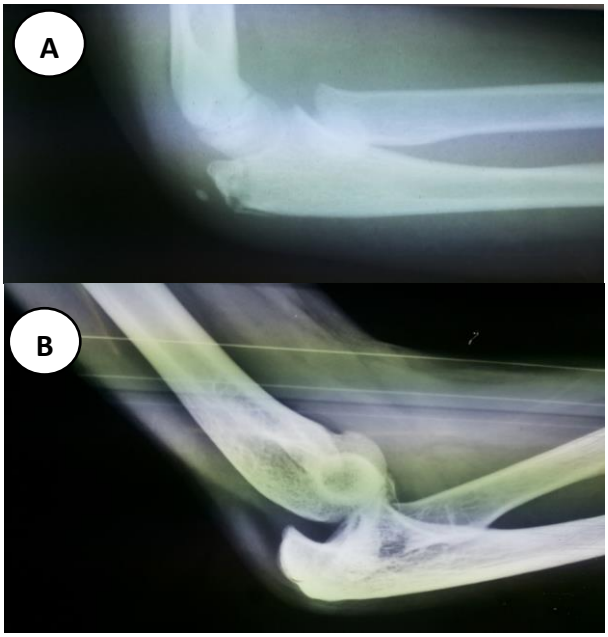

Figure 1: Lateral X-ray of the elbow with (A) grade III Broberg-Morrey fracture of the radial neck in a skeletally immature patient and (B) type IV Broberg-Morrey fracture with posterior elbow dislocation in a skeletally mature patient.

Surgical procedure: Operations were performed with a bloodless field using a tourniquet that was applied at the level of the mid-arm. For the K-wire fixation Kaplan's approach for the radial head and neck was used [11].Starting at the supracondylar ridge of the distal humerus, the origin of extensor carpi radialis longus was incised and elevated and the underlying elbow capsule was incised to show the capitulum and radial head. The interval of dissection to reach the radial neck lies just anterior to a line bisecting the radial head in the anteroposterior plane. The fracture site was revealed with a minimum dissection. In most cases, much of the orbicular ligament was ruptured. In all cases the head was still attached to the remaining part of the neck and shaft with a strip of periosteum, which

made the reduction of the fracture easier. Reduction was performed by applying traction while the forearm supinated with repositioning of the radial head to its anatomical site. After reduction, traction was gradually reduced with pronation of the arm and the radial head was entrapped in the site between the radial shaft and capitulum.

Two to three K-wires (14-18 mm) were introduced, without intraoperative image intensifier, from the capitulum into the radial head and then through the proximal one third of the radial shaft to maintain the alignment. The capsule was then closed, the incised muscles repaired, and the skin was closed without drain, and the tourniquet was removed. The average time of the operations was 45 minutes. A back-slab was applied; extending from the mid-arm to the metacarpophalangeal joints of the hand with the elbow 90^{O} flexed and the forearm fully pronated. The surgical procedure is shown in figure (2).

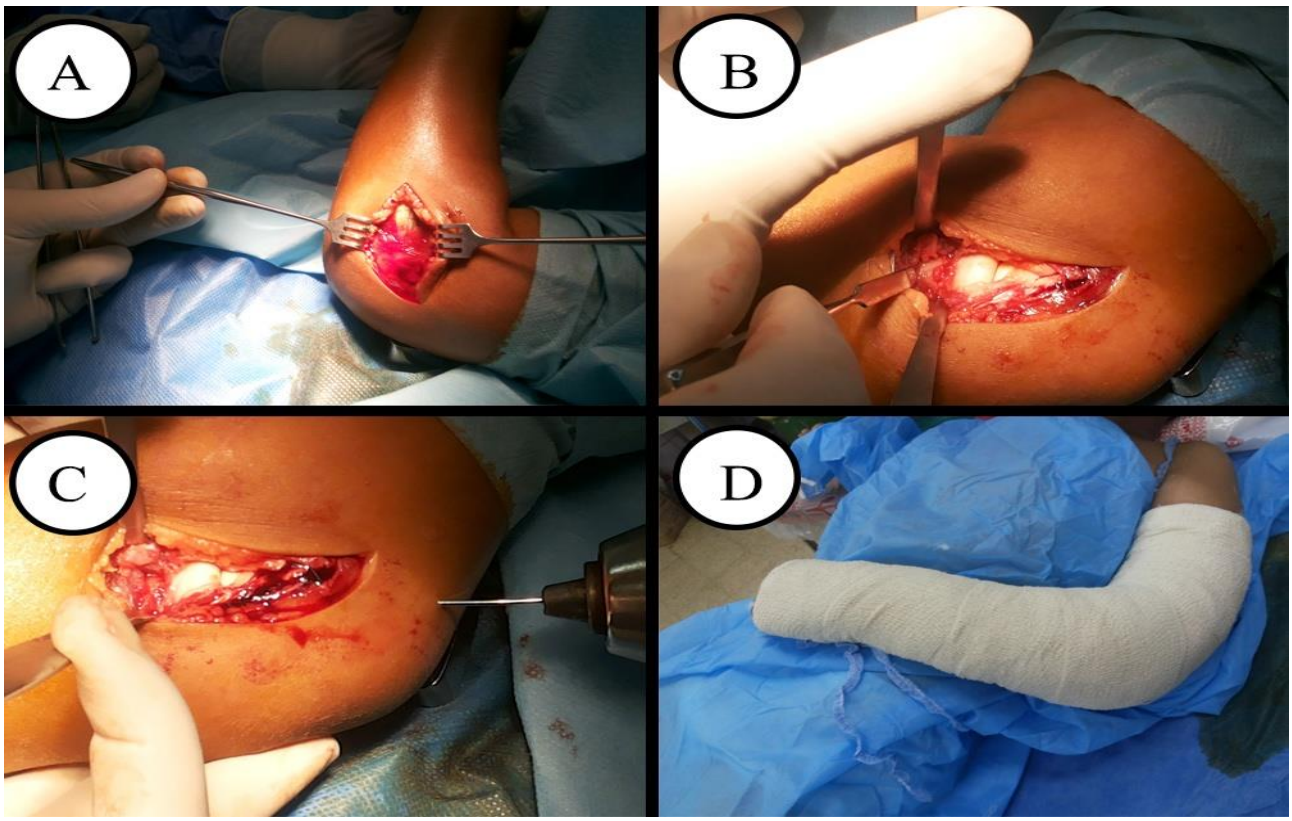

Figure *2*: Kaplan's approach for (A) exposure and (B) reduction of radial head & neck followed by (C) K-wire fixation and (D) Back-slab application.

A post-operative AP and lateral X-rays were taken for each patient (figure 3).

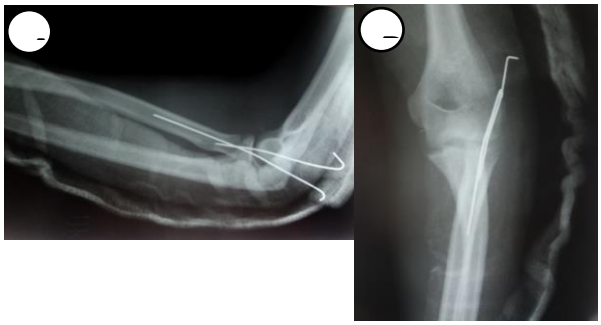

Figure 3: Postoperative X-ray of a fractured radial neck treated with ORIF using two K-wires in skeletally immature patients (A: lateral view, B: AP view).

Follow-up: Patients were seen two weeks postoperatively for suture removal and changing the back-slab into full POP. A confirmatory X-ray was taken (figure 4) at that time and another visit was schedule; two weeks later for removal of POP and K-wires and initiation of active physiotherapy for Group A patients, and 4 weeks later in Group B patients for K-wires and POP removal with initiation of active physiotherapy, after that the patients were seen once monthly.

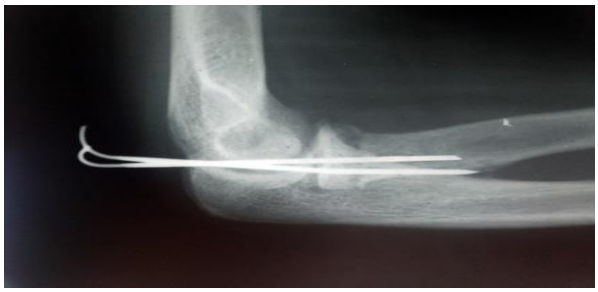

Figure 4: Postoperative lateral X-ray of a fractured radial neck treated with ORIF using two K-wires in group B before changing to POP.

After a short course of active physiotherapy, patients were assessed for pain, range of movement (elbow stiffness) and deformity; by clinical and radiological examination. The outcome was graded as excellent, good, fair and poor according to Tan and Mahadev[12](table 2). The follow-up continued for up to 6 months.

Table 2: Assessment criteria for radial neck fractures treated with K-wire fixation according to Tan and Mahadev (2011) [12].

Outcome	Description
Excellent	No pain, full range of motion, no deformity.
Good	Occasional insignificant pain, range of motion decreased <20º in any direction, <10º valgus deformity.
Fair	Occasional insignificant pain, range of motion decreased >20º in any direction, >10º valgus deformity.
Poor	Stiffness &/or deformity requiring further surgery

RESULT

The distribution frequency of patients' ages, gender and fracture grade and the related outcome percentage of K-wire fixation method are shown in (table 3).

The percentage frequency of the patients' groups is demonstrated in (figure 5).

In general, more than 66% of cases (8 of all 12 patients) are skeletally immature patients, in which only two had an excellent outcome (in Group A), while seven out of all patients (5 in Group A& 2 in Group B) had a good outcome; however, only three patients had fair outcome (1 in Group A & 2 in Group B) and none had poor outcome. The younger patients had lower grade fractures and more favorable outcome, while a higher fracture grades and less favorable outcome were associated with increasing age and skeletal maturity.

Table 3: Frequency distribution of patients' age, sex and radial neck fracture grade and the outcome percentage of treatment with K-wire fixation.

Patient group	Outcome		Fracture grade			Mean age (years)	Sex	
			II	III	IV		Male	Female
A	Excellent	2	2	-	-	12.7	1	1
	Good	5	1	4	-	15.2	4	1
	Fair	1	-	1	-	16	1	-
B	Excellent	-	-	-	-	-	-	-
	Good	2	-	2	-	20.4	2	-
	Fair	2	-	-	2	25.7	2	-

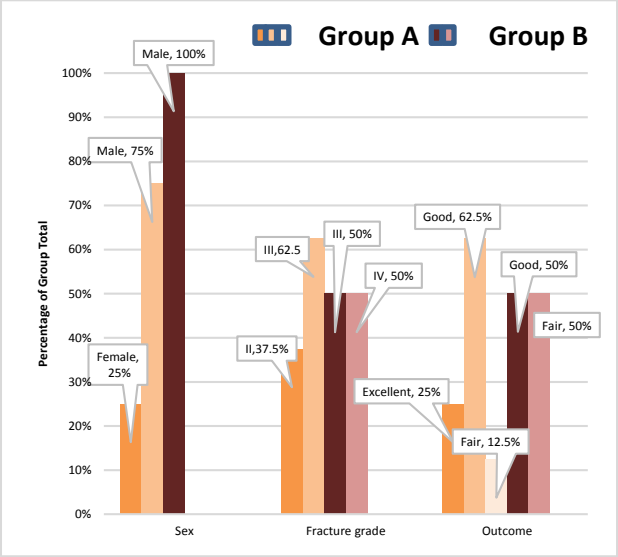

Figure 5: Frequency percentage (as total of group) of patients' sex, radial neck fracture grade and outcome of treatment with K-wire fixation.

Apart from the two patients who had an excellent outcome, the ranges of movement and valgus deformities of the other 10 patients were as shown in (table 4). The reduction of movement mainly affected supination & extension, while pronation & flexion were the least affected movements. The valgus deformity was <10º in all patients except in three patients, two of whom had the Broberg-Morrey IV combined fracture.

Table 4: Assessment of stiffness and valgus deformity in patients with radial neck fracture treated with K-wires.

Assessment criteria			Number of Patients
Stiffness	<20 º	Flexion	1
		Extension	2
		Supination	3
		Pronation	1
	>20 º	Flexion	-
		Extension	1
		Supination	2
		Pronation	-
Valgus deformity	<10 º		7
	>10 º		3

Other than stiffness and valgus deformity, two other complications occurred; in which two patients had implant failure (figure 6) and one other patient developed neuropraxia of the posterior interosseous nerve.

Figure 6: Lateral X-ray of a 16 year old patient who developed implant failure of K-wires used to treat a radial neck fracture.

Regarding the implant failure, two patients aged 12 and 16years, developed implant failure 4 weeks postoperatively, which was discovered radiologically prior to POP removal. The K-wires were removed for one of the patients because it slipped to become intra-articular, while for the other patient, the wire was left in place since it was completely intramedullary.

One patient with type IV Broberg-Morrey fracture had an associated fracture of the radial head and posterior elbow dislocation, presented postoperatively with inability to extend the thumb and metacarpophalangeal joints of the fingers and was diagnosed with posterior interosseous neuropraxia by nerve conductive study; with reassurance, physiotherapy of the hand and tonics management; the neuropraxia resolved completely 3 months after the surgery.

All patients achieved full union, which has been proven clinically and radiologically (figure 7), with insignificant occasional pain; moreover, none of them developed avascular necrosis of the radial head or radio-ulnar synostosis during the follow-up period of 6 months.

Figure 7: Lateral X-ray of a 15 year old patient showing union of radial neck fracture.

DISCUSSION

The age distribution of the patients enrolled in this study is in agreement with the general known age frequency for radial neck fractures in literature. However, higher fracture grades were seen in older ages and more advanced skeletal maturity. This may be due to the more cartilaginous nature of children's bones, which provides them with greater elasticity and a cushioning effect that reduces the severity; and hence the grade, of radial neck fractures. Adults and older children with near skeletal maturity may sustain a higher energy injury that causes greater bone and soft tissue damage.

Different methods and opinions have been proposed and studied for reduction and stabilization of type II, III and IV radial neck fractures [8]. Closed or open reduction without fixation has been followed by re-displacement and greater risk of complications like periarticular ossification, avascular necrosis and enlargement of the radial head [13]. Reduction with percutaneous pinning of the radial head provided better results than closed reduction alone but still remained unsatisfactory due to development of premature fusion of the epiphysis of the radial head in children [14]. Plate fixation is used both widely and successfully but it carries the risk of loss or limitation of forearm rotation in many patients [15].

The development of stiffness (mainly in supination and extension) in this study may be related to the prolonged period of elbow stabilization in pronation & flexion. The position of pronation was chosen at the time of

surgery because it is the position of higher stability for maintaining the reduction of radial neck fracture.

Severity of injuries and implant failure are clearly implicated in development of valgus deformity of more than 10°.

Implant failure emerged in this study may be due to poor patient compliance & type of fixation used despite good surgical technique.

Posterior interosseous nerve neuropraxia was developed in one patient in this study and it may be caused by the initial injury or due to excessive traction during surgical repair, as seen in other studies [16].

Transcapitellar K-wire fixation has been reported to have a risk of complications such as avascular necrosis and notching of the radial neck [17]. However, the current study shows that early surgical intervention with optimal reduction and good postoperative support can minimize these complications, provided that the period of follow up is extended to more than 6 months. This is in agreement with Papageorgiou*et al.* who reported that pin reduction and internal fixation with one K-wire is a safe and effective treatment of displaced radial neck fractures even when the presentation is delayed after injury [18].

Radial neck nonunion is a rare complication of a displaced radial neck fracture [19] and was not seen in the current study, which may be due to meticulous surgical approach and minimum periosteum stripping.

Conclusion

Rare in adults, radial neck fractures are more commonly seen in children. Different methods are applied for the management of displaced and complex cases. While open reduction and K-wire fixation may not be the first line of these methods, it remains a safe and fairly satisfactory technique in the absence of other instrumentation. However, for optimal results with minimal complications, the procedure requires early intervention and good patient compliance. The latter may prove problematic in the setting of the affected age group being active children. Nevertheless, early transcapitellar fixation with K-wires carries such advantages like less operative time, no exposure to image intensifier radiation, less risk of neurovascular injury and less blood loss.

REFERENCES

(1) Standring S. *Grey's anatomy, The anatomical basis of clinical practice*. 39th ed. London: Elsevier Churchill Livingstone, **2005**. 511-15. Print.

(2) Chen MY, Pope TL &Ott DJ. *Basic radiology*. 2nded. New York: lange McGraw Hill, **2011**. 163-165. Print.

(3) Miller MD & Sanders TG. *Presentation, Imaging and Treatment of Common Musculoskeletal Conditions*. Ch40: *Radial Head and Neck Fractures (Ed.: Abrams G &Safran M)* 1st ed. Philadelphia: Saunders Elsevier, **2012**. 160-163. Print.

(4) Beingessner DM, Dunning CE, Beingessner CJ, Johnson JA & King GJ. The effect of radial head fracture size on radiocapitellar joint stability. ClinBiomech, **2003** 18**(7)**:677-81.

(5) Herbertsson P, Josefsson PO, Hasserius R, Besjakov J, Nyqvist F, Karlsson MK. Fractures of the radial head and neck treated with radial head excision. J Bone Joint Surg Am. **2004**; **(86)**:1925–30.

(6) Radomisli TE & Rosen AL. Controversies Regarding Radial Neck Fractures in Children. ClinOrthopaedRel Res. **1998**; **1(353)**:30-39.

(7) Evans MC & Graham HK. Radial neck fractures in children: a management algorithm. J PediatrOrthop**1999; 8:93–**9.

(8) Ursei M, Sales De Gauyz J, Knorr J, Abid A, Darodes P &Cahuzac JP. Surgical treatment of radial neck fractures in children by intramedullary pinning. ActaOrthop. Belg., **2006(72)**: 131-137.

(9) Giffin JR, King GJ, Patterson SD & Johnson JA. Internal fixation of radial neck fractures: an in vitro biomechanical analysis. ClinBiomech, **2004 19(4)**: 358-61.

(10) Broberg MA &Morrey BF. Results of treatment of fracture-dislocationsof the elbow. ClinOrthop**1987**; 216:109-19.

(11) Wiss DA. *Master techniques in orthopaedic surgery, Fractures*. In Ch9: Ring D.: Radial head fractures: open reduction and internal fixation. 2nd ed. Lippincott Williams &Wilkins, PA, USA **2006**:127.

(12) Tan BH &Mahadev A. Radial neck fractures in children. J OrthopaedSurg**2011;19(2)**:209-12.

(13) Steinberg EL, Golomb D, Salama R &Weintroub S. Radial head and neck fractures in children. J PediatrOrthop**1988; 8**: 35-40.

(14) Futami T, Tsukamoto Y &Itoman M. Percutaneous reduction of displaced radial neck fractures. J Shoulder Elbow Surg**1995; 4**:162-7.

(15) Smith AM, Morrey BF & Steinmann SP. Low profile fixation of radial head and neck fractures: surgical technique and clinical experience. J Orthop Trauma**2007; 21(10)**:718-24.
(16) Hirachi K, Kato H & Minami A. Clinical features and management of traumatic posterior interosseous nerve palsy. J Hand Surg**1998; 23**:413–7.
(17) D'souza S, Vaishya R &Klenerman L. Management of radial neck fractures in children: a retrospective analysis of one hundred patients. J PediatrOrthop. **1993; 13(2)**:232-8.
(18) Papageorgiou TG, Panos NE, Gigis IP, Samoladas EP, Beslikas TA &Christoforidis IE. Treatment of a late presenting displaced radial neck fracture in a 10 years-old girl. J Med Cases **2011; 2(6)**: 252-4.
(19) Waters PM & Stewart SL. Radial neck fracture nonunion in children. J PediatrOrthop**2001; 21(5)**:570-6.