Modified Metaizeau technique for displaced radial neck fracture in adults

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Background and purpose
Few studies have been reported about closed treatment of the radial neck fractures in adults, which most often are found in children. A prospective study was conducted to evaluate the results of modified Metaizeau technique in the management of displaced radial neck fracture in adults.
Patients and methods
A total of 12 adults with displaced radial neck fractures were selected after excluding patients with combined neck and head fractures and patients younger than 16 years. After closed reduction, two or more K-wires were inserted from the midshaft of radius in a retrograde direction to stabilize the reduced head. The Mayo elbow performance score was used for final clinical assessment. A proposed scale by authors was used for radiological evaluation.
Results
Using the modified Masson classification, there were nine type IIb and three type IIIb fractures. After a mean follow-up of 38 months (range: 22–60 months), 10 patients were clinically rated excellent and two were good. Two patients had skin irritation and painful bursitis at the buried ends of K-wires; otherwise, no cases of superficial or deep infection, K-wire breakage or migration, and tendon or nerve injury were indicated. Asymptomatic nonunion was detected in two patients. According to the proposed radiological scale, six patients were excellent, four good, and two poor.
Conclusion
Closed manipulation and retrograde intramedullary pinning is a minimally invasive technique allowing stable fixation of displaced radial neck fractures in adults, with excellent to good outcomes and low complication rate.

Keywords:
intramedullary, Metaizeau, pinning, radial neck

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Introduction

Fracture of the radial head and neck comprises 1.7–5.4% of all fractures in adults. Approximately 15–20% of these fractures involve the radial neck [1]. Undisplaced or minimally displaced fractures usually have an excellent outcome [2,3], whereas displaced and comminuted fractures are often reported to have an inferior outcome [2,4,5]. However, conflicting results have been reported [2,5–8]. This may be because most reports have included different types of fractures of both the head and the neck.

The optimal treatment method of displaced radial neck fracture in adults remains a matter of controversy. The treatment options include open reduction and internal fixation using antegrade crossed countersunk headless screws [9,10] or low-profile plate and screws [11] and radial head excision with or without prosthetic replacement [4,12]. There is no doubt that preservation and/or restoration of radiocapitellar contact is critical to coronal plane and longitudinal stability of the elbow and forearm [9]. Although osteosynthesis yields results superior to radial head excision, it carries the risk of joint stiffness, loss of reduction, and implant failure especially when plate fixation is performed. Hardware removal is sometimes indicated in an attempt to improve range of motion [11]. Radial head resection has been observed to be complicated by instability, symptomatic proximal migration of the radius, and late posttraumatic arthritis when performed in the setting of associated disruption of the medial collateral ligament or interosseous membrane [4,13,14]. In this condition, prosthetic replacement of the radial head is preferred over suboptimal fixation as the radial head and neck will bear the increased axial, coronal, and sagittal plane forces because of the associated soft-tissue disruptions. However, pain, stiffness, and instability are the most

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common causes of failure of radial head prosthesis necessitating removal or revision of the implant [15].

The technique of closed reduction and intramedullary pinning was first described by Metaizeau *et al*. [16] for the treatment of radial neck fractures in children and achieved good results [17]. Keller *et al*. [18] used this technique for the treatment of six adults with displaced fractures of radial neck, and they noted that it is an elegant alternative to radial head excision. The current prospective study was conducted to evaluate the results of closed reduction and retrograde intramedullary Kirschner wire (K-wire) fixation of displaced radial neck fractures in adults after some modifications of the original technique.

Patients and methods

Between May 2005 and February 2012, 17 adults with displaced radial neck fractures were selected for the management by closed manipulation and intramedullary pinning at the King Saud Hospital, Unaizah, Kingdom of Saudi Arabia, and Mansoura University Hospital, Mansoura, Egypt. All patients were briefed regarding the risks and benefits of the procedure, and an informed consent was obtained to participate in the study. Exclusion criteria were young patients (<16 years of age), combined fracture of the head and neck radius, open fracture, and previous injuries that affect wrist or forearm movement. Of the 17 patients treated in this study, five were excluded, two of them were lost to follow-up, whereas closed reduction was not possible in three, which required open reduction and internal fixation in two and radial head excision in one. The remaining 12 patients (Table 1) comprised eight males and four females, with an average age at presentation of 36.4 years (range: 20–65 years). The right side was involved in nine patients, and all were dominant. Eight fractures were caused by low-energy trauma like a fall on outstretched hand or direct impact and four by high-energy trauma such as a fall from above 2 m or a motor vehicle accident. According to the Mason classification [6] modified by Broberg and Morrey [19], nine fractures were classified type IIb and three type IIIb. The fracture was associated with posterior fracture dislocation elbow in four patients. Three of them had coronoid process fracture, which required internal fixation using interfragmentary compression screw in one of them. The remaining patient had comminuted fracture of the upper ulna and was managed by open reduction and internal fixation with plate and screws. Preoperative 3D computed tomography was performed for five patients to give a clear understanding of the associated fractures, to exclude a suspected head fracture, and to assess the

Table 1 Patients' demographics and outcomes

Cases	Sex	Age (years)	Trauma	Type[a]	Associated injuries	Follow-up (months)	Time to union (months)	MEPS[b]	Radiological score	Complication
1	Male	22	Low energy	IIb	None	60	5	Excellent	Good	None
2	Female	24	Low energy	IIb	None	52	6	Excellent	Good	None
3	Male	48	High energy	IIb	Fracture ulna	48	8	Excellent	Poor	Nonunion
4	Female	65	Low energy	IIIb	Fracture coronoid	50	9	Good	Poor	Nonunion
5	Male	42	Low energy	IIb	None	40	6	Excellent	Excellent	None
6	Male	36	Low energy	IIb	None	30	5	Excellent	Excellent	None
7	Female	30	Low energy	IIb	None	31	7	Excellent	Excellent	None
8	Male	50	Low energy	IIb	None	29	8	Excellent	Excellent	None
9	Male	26	High energy	IIIb	Fracture coronoid	36	8	Excellent	Good	None
10	Female	28	Low energy	IIb	None	28	6	Excellent	Excellent	None
11	Male	20	High energy	IIb	None	22	5	Excellent	Excellent	None
12	Male	46	High energy	IIIb	Fracture coronoid	30	8	Good	good	Mild pain

MEPS, Mayo elbow performance score; [a]Mason classification modified by Broberg and Morrey [19]; [b]Mayo elbow performance score [20].

head and neck for sufficient bone suitable for fixation.

Operative technique

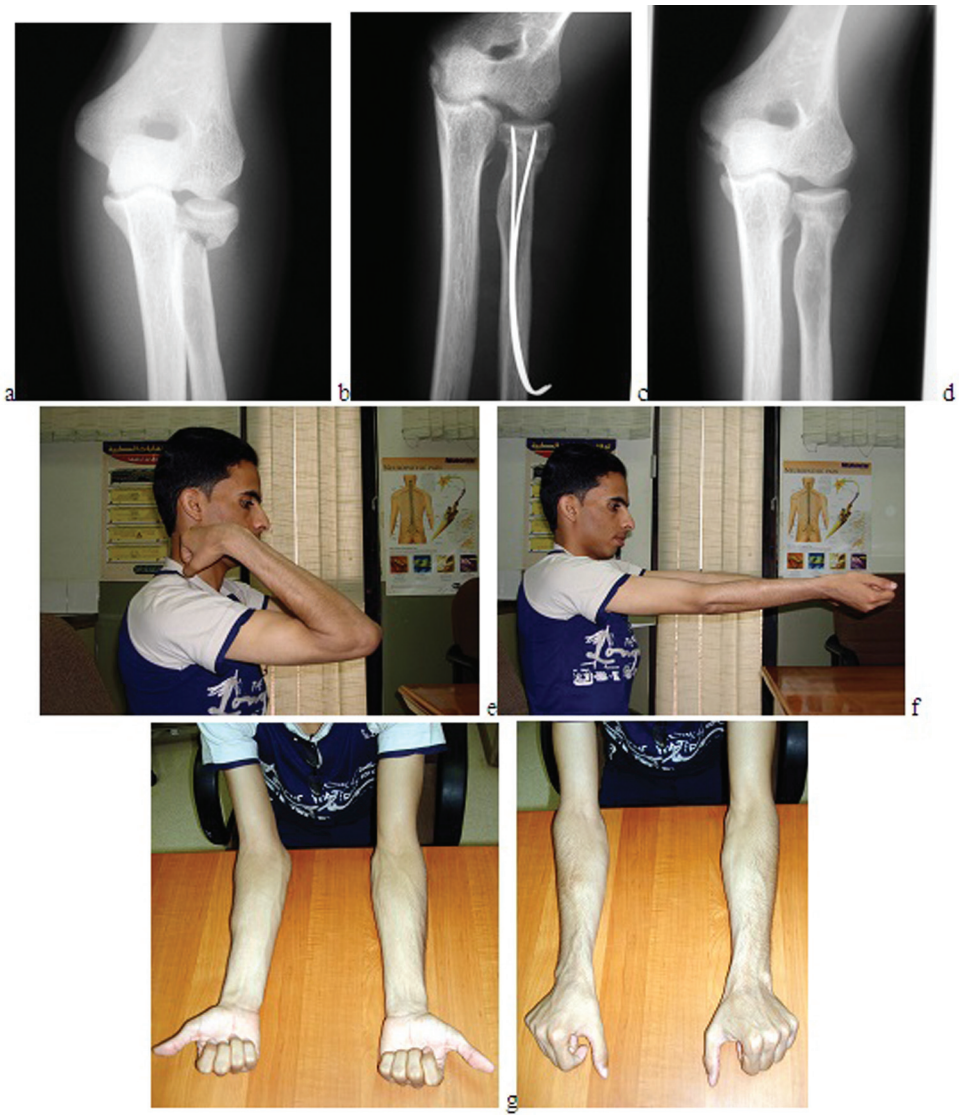
Principles of the Metaizeau technique [16] were followed but with some modifications. Most of operations were performed within 24 h of injury with an average time to surgery of 22 h (range: 6–72 h). Operation was delayed 48–72 h in three patients because of the associated head injury. Under general anesthesia, anteroposterior radiographs of the extended elbow through the range of forearm rotation were taken. The position of maximum fracture angulation was then evaluated. Owing to the effect of rotation, this angle could rarely be measured on original radiographs. The degree of radial head angulation was defined as the angle between a line perpendicular to the superior articular surface of the radial head and a line drawn along the midline of the radial shaft.

After routine sterilization and draping, closed reduction was attempted by thumb pressure over the radial head while applying longitudinal traction and varus stress on the extended elbow. Sometimes reduction was obtained by digital pressure in an anterior to posterior direction with the elbow flexed and forearm gradually pronated. Extremely forcible manipulation to achieve ideal reduction was avoided. Percutaneous leverage of the head with a smooth K-wire, as described by Akatsu [15] and Cha *et al*. [21], was required in five patients with marked displacement and difficult closed reduction. Care was taken to avoid injury to the deep branch of the radial nerve. A 2-cm longitudinal skin incision was made on the dorsoradial aspect of the mid-radius. The interval between the extensor carpiradialis brevis muscle and the extensor digitorum communis muscle proximal to the abductor pollicis longus muscle was developed. Then the cortex of the radius dorsal to the pronator muscle insertion was exposed. One slanting hole was made with a 2.5-mm drill bit that increased gradually to 4.5 mm provided that the diameter of the drill hole is less than the width of bone at the level of drilling. In patients with small-size bones, two drill holes at two different levels were made with 2.5-mm drill bit to avoid stress riser effect. A drill sleeve was used to protect the soft tissues. At first, the drill bit was directed perpendicular to the bone and then obliquely at an angle of 45–60° with care to avoid penetration of the far cortex. Through these holes, two 1.5–2.5 mm K-wires were inserted manually retrograde into the medullary canal over a T-handled drill chuck.

The tips of the K-wires were prebent by pliers and advanced into the radial head using gentle taps of a small mallet. Reduction was helped and maintained by rotation of the K-wire around its longitudinal axis through 180°, so that the bended tip guided the head to its reduced position. After obtaining an accepted position, the second wire was pushed into the head with care to avoid penetration of the articular surface. This will combat torsional and shearing forces along the fracture (Fig. 1). A third K-wire was used to add stability to the fixation construct in three patients. The use of a high-resolution image intensifier with magnification facility was helpful to ascertain the proper reduction and accurate placement of K-wires. The distal end of the K-wires was bent and buried in the subcutaneous tissues. After surgery, a long-arm posterior plaster splint with the forearm in a neutral position was applied for 3–4 weeks. In patients with associated posterior elbow fracture dislocation, external splint was continued for 3 weeks more till soft tissue healed. During the period of immobilization, patients were instructed to move fingers and clench their fists over a soft ball to allow axial compression through the fracture by the muscles crossing the elbow joint. After removal of the splint, assisted active range-of-motion exercises of the elbow and forearm were gradually started guided by pain. K-wires were removed after an average time of 4.8 months (range: 3–7 months) under local anesthesia in the operating room.

All patients were followed up clinically and radiographically every month for the first 6 months, every 2 months till completing 1 year, every 6 months thereafter, and at the final follow-up. The mean duration of follow-up was 38 months (range: 22–60 months). Clinical assessment was done for pain, range of motion of elbow and forearm, grip strength, alignment and stability of the elbow, functional status, and the development of any complications. The degree of deficits in the maximum ranges of motion, valgus angle of the elbow, and grip strength were assessed at the final follow-up by taking the contralateral uninjured limb as a control. The Mayo elbow performance score [20] was used for the final functional evaluation (Table 2). Radiological assessment included the measurement of radial head angulation and ulnar variance on anteroposterior and lateral radiographs of the elbow and wrist before surgery, immediately after surgery, and at final follow-up. These measures were compared with that obtained from radiographs of normal extremity. The series of follow-up radiographs were also checked for alignment, fracture healing, loss of reduction, nonunion, avascular necrosis, periarticular ossification, proximal radioulnar synostosis, and

Figure 1



(a) A 22-year-old male with Mason type IIb fracture of the right radial neck. (b) Follow-up radiograph after closed reduction and retrograde intramedullary pinning. (c) Radiograph at final follow-up with complete healing in nearly anatomical position and minimal ossification along the ulnar collateral ligament. (d–g) Excellent final functional results.

degenerative arthrosis. A proposed radiological scale (Table 3) was used for final radiological evaluation.

The data of patients were tabulated and analyzed using the statistical package for the social sciences (IBM SPSS statistics, IBM Corp., Armonk NY, USA) version 22 for Windows. Independent sample *t*-test, Pearson's χ^2-test, and one-way analysis of variance test were used to define relations between clinical and radiological results and the final outcome. Probability values of less than 0.05 were considered significant.

Results

The technique of retrograde intramedullary pinning was familiar to the surgeon, with the mean duration of surgery was 41.3 min (range: 25–90 min). However, the major difficulties that lengthen the operative time were the trial of closed reduction of markedly displaced radial head and the associated fractures requiring internal fixation. During the period of K-wire fixation, there were no cases of superficial or deep infection, K-wire breakage or migration, or tendon or nerve injury. Skin irritation and painful bursitis at the buried ends of wires were encountered in two patients and resolved spontaneously after planned removal of the K-wires. At the time of final follow-up, the mean deficits in the range of elbow flexion and extension were 2.5° (range: 0–10°) and 7.50° (range: 0–30°), respectively, and that of forearm supination and pronation were 5° (range: 0–20°) and 2.1° (range: 0–10°), respectively. The mean grip strength was 90% (range: 75–100%) of normal. According to the Mayo

Table 2 Mayo elbow performance score

Parameters	Description	Points
Pain (45 points)	None	45
	Mild	30
	Moderate	15
	Severe	0
Range of motion (20 points)	Arc >1000	20
	Arc 500–1000	15
	Arc <500	5
Stability (10 points)	Stable	10
	Moderately unstable	5
	Grossly unstable	0
Function (25 points)	Able to comb hair	5
	Able to feed	5
	Able to perform hygiene	5
	Able to put on shirt	5
	Able to put on shoes	5

Score: excellent 90–100 points, good 75–89, fair 60–74, poor <60.

Table 3 The proposed scale for radiological assessment

Scales	Descriptions
Excellent	The fracture healed in an anatomical position without ossification, synostosis, or degenerative changes
Good	The fracture healed in an accepted position with radial angulation <10° above normal, minimal ossification, or arthrosis
Fair	Residual angulation 10–20° above normal, moderate ossification or joint arthrosis
Poor	Nonunion, residual angulation >20° above normal, marked arthrosis, extensive periarticular ossification, or proximal radioulnar synostosis

elbow performance score, 10 (83.3%) patients were rated excellent and two (16.7%) good. There were no patients with fair or poor results. The mean MEPS was 95.8 (range: 80–100). The main reasons of lower score and the good results were the presence of mild pain in one patient and the significant periarticular ossification that limit range of elbow motion in the other.

The mean angulation of the radial head was 63° (range: 24–90°) preoperatively, 7° (range: 0–15°) postoperatively, and 8.4° (range: 0–20°) at final follow-up whereas that of the control limb was 7.6° (range: 0–100°). The ulnar variance showed no change from preoperative to postoperative or at final follow-up in nine patients. The remaining three patients had a change from 1 to 2 mm but without any functional impairment. The mean time of fracture union, after which no further progress in the healing process could be detected on plain radiographs, was 6.8 months (range: 5–9 months). Two patients developed nonunion with partial resorption of the neck and head in one of them (Fig. 2). No cases of definite avascular necrosis or proximal radioulnar synostosis were detected. Mild degenerative arthrosis of the elbow joint was seen in one patient and could explain the mild pain on activity. Periarticular ossification was noticed in three patients, and it was enough to limit the range of elbow extension in one of them. These patients had an associated fracture dislocation of the elbow. According to the proposed radiological scale, six (50%) patients were excellent, four (33.3%) good, and two (16.7%) poor. The poor radiological results were mainly related to the development of nonunion and marked periarticular ossification. The small sample size made statistical significance difficult. However, early operative intervention of young aged patients with less comminuted Mason type II fractures was significantly followed by high functional score (P=0.02, 0.02, and 0.01, respectively). A significant correlation could not be detected between the radiological outcome and the final functional score (P=0.19).

Discussion

The management of displaced fracture of the radial neck in adults remains a challenge. The limited capacity for remodeling in adults makes anatomical or near-anatomical reduction and stable fixation necessary. Healing of the radial neck fractures in displaced or angulated positions with incongruity of the radiocapitellar and superior radioulnar joint can result in restriction of movements and degenerative arthrosis [20]. Because of the low remodeling potential, the accepted angulation of the radial neck should be reduced from 30° in children to 15° in adolescent approaching maturity and less than 10° in adults [22]. Yamaguchi *et al.* [23] noted that the blood supply of the radial head is primarily by intraosseous vessels that entered the neck at the capsular margin and proceed proximally into the head. Therefore, in addition to the fracture, the dissection required for open reduction may disturb the blood supply and lead to avascular necrosis or nonunion. Furthermore, open reduction causes soft tissue damage with subsequent fibrous adhesions and loss of range of motion [9,24]. For these reasons, the trend was changed toward trying closed reduction and percutaneous fixation before proceeding with an open reduction.

The technique of closed intramedullary manipulation and pinning was practiced by Keller *et al.* [18] in adults, and they reported satisfactory results that could avoid radial head excision. The same principles were used in the current study without difficulties and with minimal postoperative complications. Insertion of the K-wires from the midshaft of the radius avoided tendon and nerve injury that could occur if they were inserted from

Figure 2

(a and b) A 48-year-old male with Mason type IIIb fracture of the radial neck associated with posterior elbow dislocation and comminuted fracture of upper ulna. (c and d) Evidence of nonunion of radial neck fracture on early follow-up radiographs. (e) Radiograph at final follow-up showing partial resorption of the neck and head of the radius. (f–i) Despite the poor radiological outcomes, the functional results were excellent.

the radial styloid. Moreover, this would shorten the length of intramedullary K-wire providing the surgeon more control during manipulation. The use of at least two K-wires added more stability to the fixation construct, prevented redisplacement, and allowed early mobilization.

Keller *et al.* [18] were able to achieve anatomical reduction in four out of six cases with residual tilting of the radial head of less than 15° in the remaining two cases. In the present study, the technique was effective in obtaining and maintaining a satisfactory reduction in 83.3% of patients, with the mean degree of radial head angulation at final follow-up being 8.4° (range: 0–20°). Excellent to good radiological outcomes were obtained in 10 cases and poor results in two. The poor radiological outcomes were mainly because of nonunion and significant periarticular ossification. Despite this, they had excellent to good clinical outcomes. Several studies have reported that most cases of nonunion of the radial neck fractures are asymptomatic, but the reason of this has not been clearly established [25]. Kang *et al.* [24] noted that fibrous tissue filling nonunion areas acting as a space-occupying structure and contributing to elbow joint stability as well as the non-weight bearing feature of the elbow joint could explain this asymptomatic state.

In the past, the radial head was considered expendable, but recent studies have described the importance of the radial head as an elbow and forearm stabilizer, reporting a considerable alteration of the normal kinematics of the elbow and the forearm after radial head excision, even in the absence of ligamentous injuries [26]. On the contrary, the clinical relevance of the functional impairment related to the absence of the radial head remains controversial [4,27]. Mikic and Vukadinovic [13] reported that valgus instability and cubitus valgus deformity could develop gradually in patients treated with radial head excision, a notion also supported by Herbertsson *et al.* [4]. In contrast, Karlsson *et al.* [28] after reviewing five patients with Masson type IIIB fractures of the radial neck managed by radial head excision found that none had developed cubitus valgus exceeding 5°. The increase of the cubitus valgus angle in the present study also did not exceed 5°.

It seemed that preservation of the radial head could withstand the valgus stress and progressive deformity of the elbow. In agreement with Hotchkiss [29] and Faldini *et al*. [30], the authors were aware that the clinical relevance of elbow instability may be enhanced in young heavy workers or athletic patients, therefore, in these cases preservation of the radial head, if possible, should be preferred.

The absence of the radial head has been reported to cause proximal migration of the radius. Nevertheless, there is no general agreement regarding the correlation between proximal migration of the radius and the clinical outcome, particularly with respect to pain and functional impairment of the wrist [4,27,31]. We could not observe any significant proximal migration of the radius, and a change in the ulnar variance not more than 2 mm was seen in only three patients without clinical impairment. Another complication frequently reported after radial head excision is the development of degenerative arthritis of the elbow [4,28,31]. In our study, we observed elbow joint arthrosis in one patient, and it was related to pain on activity. Radial head replacement is indicated after radial head excision if stability of the elbow or forearm is in question [32]. Radial head prosthesis with a modulus of elasticity near to that of bone is required to transmit physiological loads from proximal radius to the capitellum. Furthermore, radial head prostheses are not always available in the nonspecialized hospital. Therefore, the traditional concept of 'resect the radial head if in doubt' has been set aside in favor of 'preserve the radial head if possible' [33,34].

Conclusion

The main limitations of this study include the small number of patients as a result of the low incidence, the wide range of patients' age, and the absence of control groups. However, the results were encouraging and proved that modified Metaizeau technique of closed reduction and retrograde intramedullary pinning is a simple effective and minimally invasive technique, allowing anatomical reduction, stable fixation, and early mobilization in most of adult patients with displaced radial neck fractures. Care must be taken in selecting patients as this technique is not suitable for radial neck fractures with marked comminution or associated head fracture and decreased bone stock in the head fragment required for stable pinning. This study gives the necessity to plan a biomechanical study to evaluate the efficacy of intramedullary K-wires in withstanding axial, shearing, and bending forces across the fracture.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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