

## PRACE ORYGINALNE

Kończyna górna i obręcz barkowa

# Radial head and neck fractures in adults treated by percutaneous osteosynthesis and early motion

## Złamanie główki i szyjki kości promieniowej u dorosłych leczonych przezskórną osteosyntezą i wczesnym ruchem

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### Abstract

**Introduction:** Radial head and neck fractures are the most common fractures of the elbow. The treatment of complex fractures in this anatomical region remains a challenge for the orthopedic surgeon. We report a technique for closed reduction and antegrade stabilization by K-wires of displaced radial head and neck fractures in adults.

**Method and material:** Sixteen patients with isolated Mason type II or type III fractures were operated by minimally invasive percutaneous osteosynthesis. All these patients had been followed-up for 12 weeks. Patients were evaluated for pain, motion, radiological and EMG findings.

**Results:** In all cases acceptable radiographic reduction, bone union after 12 weeks was reached. At the end of observation period ten patients had excellent results, five patients had good results and one patient had a fairly-good result according to MEPS. Also DASH result improvements at 6 and 12 weeks were statistically significant. EMG evaluation showed increase in muscle electromyographic activity of the operated elbows as an early postoperative rehabilitation proceeded.

**Conclusions:** We concluded that minimally invasive percutaneous osteosynthesis is a good alternative method of operative treatment of radial head and neck fractures in adults. This operative procedure allows rehabilitation with early motion of the elbow, and thereby optimize the functional results of these potentially devastating injuries.

**Keywords:** radial head, radial neck, minimally invasive 26 technique, percutaneous osteosynthesis, functional outcome

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## Introduction

Fractures of the radial head and neck are complex bony lesions of the cancellous bone with associated capsular and ligamentous tears [1]. The Mason classification is the most referenced classification system for fractures of the radial head and neck [2], his classification system has been subsequently modified by Broberg and Morrey to better delineate the parameters that differentiate one particular "type" from another, then by Johnston where a type IV fracture was added to the system to account for fractures that are part of an elbow dislocation, and then by Hotchkiss to try to use the classification system to direct treatment of these fractures [3-5].

Regardless of the fracture type, the goals of treatment are to restore elbow stability, preserve elbow motion, and maintain the relative length of the radius. When faced with more complicated comminuted fracture pattern, one enters a gray area in which clinical decision making depends on factors unique to each patient [6].

The approach in these cases in adult patients consists of either conservative management, open reduction and internal fixation (ORIF), excision of the radial head, or radial head arthroplasty [7, 8]. The closed intramedullary pinning is used often for the reduction and fixation of displaced radial neck fractures in children [9]. We describe the minimally invasive technique of closed reduction and internal fixation with an intramedullary wire being introduced from the distal part of the radius and projected upwards in order to allow reduction by rotation of the proximal part of bent wire. We used this method of operative treatment of the radial head and neck fractures in adult patients. We decided to utilize this technique because the inter-osseous membrane will buffer less energy in the presence of the radial head, and thus less shear force will create pain along the forearm and less disturbances at the distal radioulnar joint [10]. By doing so, we do not perform any surgical "open" activity at the elbow joint what allows the patient to begin early rehabilitation.

## Materials and methods

### Study group

From September 2009 to March 2012 twenty consecutive patients with Mason type II or III fractures of radial head and neck were qualified for percutaneous osteosynthesis by K-wires and early mobilization after operation in our department. All surgical procedures in the study were performed by one consultant orthopedic surgeon with an assistance of a resident.

Five subjects, were diagnosed with isolated radial neck fractures having mechanical block to elbow motion, nine

patients with Mason type II fracture and two patients with Mason type III fracture. It has to be mentioned that in four patients operated at the time of the study we had to switch to open reduction and internal fixation intraoperatively due to lack of stability of initial K-wires osteosynthesis. Those cases were not included in the analysis. All Mason type I fractures without block to motion were treated conservatively. We did not include in our record patients with Mason type III or IV fractures with dislocated bone fragments in the elbow joint. In those cases radial head replacement or alloplasty operations were performed.

In our record 11 males and five females were included to the study, with mean age 36 years (21-63 years). Four patients had injuries in left upper limbs and 12 in right. Three patients were injured in motor vehicle accidents or falling on an outstretched hand, two concomitant coronoid fractures were diagnosed with a small bony fragment in the study group. The mean time from the injury to the surgery was 2,4 days, ranged 0-6 days.

### Surgical technique

All the patients were operated under general or brachial plexus block anesthesia, in bloodless operative field and with fluoroscopy. In the first place closed reduction technique was performed by achieving elbow flexion to 90° with maximal supination followed by digital pressure applied to the lateral aspect of the proximal fragment while the forearm is rotated gradually into full pronation. The radial head or neck fracture was stabilized by passing distally an intramedullary one or two K-wires from the radial styloid proximally into the radial head and then by performing the "joystick technique" the fragments were reduced into the right position (Fig 1).

An intra-operative radiographs were performed to confirm satisfactory bone fragments reduction and no mechanical block during full flexion and extension range of motion of the operated elbow (Fig 2). Examination under anesthesia is absolutely essential in evaluating elbow and forearm stability and range of motion after operation. In most cases no immobilization where needed after operation. Only three patients who complained of insufferable elbow pain had plaster immobilization for 3 days.

### Rehabilitation procedure

Patients commenced flexion and extension exercises with a full arc of motion from the 1st day after the surgery. For the first 2 weeks they performed passive and active-assisted exercises at our Rehabilitation Unit. Pronation-supination arm exercises where not recommended at the time of physiotherapy. Utilizing the elbow for light functional tasks was encouraged. K-wires were left in place until 5-6 weeks after the surgery.



Fig. 1. Radial Neck and head fracture – X-ray (A) and CT-scan (B). The same patient 6 weeks after operation – (C), (D).

The next 3-4 weeks, before K-wires removal, active elbow flexion-extension exercises and active-assisted arm pronation-supination exercises were continued. After K-wires removal, physiotherapy was performed and PNF technique exercises (Proprioceptive Neuromuscular

Facilitation) were added. Heavy loading activities were not allowed for the first 3 months and then gradually introduced, based on performance during strength and endurance evaluation.



Fig. 2. Multifragmental radial neck and head fracture – X-ray (A) and CT-scans (B), (C). (D) – intraoperative X-ray control. The reposition of the fracture was not acceptable – corrected through “joysticking” technique (E, F). (G, H) – the same patient 7 days after operation, good radiological reposition result and clinically full functional arc of elbow movement

## Evaluation

Clinical, radiological and electromyographical examinations were performed specifically for this study by the authors. All patients had 3 months follow-up at 1 week, 6 weeks and 12 weeks postoperatively. At each follow-up visit regular anteroposterior and lateral x-rays were performed. A functional score was collected in the form of Mayo Elbow Performance Score (MEPS) and the Disabilities of the Arm, Shoulder and Hand (DASH) Score. For evaluation of electromyographic changes in biceps and triceps brachii muscles the EMG unit (Neuro Trac ETS apparatus, Verity Medical Ltd., Hampshire, England) was used. Due to the elbow pain only eight patients agreed to be examined by EMG 1 week after the operation. At next two follow-up visits all the patients agreed for the control EMG examination.

Electromyographic activity was measured in biceps brachii and triceps brachii muscles using surface electromyography (sEMG) according to SENIAM (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles) standards.

For biceps brachii muscle evaluation, the electric potential measurements were taken in seated position with elbow joint flexed at 90° and forearm supination. Signaling electrodes were placed in the line between acromion and the distal 1/3 of cubital fossa. The reference electrode was placed over radial styloid process. 20 mm signaling electrodes were placed within 20 mm distance.

For triceps brachii muscle evaluation, the electric potential measurements were taken in seated position with shoulder joint abducted at 90°, elbow joint flexed at 90° and neutral position of forearm. Signaling electrodes were placed approximately 40 mm proximally from the line connecting the posterior border of acromion and olecranon in the half of the distance between these structures. The reference electrode was placed over radial styloid process. Both biceps and triceps brachii measurements were taken during an isometric contraction of the muscle against submaximal resistance. The final outcome was an arithmetical average calculated on basis of three consecutive measurements.

The acquired data was statistically analyzed using Fisher's exact test for MEPS score, Friedman's variation analysis and The Wilcoxon Matched-Pairs Signed-Ranks Test for DASH score, Mann-Whitney U test and Friedman's variation analysis for EMG evaluation and comparison between measurements at different time points.

## Results

### Clinical outcomes

There was no wound infection, nerve injury, increased valgus or varus deformity of the elbow observed. After

12 weeks observation acceptable radiographic reduction was achieved, in which angulation was less than 15° and displacement was less than 2 mm. In all cases bone union was present at 12 weeks postoperatively.

The clinical results according to MEPS were improving gradually regarding the baseline follow-up. Tab 1. Ten patients had excellent results, five patients had a good results and one patient had a fairly-good result. Eleven patients had complete pain relief. In four patients mild elbow pain occurred after daily activities. None of patients reported wrist pain. Moderate elbow instability was observed in one patient. In course of the rehabilitation period we found statistically significant ( $p < 0,01$ ) improvement in pain, range of motion and function subscales of MEPS at the 1st and 12th week.

In the Disabilities of the Arm, Shoulder and Hand (DASH) [11]. Score patients showed a significant disability in the first post operational week (mean DASH score = 71, range 64 – 100) which improved to 29 (range 23 – 47) at 6 weeks and reached 3 (range 0 – 16) in 12 weeks after closed reduction and internal fixation. DASH result improvements at 6 and 12 weeks were statistically significant at the level of  $p = 0,0004$  in Wilcoxon pair analysis.

### EMG outcomes

EMG evaluation showed significant decrease in muscle electromyographic activity of the operated elbows (mean 114,43  $\mu V$  for biceps brachii and 139,5  $\mu V$  for triceps brachii) in the 1st week after the operation in comparison to the healthy limb elbows (mean 439,81  $\mu V$  for biceps and 507,375  $\mu V$  for triceps). At 6 weeks post-op. biceps brachii muscle electric potential reached mean value of 279,31  $\mu V$  with triceps mean potentials of 239,56  $\mu V$  in operated limb and 424,56  $\mu V$  and 485,625  $\mu V$  respectively in the healthy one, but the difference still remained statistically significant until the 3rd measurement at 12 weeks after the operation. Analysis of EMG evaluated motor unit activity in biceps and triceps brachii at 1,6 and 12 weeks after the operation show statistically significant improvement at each of mentioned time points.

## Discussion

In recent years an open reduction and internal fixation has become widely accepted approach to Mason type II fractures [12, 13]. However some studies suggest that operative treatment has no major advantages over conservative therapy. In Lindenhovius et al. study mean MEPS score was 89 points (nine excellent, four good, two fair, and one poor) as evaluated in a long term observation (mean 22 years) after plate and screws fixation of isolated, Mason type II fracture without elbow dislocation [14]. The

authors underline that the outcomes are comparable to the ones achieved by conservative means in prior investigations [15, 16]. Frankle et al. published results of ORIF and radial head replacement for Mason type III radial head fracture [17]. They reported average Mayo Performance Score 77,5 points after mean follow up of 18 months. Authors did not however compare the results of those two procedures. In our study mean MEPS score was 71 points as soon as 12 weeks after the operation.

In the study of Lindenhovius authors analyzed similar group of patients as in ours – Mason type 2 fractures not associated with dislocation or other fractures of the elbow or forearm. The long term outcome at an average of 22 years after ORIF surgery according to Mayo Elbow Performance Score Index was 89 points (range, 55 – 100).

In case of type III Mason fractures, there are different treatment options mentioned in the literature: reconstruction techniques, radial head removal or radial head replacement [18]. Radial head removal, described by Mason as a successful procedure in his early papers is still reported in some more recent studies [19, 2]. There is however increasing criticism towards this treatment option. Some authors raise issues of elbow instability as well as radial shortening and loss of muscle strength [20].

Joint replacement is recognized as a treatment of choice in cases of complex fracture of radial head as well as concomitant ulnar collateral ligament rupture or type II or III coronoid fracture [21, 22]. Ring et al. conducted a study to evaluate the functional results of ORIF treatment of radial head fractures and concluded that it should be recommended to replace the radial head in patients with comminuted fractures with more than three fragments rather than repair it [23]. It should, however not be forgotten that radial head arthroplasty can be associated with some complications such as heterotopic ossification, loss of strength and range of motion, nerve injury and pain syndrome [24].

Closed reduction and internal fixation is a rarely mentioned procedure in the literature concerning radial head and neck fractures in adults. We only found one such study evaluating only small number of patients. Keller described results of six cases of radial neck fracture (Mason I-III) K-wire fixation [25]. At an average 9 months after the operation, there was radiographic union in all cases except one, in which primary articular surface angulation was about 90°. Authors described restoration of full range of motion in four patients and deficits of less than 20° in any of the ranges in two cases. All evaluated joints were free from heterotopic ossification.

It is useful to remember that the aim of elbow stiffness treatment, conservative or surgical, is to re-establish at least a range of motion between 30°- 130° in flexion-extension, and 50° in pronation and 50° in supination. Such a range of

motion constitutes the functional arc movement that allows the most common daily activities [26]. In our study group 10 out of 16 patients met these criteria within the first 12 weeks post-op.

EMG evaluation showed almost full normalization of biceps and triceps brachii motor unit activity after 12 weeks. In authors opinion, this was due to muscle sparing technique of closed reduction and early introduced rehabilitation. Ikeda et. al analyzed muscular strength in flexion by means of Cybex 770-NORM and observed mean 17,9% and 21,3% loss of strength in flexion in patients after radial head resection and after open reduction, internal fixation respectively. Their observation was however conducted at mean 3-10 years after the operation.

## Conclusions

Due to acceptable radiographic reduction of displacement in all cases and because the postoperative clinical results were satisfactory in all but one, the authors believe that closed reduction and percutaneous osteosynthesis by K-wires should be considered one of the reliable options for the treatment of acute, displaced radial neck and head Mason type II and even III fractures in adults. It is certainly worthwhile to attempt this procedure before the ORIF is performed, as even an imperfect but still acceptable closed reduction is more beneficial in means of future function than an open procedure.

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