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ORIGINAL ARTICLE

Percutaneous treatment of radial neck fractures in adult patients

Silvio Giannetti[1] · Alessandro Smimmo[1] · Guglielmo Torre[1] · Andrea Stancati[1] · Ernesto Pagano[1] · Attilio Santucci[1]

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Abstract

Introduction Radial neck fractures in adults are rare, but outcomes are often poor. Closed reduction and internal fixation (CRIF) technique has been advocated for the treatment of minimally displaced fractures in children, with a few reports on adult subjects. The aim of the present paper is to investigate mid-term results of a CRIF technique in adults with retrograde intramedullary K-wires in Mason's type II and III fractures. The proposed technique yields to good anatomical reduction of displaced neck fractures, faster rehabilitation, and easier hardware removal after fracture consolidation.

Material and methods A consecutive series of 17 patients were treated with closed reduction and intramedullary osteosynthesis, and outcomes were retrospectively evaluated. Elbow X-ray (XR) and CT scan were obtained preoperatively. Objective assessment before surgery and at an average 36-month follow-up included active and passive elbow range of motion (ROM). Functional evaluation was carried out through the collection of the Mayo Elbow Performance Score (MEPS), the Disabilities of the Arm, Shoulder, and Hand (DASH) score, and Elbow Self-Assessment Score (ESAS). XR at last follow-up was evaluated.

Results The cohort included 10 males and seven females, with a mean age of 32 years. Patients returned for a follow-up evaluation at a mean of 36 months (range 6–43 m) form the surgery. The DASH score revealed good to excellent outcomes with a mean of 6.32 ± 10.24 points at last follow-up. The ESAS was 98.35 ± 1.89, indicating a non-restricted elbow function. Acceptable radiographic healing was achieved in all patients.

Conclusions The advocated technique is promising for obtaining good reduction and stabilization, and good to excellent satisfaction for patients. Given the challenging technique, the learning curve could be long and initial results unsatisfactory. More research with larger cohorts and improved study design could be carried out, comparing the technique with the current choice of treatment (ORIF, radial head resection).

Keywords Elbow · Trauma · Radial neck fracture · Intramedullary nailing · Percutaneous osteosynthesis · Mini-invasive approach

Introduction

Radial neck fractures are not common fractures of the elbow, relatively frequent in pediatric population (5–10% of elbow injuries) [1]. Rarely found in adults, isolated radial neck fractures account for only 1% of all fractures in all areas. However, due to the intricate biomechanics of the elbow joint, outcomes are often poor [2, 3]. Several mechanisms can lead to isolated radial neck fractures, though the most common is the product of a valgus force with extended arm. The forearm position contributes to a possible displacement force [1], yielding to a more invasive treatment and further impairment of the outcome. The Mason classification was traditionally used to identify and treat these fractures, but subsequent modifications by Broberg and Morrey, as well as Johnston, added specific fracture subtypes [4, 5].

Conservative management is typically used for non-displaced fractures (Mason type I) in adults, while several surgical options are reserved for minimally displaced, comminuted fractures or fracture dislocation (Mason types II–IV), such as open reduction and internal fixation (ORIF), excision of the radial head, or radial head arthroplasty [6]. In adults, the evidence supports the ORIF over other surgical choices, as to concern surgical and clinical outcomes [6]. However, it has been reported that the open surgery

✉ Alessandro Smimmo
alessandro.smimmo@gmail.com

[1] Casa Di Cura Villa Stuart, Via Trionfale, 5952, 00135 Roma, Italy

represents an independent risk factor for the development of postoperative stiffness, post-traumatic arthritis, nonunion, and infection [1, 6, 7]. Closed reduction and internal fixation (CRIF) technique has been consistently advocated for the treatment of radial neck fractures only in children widely described and known as Metaizeau technique [8–10], with a few reports on adult subjects [11]. However, this mini-invasive approach is promising for an accurate reduction of the fracture and a good stability after intramedullary fixation. Results of a comparative study in children [8] showed superior clinical outcomes for those patients treated with mini-invasive K-wire fixation.

The aim of the present paper is to report the mid-term results of a minimally invasive technique in adults using CRIF with retrograde intramedullary K-wires.

The main hypothesis is that the technique results in a good anatomical reduction of displaced neck fractures, fast rehabilitation, low risk of infection, and easy hardware removal after fracture consolidation.

Materials and methods

Study setting and design

Between February 2011 and June 2023, a consecutive series of 17 patients were treated with closed reduction and intramedullary osteosynthesis. All patients were treated by a single senior trauma surgeon with a single surgical technique. Medical records of patients were retrieved retrospectively, and data were collected into a database. Outcome measures extracted form medical records concerned the patient diagnostic assessment, mechanism of injury, imaging studies, and functional and clinical assessment before surgery and at follow-up.

Study cohort and demographic details

All patients included had suffered from an isolated radial neck fracture without clinical joint instability (type II or III fractures according to Mason's classification). Furthermore, only adult patients of both sexes were considered for the evaluation. Exclusion criteria were age inferior to 18 years, open fracture, patients treated by ORIF technique or conservative management, and patients lost at follow-up evaluation or with a follow-up of less than 6 months.

Clinical and radiological evaluation

Clinical and radiological examinations (Fig. 1) were performed at patient admission (either emergency admission or transfer from territorial emergency care) by the authors and by a radiologist with special musculoskeletal expertise. Radiologic examination included a two-view elbow X-ray (XR) and a CT scan. Objective assessment consisted of a physical examination for active and passive elbow range of motion (ROM) for flexion/extension and pronation/supination as well as forearm rotation of both the injured and the contralateral healthy arm. For subjective evaluation, patients filled in the Elbow Self-Assessment Score form (ESAS) [12]. Functional evaluation was further carried out through the collection of the Mayo Elbow Performance Score (MEPS) and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. The same examination and score assessment was carried out at follow-up.

Postoperative XR was evaluated for bony healing, heterotopic ossifications, and the alignment of the radiocapitellar joint.

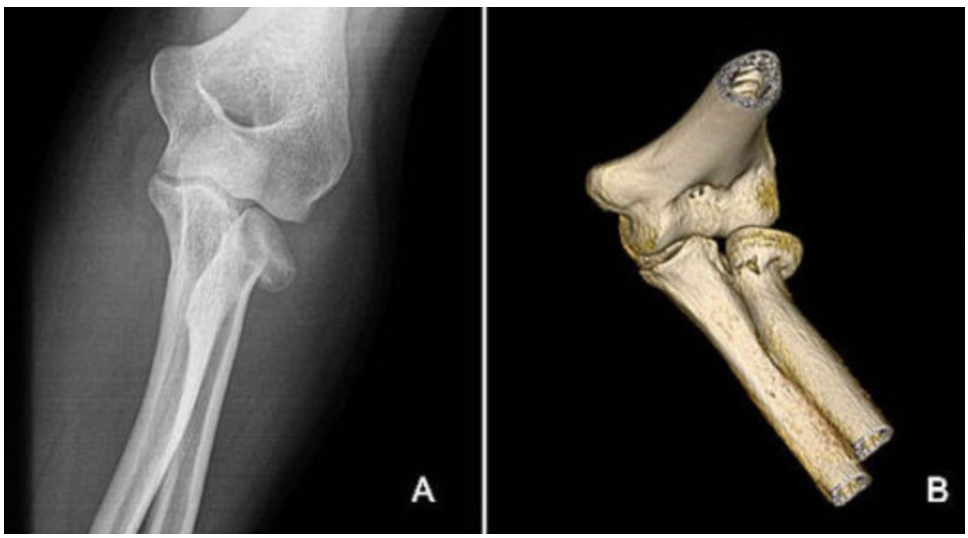

Fig. 1 Preoperative X-ray (**A**) and CT scan (**B**)

Surgical technique

After loco-regional anesthesia of the affected arm, the patient was placed supine with the injured arm on a radiotransparent table. A preliminary reduction was performed by direct external maneuvers on fracture site associated with pronation and supination maneuvers of the wrist.

The metaphyseal zone of the styloid process of the distal radius was identified under intraoperative fluoroscopy as the entry point for the K-wire (Fig. 2). Passing one or two retrograde K-wires into the radial diaphysis canal, the fragments of the neck were reduced into the anatomic position by means of the "joystick technique" (Fig. 3). Care should be taken in account the reach a good reduction of the fracture, rotating the main radial head fragment, if necessary, or pushing it through K-wires. Postoperatively, the patient was immobilized in a long arm cast for 10 days. Thereafter, the patient was allowed for gradual ROM recovery with a hinged brace. The K-wire removal was performed after 40 days (Fig. 4). Sport activities were restricted for 3 months.

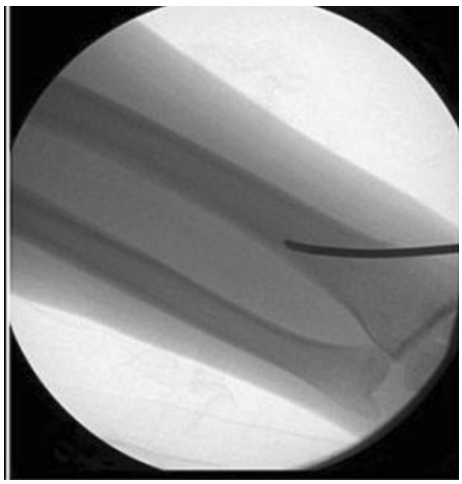

Fig. 2 Entry point for the K-wire

Fig. 4 Postoperative X-ray (AP and LL) (**A**). X-ray control after the hardware removal (**B**)

Statistical analysis

Mean, standard deviation, and range of continuous variables were reported. Raw frequency was reported for discrete or binomial variables.

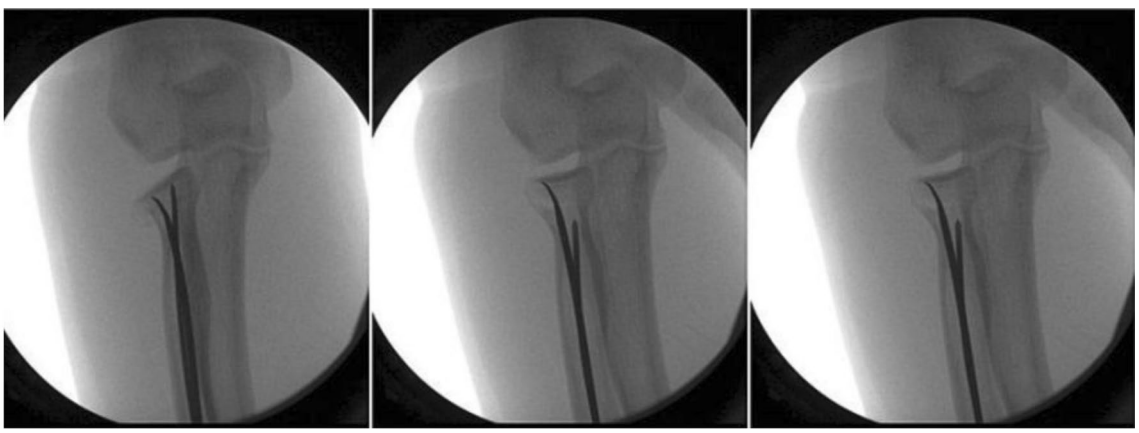

Fig. 3 Intraoperative intensifier control

Results

Demographic and diagnostic details

According to the selection criteria, all 17 patients of the consecutive series were included. Of these, 10 patients were diagnosed with Mason type II fracture and seven patients with Mason type III fracture. The cohort was composed of 10 males and seven females, with a mean age of 32 years (range 22–45 years). Seven patients sustained an injury on the left upper limb and ten on the right. The median time from injury to the surgery was 2 days (range 1–5 days). All patients returned for a follow-up evaluation at a mean of 36 months (range 6–43 months) form the surgery. No additional surgical procedure was necessary in any case.

Clinical and functional outcomes

The average MEPS at last follow-up was 95.11 ± 6.98 (range 84–100) representing a good evaluation in 10 patients and an excellent result in 7. The mean DASH score revealed good to excellent outcomes with 6.32 ± 10.24 points (range 0–28) at last follow-up. The ESAS was 98.35 ± 1.89 (range 94–100), indicating a non-restricted elbow function. Side-to-side ROM evaluation resulted in complete ROM in 16 cases for extension and flexion as well as for forearm rotation. At final follow-up, in one patient, a limitation of flexion of less than 10° was observed. Neither neurovascular nor infective complication was registered in the follow-up period.

Radiological outcomes

At final follow-up evaluation, acceptable radiographic healing was achieved, the angulation was less than 10°, and displacement was < 2 mm in median and average, respectively. In no case, heterotopic ossification or malunion was observed at last follow-up.

Discussion

The present consecutive case series showed encouraging results for the CRIF technique using intramedullary retrograde K-wires, with good functional and radiological outcomes in adults at an average of 28 months follow-up. All patients reported good to excellent subjective outcome measures, and the recovery of elbow ROM was complete. Radiological outcome was also satisfactory, in a joint at high risk of heterotopic ossification.

In the past few years, open surgery has become widely accepted to treat Mason type II or III fractures [13, 14]. In a study by Lindenhovius et al. [15], after plate and screws fixation of isolated Mason type II fracture, the authors underline that the outcomes are comparable to the ones achieved by conservative means, obtained in the previous investigations [15–18]. An intrinsic bias in this analysis is the impossibility to consider outcomes of conservative management for treatment comparison in Mason type II fracture, as surgical treatment is indicated. While open reduction is generally accepted for minimally displaced Mason type II fractures, there is a borderline condition where minimal evidence is available, in which minimally displaced type II fractures could potentially undergo closed reduction, but with a risk of further displacement with a cast. This situation can be addressed with CRIF, using minimally invasive surgical techniques to avoid the chance of post-reduction displacement. Some authors believe that closed reduction and intramedullary stabilization may be indicated, especially in cases, where ORIF may be considered overtreatment and conservative treatment insufficient. [11].

For Mason type III fractures, there are different treatment options advocated in the literature: reconstruction techniques, radial head removal [18], or radial head replacement [19]. Ring et al. conducted a study to evaluate the functional results of the ORIF treatment of Mason type III fractures and concluded that radial head replacement is superior to radial head repair in patients with comminuted fractures with more than three fragments [20].

There are few studies in the literature concerning CRIF of the radial head and neck fractures in adults. Sandmann et al. [11] and Serbest et al. [21] described good functional results and a very low complications rate of radial neck fractures (Mason II and III) in adults treated by closed reduction and internal fixation with K-wire or TEN.

A minimally invasive technique offers advantages such as the avoidance of hardware-related complications such as plate or screw mobilization or rupture, as well as impingement at the proximal radio-ulnar joint, which can lead to elbow stiffness in pronation–supination and flexion–extension. Additionally, ORIF is associated with a higher incidence of avascular necrosis [22], heterotopic ossifications [23], proximal synostosis [24], infections, and loss of ROM [23].

On the other hand, the technique described in this paper is not free of potential complications, and special attention has to be paid to avoid superficial radial nerve injuries [11]. In addition, a second procedure is necessary for the removal of the hardware.

The strengths of the presented surgical technique are (1) the possibility to anatomically reduce the fracture without the need of open surgery; (2) the possibility of obtaining a stable osteosynthesis, in order to grant an early

mobilization of the elbow during the consolidation phase; (3) the hardware removal can be performed easily when the ROM recovery is completed, and the consolidation of the fracture is at an advanced stage; and (4) the preservation of the anatomical structures around the elbow that could be damaged during the surgical approach and the operations of open reduction and internal fixation.

The present investigation has several limitations. First of all, the retrospective design did not allow a prospective and scheduled follow-up and data collection. Data were available only for follow-up, and no statistical test for mean comparison was carried out. The size of the cohort is small, and no power analysis was carried out to ensure significance of statistical testing. Furthermore, no results stratification according to fracture type (Mason type II or III) was carried out.

Conclusions

In light of the preliminary results reported, the surgical technique is successful in achieving a good reduction and stabilization, and good to excellent satisfaction for patients. However, given the challenging technique, the learning curve could be long and initial results unsatisfactory. More research with larger cohorts and improved study design could be carried out, to report more relevant results and highlight clinical improvement of patients at follow-up or compare the technique with the current choice of treatment (ORIF, radial head resection).

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Declarations

Conflict of interest The authors declare that they have not competing interests.

Ethical approval Only data regarding common clinical practice were retrospectively collected, used for diagnosis and full monitoring of the treatment. The investigation was carried out with the respect of the Declaration of Helsinki and according to the standards of Good Clinical Practice.

Patient confidentiality and consent to publication All patients signed informed consent for data collection for research purpose and for publication of anonymous data and any accompanying image.

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