



## Surgical treatment of radial neck fractures in children by intramedullary pinning

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Various surgical techniques have been used to treat displaced radial neck fractures in children, in order to reduce the displacement and to avoid complications. We report the results of a retrospective study performed on 20 patients with severely displaced radial neck fractures, who were treated with intramedullary pinning (Métaizeau technique). Mean age at injury was 9 years. Clinical and radiographic evaluation was performed. At final follow-up, there were 17 (85%) excellent or good results, 1 (5%) fair and 2 (10%) poor. Complications noted were anterior epiphysiodesis in one case and avascular necrosis of the radial head in another. Heterotopic ossification, neurovascular deficit or deep infection were noted in no instance.

**Keywords** : radial neck ; fractures ; children ; intramedullary pinning ; Métaizeau.

They can be successfully treated with cast immobilisation. Many studies (1, 2, 4-6, 8, 10, 11, 14) agreed that for fractures with moderate or severe angulation, reduction of the displaced head should be performed before casting. Several surgical methods have been described, but they are frequently associated with unsatisfactory results. Open reduction permits anatomical reduction of the fracture, but also generates a high incidence of complications.

In 1980, Métaizeau *et al* (6) proposed intramedullary nailing as a surgical alternative for the treatment of radial neck fractures. This method allows for extracapsular reduction of the fracture, using a K-wire introduced into the medullary canal through a distal metaphyseal entry point. Intramedullary pinning combines the advantages of a

### INTRODUCTION

Radial neck fractures represent 5-10% of traumatic injuries of the elbow in children and 1% of all paediatric fractures (13, 15). They result from a fall on the outstretched arm, with the elbow extended and the forearm supinated (13, 15). The choice of treatment is determined by the degree of radial head displacement, which also affects the long-term results. Severe displacement increases the risk of complications, mainly avascular necrosis of the radial head. Non displaced or minimally displaced fractures usually heal with a good functional result.

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good reduction and a stable fixation. Since then, several studies (4-6, 10, 14) have reported good results.

The purpose of this study was to evaluate the results of this technique in displaced radial neck fractures in children.

## MATERIALS AND METHODS

Between 1998 and 2004, 41 patients with radial neck fractures were treated in our department immediately after their injury. The fractures were evaluated according to the Judet classification (3), modified by Métaizeau (5, 6) :

- Grade 1 : undisplaced or horizontal shift
- Grade 2 : epiphysis tilt less than 30°
- Grade 3 : tilt between 30° and 60°
- Grade 4 : more than 60° of epiphyseal tilt, with two groups
  - 4a : tilt up to 80°
  - 4b : tilt more than 80°.

The inclusion criterion was an open growth plate at the time of injury.

We excluded 16 grade 1 or 2 fractures which were treated by cast immobilisation. We also excluded 5 patients with grade 3 and 4 fractures which were treated by closed reduction without intramedullary pinning.

We studied 20 patients (10 boys, 10 girls), with a mean age of 9 years (range : 5 to 15) who presented with 20 radial neck fractures. We recorded the fracture type, the displacement, associated injuries, specific aspects of the treatment, duration of immobilisation and time to removal of the fixation material.

Sixteen fractures were transverse metaphyseal and 4 were epiphyseal (Salter-Harris type 1 and 2). According to Judet's classification, we had 11 type 3 fractures with an average angulation of 43.7° (range : 35 to 58), and 9 type 4 fractures with an average angulation of 83.55° (range : 62 to 180). The latter group included 4 type 4a fractures and 5 type 4b fractures. Reduction of the displaced radial head was performed within the first 24 hours after injury in all patients.

Fourteen fractures were treated by closed reduction using an intramedullary pin. For 2 fractures (1 type 3 and 1 type 4 following Judet), we could not reach the displaced radial head with the medullary pin ; a percutaneous pin was therefore used in order to re-position the radial head over the tip of the centromedullary pin and

thus facilitate reduction. Four fractures (2 type 3 and 2 type 4 following Judet) necessitated an open reduction, as interposition of soft tissue rendered closed radial head reposition impossible.

As associated injuries, two children presented posterior elbow dislocation and 7 had an undisplaced olecranon fracture. These injuries were managed conservatively by closed reduction (one dislocation) or casting (olecranon fractures). The other elbow dislocation was treated by open surgery.

The operative technique used was intramedullary pinning according to Métaizeau (4, 5, 6). A 1.2-2.0-mm K-wire was introduced into the medullary canal through a small hole made 2 cm proximal to the distal physis and then hammered upward until its tip reached the displaced epiphysis. The K-wire was then pushed in order to elevate the epiphysis, and then turned 180 degrees around its axis to relocate the radial head.

We used post-operative immobilisation in a long-arm cast for 3-4 weeks. No physical therapy was made after cast removal. The K-wire was removed after an average time of two months (range : 1.5 to 3).

Average follow-up was 24 months (range : 22 to 30).

At final follow-up we evaluated clinical and radiographic results. Clinical evaluation was made at 1, 3 and 6 months and at the final follow-up and was based on pain and range of motion. Results were considered as follows :

- excellent, if no limitation in movement was noted,
- good, if the deficit in all ranges of motion was less than 20°,
- fair, if the restriction in mobility ranged between 20° and 40° and
- poor if it exceeded 40°.

Radiographic investigations consisted in antero-posterior and lateral radiographs of the elbow. MRI was performed when avascular necrosis of the radial head was suspected. Any residual angulation was measured on radiographs (fig 1). Results were considered as follows :

- excellent, if the reduction was anatomic,
- good, if a simple shift or inclination not exceeding 20° persisted,
- fair, if the tilt was between 20° and 40° and
- poor if it was beyond 40°.

Infectious or neurologic (radial nerve injury) complications were investigated, as well as nonunion, avascular necrosis of the radial head or radio-ulnar synostosis.



**Fig. 1.** — **a, b** : Grade III radial neck fracture in a 9-year-old girl. **c, d** : Postoperative radiographs after reduction of the fracture by intramedullary pinning. **e, f** : radiographic result one year after treatment.

## RESULTS

Based on the clinical evaluation criteria presented, we had 14 (70%) excellent, 3 (15%) good, 1 (5%) fair and 2 (10%) poor results.

For type 3 fractures, we recorded 7 excellent, 2 good, 1 fair and 1 poor result.

For type 4 fractures, we had 7 excellent results, 1 good and 1 poor. From a total of 20 fractures, 2 had a clinical result evaluated as poor at final

follow-up. One patient had full flexion and extension, but 20° supination and 25° pronation in the affected extremity after a type 3 fracture treated by open reduction. The other, who had an elbow dislocation associated with his type 4a radial neck fracture, had 60° pronation and 50° supination at final follow-up.

Final radiographic analysis showed 7 (35%) excellent, 10 (50%) good, 1 (5%) fair and 2 (10%) poor results.



**Fig. 2.** — **a, b** : Radiographs of a 10-year-old boy with a grade IVa fracture associated with a posterior elbow dislocation. **c, d** : Post-operative radiographs, after failure of closed methods and open reduction of the fracture. **e, f** : Radiographic control one year after surgery, showing avascular necrosis of the radial head.

In type 3 fractures we had 4 excellent, 5 good, one fair and one poor result. This last case was in a 9-year-old girl who presented with a 45° angulation of her radial head, with interposition of the capsule and annular ligament. All attempts at closed or percutaneous reduction were fruitless, and open reduction had to be performed. She ended up with a hypertrophic radial head and an anterior epiphysiodesis. In type 4a fractures we had 3 excellent and one poor result. This last case was in a 10-year-old

boy who presented a 65° angulation of the radial head and an elbow dislocation. Re-position of the radial head could not be achieved with closed procedures, so an open reduction was decided. The boy subsequently developed avascular necrosis (fig 2). Good radiological results were achieved in all five type 4b fractures.

From all the 20 patients we analysed, 17 had excellent or good clinical and radiological results at final follow-up. One patient had a fair clinical and

radiographic result (a 6 year-old-girl with a 45° angulation in her fracture, who had a 25° restriction in pronation-supination, and a residual angulation of 22° at 8 months postoperatively). Poor results, both clinical and radiological, were noted in the two cases in which open reduction of the fracture had been performed.

There was no instance of neurovascular deficit, heterotopic bone formation, radioulnar synostosis or infectious complications during this study.

## DISCUSSION

Radial neck fractures in children are not very frequent, but they deserve great attention owing to their possible complications and the long-term functional disabilities which they may generate.

Classification of radial neck fractures in children is often related to the fracture angulation, which makes the difference between a simple cast immobilisation and the necessity for reduction of the displacement. Most authors divide the angulation in 30° intervals; a 30° angulation is considered the limit between casting and reduction.

Most studies have concluded that cast immobilisation is adequate treatment for Judet type 1 and 2 fractures; on the other hand, there are diverging opinions concerning the modalities of reduction and stabilisation for type 3 and 4 fractures.

Many authors recommend closed reduction with traction followed by pronation-supination manipulation of the forearm and digital pressure over the radial head, for fractures with more than 30° of angulation (8). Métaizeau *et al* (6) suggested conservative treatment in all cases with tilt smaller than 45°, as long as the residual angulation does not exceed 20°.

Steinberg *et al* (12), in a series of 42 patients, performed closed reduction and plaster immobilisation in 28 patients, including those with severe displacement (60-90°). They reported that in 22 cases "an initially acceptable reduction was followed by re-displacement in spite of plaster fixation". Open reduction was decided as a possibility to improve the quality of reduction. However, they concluded that "despite a good reduction at operation, the final results were very often poor, most probably

due to the operative trauma and such sequelae as periarticular ossification, avascular necrosis and enlargement of the radial head."

Steele and Graham (11) obtained a satisfactory radial head reduction by leverage with a percutaneous Kirschner wire in 33 of 36 patients.

Bernstein *et al* (1) reported good results using percutaneous reduction by direct pressure over the proximal fragment using a Steinmann pin after failure of closed reduction. If the reduction was stable, internal fixation was not considered necessary. In a study on 18 patients, they had found 8 cases with an enlargement of the head or neck and one neurological complication, related to injury of the posterior interosseous nerve during reduction.

Métaizeau *et al* (4-6) proposed a new treatment modality, by intramedullary nailing. The radial head is reduced using an intramedullary K-wire which will subsequently fix the fracture and maintain a stable reduction. They reported 100% excellent results in grade 3 tilts and 74% in grade 4 tilts. This method has subsequently demonstrated its efficiency, as it combines the advantages of a good reduction and a reliable stabilisation of the fracture, with few complications.

Open reduction was widely used in the past but is now considered only for comminuted fractures or cases in which closed reduction has failed. Some fractures may need open reduction because of the interposition of the capsule or annular ligament between the head and the neck. Open reduction is related with the highest rate of severe complications such as premature fusion of the physis, radial head overgrowth, intraarticular ossification and avascular head necrosis, as it further damages the blood supply of the radial head, already damaged by the injury (1, 2, 5, 6, 7, 10-12, 14).

Some factors, such as degree of displacement, associated injuries, open treatment and residual angulation may contribute to poor outcomes.

The degree of displacement and the severity of associated injuries (a dislocated elbow is more likely to lead to poor results than an undisplaced olecranon fracture) are often related with the energy of the impact. High-energy injuries lead to soft tissue and blood supply damage, increasing the risks of avascular necrosis of the radial head.

Age is also a good predictor for the long-term result. The remodelling process varies with the age of the patient, and greater degrees of angulation can be accepted for young children. Métaizeau *et al* (5) reported that greater than 10-15° of angulation in a 12-year-old child or 20-30° in a younger child cannot be remodelled by growth. Bernstein *et al* (1) found that in a 6-year-old child, a 60° angulated fracture will remodel, but an angulation greater than 30° in a 12-year old child will not remodel.

Many controversies may be found in the literature with respect to what should be considered an acceptable reduction. Salter and Harris (9) found that no more than 15° of residual angulation should be accepted. Tachdjian (13) considered 30° as a possible limit. Métaizeau *et al* (6) stated that no more than 20° angulation can be tolerated. D'souza *et al* (2) found that fractures with less than 45° residual angulation showed remodelling and had an excellent long-term result.

In our study, Métaizeau's technique provided excellent and good results in patients with moderate and severe angulation. In 16 cases, reduction of the fracture was achieved by closed methods and no significant residual angulation was noted. They all had symmetrical range of motion at final follow-up. These results are similar to others in the literature. In the other four cases, a closed reduction was attempted, but reposition of the radial head could not be achieved. In two cases the skin and fascia were incised and the radial head was reduced by manual pressure, without opening the articular capsule. At final follow-up they had good clinical and radiographic results. In the remaining two cases, the reduction was achieved by arthrotomy. They both had interposed soft tissue making closed reduction impossible. At final follow-up, the results in these two cases were poor, with a marked limitation in the range of motion of the affected elbow. We decided to consider these cases as failures of Métaizeau's technique. It is not always possible to achieve reduction by closed manipulation, especially when there is an associated elbow dislocation following which the radial head is entrapped in the joint, or soft tissue interposed between the radial head and neck. Métaizeau *et al* (5) also reported 4 cases from a total of 16 grade 4b fractures which

necessitated open reduction because it was impossible to reach the epiphysis with the K-wire. However, after the failure of all attempts at closed reposition of the radial head, open reduction remains the last option, even though it may lead to various complications.

Intramedullary pinning, proposed by Métaizeau combines the advantages of reduction of the fracture and good stabilisation, while reducing the risk of neurological and infectious complications.

The manipulations are completely extraarticular and minimally invasive. When reduction is not possible, a percutaneous pin can be used to facilitate the manipulation of the radial head.

Open reduction should be resorted to only as the last option and should anyway be performed without an arthrotomy.

## CONCLUSION

Intramedullary pinning, as described by Métaizeau, is a simple and reliable method to treat radial head fractures in children, which provides good results and has a limited risk of complications.

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