THE CHILD ELBOW

Practical approach to traumatic and orthopedic disorders

TIMEO

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CHAPTER 3

EXTENSION-TYPE SUPRACONDYLAR FRACTURE

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KEY POINTS

Extension-type supracondylar fractures (>95%) are much more frequent than flexion-type (<5%) injuries

The remodelling potential of the distal humerus is low. The reduction quality of displaced supracondylar fractures is of paramount importance to avoid residual deformity

Age and degree of displacement dictate the treatment strategy of undisplaced and mildly displaced supracondylar humerus fractures. Closed reduction and percutaneous pinning is the treatment of choice for displaced fractures

The risk of open reduction in children with supracondylar fracture is 5% to 20%. Vascular compromise and inability to achieve a proper reduction are the two main reasons for open reduction

Vascular injuries, which mainly happen with high-energy falls, can complicate the case significantly, whereas neurological damage often resolves entirely with time

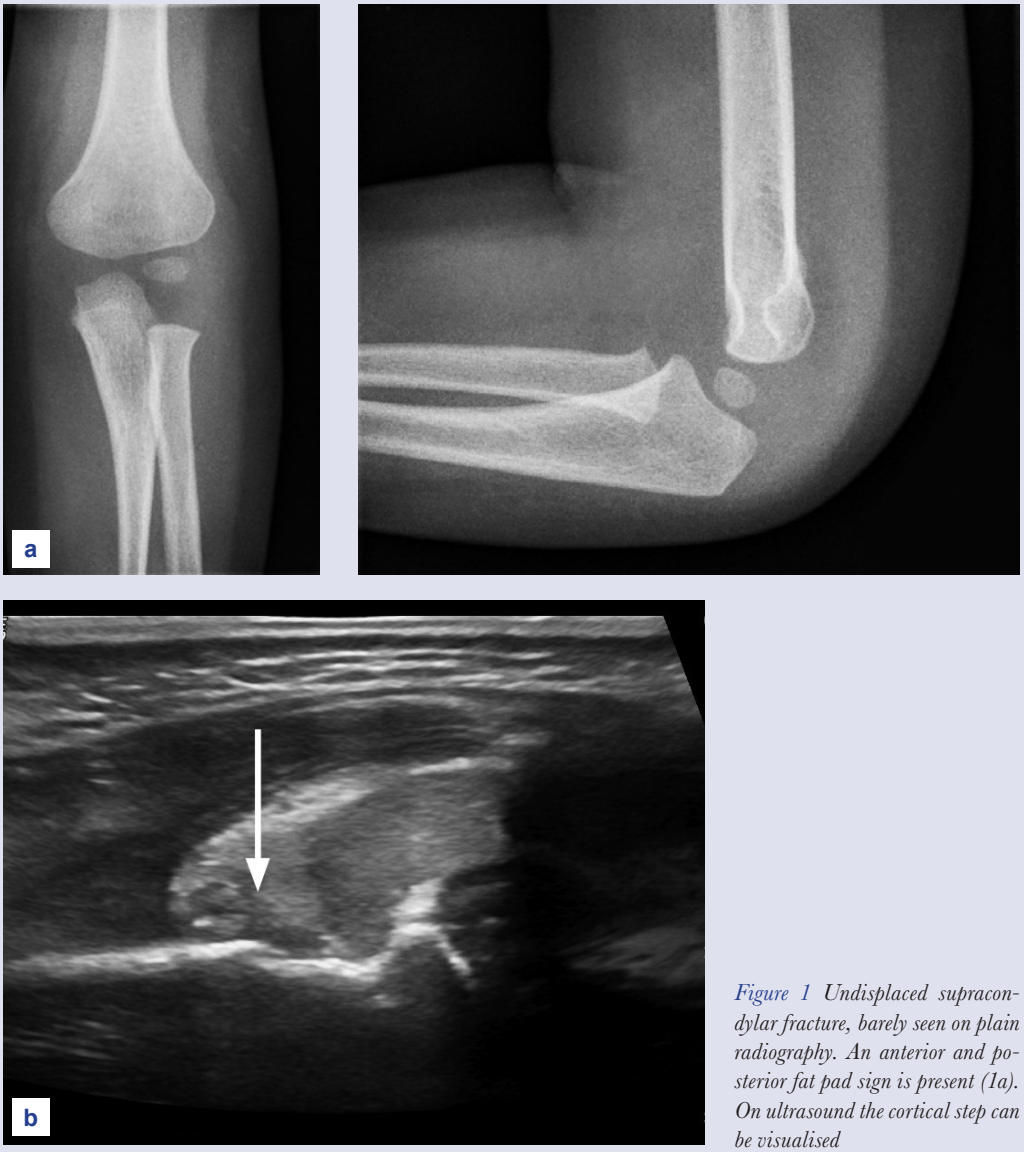

Figure 1 *Undisplaced supracondylar fracture, barely seen on plain radiography. An anterior and posterior fat pad sign is present (1a). On ultrasound the cortical step can be visualised*

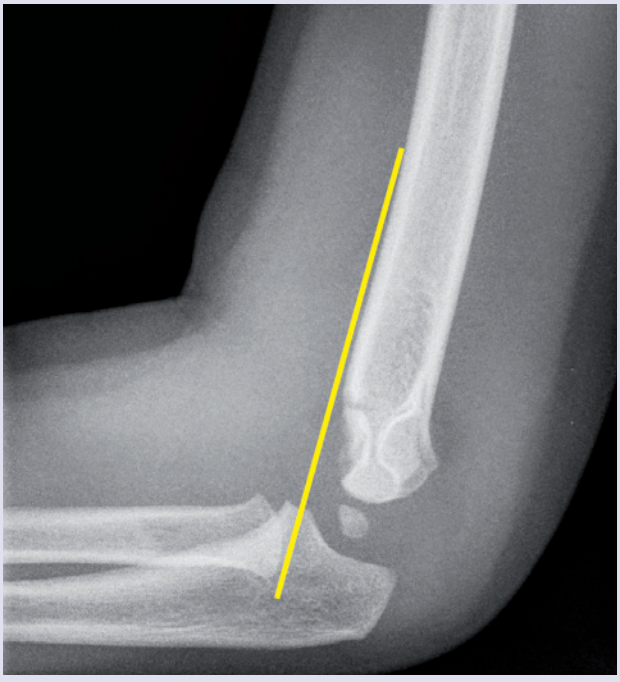

Figure 2 *Garland type II fracture. The anterior cortical line (Roger's line) does not intersect the capitellum centrally*

gressive recovery. While awaiting recovery, the patient is encouraged to keep the ulnar fingers mobile to avoid stiffness, retraction and definitive claws. In cases presenting with a sensitive deficit of the 5th finger, the patient should protect it from any risk of injury or burns.

Absence of ulnar release may lead to definitive ulnar nerve palsy, which is unacceptable. In cases involving no recovery of ulnar nerve function, with no progression of Tinel's sign, an indication for performing electromyography is obvious. In case of neuropraxia, a surgical exploration of the

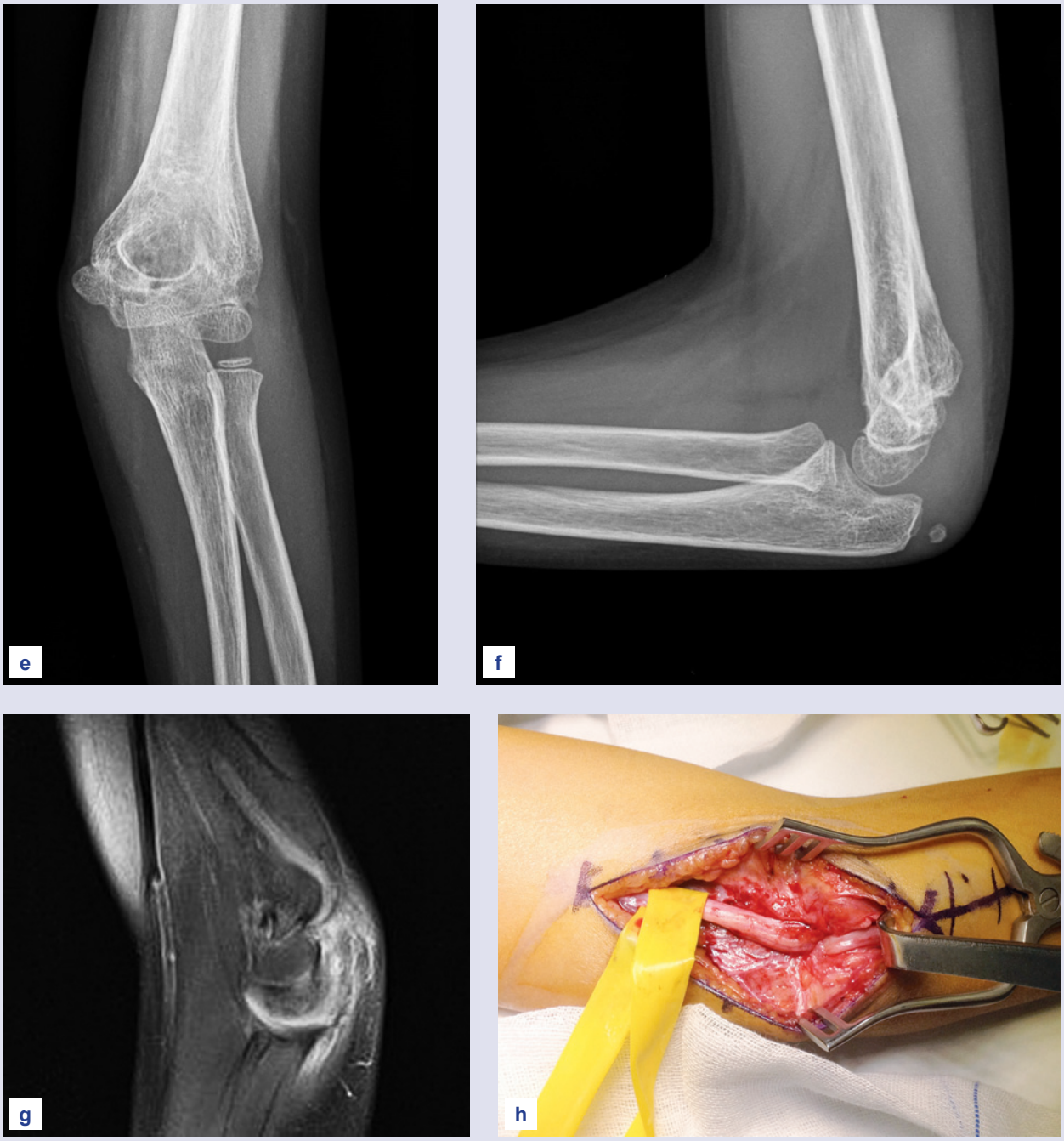

Figure 2 Girl, 8 years old. Flexion-type supracondylar fracture Gartland III (left side), Lagrange-Rigault IV with immediate partial ulnar nerve palsy (a, b). Closed reduction and fixation with 2 lateral pins 2mm (c, d). Bone union with a three months follow-up (e, f). Unfortunately, the ulnar nerve palsy remains complete, and is confirmed on EMG. On MRI, the ulnar nerve is entrapped (g) and needs a surgical exploration. The nerve is entrapped at the fracture level (h). A suture of both extremities is associated to an anterior transposition of the ulnar nerve. Partial nerve recovery is obtained one year later

ulnar nerve at the elbow is mandatory (fig. 2). A malunion, most often in a *cubitus varus*, is due to a failure of the reduction and/or the stabilisation [13]. The deformity may require a distal humerus valgus osteotomy because the distal humerus' capacity for remodelling with growth is very poor.

WHAT PARENTS SHOULD KNOW

Flexion-type supracondylar fracture of the elbow is a rare fracture and its treatment is one of the most difficult of all pediatric fractures. Perfect reduction in the operating room, together with

INTRODUCTION

Nerve injuries around the elbow are not uncommon in children, being mainly caused by fracture-related traumas and cutting lesions. Stretching may also cause a nerve injury, but it is not a common etiology in children [1].
Nerve injury can occur acutely or chronically owing to compression (pressure), ischemia (hypoxia), traction (stretch, angulation) or friction. Nerve injuries associated to elbow fractures occur primarily due to tenting or entrapment of the nerve on sharp bone fragments, while iatrogenic injuries occur either during closed manipulation or percutaneous fixation of the fracture fragments or occasionally during open procedures.
In case of an elbow fracture, closed nerve injuries should be ascertained systematically, as they may be missed at the first observation in a suffering, non-collaborating child. In younger children injury detection is even more difficult and sensitivity is not easily tested, both because of anatomical features and due to the peculiarities of pediatric patients. A nerve injury sometimes remains unidentified because of a less attentive examination [1].
Most of neural injuries in supracondylar fractures are neurapraxias and it is not routinely indicated to explore the nerve surgically [2].

CLINICAL ASSESSMENT

In the acute trauma setting, the neurological examination is challenging due to the pain and anxiety of the child and his/her parents [3]. Enough time should be taken to assess adequately the neurological and vascular status of the limb before and after any therapeutic maneuver. Many times, the child's collaboration can only be obtained after giving him/her adequate analgesia and putting on a provisory immobilization.
In children with upper limb trauma, it is important to look at the soft tissues around the elbow and forearm, with special attention to ecchymoses and edema (fig. 1). In pediatric supracondylar fractures of the humerus, neurological injury has been strongly associated with increased swelling severity as well as with skin tenting, puckering and ecchymoses, but not with superficial abrasions or open fracture [4].
Every child with an upper limb injury should routinely undergo examination of the radial, ulnar, median and anterior interosseous nerves. The examination should be performed in a simple, structured way, easy for a child to understand and obey. Radial and ulnar pulses should be examined and pulse oximetry should be performed. Assessment of warmth of the limb and capillary return are also essential [2,3].
A simple method of examining gross neurological function of the hand is to use the children's game 'rock-paper-scissors' to assess motor function of the median, radial and ulnar nerves [5]. The median nerve flexes the wrist and fingers into a fist for rock. The radial is tested by extending the fingers and metacarpophalangeal joints to produce paper. The scissors, created by

Figure 1 In children with upper limb trauma, it is important to look at the soft tissues around the elbow and forearm, with special attention to ecchymoses and edema. In pediatric supracondylar fractures of the humerus, neurological injury has been strongly associated with increased swelling severity, skin tenting, puckering, and ecchymoses

Figure 2 Anterior Interosseous Nerve injury on the left upper limb causes inability to produce an 'OK sign' with the thumb and index finger

clawing the ring and little finger and abducting the extended index and middle finger, test the ulnar nerve.

The Anterior Interosseous Nerve (AIN) can be tested by producing an 'OK sign' with the thumb and index finger (fig. 2). This allows the evaluation of the motor power of the flexor pollicis longus and the deep flexor of the index finger [3].

Performing the simple tasks of 'rock-paper-scissors-ok' is a useful initial screening tool for picking up neurological deficits in children with upper limb trauma (fig. 3). The inability to perform a complete neurovascular assessment should be documented for medicolegal reasons [3].

The occasional missing of a nerve injury can be attributed to examiner inexperience, a failure to recognize the potential for such an injury (so the proper examination is never performed), or a sense of denial by either the examiner or the patient, believing, for example, that the numbness is probably caused by swelling and the lack of movement caused by pain [1].

Nerve injuries may also be apparent after surgical treatment of elbow fractures. Lateral pinning of supracondylar fractures of the humerus put the median nerve at risk whereas the use of a medial pin increased the risk of ulnar nerve injury [6,7].

Compartment syndrome should always be kept in mind, especially when skin puckering, severe ecchymosis/ swelling, vascular alterations or concomitant elbow and forearm fractures are present. Suspicion should be raised if the child is agitated, anxious and needs increasing analgesia [2].

RADIOLOGICAL EVALUATION

In children with elbow trauma and a nerve deficit, it is important to get anterior-posterior (AP) and lateral radiographs of the elbow and forearm, in order to diagnose underlying fractures and/or dislocations that may be associated with a nerve injury. Oblique incidences may be needed to further evaluate the lesion.

Neural injuries occur in 6.5% to 19% of cases involving displaced supracondylar humerus fractures [2]. Injury to the radial nerve (with posteromedial displacements), the median nerve (with posterolateral displacements), or the AIN may occur. Ulnar nerve injuries are typically found in conjunction with medial condyle fractures or flexion type supracondylar fracture (figs. 4,5,6). In addition, iatrogenic nerve injury may happen in association with percutaneous pinning of supracondylar fractures, as medial pin placement is associated with injury to the ulnar nerve [6].

Up to 60% of displaced medial epicondyle fracture-dislocations have an associated ulnar nerve

Figure 3 A simple method of examining gross neurological function of the hand in children is to use the rock-paper-scissors to assess motor function of the median, radial and ulnar nerves. The Anterior Interosseous Nerve can be tested by producing an 'OK sign'

INTRODUCTION

Radial head fractures account for only 5% to 10% of all elbow injuries in children. Half of these radial head fractures are associated with other lesions: elbow dislocation, Monteggia-like injuries and olecranon fracture or medial epicondyle avulsion-fracture.

The ossification of the head appears around the age of five. Due to the full cartilaginous head before five years old, most of the fractures line cross at the level of the neck, creating a type I or II Salter Harris fracture. The other types of Salter Harris fracture III and IV, particularly those with intra-articular split, are exceptional.

CLINICAL ASSESSMENT

The mechanism of radial head fracture is usually a fall on an extended elbow and some valgus component. Compression forces are concentrated from the lateral condyle directly on the radial head. More valgus stress will provoke shear forces on the elbow with consequent and sequential fracture of the radial head, then a fracture of the olecranon and/or avulsion of the medial epicondylar apophysis (figs. 1a,1b).

Chambers classified these complex fractures in three groups based on the mechanism of the injury and the displacement of the radial head (fig. 2).

Depending on the seriousness of the traumatism, symptoms may vary from a slightly sore elbow a few days after a fall to a very swollen and immobile painful joint.

On clinical examination, you may find shooting pain when pressing on the radial head or in passive forearm full pronation and supination. Another clinical finding is a painful limitation of the prono-supination while flexion and extension are still possible.

RADIOLOGICAL EVALUATION

When the epiphysis is not yet ossified, the fracture will not be directly visible and only the fat pad bulging due to the joint hemarthrosis will be visualized at first.

Formerly, arthrogram was the best option for these cases but nowadays ultrasound examination performs better.

Full anterior-posterior (AP) X-rays are difficult to take due to difficulties in extending the elbow. It may be necessary to take one true AP view of the distal humerus and one true AP view of the proximal forearm to have a better understanding of the lesion (fig. 3).

Sometimes lateral view needs to be done in radio-capitellar projection so that the radial head emerges out of the ulna as described by Greenspan (figs. 4a,4b).

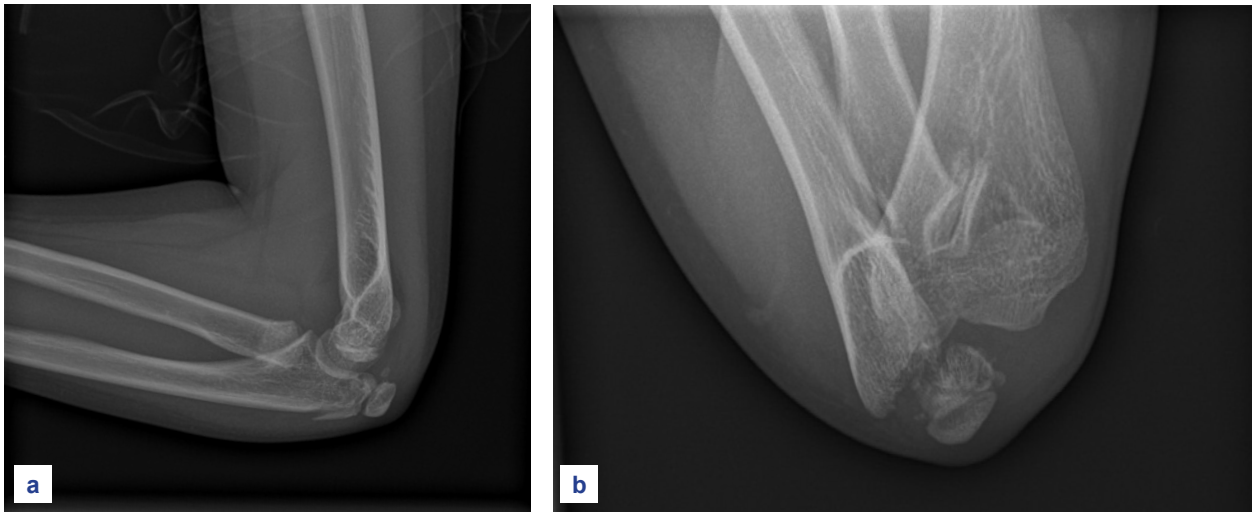

Figure 1 Chambers group II: Judet type IV radial head fracture with associated olecranon fracture (a); same patient, oblique view (b)

Group I - Primary Displacement of the Radial Head

A. Valgus fractures
   1. Type A – Salter-Harris type I and II injuries of the proximal radial physis
   2. Type B – Salter-Harris type IV injuries of the proximal radial physis
   3. Type C – Fractures involving only the proximal radial metaphysis

B. Fractures associated with elbow dislocation
   1. Type D – Reduction injuries
   2. Type E – Dislocation injuries

Group II - Primary Displacement of the Radial Neck

   A. Angular injuries (Monteggia type III variant)
   B. Torsional injuries

Group III - Stress Injuries

A. Osteochondritis dissecans or osteochondrosis of the radial head
B. Physeal injuries with neck angulation

Figure 2 Chambers classification of proximal radius fracture (from Rockwood and Wilkins Fractures in Children, 5th edition)

Figure 3 Anterior-posterior X-ray view

Figure 4 Lateral X-ray view (a); radio-capitellar view (b)

TREATMENT

Classification

Elbow dislocation is classified according to the direction of forearm bones and includes the following types:

- posterior dislocation (most common);
- anterior dislocation;
- divergent dislocation;
- medial dislocation;
- lateral dislocation.

Indications for conservative and surgical treatment

There are no well-defined management guidelines for late-presenting elbow dislocation in children. The late-presenting elbow dislocation, if presented within 3 weeks of injury, should be treated by an attempt of closed reduction only; if this is unsuccessful, then open reduction should be done. Beyond 3 weeks the likelihood of closed reduction decreases due to soft tissue contractures and owing to osteopenia, the chance of iatrogenic fracture increases. There is also a risk of iatrogenic neurologic injury (ulnar nerve) [12-14].

A case of a 6-year-old child with a 5-month-old fracture dislocation of the elbow, initially treated by local bone setter, presenting with stiffness and minimal range of movement (ROM) is presented in figures 6-12, managed by ulnar nerve exploration, open reduction, using a posterior triceps reflecting approach, and trans olecranon wire for stabilization with a follow-up of 28 months.

Figure 8 3D CT scan shows the elbow fracture dislocation involving the medial condyle

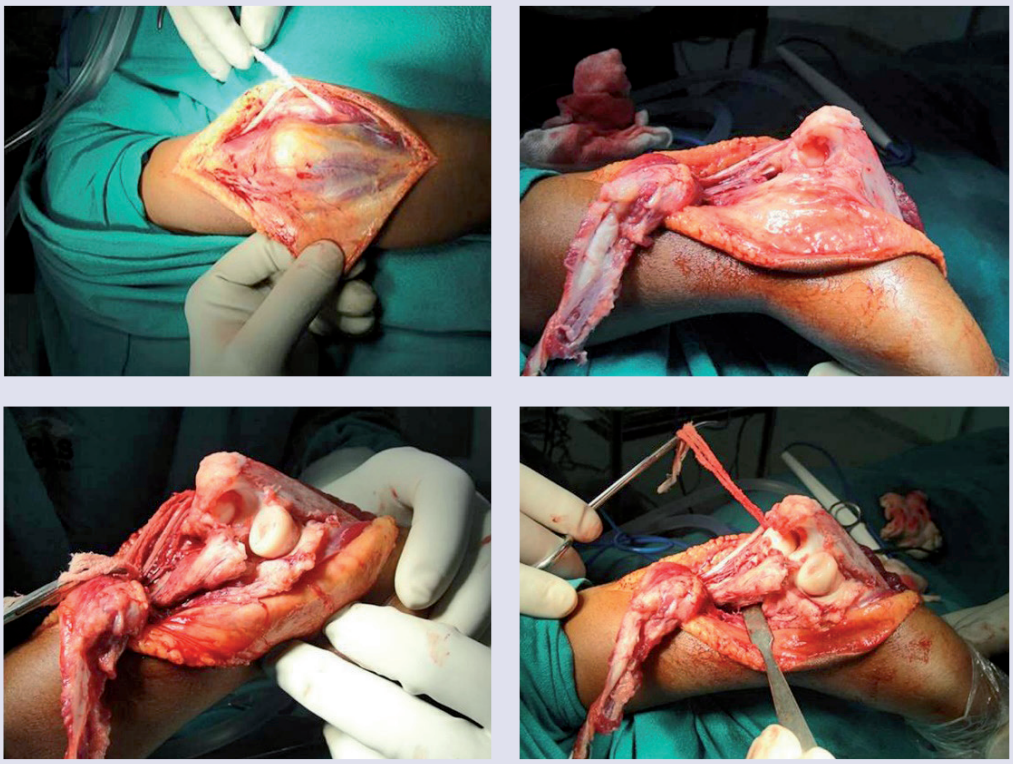

Figure 9 *Exposure of the elbow through a posterior approach, reflection of triceps, clearance of adhesions to expose the dislocated bones. The ulnar nerve is retracted with a tape*

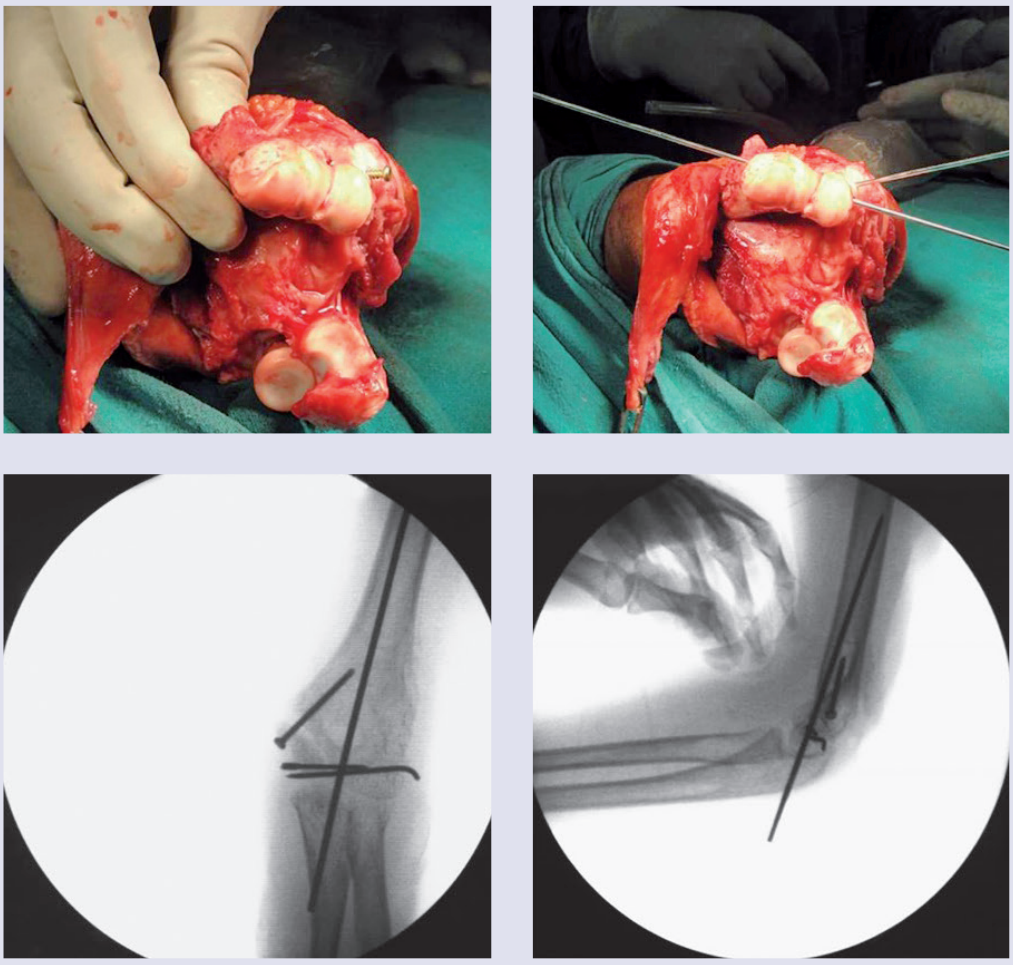

Figure 10 *Fixation of the fractured medial condyle and reduction of the elbow and intraoperative fluoroscopic images showing reduction*

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Figure 1 a) Unsuspicious clinical aspect of the elbow and x-ray evaluation of a 18-months old boy with doubtful history of elbow trauma playing with his brother; b) ultrasonographic evaluation of the elbow showing the severe dislocation of the radial head; X-ray and MRI images for comparison (outlines of the radial head and of the radial proximal diaphysis)

reduction maneuver was performed and a cast was positioned. The emergency doctor, however, described an instability with tendency to dislocate during extension of the forearm. An X-ray was performed which showed a correct articular relationship, but there was an uncertain increase of the humerus-ulnar joint space in the lateral view. An MRI was performed to exclude soft tissue interposition; it highlighted the intra-articular presence of the medial epicondyle and muscles attached to it. Open reduction and osteosynthesis was indicated (fig. 2).

Discussion

The pitfall was represented by the fact that an elbow dislocation, when correctly reduced, may lead to the impression that no further treatment is required. Instead, as described by Rasool [8], a very frequent associated lesion (in 33% of elbow dislocation in children) is the displacement of the