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UP-TO DATE REVIEW AND CASE REPORT • ELBOW - PAEDIATRICS

Osteochondral flap fracture of the coronoid in pediatric elbow dislocation: a case report and literature review

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Abstract
Osteochondral flap fractures of the coronoid are rare occult fractures, often diagnosed in delay, in pediatric patients who underwent elbow dislocations. Only 11 pediatric cases of osteochondral flap fractures of the coronoid are described in the literature. We describe a pediatric case treated in our institution for an elbow dislocation accompanied by a triad of elbow fractures, including the osteochondral flap fracture of the coronoid, and review available literature on the osteochondral flap fracture of the coronoid in pediatric patients.

Keywords Pediatric · Elbow · Dislocation · Coronoid

Introduction

The incidence of traumatic elbow dislocations in children is low, representing 3 to 6% of all elbow injuries [1]. It is more frequent in adolescents rather than young children [2]. Elbow dislocations are defined complex when associated with fractures [3]. The medial epicondyle fracture is the most frequently associated with pediatric elbow dislocation [1]. Other fractures associated with dislocation can involve the lateral condyle, the radial head, the olecranon and the coronoid process [2]. Moreover, due to the presence of ossification centers and cartilage, pediatric patients can undergo occult fractures that are not evident at the initial radiograph [4].

In the context of pediatric elbow dislocations, the incidence of coronoid fractures is inferior to 2% [5]. Among these, 11 cases of osteochondral flap fractures of the coronoid are described in the literature [6–13]. These are occult fractures, often diagnosed in delay, that accompany posterior elbow dislocation [6–13]. Sometimes the dislocation can be followed by spontaneous relocation, making the diagnosis of dislocation and of osteochondral flap fractures of the coronoid more challenging [6–13].

In case of pediatric injuries, the recall of the mechanism of trauma during a fall can be problematic. Therefore, a high clinical suspicion of elbow dislocation at presentation plays an essential role in the choice of further imaging studies to exclude or confirm associated fractures. Albeit challenging, the early diagnosis of complex elbow dislocations is essential to avoid delayed treatment and complications.

We describe a pediatric case treated in our department for elbow dislocation accompanied by a triad of elbow fractures, including the osteochondral flap fracture of the coronoid, and review available literature on the osteochondral flap fracture of the coronoid in pediatric patients.

Case report

At the beginning of July 2016, a 6-year-old Caucasian child presented to our institution after a fall from 1.5 m that was not witnessed, for a trauma of his left elbow. Swelling, pain and limitation of function of the elbow had soon ensued. The clinical examination showed swelling and tenderness at the lateral condyle, and there were no deformities. Radiographs of the elbow showed an undisplaced fracture of the lateral condyle, Milch 1 (Fig. 1). He received analgesia

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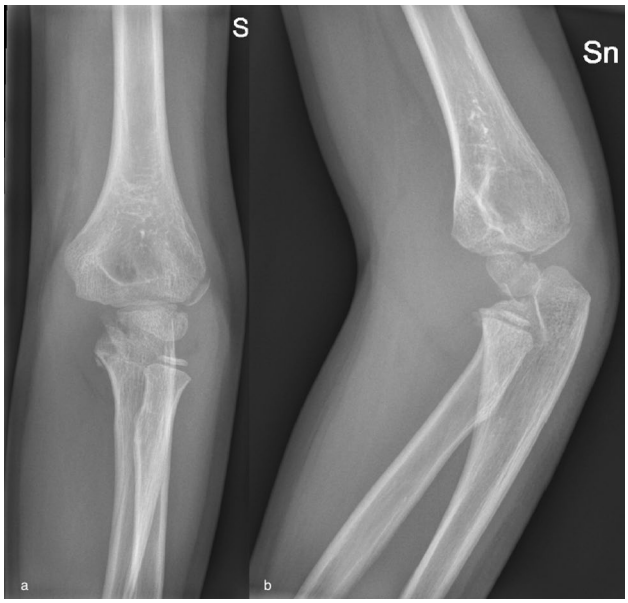

Fig. 1 First radiographs, **a** anteroposterior view, **b** lateral view

and was immobilized with an above-elbow cast. He was referred to the day case of pediatric orthopedics 4 days after the trauma for a clinical and radiographic check. The radiographs showed intra-articular fragments; therefore, a CT scan was requested (Figs. 2, 3). Apart from the lateral condyle fracture, the CT scan showed a multifragmentary coronoid fracture with the involvement of the anteromedial facet and intra-articular fragments of different size in the olecranon fossa. The CT also showed a detachment of the proximal medial cortex of the olecranon (Fig. 3). The presence of intra-articular fragments gave rise to the suspicion of an elbow dislocation, already relocated at presentation. After discussion with the parents, we obtained the informed consent for the assessment of instability, surgical exploration and treatment of associated fractures, under general and brachial plexus anesthesia. The varus–valgus stress test, carried out at 90° in supination, showed instability. We performed a medial approach that allowed the exclusion of an avulsion of the medial epicondyle and of the common flexor tendon. The ulnar nerve was localized and protected, and we decided not to transpose it. Flexor tendons were disinserted to allow the evaluation of the medial aspect of the joint. The medial ligament structures were taut but not torn, and the detachment of the proximal medial cortex of the olecranon was demonstrated. This fragment was attached to the ligaments and detached from the olecranon. A medial arthrotomy was performed, and a hemarthrosis was evacuated. In extension and pronation of the elbow, the intra-articular fragments could be evaluated. They were fragments of an osteochondral flap fracture of the coronoid. These fragments did not include pieces of capsule. The osteochondral flap fracture of the coronoid was reduced and fixed using PDS 3.0 suture, thus reconstructing the tip and anteromedial rim of the coronoid. After the suture of the coronoid, the stress test was carried out under dynamic radiographic control, showing stability of the elbow. The detachment of the proximal medial cortex of the olecranon was stable without the need for fixation. The joint capsule was sutured, and flexor tendons were reinserted with Vicryl 3/0. The lateral condyle fracture was fixed with two percutaneous K-wires. At the end of the procedure, the stress test was repeated, confirming the stability of the elbow (Fig. 4). The arm was immobilized in an above-elbow cast for 1 month. The patient was observed overnight and discharged the following day. The stability was assessed and

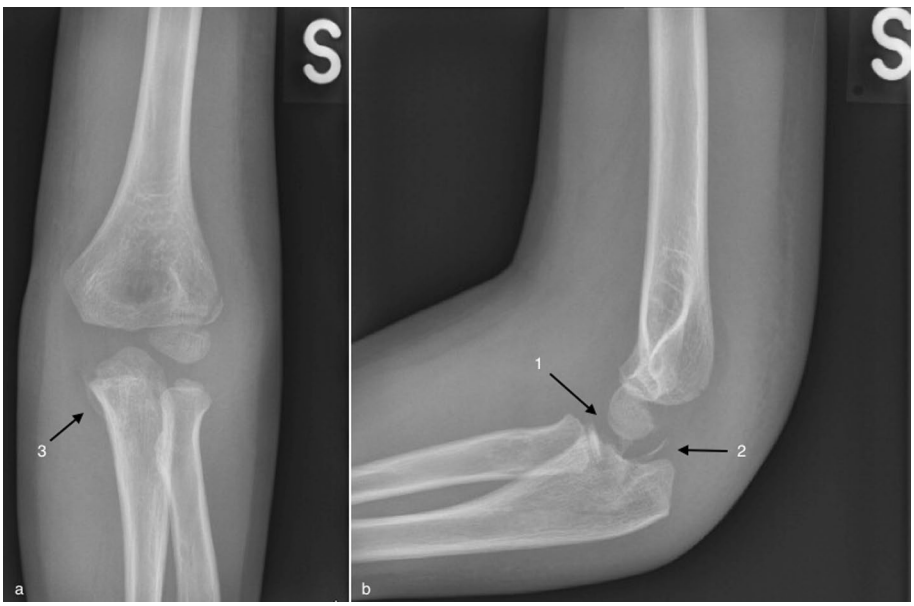

Fig. 2 Radiographs at the 4th post-traumatic day, **a** anteroposterior view, **b** lateral view; arrow 1–2: intra-articular fragments; arrow 3: detachment of the medial cortex of the olecranon

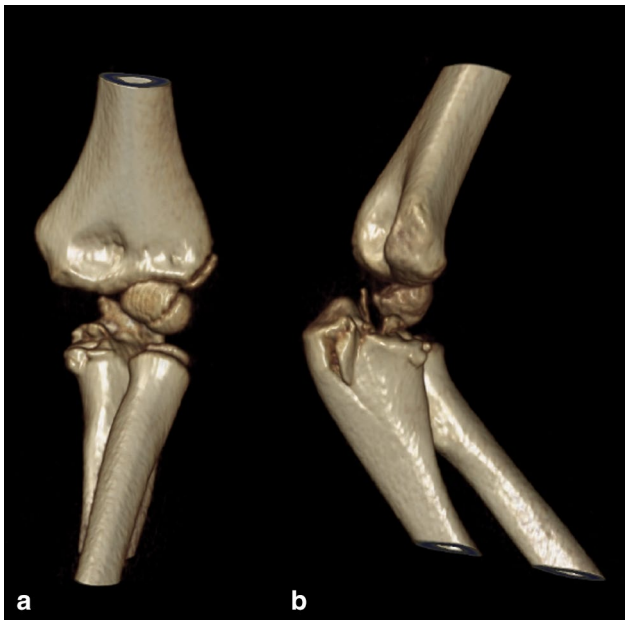

Fig. 3 CT scan at the 4th post-traumatic day, 3D showing the fracture of the anteromedial facet and tip of the coronoid, detachment of the proximal medial cortex of the olecranon, intra-articular fragments

confirmed at every control. At the first postoperative week, the patient did not complain pain and the clinical examination showed a hypoesthesia of the IV and V finger. The radiograph excluded secondary displacement of the fractures and of the elbow. At the fourth postoperative week, the radiographs showed good bone healing and the percutaneous K-wires were removed. At the second postoperative month, the extension of the elbow was limited of 15° and the flexion of 10° and physiotherapy was prescribed. At the third postoperative month, the patient showed improvement of the range of motion and of the neuropraxia. Full range of motion and complete recovery of the hypoesthesia were shown at the sixth postoperative month. At 1 postoperative year, the radiograph and the clinical examination confirmed complete healing (Figs. 5, 6). At the 18th postoperative month, the Mayo Elbow Score [14] was 100. The parents gave informed consent for the publication of the case.

Discussion

There are two main patterns of injuries for elbow dislocation, posterolateral and posteromedial [15].

In pediatric patients, the presence of ossification centers, which fuse with different timing, represent weak points subject to the pull of medial and lateral ligaments [2]. The medial epicondyle fuses to the humerus between 15 and 20 years [1]. For this reason and for the physiologic cubitus valgus, the avulsion of the medial epicondyle is frequently associated with pediatric posterolateral elbow dislocations [2]. Other lesions associated with the posterolateral pattern of injury are the radial head/neck and/or the fractures of the tip of the coronoid [3, 15]. The radial head is important against axial loads, posterolateral and valgus stress [15], whereas the coronoid represents the constraint against varus stress, posterolateral and posteromedial rotation [3, 15].

As demonstrated by clinical and biomechanics studies, the posteromedial pattern of injury in elbow dislocations is characterized by fractures of the anteromedial facet of the coronoid, avulsion of the lateral collateral ligament complex and disruption of the posterior band of the medial collateral ligament [15, 16].

Our case presented after spontaneous relocation of a complex elbow dislocation associated with an osteochondral flap

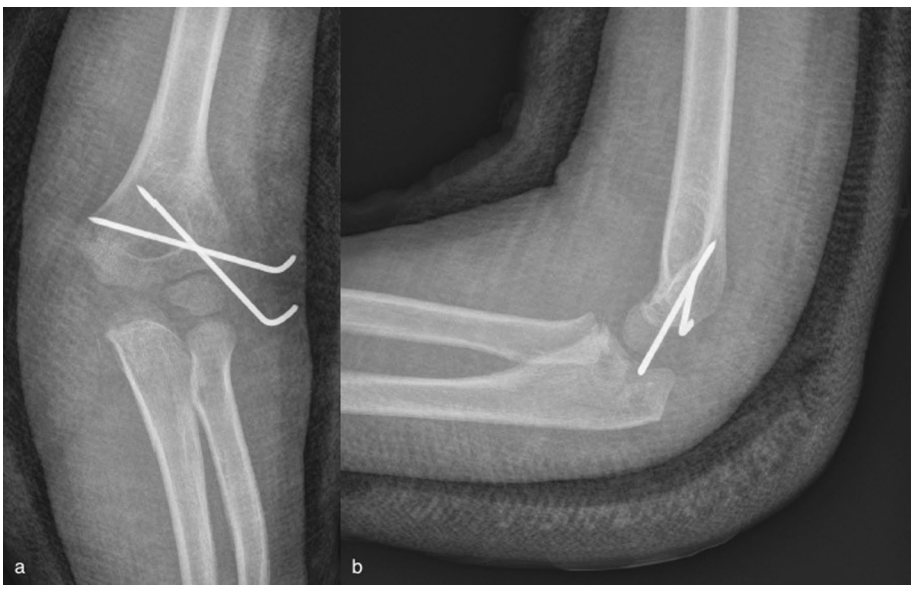

Fig. 4 Radiographs at the 10th postoperative day, **a** anteroposterior view, **b** lateral view

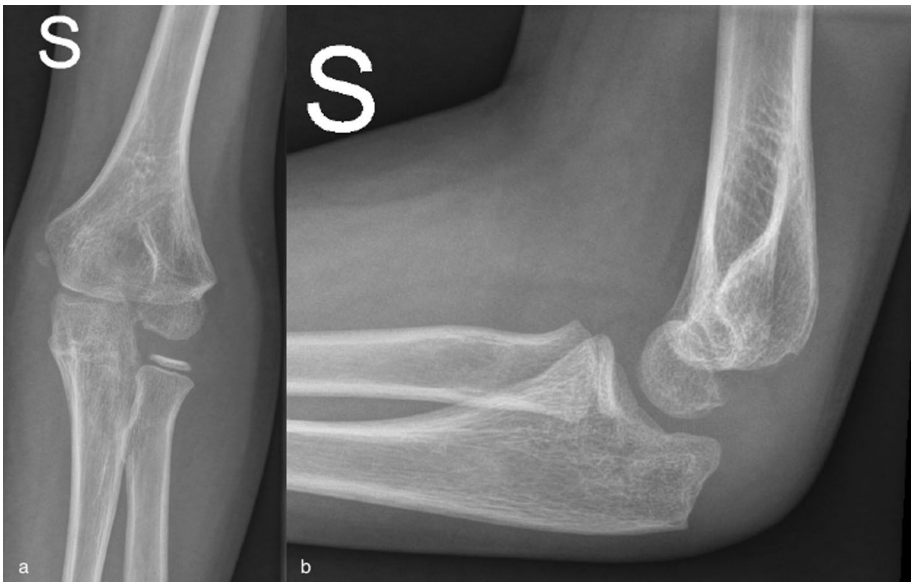

Fig. 5 Radiographs at 1 postoperative year, **a** anteroposterior view, **b** lateral view

Fig. 6 Clinical pictures at 1 postoperative year, **a**, **b** extension of both arms, **c** surgical wound, **d** flexion of both arms

fracture of the coronoid involving the tip and anteromedial facet, a lateral condyle fracture (Milch 1) and a detachment of the proximal medial cortex of the olecranon.

The osteochondral flap fracture of the coronoid is a very rare fracture in pediatric patients. As shown in Table 1, only 11 cases are described in the literature. In most cases the osteochondral flap fracture of the coronoid is an occult fracture that accompanies elbow dislocation and spontaneous relocation. It is often diagnosed in delay compared to patient presentation, and in most cases it is not associated

Table 1 Narrative review

Study	Age (y)	Mechanism of trauma	Diagnosis and associated lesions	Intervention	Follow-up
Blasier et al. [9]	4.5	Fell from 1.8 m, landed on the outstretched hand	X-rays: fragment of bone overlying the capitellum; osteochondral fragment between olecranon and trochlea; no signs of subluxation/dislocation CT: osteochondral fragment	Medial approach: reduction of the osteochondral flap fracture, which was stable Elbow stability regained Immobilization: 90° splint	Until 3po. w.: splint Then unrestricted motion; 3po. m.: full ROM 27po. m.: full ROM, no deformity, normal X-rays
Blamoutier et al. [10]	12	Fell during a high jump, landed on the arm	Clinical: posterior elbow dislocation X-rays: posterior dislocation, dislocated fracture of the coronoid Intraoperative: osteochondral flap fracture	Open reduction of the osteochondral flap Circular cast	Until 3po. w.: circular cast 12po. y.: full ROM
	13	n.a.	Clinical: posterior elbow dislocation X-rays: dislocated radial head, radial neck fracture Intraoperative: osteochondral flap fracture	Lateral approach: reduction and K-wire fixation of radial head; reduction (without fixation) of osteochondral flap fracture Cast	until 3po.w.: cast then progressive mobilization 20po. m.: deficit of extension and pronosupination; normal X-rays
	13	Motorcycle accident: fell on arm	X-rays: coronoid fracture; no signs of dislocation CT: osteochondral flap fracture	Removal of the fragment	Po.: free motion of the elbow, gaining full flexion and pronosupination; 30° extension deficit Lost to 6-m. follow-up
	5.5	Fell from a shopping cart	X-rays: undisplaced olecranon fracture, intra-articular fragment; no signs of dislocation CT: same findings	Lateral arthrotomy: reduction of osteochondral flap (use of fibrin glue); cast	Until 3po. w.: cast 6po. m.: full ROM
Kajiwara et al. [12]	7	n.a.	X-rays: coronoid fracture and fragment in the olecranon fossa; no signs of dislocation CT: same findings	Surgical treatment 10d. after injury (late referral to the center) Posterolateral approach; retrieval of the fragment in the olecranon fossa, inadequate view of the osteochondral defect Medial arthrotomy: the osteochondral fragment (o.f.) connected to part of the anterior medial collateral ligament; the o.f. included the anteromedial crista of the coronoid; reduction of the o.f. and fixation with 2 polylactic acid pins; extraction of small fragments of the tip of the coronoid Immobilization: 90° flexion with an above-elbow plaster	Until 3po. w.: immobilization After: active mobilization 12 m.: bone healing on X-ray, 5° extension deficit, stable elbow
Kowtharapu et al. [6]	n.a.	n.a.	Olecranon fracture forearm compartment syndrome	n.a.	n.a.

Table 1 (continued)

Study	Age (y)	Mechanism of trauma	Diagnosis and associated lesions	Intervention	Follow-up
Ohta et al. [8]	8	Fell from a banquette	X-ray: elbow subluxation, fragment in the ulnohumeral joint CT: fragment in the ulnohumeral joint, fragment avulsed from the coronoid, olecranon vertical fracture Intraoperative: valgus instability; elbow flexion locked at 60°	Medial approach: medial collateral ligament and fascia of flexor completely avulsed from the medial epicondyle with a small fragment; reduction and fixation of 2 osteochondral fragments with 2 K-wires (1 mm) through the olecranon; repair of the medial collateral ligament and fascia. Io. X-rays: stable olecranon fracture (conservative treatment) Elbow ROM and stability regained Elbow immobilization: 80° flexion	Until 4po. w.: immobilization Then active ROM 5po. w.: K-wire removal 12po. w.: bone healing
Quick et al. [7]	4	Fell from 1.5 m, landed on outstretched arm	X-rays: crescent opacity behind the distal humerus, olecranon fracture; no signs of dislocation US: effusion, loose body in the olecranon fossa, no damage to the extensor stabilizers CT: same findings RMI: osteochondral flap fracture	Medial approach: reduction and transosseous PDS suture fixation of chondral flap and coronoid fracture Elbow stability regained	3po. m.: full ROM, no instability
Pino Almeiro et al. [13]	2y. 8 m.	Polytrauma: fall from 1.8 m	Immobilization for distal radius and ulna fracture Clinical suspicion after 5 w. immobilization: elbow locked at 20° flexion–extension. X-rays: intra-articular fragments; no signs of dislocation	Medial approach: reduction of the osteochondral fragment Lateral approach: exeresis of the osteochondral fragment Elbow ROM regained Immobilization: 90° flexion	Until 3po. w.: immobilization Then rehabilitation 6po. m.: improvement ROM 11po. m.: full ROM, normal X-rays 24po. m.: full ROM 5po. y.: full ROM, normal X-rays
Song et al. [11]	12	Landed on outstretched arm	Clinical: posterior elbow dislocation X-ray: fragment between capitulum humeri and radial head CT: osteochondral flap fragment of the coronoid	Medial approach: arthrotomy, excision of the flap fragment because unstable and thin for fixation Immobilization: 90° flexion with an above-elbow plaster	Until 2po. w.: immobilization 4y. 2 m.: 10° extension deficit; X-rays: heterotopic ossification at the lateral condyle

d.: day; io.: intraoperative; m.: month; n.a.: not available; po.: postoperative; ROM: range of motion; w.: week; y.: year

with other fractures. It can be accompanied by the rupture of the capsule or trapping of the coronoid fragments in the ruptured capsule [8]. There are two theories explaining its pathogenesis. During spontaneous relocation of the elbow, the displaced trochlea could shear the coronoid off with a flap of cartilage toward the posterior part of the ulnohumeral joint, exposing the subchondral bone of the olecranon fossa [8], [9]. Another hypothesis is that the osteochondral flap fracture of the coronoid can be caused during the initial trauma, with elbow extension and forearm pronation, due to the impingement of the coronoid on the trochlea [8], [11], [12]. In our case, when we reduced and sutured the coronoid fragments, we could see that they belonged to the tip and anteromedial rim of the coronoid. The osteochondral flap fracture of the coronoid with the involvement of the anteromedial facet was also described by Kajiwara et al. [12].

According to the combination of fractures our patient presented, we hypothesized a posteromedial pattern of injury. As far as lateral condyle fractures are concerned, these represent 15% of all pediatric elbow fractures [17]. The mechanism responsible for this fracture is a varus stress and axial load applied to an extended elbow with the forearm supinated [17]. The pull of the lateral collateral complex and the extensor muscles can play a role in determining lateral condyle fractures [18]. The integrity of the lateral trochlear rim makes Milch type I a stable fracture, because it represents a lateral buttress for the coronoid and olecranon [19]. Despite this, Milch type I fractures were also reported associated with clinical instability and elbow dislocation [17]. A study evaluating the reliability of the Milch classification showed that only 52% lateral condyle fractures preoperatively classified as Milch 1 were confirmed intraoperatively. The remaining Milch 1 fractures were intraoperatively shown to have crossed the cartilagineous portion of the trochlear epiphysis, beyond the trochlear groove, rendering the elbow unstable [20]. The literature shows few cases of lateral condyle fractures associated with posterolateral and posteromedial elbow dislocation in children [17–19, 21–23]. In most cases, the lateral condyle fracture is associated with a posteromedial elbow dislocation where a varus stress and axial load were applied to a partially flexed elbow [17–19, 21, 22]. In our case the lateral condyle fracture could have resulted from the pull of lateral collateral stabilizers.

Another peculiarity of our case was the presence of a detachment of the proximal medial cortex of the olecranon, which was attached to the ligaments. At the proximal part of the olecranon, proximal to the sublime tubercle, there is the insertion of the posterior bundle of the medial ulnar collateral ligament (pMUCL). This structure is the primary constraint against varus stress and secondary constraint against valgus stress [24, 25]. Biomechanical studies demonstrated that when there is a coronoid fracture, the presence of an uninjured pMUCL stabilizes against varus internal rotation [25]. In our case, the medial ligament structures were taut and not torn at surgical exploration. We did not find ruptures of the pMUCL, but the detachment of its bony insertion at the proximal medial border of the olecranon. It is therefore possible that the cortical detachment of the proximal medial olecranon was caused by the pull of the pMUCL in flexion of the elbow. Moreover, there were no features commonly associated with posterolateral dislocation of the elbow, such as a fracture of the medial epicondyle, or injuries of the flexor tendons, or tears of the anterior bundle of the medial ulnar collateral ligament and capsule.

We hypothesized that the patient could have fallen with a partially flexed arm, which underwent axial load, varus stress and pronation of the forearm, as this is the typical mechanism in case of a complex elbow dislocation with a posteromedial pattern of injury [15].

The diagnosis of complex dislocations of the elbow in pediatric patients is challenging. After a spontaneous relocation, there can be occult fractures that are diagnosed in delay [17, 19]. For these reasons, CT or MRI imaging is required to have a better visualization of the fragments and of associated lesions. Instability tests are essential to prove the dislocation [18]. The limitation of passive range of motion can be explained by the impingement caused by the presence of intra-articular fragments [13].

The treatment of complex elbow dislocation is aimed at restoring normal function and stability.

Despite the rarity of the osteochondral flap fracture of the coronoid, the type of surgical treatment varies among cases. The surgical approach is chosen depending on the site where fragments are entrapped and on the valgus or varus instability. The osteochondral flap fragment can be reduced and fixed. Its fixation mainly depends on the size of the fragments. Fragments bigger than 5 mm [8] can be fixed with K-wires crossing the olecranon. Smaller fragments can be sutured with PDS or fixed with fibrin glue [7, 10]. If the elbow is stable after the reduction of the coronoid osteochondral flap fragment, its fixation could not be required [9, 10]. In fewer cases the fragment is excised, with restoration of the full function and stability of the elbow [10, 13]. The available literature does not show sequelae after the treatment of osteochondral flap fractures of the coronoid.

The anatomic reduction of the lateral condyle fracture is essential to avoid long-term complications, such as malunion or nonunion [18, 19, 22].

Complications of pediatric complex elbow dislocations can be due to misdiagnosis or inadequate treatment [23]. These can be malunion, nonunion, avascular necrosis, ulnar nerve palsy [23]. A high level of suspicion is necessary to avoid delayed diagnosis and treatment and consequent complications.

Conclusion

Complex elbow dislocations are rare lesions in pediatric patients. They can be followed by spontaneous relocation. In very rare cases, there can be an osteochondral flap fracture of the coronoid, whose diagnosis can be challenging because it is often occult at the initial radiographs. A CT scan or MRI and the assessment of elbow instability are fundamental to confirm the diagnosis and choose the appropriate treatment.

We described a case of pediatric complex elbow dislocation with lesions consistent with a posteromedial pattern of injury, including the rare osteochondral flap fracture of the coronoid.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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