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## The “floating forearm” injury in a child: a case report

Received: 2 January 2007 / Accepted in revised form: 15 March 2007

**Abstract:** The case of a eleven-year-old girl who had a fracture dislocation of the left elbow with entrapment of the ulnar nerve into the dislocated ulnar epicondyle anlage and unstable forearm fracture of the ipsilateral upper extremity is described. This severe injury to the elbow and the ipsilateral forearm is termed “floating forearm” injury. The forearm was stabilized percutaneously and the elbow fracture dislocation, remaining unstable after internal fixation was treated with a pediatric elbow fixator with motion capacity.

**Key words** Forearm injury • Elbow fracture dislocation • Hinged external fixation • Floating elbow injury

### Electronic supplementary material

The online version of this article (DOI: 10.1007/s11751-007-0017-5) contains supplementary material, which is available on SpringerLink

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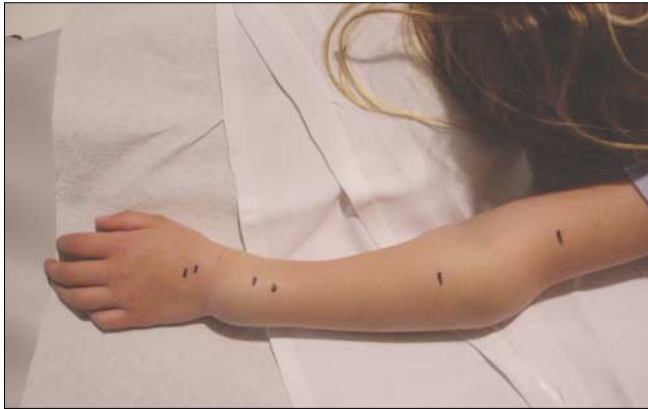
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### Introduction

Simultaneous ipsilateral fracture dislocation of the elbow and unstable fracture of the forearm – floating forearm – is extremely rare in children, as the usual injury pattern involves a fracture of both the distal humerus and the distal forearm (floating elbow) [1]. Although forearm fractures as single injury are, with 13%, the third most common entity in the age group of eight to eleven years, fracture dislocation of the elbow, with 1.6%, is rare in this age group [2]. Its combination, to our knowledge, has not yet been reported in children. Each injury alone, and especially sequelae of a paediatric fracture dislocation of the elbow joint, may result in a low functional level after these high-energy intra- and juxta-articular fractures [3–6]. We describe the case of an 11-year-old girl who had a fracture dislocation of the left elbow with entrapment of the ulnar nerve into the dislocated ulnar epicondyle anlage and unstable forearm fracture of the ipsilateral upper extremity. The forearm was stabilised percutaneously and the elbow fracture dislocation, remaining unstable after internal fixation, was treated with a paediatric elbow fixator with motion capacity.

### Case report

An 11-year-old, right-hand dominant girl had a fall 4 m from a tree and landed on the outstretched left hand. She presented initially to our hospital with pain, substantial swelling and gross deformity of both the elbow region and the forearm (Fig. 1). There was an incomplete motor and sensory ulnar nerve palsy, and no external wounds or distal vascular deficit. Radiographs of the left elbow and forearm revealed a fracture dislocation of the elbow (Fig. 2) and an unstable forearm fracture (Fig. 3). For a better understanding of the pathology of the ulnar epicondyle, a



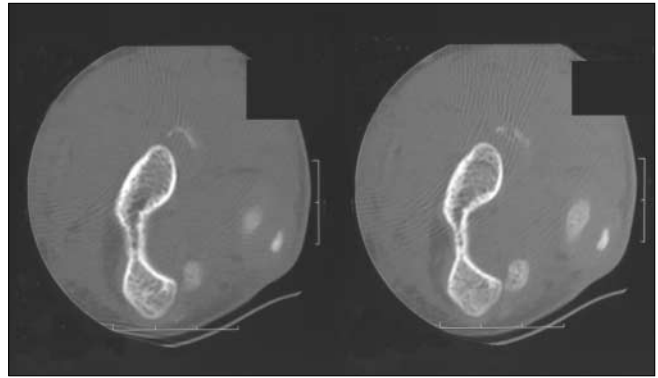
**Fig. 1** All figures are of an 11-year-old girl who sustained a floating forearm injury after a fall from a tree. Photograph demonstrating the clinical appearance of the left upper extremity (position of the arm over the head for CAT scan investigation)



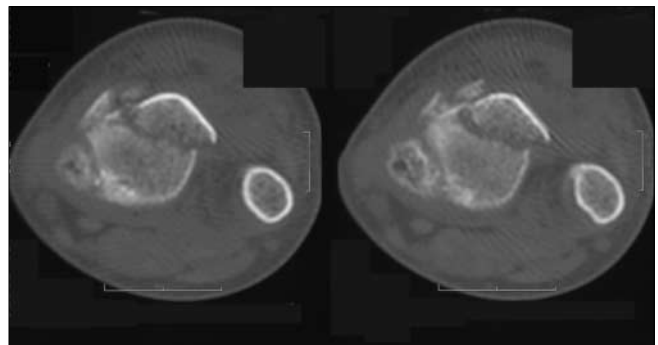
**Fig. 2** Lateral radiograph of the left elbow



**Fig. 3** Anteroposterior radiograph of the left forearm



**Fig. 4** CAT scan of the left condylar region: displacement of the medial condylar anlage and bony avulsion of the radial condyle



**Fig. 5** CAT scan of the left distal forearm: compound distal radius fracture affecting the growth plate



**Fig. 6** Intraoperative radiograph of the left distal forearm demonstrating closed reduction and internal fixation with fine-threaded wires (FFS)

CAT scan of the left upper extremity was performed, with positioning of the outstretched arm above the patient's head (Figs. 4, 5). This was tolerated well without general anaesthesia. The operation was performed one hour after admission without tourniquet in general anaesthesia. After closed reduction of the forearm fracture internal fixation was effected using fine-threaded wires (FFS; Orthofix

Inc., Italy, USA, UK; Fig. 6). Using an ulnar approach, the dislocated ulnar epicondyle with the flexor muscle group attached was identified, and the ulnar nerve was proved to be entrapped between the distal humerus and the dislodged ulnar epicondyle (Fig. 7). After decompression and repositioning of the ulnar nerve into the ulnar sulcus the ulnar epicondyle with the ulnar ligament complex was refixed using an FFS implant armed with a clawed washer (Fig. 8). Clinical examination after refixation of the ulnar epicondyle and the medial ligament complex revealed a grossly unstable elbow joint with accentuated valgus instability and direct redislocation after reduction (Fig. 9, video 1 [electronic supplementary material]). An elbow fixator with motion capacity with paediatric hinges was applied in order to regain stability. After insertion of a 2.0-mm guidewire into the centre of rotation of the elbow joint (Fig. 10), a humeroulnar external fixator with motion capacity was applied with respect to anatomical landmarks [7] and according to the surgical protocol described elsewhere [8, 9]. Intraoperative testing for stability of the elbow joint after application of the elbow fixator revealed stability of the joint in the entire range of motion (Figs. 11 and 12, video 2 [electronic supplementary material]). Postoperatively, the elbow was immobilised by locking the central unit of the elbow fixator for 4 days to allow for swelling to subside followed by active exercises under physiotherapeutic guidance. Postoperative radiographs revealed both anatomic alignment of the elbow joint and the forearm fracture (Figs. 13, 14). To avoid heterotopic ossification of the soft tissues at the elbow, indomethacin 25 mg bid was administered for four weeks postoperatively. The elbow fixator was removed as an outpatient procedure without anaesthesia after six weeks. Clinical testing of the elbow for stability showed a stable joint without apprehension to dislocation, and provocation tests for pos-



**Fig. 7** Intraoperative photograph of the dislocated ulnar epicondyle with the flexor muscle group attached: the ulnar nerve is entrapped between the distal humerus and the dislodged ulnar epicondylar anlage



**Fig. 8** The ulnar epicondyle with the flexor muscle group is reattached to the distal humerus using a fine-threaded wire armed with a clawed washer



**Fig. 9** Intraoperative radiograph documents redislocation of the left elbow



**Fig. 10** Insertion of the pilot k-wire marking the centre of rotation of the humeroulnar joint





**Fig. 11** Intraoperative photograph demonstrating full extension without dislocation after mounting of the elbow fixator



**Fig. 12** Intraoperative photograph demonstrating full flexion without dislocation after mounting of the elbow fixator



**Fig. 13** Postoperative anteroposterior radiograph of the left elbow



**Fig. 14** Postoperative anteroposterior radiograph of the left wrist



**Fig. 15** Postoperative lateral radiograph of the left elbow: to gain an unobstructed view of the elbow joint a dental film is placed between the fixator and the elbow joint

terolateral instability were negative (Fig. 15). The implants in the forearm were removed after 8 weeks (Figs. 16, 17). At final follow-up 18 months after removal of the external fixator the girl had regained full function of both elbow and forearm with extension/flexion of 0°–130°, pronation and supination of 80° each, and function of the left wrist was equal to the uninjured side (Figs. 18–21, video 3 [electronic supplementary material]). The ulnar nerve function recovered completely and there was no postoperative complication. The child took part in regular physical activities at school and her hobby of horse-riding four months after removal of the device. She coped well with the exter-



**Fig. 16** Postoperative anteroposterior radiograph of the left elbow after hardware removal



**Fig. 17** Postoperative lateral radiograph of the left elbow after hardware removal



**Fig. 18** Photograph demonstrating full flexion of the left elbow



**Fig. 19** Photograph showing a slight extension deficit at final follow-up



**Fig. 20** Photograph of pronation at final follow-up



**Fig. 21** Photograph demonstrating full supination at final follow-up

nal device and the objective functional elbow index rating [10] at final follow-up examination was excellent, with a Mayo performance index of 94 points.

## Discussion

A review of textbooks and journal articles revealed no report of simultaneous ipsilateral fracture dislocation of the elbow and unstable fracture of the forearm in a child, an injury we termed "floating forearm". This is opposed to the "floating elbow" injury, in which a high-energy trauma to the paediatric upper extremity results in displaced fractures of both the distal humerus and the distal forearm. The floating elbow injury pattern usually occurs in the age group of seven- to ten-year-old children and is associated with a high incidence of open fractures, compartment syndrome and neurovascular injury [1]. The observed fracture dislocation of the elbow with entrapment of the ulnar nerve in our case is more often found in the age group older than 11 years of age [2]. Complete displaced forearm fractures in the mono-injury setting generally yield good results, when treated conservatively after closed reduction or with percutaneous pinning, unless there is no residual translation. Mani and colleagues have demonstrated that the risk of failure in these fractures with translation of the radius of more than half the diameter of the bone was 60%, compared with 8% for fractures with less translation [3]. In a high-energy setting, as in our case, percutaneous stabilisation after reduction seems mandatory in order to restore stability of the forearm [3].

Results of paediatric fracture dislocations of the elbow are generally perceived as reasonable, with internal fixation of concomitant bony avulsions, but case reports of elbow stiffness after simple elbow trauma have drawn the focus on the difficulty to treat sequelae after paediatric elbow fracture dislocation [4–6, 11–13]. Stability of the ulnohumeral joint after elbow trauma is dependent on both bony and soft tissue constraints [10, 14, 15]. In young children it is rare and associated with high-energy trauma [2, 4]. Disruption of osseous and or articular stabilisers dramatically increases the risk of redislocation and recurrent instability [6, 12, 13]. As even simple dislocation of the paediatric elbow or single-column injuries of either the lateral or medial epicondyle are reported to lead to both deformity and loss of function [4, 5, 11, 16], in a case of multidirectional instability after sufficient restoration of the ligaments and bony components a hinged external fixator is of great value to provide stability and early mobilisation [8, 9, 14, 17]. Hinged external fixators rely on accurate placement of the hinge co-linear with the axis of rotation of the joint [7, 12]. Although an elliptic movement of the humeroulnar joint during flexion and extension occurs, for surgical purposes and to maintain a midrange of motion this can be neglected [12]. The centre of rotation in paediatric cases can be readily identified on a true lateral intraoperative image, and the k-wire should be advanced under fluoroscopic control penetrating only 1 cm into the

capitulum in order to avoid further damage to the trochlear growth-plate (compare Fig. 10). Both hinges and fixator pins have to be adjusted to paediatric dimensions, otherwise the device will be too bulky and iatrogenic fracture of the ulnar may occur. The hinged fixator allowed for immediate pro- and supination and flexion and extension after subsiding of swelling. The only other option available would have been transarticular pin fixation to maintain reduction, which inevitably would have put functional restoration of the elbow at risk [13]. Avoidance of elbow stiffness in children is the main goal in these injuries, as operative treatment of elbow contracture is reported to be less favourable and less predictable than that in adult patients [6, 12, 13].

As there are numerous reports of the use of a hinged external fixator for elbow instability after fracture dislocation of the elbow and severe distal humeral fracture [8, 9, 14, 17], the use of such a device in children has not been reported yet. In clinical situations such as we have seen, with multidirectional instability of the elbow after adequate internal fixation of the ligament complex, a hinged elbow fixator may be added to the therapeutic spectrum in these high-energy injuries.

## References

1. Ring D, Waters PM, Hotchkiss RN, Kasser JR (2001) Pediatric floating elbow. *J Ped Orthop* 21:456–459
2. Cheng JC, Shen WY (1993) Limb fracture pattern in different pediatric age groups: a study of 3,350 children. *J Orthop Trauma* 7:15–22
3. Mani GV, Hui PW, Cheng JC (1993) Translation of the radius as a predictor of outcome in distal radial fractures of children. *J Bone Joint Surg Am* 75:808–811
4. Borris LC, Lassen MR, Christensen CS (1987) Elbow dislocation in children and adults. *Acta Orthop Scand* 58:649–651
5. Skak SV, Olsen SD, Smaabrekke A (2001) Deformity after fracture of the lateral humeral condyle in children. *J Ped Orthop* 10:142–152
6. Stans AA, Maritz NG, O'Driscoll SW, Morrey BF (2002) Operative treatment of elbow contracture in patients twenty-one years of age or younger. *J Bone Joint Surg Am* 84:382–387
7. Gausepohl T, Koebke J, Pennig D et al (2000) The anatomical base of unilateral external fixation in the upper limb. *Injury* 31[Suppl 1]:11–20
8. Gausepohl T, Pennig D, Mader K (1999) The early motion fixator concept for treatment of acute unstable fracture dislocations of the elbow. *J Bone Joint Surg Br* 81[Suppl II]:191
9. Pennig D, Gausepohl T, Mader K (2000) Transarticular fixation with the capacity for motion in fracture dislocations of the elbow. *Injury* 31[Suppl 1]:35–44
10. O'Driscoll SW, Bell DF, Morrey BF (1991) Posterolateral rotatory instability of the elbow. *J Bone Joint Surg Am* 73:440–446
11. Farsetti P, Potenza V, Caterini R, Ippolito E (2001) Long-term results of treatment of fractures of the medial humeral epicondyle in children. *J Bone Joint Surg Am* 83:1299–1305

12. Gausepohl T, Mader K, Pennig D (2006) Mechanical distraction in post-traumatic stiffness of the elbow in children. *J Bone Joint Surg Am* 88:211–221
13. Mader K, Koslowsky TC, Gausepohl T, Pennig D (2007) Mechanical distraction for the treatment of posttraumatic stiffness of the elbow in children and adolescents: surgical technique. *J Bone Joint Surg Am* 89:26–35
14. Buckwalter J (1995) Should bone, soft tissue and joint injuries be treated with rest or activity? *J Orthop Res* 13:155–156
15. Eygendaal D, Olsen BS, Jensen SL et al (1999) Kinematics of partial and total ruptures of the medial collateral ligament of the elbow. *J Shoulder Elbow Surg* 8:612–616
16. Zions LE, Mirzayan R (2002) Elbow stiffness following malunion of a fracture of the lateral epicondyle of the humerus in a child: a case report. *J Bone Joint Surg Am* 84:818–821
17. Behrens F, Kraft EL, Oegema T (1989) Biomechanical changes in articular cartilage after joint immobilization by casting or external fixation. *J Orthop Res* 3:335–343