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Management of the floating elbow injury in children

Simultaneous ipsilateral fractures of the elbow and forearm

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Abstract Simultaneous ipsilateral fracture of the elbow and forearm – floating elbow – is an uncommon injury. During a 7-year period we prospectively followed 12 children who presented with completely displaced supracondylar fractures of the humerus associated with a forearm fracture of the same limb. All patients underwent emergency operative reduction and percutaneous K-wire stabilisation. At a minimum of 18 months, all patients were assessed clinically and radiologically and the results evaluated according to a conventional scoring system. Ten patients had good or excellent outcomes, and there were two fair results. The incidence of open fractures and nerve injury and the need to perform an open reduction were higher than those recorded for isolated supracondylar fractures. The floating elbow is an indicator of a high energy injury and requires aggressive operative management.

Introduction

A fracture of one or both forearm bones in conjunction with a completely displaced supracondylar fracture of the humerus represents a severe injury of the upper limb in children. It is an uncommon injury, and most reported series of supracondylar fractures and several texts on children's fracture management make no reference to this combined injury [1, 2, 3, 4, 5, 6, 9].

On average, two children with simultaneous ipsilateral supracondylar and forearm fractures present to Our Lady's Hospital for Sick Children, Crumlin, each year. The reported incidence of forearm fractures in association with supracondylar fractures varies from 2% to 13% [12]. We have treated 385 children with displaced supracondylar fractures since 1989, and of this group 15 (4%) had an associated ipsilateral forearm fracture [4, 12]. Stanitski and Micheli first used the descriptive term 'floating elbow' in a report of 6 such cases [10]. Since then there have been three reports dealing with this injury [7, 11, 13]. However, just one study included only patients with completely displaced supracondylar fractures [11]. We report our experience of the management of the floating elbow injury by prompt reduction and operative stabilisation.

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Patients and methods

Between 1989 and 1995, 15 children were admitted to Our Lady's Hospital for Sick Children, Dublin, with simultaneous ipsilateral fractures of the humerus and forearm. Three cases were excluded from the study: one suffered a partial traumatic amputation due to a machine injury, and two patients had incompletely displaced supracondylar fractures (Gartland/Wilkins grade II) [12]. Therefore, our study included 12 children with completely displaced supracondylar fractures associated with a forearm fracture (Fig. 1). All but two of the injuries were the result of indirect violence due to a fall. The average height of the fall was 2.2 m (range 1–4.5 m). Only three patients sustained the injury from a fall at ground level. In nine children the mechanism of injury was noted as a fall on the outstretched hand with the wrist and elbow extended.

Patient details are shown in Tables 1 and 2. The minimum follow-up time was 18 months. Four of the elbow injuries and one of the forearm injuries were open fractures (Fig. 1). Three patients had a neurological injury, and one had an absent pulse and an ischaemic limb. The circulation returned after immediate reduction and stabilisation.

The supracondylar fractures were Gartland/Wilkins grade III extension injuries and were treated by immediate reduction and percutaneous K-wire stabilisation. In six cases (50%) it was necessary to perform an open reduction of either the elbow or forearm fracture.

Eleven children had fractures of the distal third of the forearm. In six the radius only was involved, and in four of these, the forearm injury was treated by closed reduction and below elbow plaster immobilisation. Five patients with both bone fractures in the distal third underwent percutaneous K-wire fixation of the distal radius. One patient with a proximal forearm fracture underwent delayed internal fixation of the ulna using a compression plate af-

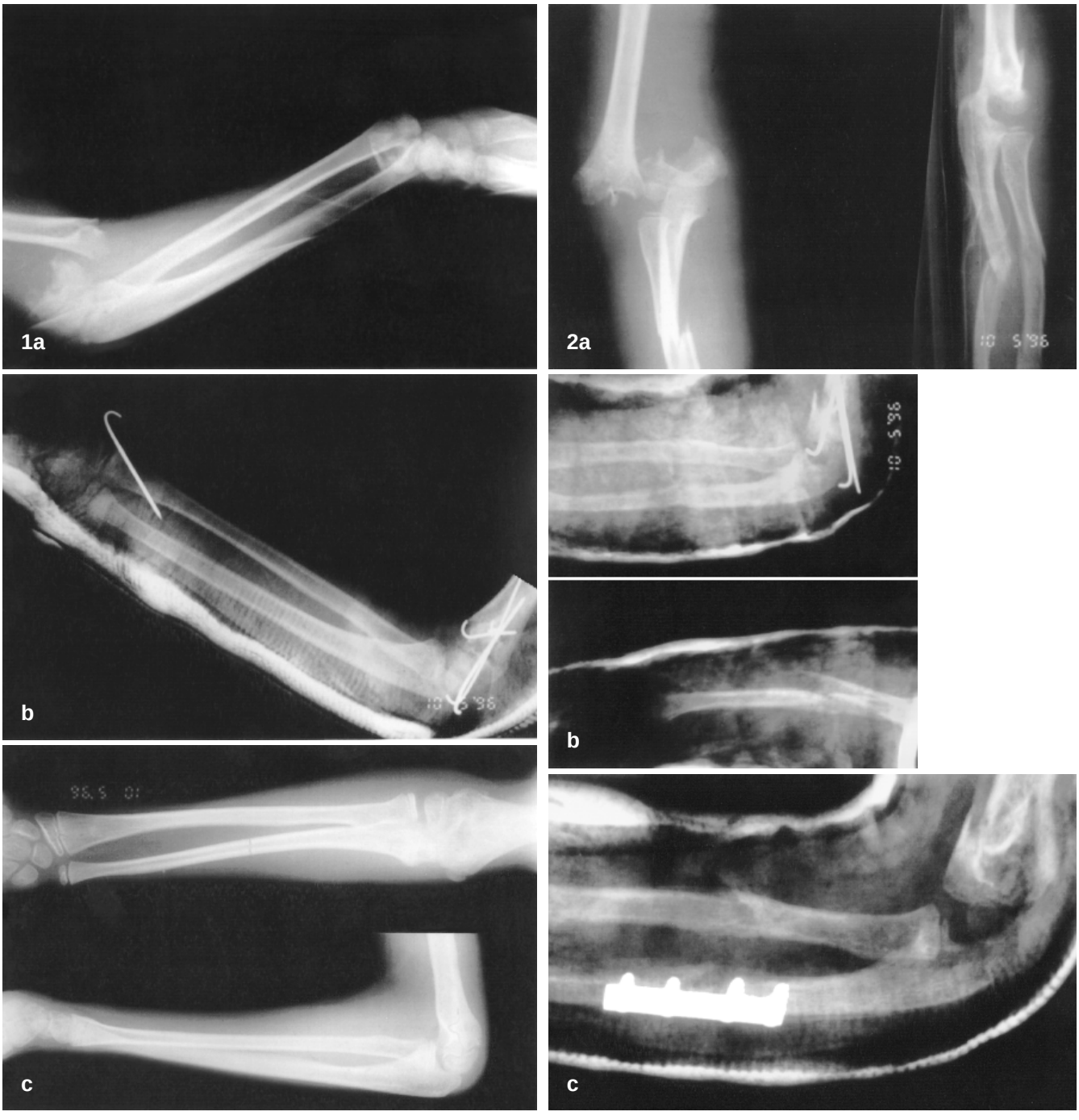

Fig. 1 Radiographs of the right arm of a 10-year-old boy after a fall from a tree. He sustained an open elbow injury and a closed distal forearm injury. **a** Long lateral film showing marked displacement of both fractures. **b** After reduction and K-wire fixation. **c** One year post-injury

Fig. 2 Radiographs of a 9-year-old girl after a road traffic accident. **a** Anteroposterior and lateral views; note proximal third forearm fracture. **b** After closed reduction, K-wire fixation of the elbow injury alone allowed subsequent loss of reduction of the forearm fracture at 2 weeks. **c** After removal of K-wires and internal fixation of the ulna

ter loss of reduction following closed manipulation and cast immobilisation of the forearm fracture (Fig. 2). All K-wires were trimmed and left deep to the skin after bending the tip to prevent migration. The five open injuries were managed with debridement and split-skin graft (n = 1), delayed primary closure (n = 2), healing by secondary intention (n = 2).Patients underwent a detailed clinical and radiological assessment at a minimum of 18 months post-injury. The range of movement at the elbow and wrist and the carrying angle were measured with a goniometer, and all measurements were compared to the contralateral normal limb. The outcome was graded according to a clinical scale proposed by Flynn modified to include assessment of the wrist [2, 11] (Table 3). The elbow and forearm were assessed separately, and the lower of the two results was taken as the result for that limb.

Table 1 Patient details (n = 12; mean age 8.2 years, range 5–12 years)

Sex:	
Male	8
Female	4
Side:	
Right	4
Left	8
Mechanism of injury:	
Fall from height	8
Other falls (skateboard, bicycle, football)	3
Road traffic accident	1

Table 2 Injury details

Supracondylar fracture:	
Closed	8
Open	4
Gustilo I	2
Gustilo II	2
Classification:	
Gartland/Wilkins grade III	12
Extension type	12
Associated injury:	
Median nerve	2
Ulnar nerve	1
Absent radial pulse	1
Forearm fracture:	
Closed	11
Open (Gustilo II)	1
Both bones:	6
Distal third	5
Proximal third	1
Radius alone:	6
Classification (Salter Harris):	
I	3
II	3

Results

Ten patients (83%) had a good or excellent outcome at the final follow-up (Table 3). Two patients had a fair result. One patient who underwent operation following loss of position after closed reduction of a mid-forearm fracture lost 35° of supination. A second patient had an extension deficit at the elbow of 15° after a Gustilo II open injury which required a split-skin graft. There were no infections and no failures of fixation. No patient had a change in the carrying angle at the elbow of more than 6°. Three patients with a neurological injury at presentation had fully recovered by between 6 and 16 weeks. Radiographs showed no evidence of growth disturbance in those cases where K-wires had transfixed the growth plate of the distal radius (Fig. 1).

Discussion

A good or excellent result was achieved in ten patients (83%). This is similar to the reported outcome for isolated supracondylar fractures. However, the floating elbow represents a more serious injury than an isolated supracondylar fracture and reflects a more violent episode of trauma.

Table 3 Assessment results in 12 patients (all measurements in degrees)

Case	Injury mechanism	Treatment[a]	Soft-tissue injury	Comment	Loss of elbow flex/extension	Loss of forearm pro/supination	Loss of wrist flex/extension	Change of carrying angle	Result[b]
1	Fall (skateboard)		Gustilo I elbow	Median nerve injury	5	12	0	0	Excellent
2	Fall from tree (3.5 m)	Open reduction elbow	Gustilo I elbow		8	8	4	2	Good
3	Fall (swing)	Forearm MUA+POP			0	0	0	0	Excellent
4	Fall (swing)	Open reduction elbow			4	0	0	4	Excellent
5	Fall (goal post)	Forearm MUA+POP			0	6	8	0	Excellent
6	Fall on stairs (2.5 m)	Forearm MUA+POP		Ant. inteross nerve injury	5	8	0	2	Excellent
7	Fall from ladder (4 m)	Open reduction elbow		Ulnar nerve injury	10	5	4	6	Good
8	Fall from tree (4.5 m)	Open reduction elbow	Gustilo II elbow	SSG elbow wound	15	8	0	6	Fair
9	Fall (goal post)				4	10	6	0	Excellent
10	Football	Forearm MUA+POP			0	8	12	0	Good
11	Farm machinery injury	Open reduction forearm	Gustilo II forearm		6	25	10	4	Good
12	RTA	Open reduction elbow, secondary ORIF ulna	Gustilo II elbow		8	35	10	5	Fair

[a] Closed reduction and percutaneous K-wire fixation of both elbow and forearm injuries unless stated
[b] Outcome classified according to modified Flynn criteria (Table 4)

Table 4 The modified Flynn classification (all measurements in degrees compared with normal un-injured limb; the largest deficit for movement in each plane is taken for assigning a clinical grade)

	Loss of elbow flex/extension	Loss of forearm pro/supination	Loss of wrist flex/extension	Change in carrying angle
Excellent	0– 5	0–15	0–15	0– 5
Good	6–10	16–30	16–30	6–10
Fair	11–15	31–45	31–45	11–15
Poor	> 15	> 45	> 45	> 15

All but two injuries were the result of a fall, and two-thirds resulted from a fall from a considerable height. It has been suggested that if the forearm fracture occurs proximal to the junction of the middle and distal third, then the lever arm of the proximal forearm is too short to generate the necessary moment of force required to produce a humeral fracture [11]. However, one patient in our series had a forearm fracture proximal to this level. We consider that the occurrence of a supracondylar fracture with a proximal forearm injury is an indicator of the greatest traumatic force in patients with a floating elbow injury.

The incidence of open fractures (33%) and neurological injury (25%) is much higher than those reported for isolated supracondylar fractures. In a meta-analysis of 61 studies totalling 7,212 supracondylar fractures, Wilkins reported open injuries in 1% and neurological injury in 7.7% [12]. Similarly, open reduction is more frequently required in patients with a floating elbow injury (50%). This is because the greater violence involved results in a more severely displaced supracondylar fracture. There is an increased likelihood that the spike of the proximal humeral fragment will become 'button-holed' through the anterior soft tissues, rendering the fracture irreducible by closed manipulation.

Although difficult to perform on a severely swollen limb, one benefit of performing an open reduction is that it allows the evacuation of the large anterior haematoma, resulting in rapid resolution of swelling. Williamson and Cole employed traction and delayed manipulation with percutaneous pinning in patients with severe elbow swelling, which they recognised as a major problem [13]. However, the prolonged hospitalisation required by traction introduces financial and psychological concerns for patients and their families [8]. Also, traction does not allow adequate access to the limb for monitoring purposes. We agree with Stanitski and Micheli that the supracondylar fracture deserves priority in this combined injury because of the greater potential for associated complications [10]. Once the elbow injury is stabilised, the management of the forearm fracture is relatively straightforward, and the treatment of the soft-tissue injury in open fractures is greatly facilitated. With one exception all previous studies of ipsilateral elbow and forearm fractures have recommended closed reduction of the forearm fracture [11], and four patients in this series were successfully treated in this way. However, in each of these four cases, the forearm injury involved the radius only, with a Salter-Harris I/II epiphyseal injury. Five patients sustained a fracture of both bones in the distal third with complete displacement and were treated by percutaneous K-wire fixation. This allowed immobilisation with the wrist in a neutral position. Management of such severely displaced forearm fractures by closed reduction and casting in a position of pronation and palmar flexion would make it difficult to monitor the radial pulse and impossible to adequately test finger and wrist movement. Our practice of trimming the K-wires beneath the skin resulted in no pin-track infections, but this did necessitate a second general anaesthesia to remove the wires.

The floating elbow in children is a serious injury that reflects high-energy trauma. Most of the children in this series fell from a height of 2 m or more. Nevertheless, excellent results can be anticipated with aggressive operative management. Previous reports which suggested that 'regardless of treatment and severity of injury, results did not differ appreciably from the common forearm or elbow injuries' are misleading, as they included undisplaced and incompletely displaced supracondylar fractures in the definition of the floating elbow [7]. We consider that non-operative management of the elbow injury in these patients by closed reduction and plaster immobilisation is contraindicated. Rather, because of its nature and the severe swelling associated with this high-energy injury, the floating elbow injury demands definitive operative stabilisation.

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