REFRACTURE OF THE FOREARM IN CHILDREN

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In a retrospective study we reviewed 28 refractures of the forearm in children, which occurred at a mean of 14 weeks after conservative treatment of the primary fracture. The cause for the refracture was incomplete healing of a primary greenstick fracture in 21 cases (84%). Twenty-two recurrent fractures were treated conservatively, but two had a second refracture.

Fifteen patients were followed for over two years. Definitive angulation of more than 10° caused a deficit of forearm rotation.

To prevent refracture of the forearm in children, complete and circular consolidation of the primary fracture must be guaranteed.

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In children, refracture is a relatively common complication of a forearm fracture, seen in about 5% of cases (Tischer 1982). There are few published reports: we could find only four papers which dealt specifically with this subject (Arunachalam and Griffiths 1975; Filipe, Dupont and Carlzioz 1979; Gruber and von Laer 1979; Lascombes et al 1988). These discussed the causes of refracture, but gave little information about treatment and outcome. Lascombes et al (1988) suggested that such fractures should be treated "more vigorously than the primary fracture", but provided no details or results.

Refracture is thought to be caused by repetition of the same injury (Arunachalam and Griffiths 1975), by impaired

local perfusion (Frinta 1957), by removal of plaster too early (Lascombes et al 1988; Ogden 1990), by poor cast technique (Hager, Ploberger and Povacz 1989), or by inadequate reduction (Gruber and von Laer 1979). The most convincing theory is based on the observation that most refractures occur after greenstick shaft fractures which have not fully healed because of persistent angulation (Filipe et al 1979; Gruber and von Laer 1979). Incomplete consolidation is thought to reduce the strength even months after the original fracture. Our review aimed to test the hypothesis that incomplete consolidation was an important cause of refracture of the forearm in children, and to compile data concerning treatment and outcome.

PATIENTS AND METHODS

Our retrospective multicentre study involved a total of 28 patients from nine hospitals. They were selected on the basis of the diagnosis of a refracture, and not on the forearm fracture. No conclusion can be drawn therefore on the frequency of refracture.

We defined refracture as one which is at least partly in an older fracture line, with an obvious causal connection. In a greenstick fracture in diaphyseal cortical bone, one cortex is ruptured transversely and the opposite cortex is bent, but not broken. The cortical fracture commonly ends in fissures parallel to the long axes of both proximal and distal fragments (Figs 1 and 2).

Primary fracture. There were 23 boys and 5 girls aged 4 to 13 years: the left side was involved in 16, the right side in 12 cases. Four patients had incomplete radiological records of the primary fracture; these are included only in the analysis of refractures.

Of 24 sets of primary radiographs, 16 showed that both the radius and ulna had been fractured and six showed only radial and two only ulnar fractures. There were greenstick fractures of 16 ulnae and 15 radii, with complete fractures in two ulnae and six radii and a torus fracture in one radius (Table I). Sixteen ulnar and 15 radial fractures were in the middle third of the shaft.

The primary fractures had been treated in an above-elbow cast for 3 weeks (2), 4 weeks (6), 5 weeks (5), 6 weeks (11), and 7 weeks (1). In three patients the duration was not recorded.

The primary fracture was followed up for less than six months in six patients, for six to 12 months in two, for 12 to 24 months in five, and for over 24 months in 15 patients up to a maximum of 26 years.

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Fig. 1

A five-year-old boy had plaster fixation of a greenstick fracture of the forearm (A). There was a marked fracture gap on the volar site of the radius and ulna six weeks after injury (B arrow). Refracture 16 weeks after injury was caused by a fall in the street (C).

Refractures. Eighteen of the 24 patients had had a greenstick fracture of one or both forearm bones, and in all but one there was persistent angulation, usually in a dorsal direction with incomplete consolidation of the original fracture. The gap in the fractured cortex had widened during immobilisation; on this side of the bone there had been no bony bridging before refracture (Fig. 1). Three other patients showed incomplete consolidation, two after a complete fracture, and one in whom the type of the original fracture was not known. Thus in 21 of the 25 patients who could be assessed there had been incomplete consolidation before the refracture (Table II).

Four patients apparently had complete healing of the primary fracture before refracture. One child with a torus fracture treated in plaster for three weeks sustained a refracture in a fall from a wall four weeks later. One other fell from a bicycle and another from an unknown height, both at ten weeks after the primary fracture. The fourth patient had a fall after 12 weeks. Refractures were seen at 4 to 32 weeks (mean 13.8) after the primary fracture; 12 patients refractured later than three months after the first injury.

The refracture was completely displaced in most patients; seven were incomplete and there was only one greenstick fracture. Four refractures were treated operatively by plating or intramedullary pins. Two other

Fig. 2

A six-year-old boy had conservative therapy of a greenstick fracture (A). There was complete healing of only the radius (B arrow). A refracture (C) was treated conservatively and again showed complete healing of the radius, but with a persistent fracture gap on the ulna (D). Twenty-three weeks after the initial injury the patient had a second refracture (radiographs not available) which was also treated by plaster cast. Two years after the first injury the patient was asymptomatic with a free range of movement and an almost anatomical radiological result (E).

Table I. Details and results of treatment of refracture of the forearm in 28 children

Case	Age	Type of first fracture		Delay* (wk)	Refracture	Therapy (wk)	Follow-up (mth)	Limitation ROM	Axial deviation
		Radius	Ulna						
1	9	Greenstick	Greenstick	30	Ulna	POP	4 36	None	Radius 15°
2	5	Greenstick	Greenstick	14	Both		4 0		
3	13	Greenstick	Intact	18	Radius		6 20	None	Radius 3°
4	11	Greenstick	Greenstick	8	Both	Plate	15	None	Radius 5°, ulna 5°
5	5	Intact	Greenstick	7	Ulna		4 5	None	None
6	4	Greenstick	Greenstick	8	Both		7 0		
7	13	Greenstick	Intact	15	Radius		4 9	Supination -60° Pronation -20°	Radius 20°
8	6	Greenstick	Greenstick	21	Both		5 53	None	Radius 5°
9	4	Greenstick†	†	4	Radius		6 141	Supination -5°	Radius 5°
10	8	Greenstick	Greenstick	10	Both		8 12	None	Radius 5°, ulna 5°
11	6	Intact	Greenstick	8	Ulna		6 139	None	Ulna 5°
12	10	Complete	Greenstick	14	Both		6 164	None	Radius 3°
13	11	Greenstick	Intact	30	Both		6 228	Supination -60° Pronation -25°	Radius 18°
14	13	Greenstick	Greenstick	12	Both	Plate	84	None	None
15	7	Greenstick	Greenstick	10	Both		6 0		
16	12	Complete	Greenstick	22	Both		5 0		
17	7	Greenstick	Greenstick	16	Both		6 8	Not evaluated	Radius 3°, ulna 8°
18	4	Greenstick	Intact	6	Radius		4 108	None	None
19	6	Greenstick	Greenstick	8	Both		8 23‡	None	Radius 5°
20	12	Complete	Intact	22	Radius		8 24	Supination -80° Pronation -55°	Radius 20°
21	12	Greenstick	Greenstick	17	Both		8 123	None	Ulna 5°
22	13	Complete	Complete	10	Both		6 200	Supination -10° Pronation -15°	Radius 15°, Ulna 15°
23	9	Subperiost	Intact	4	Radius		4 20	None	None
24	10	Complete	Greenstick	10	Both	Plate	34	None	None
25	6	Complete	Complete	8	Both	Plate	0		
26	11	†	†	11	Both	Wires	49‡	None	Radius 8°
27	7	†	†	32	Both	Wires	45	Supination -5°	Radius 8°
28	4	†	†	10	Both		4 30	Supination -30° Pronation -15°	Radius 8°

*between first fracture and refracture

†missing radiograph

‡two refractures

Fig. 3

A seven-year-old boy one week after injury (A); the fracture was completed (C) for persistent angulation (B arrow). The fracture healed by circular callus formation (D). The clinical and radiological outcome two years later was perfect (E).

patients with increasing angulation required secondary open reduction and internal fixation. There were no complications or problems with fracture healing after operation.

Conservative treatment of the refracture led to complete circular consolidation in all but five patients, one of whom had a second refracture (Fig. 2). One other patient sustained a second refracture with no obvious cause, but the radiographic series was incomplete and could not be evaluated.

RESULTS

A total of 23 patients was followed up for six months after refracture and 15 for two years or more.

At six months none had pain and movements were full with the exception of forearm rotation (Table I). Of the 17 treated conservatively, 11 had no limitation and three had less than 50% loss of forearm rotation. Three patients had a loss of over 50% as compared with the contralateral side due to an angulation of more than 10°. In the six patients operated on for the refracture, only one had angulation of only 8°, and only one had a supination deficit of 5°.

At two years after injury ten of the 11 patients reviewed after conservative treatment showed some angulation; this was greater than 10° in five, and over 20° in the other five. Three of the latter five patients had functionally impairing

limitation of forearm rotation by more than 50%, but only one of the five with angulation under 10° had slight limitation of rotation. The three children with permanent functional impairment were all older than ten years of age at the time of injury, and their loss had not improved since the six-month review. After operative treatment angulation was under 10° in two and absent in two. One patient had a loss of supination of 5°; the others were normal.

DISCUSSION

In children greenstick fractures of the forearm need special attention because the elasticity of the intact part of the cortex can impede healing and adversely affect conservative management. Blount, Schaefer and Johnson (1942) therefore proposed that this cortex be fractured, and Ogden (1990) agreed, although admitting that this may predispose to recurrent displacement. On refracture Blount et al (1942) stated that this is frequent during the first six months after trauma, and Gruber and von Laer (1979) showed a relationship between greenstick injuries and refracture, with an incidence of 34% of greenstick fractures in a series without refracture, but of 85% in those with refracture. Filipe et al (1979) discussed angular deviation as a cause of refracture.

Table II. Causes of refracture of the forearm in 25 children

	Number
Greenstick fracture with incomplete consolidation	21
Duration of fixation too short	1
Adequate second injury possible	2
No explanation	1

In our series of 25 refractures 84% showed incomplete consolidation, and this was almost always associated with angulation of a greenstick fracture. It is obvious that periosteal new bone formation is limited because of the relative stability provided by the intact section of cortex in greenstick fractures. The lack of compression forces impedes fracture healing, and there is often widening of the fracture gap during treatment. These gaps can heal spontaneously. We have seen this after primary fracture and refracture, but it is uncertain how long this takes; it may be from two to six months. We have seen no unhealed fracture gaps after six months.

Such a healing disturbance is rarely seen in complete primary fractures as the lack of stability in conservative treatment initiates the production of circular periosteal callus. Thus, refracture in complete fractures of the forearm is rare (Gruber and von Laer 1979). How can refracture of the forearm be prevented? If the observation is correct that all fracture gaps close spontaneously, protection by a splint for up to six months after injury should be curative. Lascombes et al (1988) immobilised fractures of the forearm in children for 90 days and recommended further immobilisation until remodelling of the cortex occurred in the case of partial healing.

It is assumed that correct and complete reduction of a greenstick fracture prevents incomplete healing by exerting intrafragmentary compression. Whether this can be done by a careful plaster technique (Ogden 1990) remains to be answered. The other method is to break the intact cortex thus producing an unstable fracture similar to a complete

fracture (Fig. 3). Gruber and von Laer (1979) and Lascombes et al (1988) favour this method whereas von Laer (1996) advocates it only for all fractures with an angulation of more than 20°; in those with angulation of less than 20° he suggests closure of the transverse fracture gap by wedging of the plaster.

We are not aware of any study which has prospectively evaluated the rate of refracture after different treatment methods of the primary fracture. Prevention of refracture means prevention of healing disturbances as the refracture is closely related to an incompletely healed primary fracture. Conservative treatment of the refracture gave very good or good results in 14 out of 17 patients. Three patients, however, had pronounced restriction of forearm rotation. Healing in a malaligned position should be avoided in patients older than ten years because of the limited potential for correction. If maintenance of reduction of a refracture is not possible, early open reduction and internal fixation is indicated. The disadvantage of operation is balanced by an almost ideal result.

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