BUTTERWORTH HEINEMANN

Injury Vol. 26, No. 9, pp. 587–593, 1995

0020–1383/95 $10.00 + 0.00

0020-1383(95)00111-5

A new functional brace for the treatment of Colles' fractures

J. S. Moir, S. R. Murali, G. P. Ashcroft, D. Wardlaw and A. B. Matheson[1]

Departments of Orthopaedics and [1]Accident & Emergency Medicine, Aberdeen Royal Infirmary, Aberdeen, Scotland, UK

A new prefabricated brace for the functional treatment of Colles' fractures has been developed. It is applied at fracture reduction and maintains fracture position by the application of three-point loading. In a prospective randomized clinical trial treating 85 displaced Colles' fractures, with blind independent follow-up, the brace gave better functional results than conventional plaster treatment. The improved function was apparent up to 6 months after injury. Finger function and pinch strength were also better in the brace-treated patients. Anatomical results were similar in the two groups.

Injury, Vol. 26, No. 9, 587–593, 1995

Introduction

The eponymous fracture of Abraham Colles[1] is one of the commonest in orthopaedic practice and yet the optimal method of treatment remains a matter of debate. Dissatisfaction with the results obtained from cast immobilization has led to the promotion of various other methods of maintaining fracture reduction, including 'pins in plaster'[2–4] external fixation[5–7], percutaneous wiring[8–10], and open reduction and internal fixation[11,12]. These operative methods all have their own complications[13–15] and, in view of the epidemiology of the fracture, it is likely that the majority of patients will continue to be treated without operation.

Functional treatment has attracted some interest in recent years largely due to the work of Sarmiento et al.[16,17]. However, despite some encouraging trials[18–20], bracing of Colles' fractures has not become a popular method of treatment.

Recently Ledingham et al.[21] reported improved anatomical and early functional results in displaced Colles' fractures treated *ab initio* in a plaster brace compared to treatment in a conventional forearm cast. This brace maintained fracture reduction by three-point loading while allowing almost free movement of the radiocarpal joint. The brace required some expertise in application and therefore a prefabricated brace with 'in-built expertise', which can be applied by relatively inexperienced staff, has been developed.

A prospective randomized clinical trial has been carried out comparing the Aberdeen Colles' fracture brace with conventional plaster immobilization in the treatment of displaced Colles' fractures.

Materials and methods

Entry criteria to the trial were a Colles' fracture requiring reduction, the patient being 18 years or older with fused epiphyses, with no previous fracture to either wrist or bilateral wrist fractures (as the non-injured wrist was used for comparison) and the ability to understand simple instructions and co-operate with treatment.

Randomization to different treatments was computer generated, and due to the spread of medical expertise in those treating these patients, junior doctors each had a randomization sheet. In both groups the cast or brace was applied immediately after reduction under general or regional anaesthesia.

Control treatment

Patients randomized to standard plaster immobilization were treated in a moulded dorsoradial plaster slab which was completed to a full forearm cast following check radiographs at 10 to 14 days.

Brace treatment

The brace consists of two pieces of plastic, a larger dorsoradial portion with distal and proximal raised loading areas and a smaller volo-ulnar portion with one loading area, connected by two elasticated Velcro straps (*Figure 1*). It is applied, over layers of stockinette and plaster wool, immediately following reduction of the fracture. The slack in the straps is taken up and the straps are then tightened by 3 cm as shown by coloured markers, stretching the elastic, and applying a three-point loading to the forearm which is maintained by the energy stored in the elastic. The ends of the stockinette are then folded back over the brace and taped together to discourage tampering with the straps.

Studies using intracast pressure measurements have verified that a three-point load is applied by the brace, even as fracture swelling reduces, due to the tension stored in the elastic straps. This is maintained throughout fracture healing. In comparison a moulded plaster cast quickly becomes ineffective[22].

In both groups, check radiographs were carried out at 10 to 14 days and, if satisfactory, treatment was continued

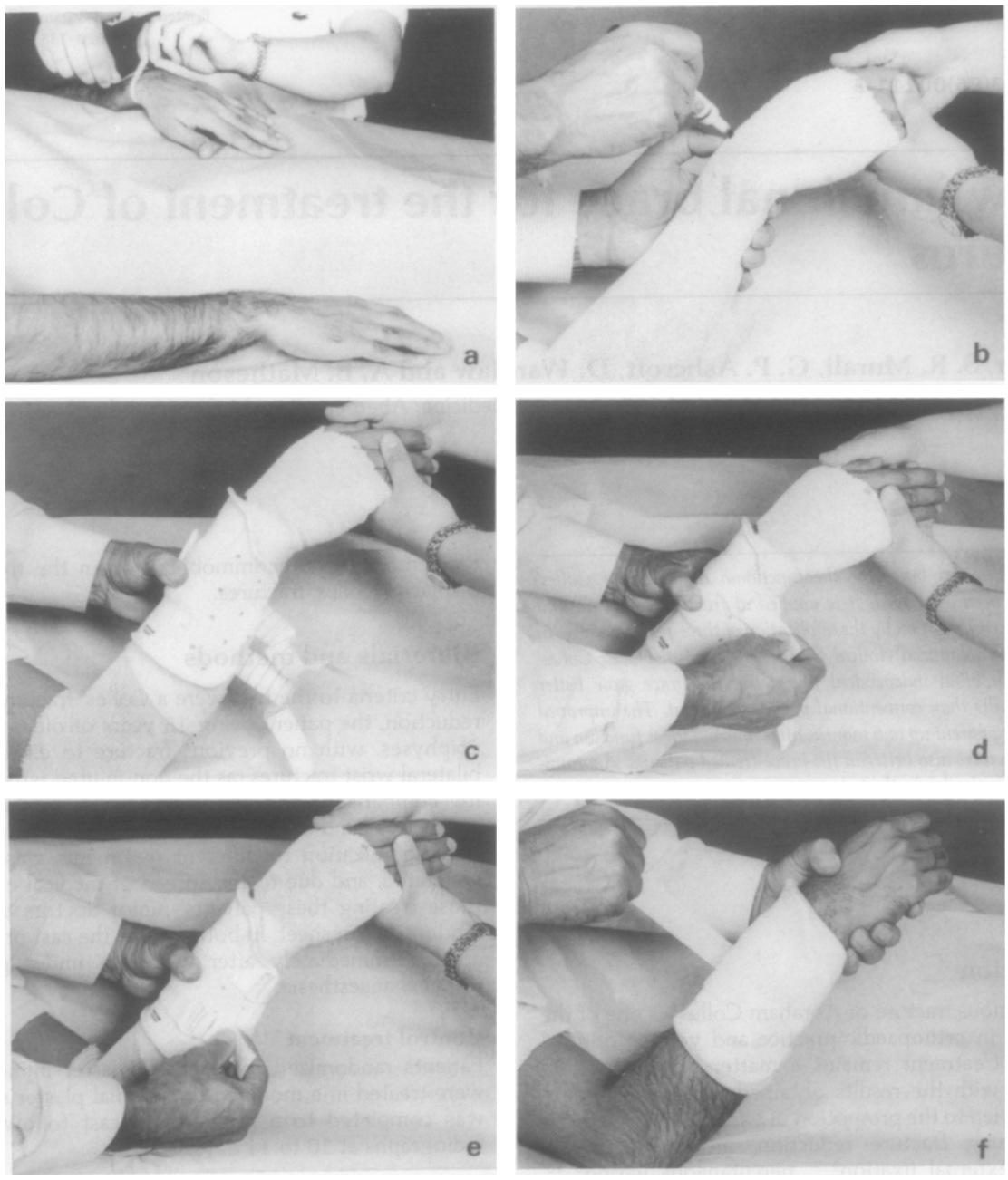

Figure 1. Method of application of brace. *a*, Measure un-injured wrist circumference and select brace of correct size. *b*, After reduction of fracture, fit stockinette and mark the level of the radial styloid. *c*, Fit brace with the forearm in neutral rotation. Apply the dorso-radial portion with the distal end at the level of the radial styloid so that it lies obliquely on the forearm. *d*, Position volo-ulnar portion and firmly compress the two parts together. Pass the distal strap through the loop and take up the slack. Note the colour marking and tension the strap three marks to next mark of same colour. Fix Velcro. *e*, Similarly tension the proximal strap. Check wrist movement to ensure correct level of application. *f*, Fold back the stockinette and tape in position. Carry out check radiograph to confirm reduction. Post-operative elevation is recommended.

until the splint was removed at 5 to 6 weeks.

If re-reduction was required the initial treatment method was continued.

Assessment

Patients were usually seen on the day following reduction for a routine clinical check, again at 10 to 14 days, and then at plaster or brace removal at 5 to 6 weeks after fracture. Blind functional assessment of recovery was carried out by an independent assessor (A.B.M.) at 8, 13 and 26 weeks after fracture, using a modification of the Gartland[23] demerit scoring system (*Table I*).

Grip strength and pinch strength measurements were carried out with an electronic dynamometer (MIE Medical Engineering Ltd, Leeds, UK) comparing results with the un-injured side.

Anatomical assessment was made using the radiographic displacement method of Lidstrom[24], and Sarm-

iento et al.[17], which has been modified to a demerit scoring system, using radiographs at presentation, post-reduction, 10 to 14 day check, and at cast or brace removal as the result, with comparison with the normal wrist (*Table II*). An analogue pain score was also marked by the patients at each assessment.

Statistical analysis was by the Mann–Whitney *U*-test for the comparison of population medians when a parametric distribution could not be assumed, and the corresponding two-sample *t*-test for variables where a normal distribution could be assumed.

Results

Eighty-five patients were entered. Six patients – five brace and one control – were withdrawn and therefore follow-up was available for 44 brace and 35 control patients. The mean age was similar for both groups (*Table III*).

Functional results were significantly better in the brace treated group at 8, 13 and 26 weeks (*Table IV*).

By the Frykman[45] classification of fracture severity (Grade I (least severe) to Grade VIII (most severe)) the median score in the brace group was V and the control group was IV, but this was not significant. Despite randomization, the group of brace-treated fractures were initially less severely displaced than the control patients as measured by the Sarmiento[17] scoring method. The brace group had a better score following reduction than the control group, possibly reflecting the initial displacement, and both groups lost equivalent position during splintage (*Table V*). Grip strength was better in the brace group at splint removal and at 8 weeks, but by 13 weeks this advantage was lost (*Table VI*). However pinch strength in the brace group remained significantly better than the control group throughout most of the treatment and follow-up period (*Table VII*).

Three patients were withdrawn from the brace group because of 'discomfort' in the brace, one in each group because marked fracture instability led to operative treatment, and one was withdrawn because the brace had been incorrectly applied. At each visit the patients were asked to fill in an analogue pain score, from '0 = no pain' to '10 = most severe pain'. *Table VIII* shows that there was little difference between the two groups either at presentation or during treatment but during the follow-up period there was initially a better score in the brace group, especially at the time of splint removal, suggesting that towards the later stages of treatment the brace was more comfortable than plaster.

Finger movement and hand swelling were also assessed during splintage. Finger movement was poor if none of the fingers could be flexed to touch the palm and swelling of

Table I. Functional scoring method

Subjective complaints					
Pain	Limitation of movement	Disability	Restriction of activity	Result	Score
None	None	None	None	Excellent	0
Occasional	Slight	None	None	Good	2
Occasional	Slight	Minor	Some	Fair	4
Often	Present	Definite	Marked	Poor	6
Objective evaluation					
Movement/function		*Range (degrees)*			
Dorsiflexion		< 45			5
Palmar flexion		< 30			1
Ulnar deviation		< 15			3
Radial deviation		< 15			1
Supination		< 50			2
Pronation		< 50			2
Circumduction		loss			1
Finger flexion		Not to distal crease			1–2
Grip		Loss of strength (< 60% normal side)			1
Complications					
Median nerve compression					1–3
Other (e.g. ulnar nerve compression)					1–2

Final grade: excellent 0–2, good 3–8, fair 9–14, poor 15+.

Table II. Anatomical scoring method

Dorsal angle	*Loss of radial length (mm)*	*Loss of radial angle*	*Score*
Neutral	< 3	0–4°	0
1–10°	3–6	5–9°	1
11–14°	7–11	10–14°	2
> 15°	12+	15°+	4

Final grade – combined score: excellent 0, good 1–3, fair 4–6, poor 7–12.

the dorsum of the hand assessed as either mild/moderate or severe (*Table IX*). It can be seen that finger movement in the brace group was better throughout the treatment period. Also fewer patients had hand swelling in the brace treated group at the first day check (although one-fifth of those were classified as severe) and at cast removal (when no patients had severe swelling).

Four brace and two plaster treated patients required re-reduction of the fracture following the routine radiographic check at 10 to 14 days. In all but one of these cases the initial reduction was inadequate, and the initial treatment method was continued uneventfully (*Table X*).

Eight brace-treated and five control patients had evidence of median nerve compression although none were severe enough to merit operative decompression and all but three had settled completely by 6 months. Four patients had symptoms suggestive of ulnar nerve compression and two, although mild, persisted to the 6-month follow up.

A complication unique to the brace-treated patients was paraesthesia and/or numbness over the distribution of the superficial radial nerve, presumably due to direct pressure by the distal loading area of the brace. All such symptoms resolved by 6 months.

Two patients in the brace group had a mild reflex sympathetic dystrophy which persisted beyond 3 months and three cases were noted in the control group for a similar period. None required more active treatment than physiotherapy.

Discussion

Since the publications of Sarmiento et al.[16,17] on functional bracing of Colles' fractures there has been increased interest in this subject. Sarmiento advocated bracing in supination to counter the action of the brachioradialis muscle, which, he maintained, leads to loss of fracture reduction, and reported 90 per cent excellent or good functional results following bracing in supination.

In clinical trials, some investigators have also found improved function after bracing in supination[18–20] while others have found no benefit over conventional treatment[26], or only for selected fractures[27]. In these trials, there was an initial period of cast immobilization before brace application. An alternative to bracing in supination is the 'Chinese method'[28], using either wood or plastic splints to construct a brace which maintains fracture reduction by direct dorsoradial loading over the fracture fragment while allowing movement at the radiocarpal joint. Good results have been reported[29,30], but this method has not gained acceptance, possibly owing to significant risk of circumferential compression and hand swelling observed in the brace.

Using a plaster brace, which applied a three-point loading to the fracture in a method similar to that described by Charnley[31], and yet allowed free movement at the radiocarpal joint, Ledingham et al.[21] showed improved anatomical and functional results over conventional plaster immobilization. This brace required some expertise in its application.

A prefabricated brace which can be applied by less experienced staff has been developed. This is available for both sides and in three sizes, chosen according to the circumference of the uninjured wrist. It is straightforward to apply at the time of fracture reduction by following simple instructions. If required it may be adjusted by the clinician during treatment, although this should not be necessary if applied correctly. In fact, in this study, one brace was applied inverted and at least one other was considered to be too loose, and therefore ineffective at maintaining reduction. This emphasizes the importance of understanding the mechanism of the brace and following application instructions correctly.

The two groups in this prospective study were similar in terms of age, sex, and hand dominance. The control group were initially more displaced than the brace-treated patients and this was maintained following reduction and at splint removal. Although by the Frykman[25] grading system of fracture severity, which depends on the relationship of the fracture lines to the radio-carpal and radio-ulnar joints and also on the presence of an ulnar styloid fracture, there was no significant difference between the median scores for the two groups, approximately $\frac{2}{3}$ of the brace group were intra-articular fractures, which would be expected to give a poorer outcome, compared to $\frac{1}{2}$ of the control group. Also there may be associated injuries, such as to carpal ligaments and the triangular fibrocartilage, not obvious on plain radiography, which increase the heterogeneity of distal radial fractures.

The relationship between initial displacement of the fracture and early function, and anatomical result and late function, is still a matter of controversy.

Stewart et al.[26] reported that the functional result at three months was related to initial displacement, but that this effect was lost at 6 months. Lidstrom[24] found that the amount of primary displacement had little effect on the end results. de Bruijn[27] found a correlation between anatomical

Table IV. Functional results: median values (Mann–Whitney *U*-test)

	8 weeks	*13 weeks*	*26 weeks*
Brace	10	4	2
Control	14	11	5
P value	0.02	0.003	0.02

Excellent 0–2, good 3–8, fair 9–14, poor 15+.

Table III. Trial demography

	No. entered	*Withdrawals*	*No. followed*	*Age*	*Wrist injured*	*Sex (F:M)*
Brace	49	5	44	Median 55 (22–86)	20D : 24ND	38:6
Control	36	1	35	Median 60 (21–84)	17D : 18ND	32:3

Withdrawals: from brace group, 1 due to fracture instability (had operative treatment), 3 due to discomfort in brace, 1 due to incorrect application of brace; from control group, 1 due to fracture instability (had operative treatment). D, dominant; ND, non-dominant.

Table V. Anatomical results: median values (Mann–Whitney *U*–test)

	Frykman score	*Anatomical score*			
		Presentation	*Post reduction*	*Check*	*Result*
Brace	V	6	0	2	3
Control	IV	8	1	3	4
P value	0.3	0.004	0.001	0.04	0.01

Excellent 0, good 1–3, fair 4–6, poor 7–12.

Table VI. Grip strength as % of uninjured side (two sample *t*-test)

	Day 1 (post-op.)	*Days 10–14*	*Splint removal*	*8 weeks*	*13 weeks*	*26 weeks*
Brace	8	15	34	50	60	73
Control	10	12	23	35	54	71
P value	0.3	0.2	0.001	0.0006	0.1	0.6

Table VII. Pinch strength as % of uninjured side (two sample *t*–test)

	Day 1 (post-op.)	*Days 10–14*	*Splint removal*	*8 weeks*	*13 weeks*	*26 weeks*
Brace	19	26	50	65	77	87
Control	10	17	40	52	70	80
P value	0.03	0.02	0.04	0.01	0.2	0.07

Table VIII. Analogue pain score; median (Mann–Whitney *U*-test)

	Presentation	*Day 1 (post-op.)*	*Days 10–14*	*Splint removal*	*8 weeks*	*13 weeks*	*26 weeks*
Brace	6	5	3	1	1	1	0
Control	6	4	4	2	2	1	1
P value	0.4	0.4	0.5	0.02	0.048	0.3	0.4

10, 'most severe pain' to 0, 'no pain'.

Table IX. Early complications (%)

	Poor finger movement (unable to touch palm with fingers)			*Hand swelling (assessed as mild/moderate or severe)*		
	Day 1 (post op.)	*Day 10–14*	*Splint removal*	*Day 1 (post-op.)*	*Day 10–14*	*Splint removal*
Brace	64	21	9	75 (19 severe)	43 (5 severe)	26
Control	46	39	32	86	39	41

Table X. Other complications (number of patients)

	Re-MUA	*Median nerve compression*	*Ulnar nerve compression*	*Sup. radial nerve compression*	*RSD*
Brace	4	8	1	3	2
Control	2	5	3	0	3

and functional end results, and a causal relationship between initial displacement and functional end results. Bunger et al.[18] found no functional difference between patients treated by plaster immobilization, functional bracing, and external fixation at 3 and 6 months, although the anatomical result was better after external fixation. Gartland and Werley[23] found that poor anatomical results adversely affected the functional results, although Porter and Stockley[32] did not find a clear relationship between anatomical and functional results at two years unless the deformity was severe. However, McQueen and Caspers[33] stated that mal-union of a Colles' fracture resulted in significant functional deficit, and although Frykman[25] found that intra-articular involvement was the most important indicator of outcome, he conceded that functional outcome deteriorates with increasing deformity.

The functional results in our series were superior in the brace group throughout the follow-up period. Both groups lost some of the reduction. In the brace group the initial displacement was less severe and the anatomical result was better.

Grip strength was better initially in the brace group, though this was lost by 3 months. There was significantly better pinch strength in the brace which does not initially immobilize the wrist in flexion. Three patients requested early removal of the brace because of discomfort and these were therefore not included in the post-splint functional assessment. However, they were included in the pain assessment and there was no significant difference overall in the pain scores between the groups, although the results would indicate that the brace is more comfortable in the later stages of treatment.

Hand swelling, most prominent over the metacarpals, is present in most patients following a Colles' fracture, but will be less noticeable under a plaster. It was recorded more frequently in the cast group. Nearly one-fifth of patients treated in the brace were recorded as having 'severe' swelling initially, perhaps due to the fact that the whole hand is visible, although only 5 per cent persisted after the first week.

Patients in both groups were encouraged to elevate the hand and exercise the fingers to reduce oedema. That this was effective, particularly in the brace group, can be seen from the results for hand swelling and finger movement at splint removal. It should also be noted that the brace is much lighter than a conventional forearm cast which is another factor which may encourage use of the injured limb.

In conclusion, although the numbers in the trial were relatively small, the Aberdeen Colles' fracture brace would appear to have benefits over conventional treatment. The improved functional results, particularly in terms of pinch and grip strength, are particularly important in the group of elderly patients who live alone. The brace is applied after fracture reduction by following simple instructions and, due to its design, does not require a high level of orthopaedic expertise.

References

1 Colles A. On the fracture of the carpal extremity of the radius. *Edinb Med Surg J* 1814; **10:** 182.

2 Carrozzella J. and Stern PJ. Treatment of comminuted distal radius fractures with pins and plaster. *Hand Clin* 1988; **4:** 391.

3 Kwasny O, Fuchs M, Hertz H. and Quaicoe S. Skeletal transfixion in treatment of comminuted fractures of the distal end of the radius in the elderly. *J Trauma* 1990; **30:** 1278.

4 Scheck M. Long-term follow-up of treatment of comminuted fractures of the distal end of the radius by transfixation by Kirschner wires and cast. *J Bone Joint Surg [Am]* 1962; **44A:** 337.

5 Clyburn TA. Dynamic external fixation for comminuted intra-articular fractures of the distal end of the radius. *J Bone Joint Surg [Am]* 1987; **69A:** 248.

6 Cooney WP. External fixation of distal radius fractures. *Clin Orthop* 1983; **180:** 44.

7 D'Anca AF, Sternleib SB, Byron TW and Feinstein PA. External fixator management of unstable Colles' fractures. *Orthopedics* 1984; **7:** 853.

8 Clancey GJ. Percutaneous Kirschner-wire fixation of Colles' fractures: a prospective study of thirty cases. *J Bone Joint Surg [Am]* 1984; **66A:** 1008.

9 Mah ET and Atkinson RN. Percutaneous Kirschner wire stabilisation following closed reduction of Colles' fractures. *J Hand Surg [Br]* 1992; **17B:** 55.

10 Stein AH and Katz SF. Stabilization of comminuted fractures of the distal inch of the radius: percutaneous pinning. *Clin Orthop* 1975; **108:** 174.

11 Bradway JK, Amadio PC and Cooney WP. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. *J Bone Joint Surg [Am]* 1989; **71A:** 839.

12 Kristiansen A and Gjersoe E. Colles' fracture–operative treatment, indications and results. *Acta Orthop Scand* 1968; **39:** 33.

13 Chapman DR, Bennett JB, Bryan WP and Tullos HS. Complications of distal radius fractures: pins and plaster treatment. *J Hand Surg* 1982; **7:** 509.

14 Green DP. Pins and plaster treatment of comminuted fractures of the distal end of the radius. *J Bone Joint Surg [Am]* 1975; **57A:** 304.

15 Weber SC and Szabo RM. Severely comminuted distal radial fracture as an unsolved problem: complications associated with external fixation and pins and plaster techniques. *J Hand Surg [Am]* 1986; **11A:** 157.

16 Sarmiento A, Pratt GW, Berry NC and Sinclair WF. Colles' fractures – functional bracing in supination. *J Bone Joint Surg [Am]* 1975; **57A:** 311.

17 Sarmiento A, Zagorski JB and Sinclair WF. Functional bracing of Colles' fractures: a prospective study of immobilisation in supination vs. pronation. *Clin Orthop* 1980; **146:** 175.

18 Bunger C, Solund K and Rasmussen P. Early results after Colles' fracture: functional bracing in supination vs. dorsal plaster immobilization. *Arch Orthop Trauma Surg* 1984; **103:** 251.

19 Gibson AGF and Bannister GC. Bracing or plaster for Colles' fractures?: a randomised prospective controlled trial. *J Bone Joint Surg [Br]* 1983; **65B:** 221.

20 Ross RE, Gourevitch D and Lawton A. A prospective randomised trial of functional bracing in Colles' fractures. *J Bone Joint Surg [Br]* 1984; **66B:** 776.

21 Ledingham WM, Wytch R, Goring CC, Matheson AB and Wardlaw D. On immediate functional bracing of Colles' fracture. *Injury* 1991; **22:** 197.

22 Moir JS, Wytch R, Ashcroft GP, Neil G, Ross N and Wardlaw D. Intracast pressure measurements in Colles' fractures. *Injury* 1991; **22:** 446.

23 Gartland JJ and Werley CW. Evaluation of healed Colles' fractures. *J Bone Joint Surg [Am]* 1951; **33A:** 895.
24 Lidstrom A. Fractures of the distal end of the radius: a clinical and statistical study of end results. *Acta Orthop Scand* 1959; (Suppl. 41).
25 Frykman G. Fracture of the distal radius including sequelae – shoulder hand syndrome, disturbance in the distal radio-ulnar joint and impairment of nerve function. *Acta Orthop Scand* 1967; (Suppl. 108).
26 Stewart HD, Innes HR and Burke FD. Functional cast-bracing for Colles' fractures – a comparison between cast-bracing and conventional plaster casts. *J Bone Joint Surg [Br]* 1984; **66B:** 749.
27 de Bruijn HP. Functional treatment of Colles' fracture. *Acta Orthop Scand* 1987; **58:** (Suppl. 223).
28 Chow YC, Fang HC, Shang TY and Ku YW. The integration of modern and traditional Chinese medicine in the treatment of fractures – IV. Treatment of Colles' fractures. *Chin Med J* 1964; **83:** 425.
29 Ferris BD, Thomas NP, Dewar ME and Simpson DA. Brace treatment of Colles' fracture. *Acta Orthop Scand* 1989; **60:** 63.
30 Futami T and Yamamoto M. Chinese external fixation treatment for fracture of the distal end of the radius. *J Hand Surg [Am]* 1989; **14A:** 1028.
31 Charnley J. *The Closed Treatment of Common Fractures.* 3rd Ed. Edinburgh: Churchill Livingstone, 1961, p. 133.
32 Porter M and Stockley I. Fractures of the distal radius – intermediate and end results in relation to radiologic parameters. *Clin Orthop* 1987; **220:** 241.
33 McQueen M and Caspers J. Colles' fracture: does the anatomical result affect the final function? *J Bone Joint Surg [Br]* 1988; **70B:** 649.

Paper accepted 5 June 1995.

Requests for reprints should be addressed to: J. S. Moir, Orthopaedic Suite, Woodend Hospital, Aberdeen AB9 2YS, Scotland, UK.