We present a prospective study of the treatment of 32 unstable Colles’ fractures by external fixation and cancellous grafting with minimal exposure. We inserted an external fixator between the radius and the second metacarpal, and maintained ligamentotaxis for five weeks.

In 27 patients the result was good or excellent, but five fractures healed with malunion. All patients made a satisfactory functional recovery. At a mean follow-up of three years (1 to 5) after injury none had pain in the wrist and all were satisfied with the result. The average grip strength was 95% of normal. Seven patients had algodystrophy with mild impairment of finger movements in four.

We conclude that the combination of cancellous grafting and external fixation is effective for the treatment of unstable Colles’ fractures.

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Severely displaced, comminuted Colles’ fractures tend to heal with malunion. Conventional immobilisation with plaster of Paris often does not prevent early collapse. Several alternative methods have been tried with varying success such as percutaneous wire fixation, pins and plaster and external fixation. More recently, the option of primary bone grafting has been explored. Leung et al were the first to report good anatomical and functional results with the combination of cancellous grafting and ligamentotaxis. McBirnie, Court-Brown and McQueen described the use of corticocancellous grafts and single Kirschner (K)-wire fixation with a rate of malunion of 22%. Cancellous grafting is considered to have both a mechanical and a biological effect, by simultaneously increasing the intrinsic stability of the fracture and the speed of bone healing.

We have developed a technique of cancellous grafting and external fixation, similar to that described by Leung et al, for the treatment of unstable Colles’ fractures with persistent or recurrent shortening of the radius. We now present the results of a prospective study.

PATIENTS AND METHODS
From 1991 to 1994 we treated 383 patients with displaced Colles’ fractures by reduction under local anaesthesia and immobilisation in a below-elbow plaster cast. Radiographs were taken immediately and after three to five and seven to ten days. Unless precluded by age or poor health, persistent or recurrent shortening of the radius of at least 5 mm as measured according to Gartland and Werley, or shortening at the distal radio-ulnar joint of at least 3 mm as measured according to Abbaszadegan, Jonsson and Von Sivers, was an indication for external fixation and cancellous grafting. Of the 383 patients, 32 were selected, five men and 27 women, with an average age of 68 years (47 to 91). The operation was performed at a mean of 10 days after the injury (1 to 23).

Radiological assessment. The radial angle, dorsal angle and radial shortening as well as shortening at the radio-ulnar joint were measured at injury, closed reduction, pre- and postoperatively and at final assessment (Fig. 1). Radiographs of the uninjured wrist were taken for comparison. Three different classifications were used: those of Older, Stabler and Cassebaum, Frykman and Sarmiento and

Fig. 1
Diagrams showing measurements taken from radiographs.
Table I. Classification of the fractures according to Older et al, Frykman, and Sarmiento and Latta

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<th>Fracture type</th>
<th>Older et al</th>
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<td>Frykman</td>
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Latta (Table I). Most of the fractures were allocated to the worst grades in all of the classifications.

Operative technique. The operations are performed under general anaesthesia. For ligamentotaxis we use a small ASIF external fixator. Two pairs of self-tapping 2.5 mm pins are inserted, one pair into the radius at least 60 mm proximal to the joint, and the other into the second metacarpal. The fracture is then reduced by traction and manip-

Anteroposterior and lateral radiographs showing a severely displaced Sarmiento type-II fracture (a,b), the same fracture after external fixation and cancellous grafting (c,d) and union of the fracture in the anatomical position (e,f).
ulation and the fixator is locked after the position of the fracture and pins have been checked on an image intensifier. Grafting is performed with minimal exposure of both the donor and recipient site. Through a 2 to 3 cm dorsal incision the fracture gap is exposed and prepared with a 6 mm punch. Three to four bone plugs are taken from the iliac crest, percutaneously, with an 8 mm crown drill. These are packed into the prepared cavity.

The fixator is removed after five weeks. No braces are used. Patients are advised to use their hand for daily activities but to refrain from heavy work for six weeks.

Final assessment. For assessment of the anatomical result we used Sarmiento and Latta’s modification of the classification of Lidström as follows:

Poor. Severe deformity: dorsal angulation of at least 15°, shortening of at least 12 mm or loss of radial deviation of 15° or more.

Fair. Moderate deformity: dorsal angulation of 11 to 14°, shortening of 7 to 11 mm or loss of radial deviation of 10 to 14°.

Good. Slight deformity: dorsal angulation of 1 to 10°, shortening of 3 to 6 mm or loss of radial deviation of 5 to 9°.

Excellent. No or insignificant deformity: dorsal angulation not exceeding 0° (neutral), shortening of less than 3 mm or loss of radial deviation not greater than 4°.

For assessment of the functional result we used Sarmiento’s modification of the criteria outlined by Gartland and Werley.10,15

RESULTS

Anatomical results. Of the 32 patients, 27 had an excellent or good anatomical result (Fig. 2) but in five the outcome was unsatisfactory (4 fair and 1 poor, see Table III). Four of these had had an Older/Sarmiento type-IV fracture. In all five a good or excellent reduction had been obtained at operation, but the deformity had recurred before bony union (Fig. 3). Shortening of the radius had increased by a mean of 12 mm (7 to 22) and loss of the radial angle by a mean of 15° (9 to 22). In three patients special circumstances contributed to this late collapse. In one the proximal pins had broken during the last few weeks of fixation, in another the fixator had to be removed early (28 days) because of pin-track infection, and the third had had a Barton-type fracture of the same wrist a few weeks before the Colles’ fracture as well as pin-track infection requiring early removal of the fixator (21 days).

Table II shows the radiological measurements at different stages. In all but three patients the final radial length had improved compared with that preoperatively. The mean gain in length was 5 mm if measured at the styloid process and 2 mm if measured at the distal radio-ulnar joint. The mean final shortening was 2 mm and 1 mm, respectively. The mean dorsal angle was –2° (volar) and the mean radial angle 19°. The same five patients showed the worst shortening measured at the styloid process and the greatest loss of radial angle. We found a similar relationship between shortening at the distal radio-ulnar joint and dorsal angulation. The final anatomical classification was compared with that preoperatively. Three fractures had been upgraded by three classes (poor to excellent), 12 by two (poor to good or fair to excellent) and 14 by one. Three had remained equal or been downgraded by one class (Table III). We also compared the final result with the postoperative rating. Apart from the five malunions only one fracture had moved up one class and one moved down one class.

Functional results. The mean follow-up was three years (12 to 60). During this time one patient had a cerebral haemorrhage with paralysis of the affected limb. She was
excluded from the functional evaluation. All the other patients had an excellent or good functional recovery and were satisfied with the outcome (Table III). Of the five with malunion two had an excellent and three a good functional score. At subjective assessment 24 patients scored zero points (excellent) and seven scored 2 points (good). None complained of pain in the wrist or showed signs of osteoarthritis at the time of the follow-up examination. The average grip strength was 95% of the unaffected side.

**Complications.** Seven patients had algodystrophy (reflex sympathetic dystrophy) as defined by Goris. Three had a full recovery at follow-up but four showed some residual stiffness of the fingers. Five had a good functional result and two an excellent result. Pin-track infection was seen in six patients which required early pin removal in three. All infections healed spontaneously after removal of the fixators. Breaking of pins occurred once and one patient had a mild carpal tunnel syndrome which did not require operation.

**DISCUSSION**

Restoration of the anatomy in Colles’ fractures is still controversial. Several studies have cast doubt on the functional benefit of anatomical reduction, but most authors believe that there is a firm relationship between the quality of reduction and the restoration of function. It could be argued that the relationship between anatomy and function is not necessarily causal assuming that the quality of functional recovery depends on the extent of the soft-tissue damage, but this has been refuted by several prospective studies which showed considerable differences between the functional results of similar injuries.  The appearance of malunion also deserves consideration. The best attainable anatomical result should therefore remain the primary objective of treatment.

Villar et al showed that radiological shortening of the radius is most consistently correlated with poor function. Abbaszadegan et al, using a different definition of shortening, concluded that initial shortening is the best predictor of future instability. We therefore focused on the prevention of radial shortening more than on reduction of dorsal angulation and radial deviation. We think that at the time of intervention most fractures would have deteriorated further if left in plaster. We have limited the exposure of both the donor and recipient site thereby minimising the operative trauma and saw no need for open reduction as closed traction and remanipulation were successful in all cases.

Five fractures (15%) healed with malunion, all early in the series. We think that the amount of cancellous bone used was insufficient to provide mechanical support. Later, we paid more attention to the mechanical aspect of bone grafting by using larger quantities of bone. Our anatomical results agree with those in the literature on external fixation without cancellous grafting. Most authors have reported 85% to 95% of good or excellent anatomical results, but none has shown functional results similar to these and moderate or poor results ranged from 10% to 40%. In our series, although the overall anatomical result was average (85% good or excellent), recovery of function was good or excellent in all patients, even in those with malunion. Possible explanations are the speed of union as a result of grafting, the relatively long follow-up (mean 36 months) and the absence of severe algodystrophy.

Reflex sympathetic dystrophy (RSD) is probably the most common and most underestimated complication of wrist fractures. The incidence is about 15% to 30% in any series of Colles’ fractures if the criteria outlined by Goris are adhered to. Atkins et al reported an incidence of 37% in patients treated with plaster, using similar criteria. Severe dystrophy often leads to a permanent loss of movement, which precludes a satisfactory functional outcome, but none of our seven patients was in this category. In four some residual stiffness of the fingers meant that the result was good rather than excellent. It is not certain whether the use of cancellous grafts has any influence on the incidence of RSD. Previous studies have had a low incidence (1% to 3%), but the criteria for the diagnosis were not stated. Other complications, such as pin-track infection, probably had little effect, although in a few instances early pin removal may have influenced the anatomical result.
Our findings agree with those of Leung et al\textsuperscript{7,8} and confirm the usefulness of cancellous grafting in unstable comminuted Colles’ fractures. The anatomical result was not as good as we had hoped for, but the overall result was very satisfactory. This is noteworthy since our series comprised the worst 8.5% of displaced Colles’ fractures and the worst 3.5% of all wrist fractures treated at our hospital in this period.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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