Clinical and radiological outcome of cast immobilisation versus surgical treatment of acute scaphoid fractures at a mean follow-up of 93 months

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We report the outcome at a mean of 93 months (73 to 110) of 71 patients with an acute fracture of the scaphoid who were randomised to Herbert screw fixation (35) or below-elbow plaster cast immobilisation (36). These 71 patients represent the majority of a randomised series of 88 patients whose short-term outcome has previously been reported. Those patients available for later review were similar in age, gender and hand dominance.

There was no statistical difference in symptoms and disability as assessed by the mean Patient Evaluation Measure (p = 0.4), or mean Patient-Rated Wrist Evaluation (p = 0.9), the mean range of movement of the wrist (p = 0.4), mean grip strength (p = 0.8), or mean pinch strength (p = 0.4).

Radiographs were available from the final review for 59 patients. Osteoarthritic changes were seen in the scaphotrapezial and radioscapoid joints in eight (13.5%) and six patients (10.2%), respectively. Three patients had asymptomatic lucency surrounding the screw. One non-operatively treated patient developed nonunion with avascular necrosis. In five patients who were treated non-operatively (16%) there was an abnormal scapholunate angle (> 60º), but in four of these patients this finding was asymptomatic.

No medium-term difference in function or radiological outcome was identified between the two treatment groups.

The scaphoid is the most common carpal bone to fracture. Such an injury is usually treated by immobilising the wrist in a below-elbow plaster-of-Paris cast for six to eight weeks. Recently, there has been a trend to fix the acute scaphoid fracture, with claims of a better outcome. The short-term results of both operative and non-operative treatments have been reported as comparable. The medium- and long-term consequences of the method used to treat the fractured scaphoid are not well documented. The literature on long-term outcome is sparse, and most reported studies are retrospective. Saedén et al reported no difference in clinical outcome between scaphoid fractures which were treated non-operatively and those secured with a Herbert screw, but a higher incidence of osteoarthritic change in the scaphotrapezial joint did occur following fixation. We prospectively evaluated the medium-term results of surgical stabilisation and below-elbow cast immobilisation of acute undisplaced scaphoid fractures to define the consequences of the initial choice of treatment. We also investigated the association of malunion, dorsal intercalated segment instability and osteoarthritis with the clinical outcome. The short-term results of this cohort of patients have been described previously at which stage the outcome following both forms of treatment was comparable. We now report the results of the same group of patients at a mean of eight years’ follow-up.

Patients and Methods

All patients attending the Leicester Royal Infirmary, Leicester, United Kingdom, between October 1996 and November 1999 with a fractured scaphoid were included in this study. Children (aged < 16 years) and those with fractures of the tuberosity of the scaphoid, arthritis of the wrist, multiple injuries and significant illness were excluded.

The sample size was calculated to detect a 10% difference in grip strength, wrist movement, and the Patient Evaluation Measure to provide a 90% power with p < 0.05. The outcome measures information from previous assessments were used, and further confirmed with an in-trial assessment of the sample size. These determined that 42 patients were required in each group. This study had approval of the ethics committee, and patients gave their informed written consent.
A total of 88 patients with a bicortical fracture of the scaphoid waist were prospectively randomised to undergo early fixation or non-operative treatment. In total, 44 patients were randomised to have open reduction and internal fixation through the volar approach using a Herbert screw (Zimmer UK, Swindon, United Kingdom) (36 patients) or a cannulated Whipple screw (Zimmer UK) (six patients), with an additional Kirschner wire (three patients). Two patients had their fracture stabilised using two Kirschner wires only. Of those patients undergoing internal fixation, 28 were carried out by the senior author (JJD) and 16 were performed under his supervision. The fracture fixation was performed within two weeks of the injury in 41 patients, and none had bone grafting. All but two patients were allowed to move their hand and wrist after fixation.

In the 44 patients treated non-operatively, immobilisation of the wrist was undertaken in a below-elbow cast for eight weeks with the thumb left free. Patients were encouraged to resume normal activity, including return to work, and to take part in leisure activities as soon as possible, even when the cast was still in place. A Futuro splint (Beirdsorf AG, Hamburg, Germany) was used to protect the fracture if the state of union was uncertain after eight weeks.

The wrist was assessed clinically and radiologically up to one year after surgery. CT was performed on fractures in which there was doubt about healing at 12 weeks. If a gap was evident on CT scans, internal fixation was recommended.

The short-term results of this study up to one year have been published. There was no difference in age, gender, dominance, occupation, and side of injury or mechanism of injury between the two groups. At one-year follow-up there was no difference between the two groups for any outcome measure. No major complications occurred, apart from scar-related problems in ten patients after fixation. All but two patients were allowed to move their hand and wrist after fixation.

After almost eight years all patients were invited for review. Only 18 attended the follow-up clinic. Patients who did not attend were located through the Leicestershire Health Authority to identify any change of address. Some were located through their parents and relatives. As these were young patients, a number had moved away from Leicestershire. Many telephone calls and letters enabled us to find and review a further 38 patients. We then used the National Health Service tracking system to find the remainder. At each stage the rate of response was poor, as most of them were young, working and asymptomatic. With persuasion we managed to review 71 of the 88 patients. One patient had died, one had emigrated to Australia, three declined to take part in the review, and 12 patients were not traceable.

Patients were assessed clinically for tenderness, crepitus and range of wrist movement. Tenderness at the scaphoid tuberosity, the anatomical snuff box and the proximal pole of the scaphoid was noted. Grip and pinch strength were measured with the same calibrated Jamar dynamometer (Sammons Preston Roylan, Chicago, Illinois) in all patients. Range of movement, grip and pinch strength were expressed as a percentage of the opposite side. Symptoms, function and satisfaction with treatment were assessed by the Patient Evaluation Measure and Patient-Rated Wrist Evaluation questionnaires. Both of these are in a visual analogue form and validated. The Patient Evaluation Measure has three sections that assess patient satisfaction with the care provided, the Hand Health Profile, and the overall result. Patient-Rated Wrist Evaluation consists of two sections that assess pain, and limitation of specific and usual activities. The scores are calculated as a percentage of the maximum possible score, with a higher score representing worse symptoms, disability and less satisfaction.

Standardised radiographs of the scaphoid were obtained comprising posteroanterior, lateral, semisupinated oblique, and semipronated oblique views. Radiographs were assessed for union of the fracture, osteoarthritic changes, avascular necrosis, implant status, the shape of the scaphoid, specifically the development of a humpback deformity and signs of scapholunate instability. Osteoarthritic features of loss of joint space, joint incongruity and osteophytes were noted at the radioscaphoid, scaphotrapezial and scapholunate joints. Implant position was recorded as being within the central third of the scaphoid, biased in a radial or ulnar direction on the posteroanterior radiograph and biased in a palmar or dorsal direction on the lateral view. Apart from these, the engagement of the screwthread, migration of the screw and whether it had been removed were documented, as was any lucency around the screw.

**Descriptive data analysis.** Mean, SD and standard error of the mean (SEM) were computed for range of movement, grip strength, pinch strength, Patient Evaluation Measure and Patient-Rated Wrist Evaluation scores at the final follow-up. The outcomes were compared between groups on the basis of intention to treat, using analysis of variance (ANOVA) for items that were normally distributed. The questionnaire scores, range of movement of the wrist and grip strength data were significantly skewed, so a Mann-Whitney U-test was used to compare the two groups. Multiple regression analysis was used to investigate whether the presence of osteoarthritis in different joints, lucency around the screw or a prominent end of the screw could predict the pain scale of the Patient-Rated Wrist Evaluation. We also investigated whether the development of osteoarthritis was related to an abnormality of the scapholunate angle, and the formation of a humpback deformity using cross-tabulation (chi-squared test) and age using ANOVA. All
calculations were performed using SPSS V12 (SPSS Inc., Chicago, Illinois). Statistical significance was set at p < 0.05.

Results
At the final follow-up, 71 of the original 88 patients were assessed by questionnaire but nine of the 71 patients were unable to attend the follow-up clinic for examination and were assessed by questionnaire only. Three patients who were reviewed clinically refused to be radiographed. The mean age of the 71 reviewed patients at the time of injury was 30 years (16 to 61). There were 62 men and nine women (Table I). The proportion of patients reviewed after fixation (n = 35) and non-operative management (n = 36) were similar. The mean follow-up was 93 months (73 to 110) (Table I).

Three patients in each treatment group had crepitus on movement of the wrist joint. One of these patients had crepitus in both the injured and the uninjured opposite wrist. The mean grip strength of the injured hand was 96% (SEM 3.4) of that of the uninjured hand in the operated patients, and 99% (SEM 3.3) in patients treated without surgery. The mean pinch strength was 96% (SEM 3.5) following fixation and nearly 100% (SEM 3.3) following treatment in a cast. The range of movement was similar, with mean values of 92% (SEM 2.6) for operated and 95% (SEM 1.4) for non-operated patients. None of these differences between groups was statistically significant (grip strength Mann-Whitney, p = 0.8; pinch strength ANOVA, p = 0.4; range of movement, ANOVA, p = 0.4). Similarly, there was no statistically significant difference in the Patient Evaluation Measure (Mann-Whitney, p = 0.4) or Patient-Rated Wrist Evaluation (Mann-Whitney, p = 0.9) between the groups (Table I).

Of 71 patients, contemporary radiographs were obtained in 59, of whom 28 had undergone internal fixation and 31 immobilisation in a cast (Table II). In these 59 patients, narrowing of joint space at the radioscaphoid joint was observed in six (10%), of whom five had received treatment in a cast. However, osteophyte formation and joint incongruity were noted in only two patients from the immobilisation group. Narrowing of the scaphotrapezial joint space was found in eight patients (13.6%), five of whom had undergone treatment in a cast and three had internal fixation. All three patients receiving internal fixation had scaphotrapezial joint incongruity in addition to joint space narrowing, but only two of five patients treated with a cast had joint incongruity. Osteophytes at the scaphotrapezial joint were observed in one patient from each treatment group. In four of the eight patients with scaphotrapezial joint space narrowing, osteoarthritic changes were related to attrition from prominence of the screw. Scapholunate joint space narrowing was observed in one patient who had treatment with a cast, but no additional osteoarthritic features were present (Table II).

Of the 31 patients who were treated in a cast who were available for review, four of those who required subsequent internal fixation were included; two of these had Kirschner wires inserted and two had screws for fixation. The other three patients from the original cohort of 44 who had treat-
ment in a cast and required later surgical treatment were unavailable for review. All the patients who underwent primary internal fixation were fixed with screws except one in which the screw was supplemented with a Kirschner wire. The screw was found to be in the central third of the scaphoid in 22 of 32 patients. Lucency around the screw was noted in three patients, but it had not backed out or migrated (Table II) and no patient required removal of the screw.

Of the patients treated in a cast, five (16%) were found to have an abnormal scapholunate angle of > 60º (Fig. 1). Three of these also had a scapholunate gap of > 2 mm. Only one patient had an occasional mild ache. One patient who developed a nonunion following non-operative treatment had avascular necrosis of the proximal scaphoid and osteoarthritic changes in the radioscaphoid joint (Table II). Humpback deformity was noted in four of 28 patients who had fixation and two of 31 treated non-operatively.

Prominence of the end of the screw within a joint and the presence of lucency around it (Fig. 2) was not predictive of an increased pain score in the Patient-Rated Wrist Evaluation on multiple regression (adjusted $R^2$ -0.02, $p = 0.5$). The presence of osteoarthritis in the radioscapophoid, scaphotrapezial or scapholunate joints, a humpback deformity of the healed scaphoid and an abnormal scapholunate angle > 60º were also not predictive of an increase in pain score on multiple regression (adjusted $R^2$ -0.02, $p = 0.7$). Three of the five patients with an abnormal scapholunate angle had osteoarthritis, whereas only eight of 54 patients with a normal scapholunate angle had osteoarthritis (Pearson’s chi-squared = 6.3, Fisher’s exact test $p = 0.04$, odds ratio = 4.0, SEM odds ratio = 3.3). The presence of a humpback scaphoid in six patients did not relate to osteoarthritis (Pearson’s chi-squared 1.5, Fisher’s exact test $p = 0.6$). The 11 patients with osteoarthritis at final review had a mean age of 37 years (16 to 48) whereas the 48 patients without arthritis had a mean age of 29 years (19 to 53); this difference was significant (ANOVA, $p = 0.02$) and medium to large (Eta = 0.31).

**Discussion**

This study investigated the mid-term seven-year consequences of early internal fixation of a scaphoid fracture or treatment in a below-elbow functional cast, followed by
delayed fixation after eight weeks if there was concern about the state of union. We found no difference in tenderness, crepitus or outcome measures between patients treated in either manner. This is in accordance with the results of the only other study reporting outcomes of these treatments in the medium term. In the report by Saedén et al. the outcome at 12 years of a prospective randomised study evaluating non-operative treatment and Herbert screw fixation for acute scaphoid fractures was presented. Although a similar proportion of patients complained of symptoms following cast treatment or fixation, their clinical evaluation was based on an unvalidated questionnaire. However, they also found no difference in grip strength and range of movement at the wrist between the treatment groups. Whether patients have their fractured scaphoid fixed early, or whether they have their wrist immobilised in a below-elbow plaster-of-Paris cast with subsequent fixation if union is uncertain, has no identifiable consequence in the medium term.

In our study, no difference was noted in the incidence of malunion between treatment groups but dorsal intercalated segment instability was noted only in those treated with a cast (p = 0.02). Düppe et al. found that all three cases with a dorsal intercalated segment instability of 56 conservatively-treated scaphoid fractures occurred following non-union. Lindström and Nyström suggested that when the scaphoid fracture is associated with a ligament injury, bone healing may be compromised. We found that four of five cases with a dorsal intercalated segment instability occurred in fractures that healed after non-operative treatment. The one patient with an ununited fracture at review also had this deformity. Neither malunion nor dorsal intercalated segment instability were reported by Saedén et al. In our study, no statistical difference (p = 0.2) was found in the rate of radioscaphoid osteoarthritis after operative fixation (1 of 28) and cast treatment (5 of 31). Saedén et al. also reported similar findings, but had a higher rate following both operative (9 of 23) and non-operative treatment (5
of 16) when analysed with CT. We found the incidence of scaphotrapezial joint osteoarthritis between the treatment groups to be similar (operative 11% (3 of 28), non-operative 16% (5 of 31)) and are similar to the findings of Nicholl and Buckland-Wright\textsuperscript{13} in a retrospective review study at six years. However, Saedén et al\textsuperscript{7} reported an incidence of scaphotrapezial osteoarthritis of 61% (14 of 23) following fixation, and only 25% (4 of 16) after non-operative treatment and suggested this difference resulted from possible injury to the scaphotrapezial joint surface during surgery. The lower rate of osteoarthritis in our study may be due to a shorter follow-up and reliance on plain radiographs rather than CT. Kehoe, Hackney and Barton\textsuperscript{14} did not note any osteoarthritic changes at the scaphotrapezial joint six years after Herbert screw fixation of the fractured scaphoid in 20 patients. In eight patients they found some irregularity of the joint surface at the site of insertion of the screw near the radial margin of the trapezium. We noticed similar appearances in four patients, caused by either a prominent screw head or a Kirschner wire (Fig. 3).

One study\textsuperscript{15} reported a high association of humpback deformity with osteoarthritis. Another\textsuperscript{6} attributed osteoarthritis to the alteration of carpal dynamics due to deformation and shortening of the scaphoid that produced the humpback deformity, and suggested that this may be avoided by fixing the fracture, especially if it was angulated or compressed. We found that the humpback deformity was more frequent following fixation (4 of 28) than after non-operative treatment (2 of 31). This could be related to the palmar position of the screw within the scaphoid contributing to intrascaphoid angulation (Fig. 4). Amadio et al\textsuperscript{16} studied the humpback deformity in 46 scaphoid fractures six months after union. In 20 patients the intrascaphoid angle was < 35°; 83% of all the patients had a satisfactory clinical outcome and 22% developed post-traumatic arthritis. Where the intrascaphoid angle exceeded 45° an unsatisfactory outcome occurred in 73% of patients and post-traumatic arthritis in 54%. We found no association between the presence of a humpback deformity and the clinical outcome or osteoarthritic changes in the wrist. There was no correlation between dorsal intercalated segment instability and poor clinical outcome. A retrospective review of 63 patients\textsuperscript{15} at a mean of 54 months after conservative treatment reported dorsal intercalated segment instability in five patients, but there was no association between this malalignment and the functional results. Osteoarthritis developed in approximately one-third of the series, mainly at the radioscapoid and scaphotrapezial joints, with this condition related to the patient’s age and the presence of a humpback deformity. However, no correlation was noted between osteoarthritis and pain, grip strength or work capacity. Another retrospective review of 229 patients seven years after non-operative treatment of scaphoid fractures\textsuperscript{6} recorded radioscapoid osteoarthritis in only 4.8% of the patients, but those affected also had pain, weakness of grip and reduced range of wrist movement. We have identified the association of arthritis with age (p = 0.2) but not with the outcome. This might imply that older patients are more likely to damage the articular cartilage, or that the appearance of arthritis is associated with the physiological processes of ageing. A long-term review\textsuperscript{5} of 52 patients with acute fractures 30 years after
non-operative treatment recorded five patients with non-union, three of whom had radiocarpal osteoarthritis. Only one of 47 patients was noted to have osteoarthritis in the absence of nonunion. In our study one patient developed nonunion, and this was associated with radioscaphoid osteoarthritis.

Undertaking a mid- to long-term review of patients treated for scaphoid fracture is difficult as mainly young males are affected. Subsequent changes of address makes tracing patients difficult. In the United Kingdom, it is possible to locate most patients using the National Health Service (NHS) tracking system and their NHS number provided they are registered with a doctor at their current address. Nevertheless, poor compliance with requests that the patient attends for review has been encountered in other studies. Saedén et al. managed to review only 82% of their patients, in whom imaging was obtained in only 69%. Similarly, Lindström and Nyström retrospectively reviewed only 48% of their series. Düppe et al. did not declare the number of patients treated during the study period. They attempted to review 75 patients who resided in their local region and succeeded in seeing only 56 (75%).

In conclusion, our study revealed that, including the outcome of patients who required delayed fixation after non-operative treatment, the outcome of early fixation is comparable to that of initial non-operative treatment. On the other hand, the early complications of fixation did not have a significant impact on the mid-term results. We continue to treat undisplaced acute scaphoid fractures in a below-elbow cast. If fracture union is uncertain at eight weeks it is investigated with a CT scan and a delayed fixation is performed if a gap is confirmed. This study demonstrates that this management approach does not compromise the early or mid-term outcome.

Supplementary Material

A further opinion by Mr B. Ferris is available with the electronic version of this article on our website at www.jbjs.org.uk

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References