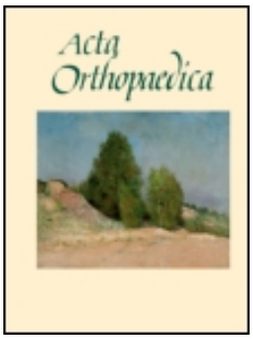

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Comparison of direct and indirect costs of internal fixation and cast treatment in acute scaphoid fractures

A randomized trial involving 52 patients

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Background **The most cost-effective treatment of scaphoid fractures has not yet been determined.**

Methods **In a prospective trial, 52 employed or self-employed patients with scaphoid fractures were randomized to closed (cast) or surgical treatment.**

Results **There were 3 complications in the surgical group and 1 in the cast group. Median time off work was numerically but not statistically significantly greater after cast than after surgery (74/39 days). Manual workers (manuals) had a longer time away from work than non-manual employees/individuals who were self-employed (non-manuals; median 84 days and 16 days, respectively; $p < 0.001$) and they had a longer time off work after cast than after surgery (median 100 days and 61 days; $p = 0.03$). Hospital costs were lower after cast than after surgery ($p < 0.001$). Work disability costs were numerically but not statistically significantly higher after cast than after surgery, and similarly, the total costs were lower after cast than after surgery. Work disability costs and total costs were higher in manuals than in non-manuals ($p < 0.001$). Non-manuals had lower total costs after cast than after surgery ($p = 0.05$).**

Interpretation **There was a longer period of absence from work after cast than after surgery in manuals, but not in non-manuals. In non-manuals, total costs were lower after cast than after surgery. Socioeconomic classification had a greater influence on cost than mode of treatment.**

Advances in medical technology are a major contributor to the increase in healthcare spending (Bozic et al. 2004). Since resources are limited, in order to optimize health services, decisions concerning allocation of resources not only require clinical evaluations but also health economic evaluations (Maniadakis and Gray 2000).

Acute scaphoid fracture is an injury that mainly affects young, working individuals. For the majority of patients the prevailing treatment regime is nonoperative, with immobilization in a plaster cast. Immobilization often seriously affects an individual's ability to work, and it can sometimes have serious consequences regarding employment, finances, and activities of daily life. The total cost to society includes both treatment and work disability costs—the latter being responsible for up to 90% of the total cost of treatment of scaphoid fractures (Fusetti et al. 2003).

Currently, internal fixation is mainly used in displaced scaphoid fractures, which make up a small proportion of all fractures. Although there is also increasing interest in this treatment modality for undisplaced fractures, there is little consensus or scientific information on any definite overall advantage of this more complicated procedure. Recent studies have, however, suggested that internal fixation allows early mobilization of the wrist and earlier return to work (O'Brien and Herbert 1985, Inoue and Shionoya 1997, Saeden et al. 2001).

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The development of minimally invasive techniques with limited or no immobilization reduces surgical morbidity, and union rates approaching 100% have been reported (Inoue and Shionoya 1997, Adolfsson et al. 2001, Bond et al. 2001, Yip et al. 2002). A union rate of 100% has also been reported for proximal pole fractures treated with internal fixation (Rettig and Raskin 1999).

The nonunion rate has been reported to vary between 5% and 13% after closed treatment (Eddeland et al. 1975, Leslie and Dickson 1981, Dias et al. 1989). This rate could be reduced if most fractures were treated surgically, but this would severely strain the resources of most orthopedic/hand surgery departments.

The hypothesis of the present study was that surgical treatment would be an economically better choice for society than nonoperative treatment with casting, based on the idea that economic effects of a reduction in time off work would more than compensate for the cost of an operation. The aim was to compare the direct and indirect costs of internal fixation and cast treatment in patients with acute scaphoid fractures, taking occupational status into account.

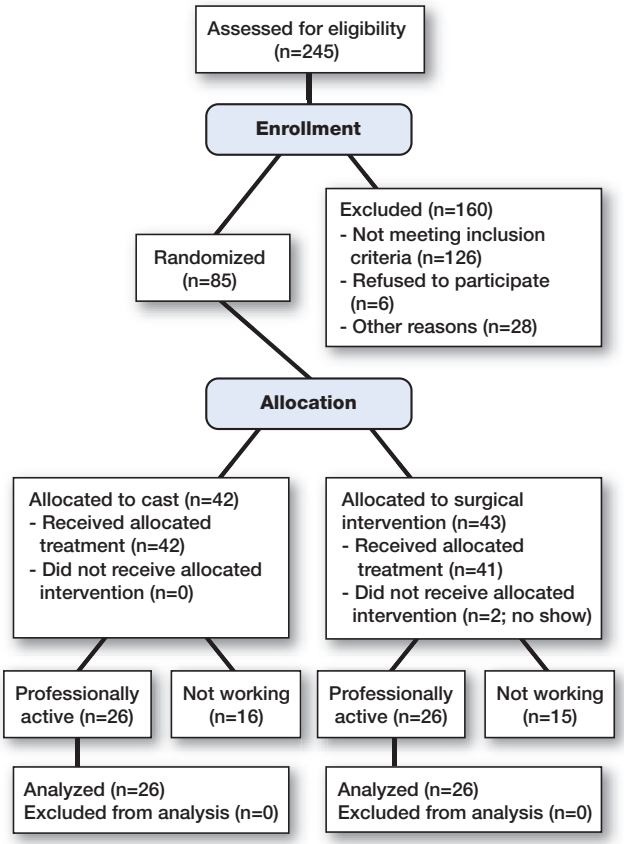

Diagram showing the flow of patients through each stage of the randomized trial according to the CONSORT statement (http://www.consort-statement.org).

Patients and methods

Patients

The present investigation was performed on a subgroup of occupationally active individuals participating in a randomized clinical trial comparing clinical results, complications, and union rates between closed and operative treatment for acute undisplaced scaphoid fracture (to be published). During the period 1992–1997, all patients with acute scaphoid fractures referred to the Department of Hand Surgery, University Hospital, Uppsala, were considered for inclusion in a randomized study. The inclusion criteria were: (1) a history of trauma occurring less than 28 days previously, (2) age 17–65 years at injury with a radiographically mature skeleton, (3) no other carpal skeletal injury, (4) displacement of ≤ 1 mm, and (5) that the patient could be expected to comply with instructions. Isolated fractures of the tubercle (Herbert type A1) or open fractures were not included. Assessment of the fracture (as the basis for fulfillment of inclusion criteria) was based on plain radiography. The two treatment modalities were traditional cast treatment and surgical stabilization of the fracture with a Herbert screw.

Of 245 patients who sought healthcare after acute scaphoid fractures, 119 fulfilled the inclusion criteria and 85 agreed to participate in the main study (Figure). Of the latter, the 52 who were currently employed or self-employed formed the material of the present analysis.

Table 1. Swedish socioeconomic classification

Socioeconomic group	Code	Delineation	Aggregated groups
Unskilled and semiskilled workers	11–21	Less than 2 years of post-comprehensive school education	Manual workers
Skilled workers	21–22	2 years or more of post-comprehensive school education	Manual workers
Assistant non-manual employees	33–36	Range: less than 2 years to 2 but not 3 years of post-comprehensive school education	Non-manual employees/ self-employed
Intermediate-level non-manual employees	44–46	3 but not 6 years of post-comprehensive school education	Non-manual employees/ self-employed
Employed and self-employed professionals, higher-level civil servants and executives	54–60	At least 6 years of post-comprehensive school education	Non-manual employees/ self-employed
Self-employed (other than professionals)	76–87	Small/large-scale entrepreneurs Small/medium-scale farmers	Non-manual employees/ self-employed

Reports on Statistical Coordination 1982:4, Statistics Sweden.

Patients were randomly allocated to one of the treatment regimes using computer-designed blocks with a randomly generated consecutive series of odd and even numbers (representing assignment to the groups receiving cast treatment and surgical treatment, respectively). Administration of the allocation process was done by a secretary at the department and was concealed until interventions were assigned. After giving informed consent and after having been assigned to that particular group, patients allocated to the cast regime had treatment initiated by the doctor who was initially consulted. Patients who were assigned to surgical treatment were scheduled for surgery as soon as was reasonably practicable, usually within a week. Two surgeons (BV and FaE) performed all procedures.

The intention-to-treat principle was used in the assessment. The treatment objective was union of the fracture. This was assessed clinically and was based on standard radiographs. The patients were followed up until healing, removal of casts, and return to work.

After exclusion of students, unemployed, and retired individuals, the study was based on the 52 patients who had occupations at the time of injury. Sex distribution was similar in both groups: 17 males in the cast group and 19 males in the surgical group. Median age was 32 (20–61) years in the cast group and 29 (18–61) years in the surgical group. Median immobilization time was 10 (6–20) weeks in the cast group and 2 (2–17) weeks in the operated group. Only 3 fractures were proximal, 47 were midscaphoid, and 2 were distal. They were evenly distributed between the groups.

The occupation of each patient was recorded using the Swedish socioeconomic classification (Guteland 1995) developed by Statistics Sweden (the central government authority for official Swedish statistics). The socioeconomic classification of individuals in the labor force is based primarily on their occupation (Table 1) and comprises 6 groups. In the present study the six groups were aggregated into two groups, "manual workers" and "non-manual employees and individuals who were self-employed".

The study was conducted according to the ethical principles of the Declaration of Helsinki as revised in Tokyo 2004, and was approved by the ethics committee of Uppsala University.

Modes of treatment

Cast immobilization

Patients were treated with a below-elbow scaphoid cast—with the thumb in volar abduction, the interphalangeal joint free, the wrist in neutral position or slight dorsal extension, and the forearm in neutral rotation—for an initially planned period of 6 weeks. The cast was then removed, radiographs were taken, and, depending on the surgeon responsible for treatment, a new cast was applied for another period of 2–4 weeks. The surgeon was free to decide upon the intervals and number of

Table 2. Unit costs (€) of various parts of medical treatment, 1992–1997

Year	1992	1993	1994	1995	1996	1997
Inpatient costs						
Cost per day	294	294	348	364	374	389
Surgery, cost per min	10.4	10.4	10.9	11.5	11.7	13.5
Anesthesia time, cost per min	1.9	1.9	2.1	2.2	2.3	2.3
Outpatient costs						
Outpatient visit (including radiographs)	96	96	101	107	110	118
Surgery, cost per procedure < 20 min	307	255	268	282	290	313
Surgery, cost per procedure > 20 min	307	543	570	601	617	666

1 € = 9.2 SEK (September 2005).

follow-up visits, and further need for radiographic control. The surgeon removed the cast when the fracture was considered united, and mobilization was encouraged. Union was based on clinical presentation and standard radiographs. Hand therapy training was initiated when indicated.

Surgical treatment

11 patients were treated as inpatients and 15 were operated in day-surgery. Surgery was performed with the patient under plexus block (the vast majority) or general anesthesia. The patient was placed in a supine position with the arm on a radiolucent arm-board. A tourniquet was used routinely. Most fractures were approached with a standard volar z-shaped or angled incision, but in some cases a dorsal approach was used (due to a proximal fracture). The scaphoid was exposed and the fracture stabilized with a standard Herbert screw (Zimmer Inc., Warsaw, IN). In 2 patients, a cannulated Herbert-Whipple screw (Zimmer) was used. The alignment jig was used as described by Herbert and Fisher (1984), but in some patients a mini-incision technique exposing only the trapezio-scaphoid joint was used. The fracture was then often initially stabilized with a K-wire and the screw was inserted with a freehand technique under fluoroscopic control. After skin closure, a well-padded short-arm Colle's-type cast was applied for 2 weeks. In a few patients, the immobilization time was extended due to findings at surgery such as incomplete ligament injury or the use of a bone graft due to comminution of the fracture (3 patients).

Economic evaluation

The medical records of all patients were reviewed and the number of outpatient visits and the surgical procedure were recorded. In the surgical group the total time of surgery, anesthetic time, and the number of days in hospital were recorded. Cost of radiography was included in the cost of the outpatient visit, and thus not reported separately. Cost data for the different procedures during this time period were taken from the price list retrieved from the Hospital Accounting Department (Table 2) and the cost for each patient was then calculated. The hospital price list was constructed so as to fully cover costs for outpatient visits, in-hospital stays, and surgical procedures, and is based on a continuous internal cost analysis process.

The National Swedish Health Insurance System started in 1955 and has undergone some modification since then. It now covers 80% of an individual's income (up to an upper income limit) during sick leave. This is currently paid by the employer (sick pay) for days 2–14, and thereafter by the Health Insurance System (sickness benefit). Both sick pay and sickness benefit are classified here as work disability costs. Payroll tax and value-added tax are not included in the disability costs.

For most patients, information on sick leave (i.e. time absent from work) and work disability costs covered by the Insurance Act was retrieved from the National Health Insurance Office. Where data retrieved in this way were insufficient, patients were contacted by telephone to obtain additional information. The medical costs and work disability costs for each patient were recalculated according to the consumer price index for 2003 (Statistics Sweden; www.scb.se). For 3 patients for whom data were missing, the work disability cost was calculated using the median wages for that particu-

Table 3. Cost assessment (based on treatment)

	All patients		Manual workers (n = 25)		Non-manual employees/ self-employed (n = 27)	
Treatment	Closed	Surgical	Closed	Surgical	Closed	Surgical
Number	26	26	13	12	13	14
Outpatient visits						
median	6	5				
95% CI [a]	5–6	4–6				
Time absent from work (days)						
median	74	39	100	61 [b]	0	19
95% CI [a]	0–100	21–59	60–139	46–84	0–96	1–42
Hospital costs (€)						
median	688	1,649 [c]	642	1,934 [d]	717	1,295 [c]
95% CI [a]	553 –717	1,268–2,099	463 –837	1,290–2,309	448 –770	1,158–3,288
Work disability costs (€)						
median	1,913	777	3,022	2,705	0	453
95% CI [a]	0 – 3,044	336–1,893	1,034–5,840	645–3,527	0– 2,148	0–875
Total costs (€)						
median	2,507	3,155	3,485	4,529	770	2,253 [e]
95% CI [a]	810–3,739	2,018–4,663	1,547–6,419	2,458–5,836	682–2,842	1,158–4,163

[a] Non-parametric confidence interval; [b] p = 0.03 vs. cast group; [c] p < 0.001 vs. cast group; [d] p = 0.001 vs. cast group; [e] p = 0.047 vs. Cast group. All p-values 2-tailed.

lar occupation from Statistics Sweden, and time absent from work was as indicated in the medical charts or by the employer. Costs are reported in € (euros).

Power and statistical methods

A sample-size calculation for the present study was done using t-test for 2 independent groups. The planned immobilization time in the operative group was 2 weeks and the expected time off work was 6 weeks. The immobilization time in the cast group based on clinical practice was 10 weeks on average, and the expected time off work was 12 weeks. A calculation based on these data indicated that we would need 26 patients in each group to provide a power of 91% to detect a difference of 6 weeks (alpha 0.05, 2-tailed, SD 45). A more cautious power analysis adapted for non-parametric analysis and with the addition of 15% more subjects would still yield a power of more than 80%.

The results are presented as median and 95% non-parametric confidence interval, as calculated from SPSS software release 14.0. Differences (presented as 2-tailed) between groups were assessed by the Mann-Whitney U test.

Results

There were 2 implant-related complications in the surgical group, where the bone screw was not positioned satisfactorily and was therefore removed. In 1 patient the fracture was stabilized with K-wire and a cast, and in the other it was treated with only a cast. 4 implants were removed for various reasons, and the costs for this procedure are included in the medical costs. 1 patient in the surgical group sustained a reflex sympathetic dystrophy and had a very long sick leave (6 months).

1 patient in the cast group was treated with a cast for 3 months. As the radiographs showed signs of nonunion, the patient was treated surgically with bone grafting and Herbert bone screw fixation. This was regarded as a failure of conservative treatment and the cost for surgery was included in this group.

The median time of absence from work for the 52 patients studied was 74 days in the cast group and 39 days in the surgery group (p = 0.32) (Table 3). Those with manual work had a longer time off work than the non-manual employees/self employed (median time 84 days as opposed to 16 days; p < 0.001) (Table 4). In the manual worker group, there was a significantly longer period of

Table 4. Cost assessment based on occupation (both treatment groups). Values are median (95% non-parametric confidence interval)

	Manual workers (n = 25)	Non-manual employees/ self-employed (n = 27)
No. of outpatient visits	5 (4–6)	6 (5–6)
Time absent from work (days)	84 (59–100)	16 (0–42) [a]
Hospital costs (€)	1,285 (682–1,933)	1,070 (717–1,268)
Work disability costs (€)	2,847 (1,782–3,706)	99 (0–875) [a]
Total costs (€)	4,396 (2,458–5,460)	1,240 (810–2,842) [a]

[a] $p < 0.001$ vs. manual workers.

absence from work in those undergoing closed treatment than in those undergoing surgery (median 100 and 61 days, respectively; $p = 0.03$) (Table 3). In contrast, there was no difference regarding absence from work between those treated nonoperatively and those treated surgically in the non-manual employees/self-employed group (median 0 and 19 days, respectively; $p = 0.5$).

Hospital costs were higher in the operated group than in the cast group ($p < 0.001$) (Table 3). There was no difference in hospital costs between those with manual work and those in the non-manual employees/self employed group. Work disability costs were numerically but not statistically significantly higher in the nonoperatively treated group than in those who underwent surgery (€1,913 as opposed to €777; $p = 0.4$) (Table 3). However, work disability costs were statistically significantly higher in the manual workers than in the non-manual employees/self employed group (median €2,847 as compared to €99; $p < 0.001$) (Table 4). Although the figures were numerically higher in the cast group than in the surgically treated manual worker group, there was no statistically significant difference in work disability costs between the two treatment regimens (€3,022 and €2,705, respectively; $p = 0.6$) (Table 3).

The median total cost was numerically but not significantly higher in the operated group than in the cast group (€3,155 and €2,507, respectively) (Table 3). With respect to socioeconomic classification, the total costs were higher in manual workers than in the non-manual employees/self-employed group (median €4,396 as opposed to €1,240; $p < 0.001$) (Table 4). In the non-manual employees/self employed group, the total costs were lower in the cast group than in the operated group (€770 and €2,253, respectively; $p < 0.05$) (Table 3.). This can be explained by the fact that more than half (7 of 13) of the non-manual employees/self employed individuals were able to work with a plaster cast and consequently had no work disability cost.

Discussion

Our study is the first attempt to assess the health economic consequences of treatment of scaphoid fractures using a randomized approach. We found that the major predictor of postoperative time of absence from work, and for total healthcare costs, was the socioeconomic status of the patient. Mode of treatment affects time off work, but the size of the study did not permit detailed conclusions regarding definite economic advantages of either of the treatments.

At the time of our study, there was a generous attitude towards operating on this patient group on an in-hospital basis—a consideration that has influenced treatment costs for the operated group. Since then, simplified minimally invasive techniques with cannulated screws have facilitated the surgical procedure, which is why this surgery is performed on a day-surgery basis both in our hospital and elsewhere (Adolfsson et al. 2001). Thus, current hospital costs are less than when the study was performed.

In 2001, Saeden et al. found—also in a randomized group of patients—that surgical treatment with a Herbert screw resulted in shorter sick leave than cast treatment, but the validity of the sick leave assessment was not reported. These results have been corroborated in our study, where information on the true sick leave was obtained from

the National Swedish Health Insurance System. Furthermore, the observation of these authors that the benefit of shorter sick leave was restricted to "blue-collar occupations" is similar to the observation made by us using formal criteria for the socioeconomic status of the patients.

The variable period of absence from work is influenced by many factors. The single most important is the patient's occupation and the incentive to resume work. We found that socioeconomic classification had a greater influence on cost than mode of treatment. Regardless of treatment, non-manual employees and self-employed individuals had less time off work than manual workers.

The prevailing health insurance system is known to affect the extent of "time off work". In a study from the Netherlands, Van der Molen and colleagues (1999) reported that less than 2% of patients with nonoperatively treated fractures worked with a plaster cast, whereas Fusetti and colleagues from Switzerland (2003) reported that 34% resumed work with the wrist immobilized in plaster. In our study, one-third of the nonoperatively treated patients could work with a plaster cast.

A recent non-randomized Swiss study showed that surgical treatment of scaphoid fractures using a minimally invasive technique markedly reduced work compensation costs (Papaloizos et al. 2004). Numerically, their figures are similar to ours, but the interindividual variation in their study was less and the power to ascertain statistical differences was consequently larger.

A key issue is that the overall consequences of long sick leave to society are difficult to ascertain. It has, however, been pointed out recently that a long period of time on sick leave has potentially negative consequences for the individual (Vingard et al. 2004).

The main strength of our study is undoubtedly the prospective and randomized approach. There are a number of limitations, however. One such limitation is that the naturalistic approach led to variations in treatment strategies that could have been minimized by a more strict study protocol. The casting time, for example, depended largely on the surgeon's preference and clinical evaluation. Furthermore, for subjective and logistic reasons there were differences concerning whether patients were operated on an inpatient or on a day-care basis. One last weakness, which reduced the power of the study, is that the socioeconomic classification used does not fully dichotomize manual and non-manual workers.

Although our study is too small to allow us to assess differences between treatments with high statistical power, it is still obvious that the predominant variable determining the need for sick leave, and thus total costs, is the socioeconomic status of the patient. As previous studies have shown that the main difference between cast and surgical treatment of minimally displaced scaphoid fractures is the time in plaster rather than improved healing (Adolfsson et al. 2001), it seems rational to suggest that surgical treatment should mainly be considered in cases where time in plaster affects the patient's ability to work at his or her chosen occupation.

Contributions of authors

BV: was the main author, operated on most patients, and designed the study. FE: initiated the study and was responsible for conduction of the study; also, revision of the manuscript. BG: analyzed and compiled data, and revised the manuscript.

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