

Fixation of nondisplaced scaphoid fractures: making treatment cost effective

Prospective controlled trial

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Abstract

Introduction Nondisplaced scaphoid waist fractures treated with prolonged plaster immobilisation often lead in transient joint stiffness and to a delay in return to sport and work activity. The long time off work increases the work off compensation costs. Internal fixation of scaphoid fractures has resulted in a shorter time to union and to return to work and sports. This prospective study compares cast immobilisation with screw fixation and the direct cost with indirect cost of conservative and minimally invasive treatment of undisplaced scaphoid fractures.

Materials and methods Forty-seven patients with an acute nondisplaced waist fracture of the scaphoid were allocated into either cast immobilisation or internal screw fixation for this study. Cost data concerning the groups of nonoperated and operated patients were analysed. Range of wrist motion, grip strength, DASH-score, time to fracture union, return to work time and the needed physiotherapy at the final follow-up at 6 months were evaluated.

Results Twenty-one patients were included in the group of screw fixation and 23 patients were included in the group of cast immobilisation. At final follow-up there was no significant difference in the range of motion of the wrist or in grip strength. The operatively treated group had a better mean DASH-score than the

conservative group. Fracture union was seen in the screw fixation group at a mean of 43 days and in the cast immobilisation group at a mean of 74 days ($P < 0.5$). The average time of return to work was 8 days for patients who had an internal screw fixation, while those treated with a cast returned to work at a mean of 55 days ($P < 0.5$). In total the internal fixation of undisplaced scaphoid fractures is less expensive than conservative treatment.

Conclusion Internal screw fixation of nondisplaced scaphoid fractures had a shorter time to bony union and the patients returned earlier to work compared with cast immobilisation. Although it is assumed that operative treatment is more expensive, in this study the cost was not found to be higher.

Keywords Scaphoid fractures · Conservative treatment · Screw fixation · Treatment costs

Introduction

The established treatment for undisplaced scaphoid fractures is immobilisation in a cast for 8–12 weeks [15, 22]. Nonoperative treatment is successful in achieving union in 88–95% [4, 5]. But the long period of casting and resultant long immobilisation time needed in young, working and active adults often leads to non-compliance (removing of cast) of these patients. Even after fracture union and removal of the cast, recovery of wrist motion needs 1–4 weeks to return to normal [8]. The long time off work, the financial loss and the long immobilization of these patients led to an increasing use of internal fixation, which does not require an immobilization and allows

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for a more rapid return to sport and work activities [9, 16, 19]. This prospective study compares the functional and the radiological outcome, and the accruing cost of acute scaphoid fractures after nonoperative treatment with immobilisation in a cast versus internal screw fixation.

Materials and methods

This study received the approbation at the ethics committee of our university hospital. From November 2003 to December 2005 a total of 86 patients with a fracture of the scaphoid were treated in our unit. All working adult patients (>18 years) with a mature skeleton suffering from an isolated, undisplaced waist fracture (Type B2, according to Herbert and Fischer) of the scaphoid were invited to participate in the trial [10]. Patients with associated injuries, self-employed and unemployed patients were excluded. Patients who were examined 3 weeks or longer after injury were also not included in the study. Benefits and risks of operative and nonoperative treatment were discussed with the patients. All of them got an information sheet and after their concurrence a written consent was obtained. Forty-seven patients who met the inclusion criteria were included in this study. Three patients (operation group, $n = 2$; conservative group, $n = 1$) did not show up for final follow-up evaluation.

Groups of treatment

Our patients were allocated into one of two treatment groups.

Group 1 consisted of 21 patients who had percutaneous scaphoid fixation under regional or general anaesthesia. Patients had to stay overnight in the hospital.

Group 2 consisted of 23 patients who were treated with immobilisation in a below the elbow cast with the thumb closed to the interphalangeal joint and the wrist in a functional position.

In total there were 12 women and 32 men; their average age was 33 years (range, 20–56 years). The diagnosis was based on standard scaphoid view (posteroanterior, lateral, semisupinated oblique, semi-pronated oblique) radiographs and on CT scans. Around 23 fractures were on the dominant side and 21 on the non-dominant side. In 24 patients (54%) the cause of the fracture was a fall from height of some sort. Ten patients (23%) sustained a work and 10 patients (23%) a sports-related accident. Twenty patients (45%) were manual labourers, 19 patients (44%) were employed in administrative positions,

and five patients (11%) were students. Age, gender, dominant hand, injured side and occupation of the patients for each treatment group was similar and is shown in Table 1.

Treatment modality

Patients of Group 1 were treated using a longitudinal incision over the scaphotrapezail joint. Under ulnar deviation of the wrist a 1.0 mm Kirschner wire was inserted retrogradely into the scaphoid. The correct position of the wire was controlled using the image intensifier in two planes. After the length was measured, a cannulated screw (Bold-screw, $n = 12$; Acutrak-screw, $n = 9$) was inserted under fluoroscopic control, the wire was removed and the skin mended with stitches. A short palmar splint was applied post operatively. Patients were encouraged to begin active finger motion before discharge. After wound healing the suture and the palmar splint were removed and the position of the screw was confirmed radiographically (Figs. 1a–2c). Physiotherapy with active wrist motion was started, but full load bearing, extreme wrist positions, hard manual work and sport activities were not permitted until there was a radiological sign of union. Fracture union and bone healing was assumed when trabecular bone could be seen crossing the fracture site on all standard scaphoid view radiographs [18].

The patients in the nonoperative Group 2 were treated with immobilisation in a below-elbow cast with the thumb closed to the interphalangeal joint and the wrist in a functional position until radiological sign of union was seen (Figs. 3a–4c). Casts were changed after every 4 weeks and at the same time radiographs were performed and functional evaluation was made. After fracture union the cast was removed and physiotherapy was started. The patients were advised to resume activity as much as possible and return to work was allowed when the patient felt ready.

Table 1 Patients demographics

	Operative ($n = 21$)	Conservative ($n = 23$)
Mean age in years (\pm SD)	35 \pm 11.9	32 \pm 8.5
Gender (F/M)	5/16	6/17
Side of injury (L/R)	10/11	12/11
Injury of dominant hand	11	12
Occupation (number of patients)		
Manual work	9	11
Office	9	10
Students	3	2

Fig. 1 Anteroposterior (a), oblique (b), and lateral (c) radiographs of thirty-eight year old man with an acute nondisplaced fracture of the scaphoid waist who decided to have an internal fixation

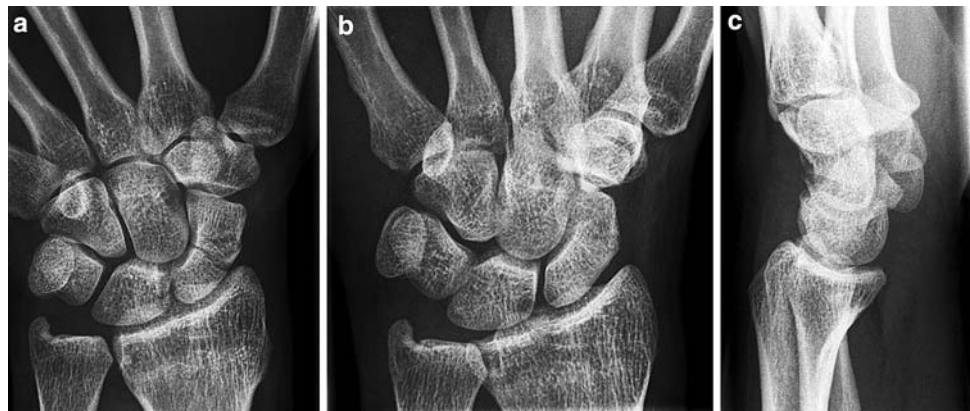
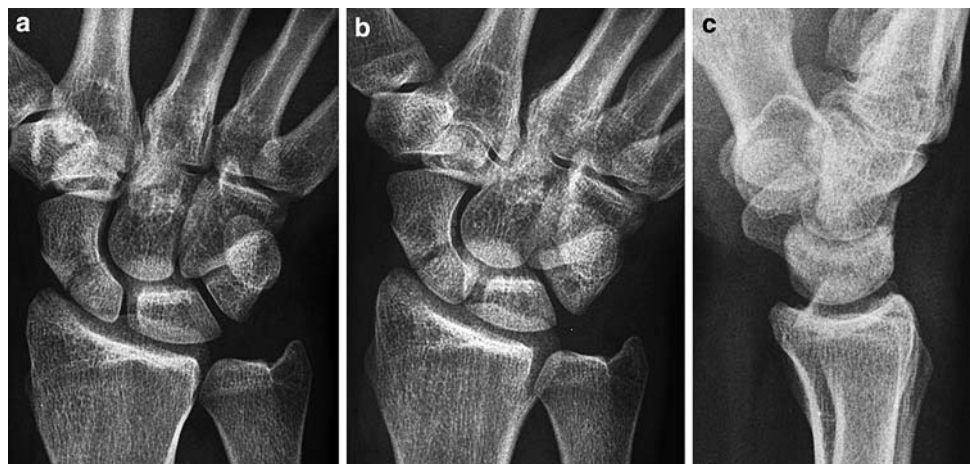


Fig. 2 Postoperative anteroposterior (a), oblique (b), and lateral (c) radiographs of the patient whose radiographs are shown in Fig. 1



Fig. 3 Anteroposterior (a), oblique (b), and lateral (c) radiographs of a thirty-four year old man with an acute nondisplaced fracture of the scaphoid waist who decided to have nonoperative treatment with cast fixation



Functional and radiological evaluation

Functional and radiographic assessments were performed after 10 days (operative group), at 4, 8, 12 and 24 weeks. At the final follow-up bone healing was also confirmed using a CT scan. Functional assessment included measurement of active range of wrist extension, flexion, radial deviation, ulnar deviation, pronation and supination using a goniometer.

Grip power was measured with a dynamometer (Jamar; Therapeutic Equipment, Clifton, NJ). Functional subjective outcome was measured by the disability of the arm, shoulder, and hand (DASH) questionnaire at final follow-up [14]. Wrist pain was evaluated using the visual analogue scale (VAS 0: no pain, VAS 100: severe pain). Measures of analysis of variance was used to test for any average difference between the two different treatment groups at each

Fig. 4 Follow-up anteroposterior (a), oblique (b), and lateral (c) radiographs of the patient whose radiographs are shown in Fig. 3. Fracture healing was confirmed at 12 weeks



follow-up visit and at final follow-up and if there was any change over the time. Fractures that showed no bone healing at 24 weeks in computed tomography were classified as non-union and second surgery was recommended.

Cost calculation

All patients were followed-up clinically and radiologically until recovered. All medical and paramedical acts were recorded on a separate form allowing the collection of data on direct cost. More over the date of return to work and the needed hand therapy sessions were documented. Hospital cost information was retrieved from the cost allocation. Work disability costs were assumed according to the Austrian standard wages for employees and the therapy cost were retrieved from the physiotherapy office. Students (three students in the operation group, two students in the conservative group) were not included in the cost data collection.

Statistical analysis

SPSS for Windows 12.0 (SPSS, Chicago, Illinois) was used for the statistical analysis. A Student's *t*-test was performed if the samples were normally distributed and the homogeneity of variances was given. Otherwise, non-parametric Mann–Whitney *U*-test was used. The Kolmogorov–Smirnov test was performed to determine whether the distributions differ significantly from a normal distribution. The Levene test was used for determination of the homogeneity of variances. A *P* value of less than 0.05 was considered statistically significant.

Results

Radiological and functional

Forty-four patients were included into the study. The mean age, sex, injured side; hand dominance and occupation were comparable in the operative and conservative groups (Table 1). Mean time from injury to surgery was 7.8 ± 3.4 days (range 1–13 days). Conservatively treated patients were treated in mean 2.2 ± 4.2 days (range 0–12 days) after injury. Time to fracture union is shown in Table 2. Fracture union was seen in Group 1 at a mean of 43 ± 5.2 days (range 31–52 days) and in Group 2 at a mean of 74 ± 8.3 days (range 65–97 days). Time to union in the operated group was significantly shorter than in the cast immobilisation group ($P < 0.05$). There was one

Table 2 Fracture union at follow-up (4, 8, 12, 24 weeks)

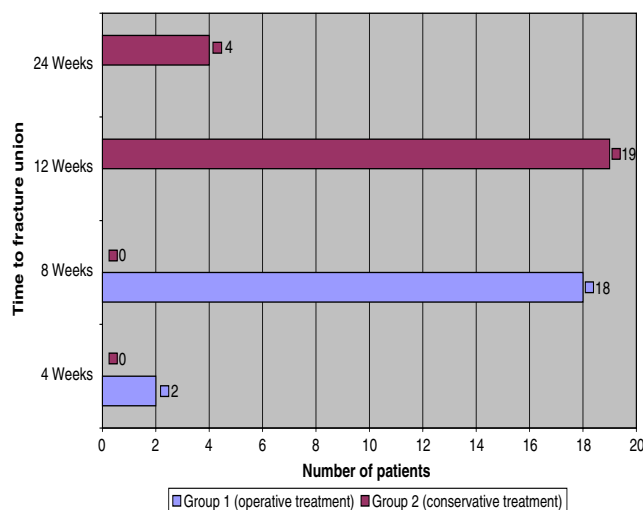


Table 3 Outcome measures of active range of motion

	4 weeks	8 weeks	12 weeks	24 weeks
Extension*	48 ± 11.5	61 ± 10.4	66 ± 10.8	69 ± 8.3
Extension**	55 ± 7.1	53 ± 7.6	65 ± 7.8	71 ± 5.6
<i>P</i> value	0.472	0.280	0.815	0.608
Flexion*	44 ± 11.4	56 ± 11.0	62 ± 13.9	63 ± 16.9
Flexion**	35 ± 7.1	37 ± 15.3	61 ± 9.1	69 ± 7.8
<i>P</i> value	0.360	0.031	0.852	0.321
Radialdeviation*	19 ± 6.5	23 ± 8.4	25 ± 4.4	28 ± 7.6
Radialdeviation**	18 ± 3.5	25 ± 5.0	21 ± 6.8	24 ± 3.5
<i>P</i> value	0.779	0.731	0.162	0.242
Ulnardeviation*	23 ± 4.5	29 ± 5.6	36 ± 6.9	44 ± 19.0
Ulnardeviation**	30 ± 4.7	23 ± 11.5	33 ± 12.3	32 ± 8.8
<i>P</i> value	0.025	0.257	0.263	0.082
Pronation*	90 ± 0.0	89 ± 3.3	90 ± 0.0	90 ± 0.0
Pronation**	90 ± 0.0	87 ± 5.8	88 ± 4.2	89 ± 3.5
<i>P</i> value	1.0	0.392	0.146	0.317
Supination*	90 ± 0.0	88 ± 3.8	90 ± 0.0	85 ± 13.4
Supination**	90 ± 0.0	89 ± 5.7	87 ± 4.8	89 ± 3.5
<i>P</i> value	1.0	0.392	0.067	0.927

*Group 1 (operative treatment), **Group 2 (conservative treatment)

Table 4 Outcome measures of strength and pain

	4 weeks	8 weeks	12 weeks	24 weeks
Grip strength*	28 ± 9.1	35 ± 10.6	43 ± 14.9	46 ± 10.7
Grip strength**	26 ± 4.3	40 ± 5.3	41 ± 9.8	42 ± 10.2
<i>P</i> value	0.968	0.921	0.918	0.771
Pain*	28 ± 9.1	13 ± 11.5	12 ± 11.3	2 ± 6.3
Pain**	30 ± 5.7	16 ± 11.4	8 ± 9.9	3 ± 5.7
<i>P</i> value	0.921	0.513	0.132	0.432

*Group 1 (operative treatment), **Group 2 (conservative treatment)

patient in the Group 1 with non-union after 24 weeks. In the Group 2 union was achieved in all patients.

The outcome measure of range of motion is shown in Table 3. Analysis of range of motion showed no significant difference between both groups at final follow-up and between each follow-up visit ($P > 0.05$). Results of grip strength and pain are shown in Table 4. The grip strength and pain showed no significant treatment effect at final follow-up and between each follow-up visit ($P > 0.05$). The operatively treated group with a mean DASH-score of 4 ± 4.2 points (range 0–13 points) had significant better results ($P < 0.05$) than the conservative group with a mean DASH-score of 13 ± 14.1 points (range 0–42 points).

In the operatively treated group, four complications (19%) were observed. One male patient showed a non-union at follow-up at month six. Second surgery was offered to him but he declined it and has still a radiographically non-union which is asymptomatic. There was one superficial wound infection, which was treated with oral antibiotics. Complex regional pain syndrome occurred in two patients and was dealt with physiotherapy and oral analgesics. No

secondary surgical procedures were performed. In the conservatively treated group there were no complications related to the application or wearing of the cast.

Cost data

The mean time of immobilisation in the operative group was 11 ± 2.3 days (range 8–16 days) while patients in the conservative group had a mean immobilisation of 76 ± 10.6 days (range 63–98 days). The operatively treated group had significant shorter immobilisation time ($P < 0.05$). Patients who had an internal screw fixation returned to work at a mean of 8 ± 8.1 days (range 0–21 days), while those treated with a cast returned to work at a mean of 55 ± 49.6 days (range 0–140 days). The time off work was significant shorter in the operative group ($P < 0.05$). All patients returned to their previous jobs. The cost-analysis of both treatments is given in Table 5. The mean primary costs (radiographs, medical visits, plaster and plaster replacement, surgery) were significantly higher in operated patients than in conservatively treated patients

Table 5 Treatment needs and cost of internal screw fixation and conservative treatment

	Operative (<i>n</i> = 21)	Conservative (<i>n</i> = 23)	<i>P</i> -value
Radiology*	4.9 ± 0.6	6.9 ± 2.2	<0.05 ^b
Radiology**	66.8 ± 8.4	93.3 ± 29.1	<0.01 ^b
Visits*	5.6 ± 1.4	8.2 ± 1.9	<0.01 ^a
Visits**	109.7 ± 25.4	163.6 ± 34.6	<0.01 ^a
Cast changes*	1.0 ± 0.0	3.8 ± 1.3	<0.01 ^b
Cast changes**	17.8 ± 0.0	66.0 ± 22.4	<0.01 ^b
Physical therapy*	3.2 ± 5.9	15 ± 7.7	<0.01 ^a
Physical therapy**	123.2 ± 233.5	585.0 ± 299.2	<0.01 ^a
Time off work in days	7.5 ± 8.1	54.6 ± 49.6	<0.01 ^b
Off work compensation**	200.3 ± 216.5	1453.2 ± 1320.8	<0.01 ^a
Surgery**	1579 ± 16.7	0	
Total costs	2097.1 ± 325.0	2363.1 ± 1394.7	>0.05 ^a

*Needed treatment, **cost in Euro

^a *T*-test, ^b Mann–Whitney test

($P < 0.05$). The secondary costs (work compensation cost, therapy costs) were significantly lesser in operated patients than in the conservative group ($P < 0.05$). In total, mean operative treatment (D2097) was less expensive than conservative treatment (D2363), but this was not statistically significant ($P > 0.05$).

Discussion

The scaphoid is the most commonly fractured carpal bone [13]. Hove reported from Norway, that 82% of the scaphoid fractures were in young and working males with a mean age of 25 years [11]. Up to 80 percent of scaphoid fractures occur at the waist or midportion [3, 20]. Internal fixation allows for early active motion, mobility, faster healing, earlier return to sports and work and higher patient satisfaction [9, 19].

In this prospective controlled study, we compared the two methods of treatment to clarify whether there is a difference with respect to early functional and radiological outcome, time off work and the work-compensations cost.

In previous prospective trials, no significant differences have been found for range of motions and grip strength at the 2-year review. Pain data were not reported in this series [2, 23]. Even though our final follow-up was at 6 months, we also did not find any significant difference for range of motion and strength between the group treated operatively and the group treated nonoperatively. The benefits of the shorter time of immobilisation in the operative group with respect to range of motion and grip strength were transient. No significant difference was found between the two groups regarding pain. At final follow-up patients of both groups reported about little or no pain.

In this study fractures treated with internal fixation have healed in average 31 days earlier than those treated with cast. The operative treated patients returned to work more than six and a half weeks sooner. These results are consistent with those of other reports. Bond et al. [2] reported a mean time to fracture union (trabecular bone bridging) of 7 weeks in fractures treated with internal fixation and a mean time of 12 weeks in conservatively treated fractures. Their patients with internal fixation returned to work 7 weeks earlier. Inoue and Shionoya reported a shorter time to union (trabecular bone bridging) and an earlier return to manual labour of operative treatment compared to conservative treatment. In the surgery group the fractures healed at an average time of 6 weeks, whereas those in cast group healed at an average of 9 weeks. Manual workers returned to work at an average of 6 weeks after internal fixation and at an average of 10 weeks after cast immobilisation [12].

In general, it is difficult to predict a fracture union on the basis of the fracture type [7]. Displacement can be used only as an indication for surgery [22]. Saeden et al. and Dias et al. [23, 6] reported about higher rate of union of about 95% for the group that had internal fixation than for the group that had nonoperative treatment. Bond et al. [2] compared 11 patients with percutaneous screw fixation with 14 patients treated with cast immobilisation. He reported no non-unions in both treatment groups. In this study we had only one (5%) non-union in the operatively treated group. Our study could not confirm that the union rate was higher in the operative than in the conservative group.

The cost analysis in this study revealed that treatment of undisplaced scaphoid fractures with internal screw fixation is finally less expensive than conservative treatment with cast immobilisation. Although high

variable, primary cost was smaller in operated patients and the end costs were higher in conservatively treated patients. Analysing the statistical results more in detail, the mean costs of the operative group are not varying very much (standard deviation: D325) while the cost of the conservative group are highly variable (standard deviation: D1395). This may be explained through the different number of needed therapies in the conservative group. Patients with screw fixation returned earlier to work and needed less therapy for recovering the range of motion than patients treated conservatively. This reduces significantly the work compensation and the therapy costs.

Cost analyses of diagnosis and treatment methods of scaphoid fractures are rare. Papaloizos et al. compared the cost of conservative ($n = 62$) and minimally invasive ($n = 23$) treatment for undisplaced scaphoid fractures in Switzerland. They reported that treatment with minimally screw fixation was overall less expensive than conservative treatment in cast [17].

The comparison of cost data of our study with other studies from other countries is limited. There are big differences of the health care and insurance systems. The work off compensation depends on the prevailing insurance system of the country and may influence the time off work.

In total, from medical point of view, the benefit for the patient of internal fixation of an undisplaced scaphoid waist fracture is difficult to quantify, except the faster bone healing and the early return to work and daily activity. Comparing the functional results, complications and the union rate of internal fixation and the nonoperative treatment of scaphoid waist fractures, we believe that this kind of fractures can all be treated conservatively. The surgical procedure only helps the patient to lead to better quality of life during limited span but has the risks of complications. If a medical perspective is taken, internal fixation should be offered only to patients who cannot carry on their jobs with a cast and are aware of losing their jobs.

From the economical point of view, the long period of immobilisation leads to a prolonged time off work of the young and employed patients, which increases the work off compensation costs. From the perspective of the health insurance system of a country that has to pay the operative and the conservative treatments, surgery seems to be costly. But at the end of the treatment, the internal fixation of undisplaced scaphoid fractures is less expensive than conservative treatment, because work compensation costs and therapy costs can be reduced by surgery.

We offer internal fixation to patients who cannot continue their jobs with a cast and are aware of losing

their jobs. From an economical point of view, internal fixation could be offered to all patients.

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