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Percutaneous fixation of acute scaphoid waist fractures: long-term patient-reported functional outcomes and satisfaction at a mean of 11 years following surgery

Traitement chirurgical par vissage percutané des fractures du tiers moyen du scaphoïde : résultats fonctionnels au recul moyen de 11 ans après la chirurgie

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ABSTRACT

Objectives: The aim of this study was to report the long-term functional outcomes and complication rates following early percutaneous fixation of acute fractures of the scaphoid.

Materials and Methods: A trauma database was searched to identify all skeletally-mature patients with an undisplaced or minimally-displaced scaphoid waist fracture managed with early percutaneous retrograde screw fixation over a thirteen-year period from 1997-2010. Medical records were retrospectively reviewed, and complications documented. Long-term follow-up was by a questionnaire-based review. The Patient-Rated Wrist Evaluation (PRWE) was the primary outcome measure. Secondary outcomes included the Quick version of the Disability of the Arm, Shoulder and Hand score (QuickDASH), the EuroQol 5-dimensions score (EQ-5D-5L), and complications.

Results: During the study period 114 patients underwent this procedure. The mean age was 28 years (range, 17-62) and 97 patients (85%) were male. The median time from injury to surgery was nine days (range, 1-27). Twelve patients (11%) reported a complication, all of whom required repeat surgical intervention (six revision ORIF for non-union, five elective removal of hardware, one early revision fixation due to screw impingement). Long-term outcome data was available for 77 patients (68%) at mean follow-up of 11.4 years (range, 6.4-19.8). The median PRWE was 0 (IQR 0-7.5), median QuickDASH 0 (IQR 0-4.5) and median EQ-5D-5L 1.0 (IQR 0.837-1.0). There were 97% (n=74) patients satisfied with their outcome.

Conclusion: Early percutaneous fixation of acute non-displaced or minimally displaced scaphoid fractures results in good long-term patient reported outcomes and health-related quality of life. Although comparable with previous studies, the overall surgical reintervention rate is notable and can result in inferior outcomes.

Keywords: Scaphoid; percutaneous fixation; functional outcomes

Level of Evidence: Therapeutic level III (Retrospective Cohort Study)

RESUMÉ

L'objectif de cette étude était de présenter les résultats fonctionnels à long terme du vissage percutané pour les patients présentant une fracture non déplacée du tiers moyen du scaphoïde. Il s'agissait d'une étude rétrospective. Les patients opérés pour une fracture du scaphoïde récente non déplacée par vissage percutané sur une période de treize ans (1997-2010) ont été inclus (114 patients). Les scores PRWE, QuickDASH, EQ-5D-5L, et les complications ont été collectés par téléphone. Les données concernent 77 patients (68% après un suivi de 11,4 ans). L'âge moyen était de 28 ans et 97 patients (85%) étaient de sexe masculin. Le délai médian entre la blessure et la chirurgie était de neuf jours. Douze patients (11%) ont signalé une complication, qui a toujours nécessité une réintervention chirurgicale (six pour pseudarthrose, cinq ablations électives du matériel, une révision précoce d'ostéosynthèse pour un conflit avec la vis. Le score PRWE médian était de 0 (IQR 0–7,5), le score QuickDASH médiane était de 0 (IQR 0–4,5) et le score EQ-5D-5L médian était de 1,0 (IQR 0,837–1,0). Le taux de satisfaction était de 97%. Cette technique apporte excellents résultats fonctionnels et qualité de vie à long terme, de hauts niveaux de satisfaction de patients.

***Mots-clés:** scaphoïde; vissage percutané; résultats fonctionnels*

***Niveau de preuve:** Thérapeutique, niveau III (étude de cohorte rétrospective)*

INTRODUCTION

Stable non-displaced or minimally-displaced fractures of the scaphoid waist are routinely managed nonoperatively[1], with surgery reserved for displaced or unstable fracture patterns[2]. More recently, the concept of early fixation of acute minimally-displaced fractures has gained support[3–5]. Proponents of early percutaneous fixation cite shorter union times and quicker return to work and sports[6–8] when compared with conservative treatment, which can lead to temporary but disabling joint stiffness and muscle weakness[8,9]. Comparable cost-effectiveness of both techniques has been reported by some[9,10], although the recently reported SWIFFT study found no difference in the patient reported outcomes at one year and non-operative management was significantly cheaper[11]. The optimum treatment of acute minimally-displaced scaphoid waist fractures continues to be debated[12] and management varies significantly depending on geographic location and local expertise[13].

Positive long-term patient-reported outcomes measures (PROMs) have previously been reported following open reduction and internal fixation (ORIF) of scaphoid fractures[14–16]. However, there are very few studies that describe the long-term PROMs following acute percutaneous fixation of non-displaced or minimally-displaced fractures. These studies are usually limited by heterogenous fixation techniques[14,15,17], small patient cohorts[18–20] or short follow-up periods[18–21]. Disabling complications relating to non-union and post-traumatic arthrosis may not appear for many years following a scaphoid fracture[22], and it is evident that studies reporting early and mid-term follow-up following percutaneous fixation may underestimate these complications. At present, there is a paucity of literature regarding the long-term outcomes of scaphoid fractures managed with acute percutaneous fixation.

The primary aim of this study was to describe the long-term upper limb-specific PROMs following acute percutaneous fixation of non-displaced or minimally-displaced

scaphoid waist fractures. Secondary aims were to describe health-related quality of life (HRQoL), patient satisfaction, and complications following this procedure.

PATIENTS AND METHODS

The setting for this study was a single level I trauma centre. The study cohort was identified retrospectively over a 13-year period (1997-2010). The inclusion criterion was all skeletally-mature patients who underwent early percutaneous screw fixation for non-displaced or minimally-displaced acute scaphoid waist fractures. Exclusion criteria were skeletally immature patients who were treated at a separate specialist paediatric institution, patients with established non-union of the scaphoid, or patients with an absolute indication for mini-open or open fixation, (proximal pole fractures, displaced fractures that could not be satisfactorily reduced closed, trans-scaphoid perilunate fracture dislocations). The study was reviewed by the local NHS Research Ethics Service (NR/166AB5) and registered with the local musculoskeletal quality improvement committee.

Management pathway

During the study period patients with a radiographically confirmed acute fracture of the scaphoid (Figure 1) were referred to the local hand trauma clinic under the supervision of two consultant hand surgeons with level V experience[23]. Patients with acute non-displaced or minimally displaced fracture patterns were offered either conservative management with 6-10 weeks immobilisation followed by physical therapy, or acute percutaneous fixation followed by early mobilisation. There was no randomisation or concealment of treatment.

Percutaneous fixation was undertaken as a day case procedure under general anaesthesia (GA) using a high-arm tourniquet. All patients received intravenous antibiotic prophylaxis. The procedure was undertaken utilising either the Acutrak or mini Acutrak headless screw system (Acumed, Hillsboro, Oregon). The screw was inserted retrograde via a 5mm incision over the distal pole of the scaphoid under intraoperative fluoroscopy using a standard technique[24]. The surgical wound was closed with a single interrupted suture or

adhesive wound dressing strip, which was removed after ten days. Patients routinely took down a bulky bandage dressing at 72 hours and were offered a wrist splint for 10-14 days for comfort if required but were instructed to mobilise their wrist as tolerated. Physiotherapy was initiated at the discretion of the treating surgeon.

Complications

Patients underwent short-term follow-up assessment at our centre, which is the solitary provider of orthopaedic trauma care in the region. Postoperatively all patients were reviewed in the outpatient clinic until satisfactory function was regained and radiographic union had been confirmed (Figure 2). Radiographic union was defined as consolidation and progression of the normal trabecular pattern across the fracture site on three out of four radiographic views[25]. Details of complications and subsequent surgeries were recorded at each visit, as was the progression to union on radiographs. Radiographs were reviewed retrospectively where available (n=53, 47%).

Long-term patient-reported outcomes

Follow-up was via telephone interview and questionnaire review conducted by two of the authors (PHCS and RDB). The primary outcome measure was the Patient-Rated Wrist Evaluation (PRWE)[26]. Patients also completed the Quick version of the Disabilities of the Arm, Shoulder, and Hand score (QuickDASH score)[27], and HRQoL was assessed using the EuroQoL 5 dimensions score (EQ-5D-5L)[28]. Patients were also asked if they had persistent pain or stiffness in their wrist and their responses were graded on a 10-point Likert scale. Patient satisfaction was assessed by asking “how satisfied are you following your surgery?” Responses were measured on a 10-point Likert scale, and patients who reported scores of five or over were considered to be satisfied. This is consistent with previous studies describing

satisfaction following hand surgery[29]. Data relating to time required to return to work and sports was also documented. Telephone consultation was also used to confirm complications and if any further surgery had been undertaken. Patients who were not contactable by telephone underwent electronic chart and radiograph review to investigate the presence of any further complications since their final clinical review.

Statistical Methods

Data was checked for normality using the Shapiro-Wilk test. Parametric data is presented as mean and Standard Deviation (SD). Non-parametric data is presented as median and interquartile range (IQR). Categorical data was compared using the Chi-squared test, or Fisher's exact test if there were fewer than five observations. Mean values were compared using the Student *t*-test, and median values were compared using the independent samples Mann-Whitney U test or the Kruskal-Wallis test for more than two groups. Correlation between continuous variables was assessed using Pearson's correlation for parametric and Spearman's correlation for non-parametric data. The relationship between the occurrence of a complication and long-term PRWE was tested using multivariable regression analysis. Age, gender, and socioeconomic deprivation status were also entered into the model as these have previously been shown to influence functional outcomes following fractures of the upper limb [30–32]. The beta coefficients and 95% confidence intervals are reported. A *p*-value of 0.05 was considered to be statistically significant.

RESULTS

During the study period 114 patients met the inclusion criterion. The mean age at time of surgery was 28 years (SD 9; range 17-62 years) and 97 patients (85%) were male. The median time from injury to surgery was nine days (IQR 5-13; range 1-27 days).

Complications

The mean time to radiographic union was 13 weeks (SD: 7; range 5-40 weeks). Across the entire cohort of 114 patients, 12 complications occurred (11%). Three distinct types of complication were encountered: six patients (5%) required revision ORIF for non-union (Figure 3), five patients (4%) required elective removal of hardware due to screw impingement or irritation, and one patient required revision percutaneous fixation within one week due to screw impingement.

Long-term patient-reported outcomes

Complete long-term outcome data was available for 77 patients (68%) at a mean follow-up of 11.4 years (range, 6.4-19.8). For this group, the mean age at time of surgery was 30 years (SD: 10; range 17-62 years) and 67 patients (87%) were male. The median time from injury to surgery was nine days (range 1-27; IQR 6-13 days). Non-responder analysis was undertaken: two patients did not wish to participate, and 35 had moved to another geographic region and were unavailable for telephone consultation. Non-responders were significantly younger than those who responded (25 vs 30 years; $p=0.011$) but no significant difference was observed in percentage of males (89% vs 87%; $p=0.740$) or percentage of complications at last clinical and radiographic follow-up (5% vs 13%; $p=0.499$).

PROMs were excellent with a median PRWE of 0 (IQR: 0-7.5), median QuickDASH of 0 (IQR: 0-4.5), and median EQ-5D-5L of 1.0 (IQR: 0.837-1.0). The majority of patients

reported a PRWE score of 0 (51% of patients) and QuickDASH score of 0 (55% of patients). The follow-up time from surgery did not correlate significantly with the PRWE score, QuickDASH score or EQ-5D-5L. Fourteen patients (18%) reported a degree of pain in their wrist and 19 patients (25%) reported a degree of stiffness: among these patients the median subjective score for pain was 3.5 and for stiffness 3, but the median scores were 0 for both pain and stiffness across the entire cohort. There were 97% (n=75) of patients satisfied with the outcome of their surgery.

There were 75 patients (97%) employed at the time of injury and all patients returned to work following surgery. The median period of absence from work was two weeks (IQR 1-5.5; range 1-44 weeks) and the median QuickDASH work module score was 0.66. There were 66 patients (86%) who actively participated in sports at the time of injury. Three patients did not return to sport due to other concurrent upper limb disorders, but the remaining 63 were able to return at a median of four weeks (IQR 2-8; range 1-36 weeks). The median QuickDASH sports and performing arts module scores were 0.

Predictors of long-term outcome

No correlation was observed between the time from initial injury to surgery and the PRWE ($r=0.05$; $p=0.667$), QuickDASH ($r=0.08$; $p=0.490$), or EQ-5D-5L ($r=0.06$; $p=0.592$). Of the 77 patients with available PROMs data, ten patients (13%) reported a complication during their recovery (five cases of revision ORIF, and five cases of symptomatic screw impingement necessitating elective removal of hardware). Patients with complications reported significantly worse PRWE and QuickDASH, but no significant difference was found for the EQ-5D-5L (Table 1). The worst outcomes were seen in patients who required revision for non-union. When these patients were removed from analysis, functional outcomes and HRQoL were comparable between patients without complications and those who required screw removal

(Table 1). The presence of a complication was found to be an independent predictor of poorer primary outcome (PRWE) on multivariable regression analysis (Table 2).

DISCUSSION

To our knowledge, this is the largest study that reports on the long-term patient reported outcomes following acute percutaneous fixation of minimally displaced scaphoid waist fractures. We have reported good long-term patient reported function and health related quality of life. High patient satisfaction, along with return to work and physical activities were also observed, with minimal morbidity and low overall pain scores. These results are not intended to compare the use of percutaneous fixation with non-operative management for these injuries, but the data can be used to inform all physicians and patients who may be considering treatment options for non-displaced or minimally displaced fractures of the scaphoid waist.

The primary finding of this study is excellent long-term functional outcomes following acute percutaneous fixation of non-displaced or minimally displaced scaphoid waist fractures. Previous authors have reported promising functional outcomes in the short and medium term [18–21] but few studies report longer term follow up utilising PROMs for this treatment strategy[14,33]. The functional outcomes reported in our study are comparable with the long-term functional outcomes of conservative treatment[14,15] and percutaneous fixation[14], as well as the normative values of PROMs reported by a healthy population without pathology affecting the hand or wrist[34,35]. However, significantly worse outcomes were reported by patients who reported a complication.

The total complication rate of 11% in this study is not trivial, but it is important to note that this is comparable with previous studies investigating percutaneous fixation[18–21,36], and cast immobilisation[17,37]. Non-union occurred in 5% of cases, and these patients reported the worst functional outcomes, although satisfaction was high. The prevalence of non-union in our study is consistent with results of previous randomised controlled trials that compared operative and nonoperative treatment of these injuries. Saeden et al. and Dias et al reported rates of 3% and 0% respectively[15,17], but these studies utilised heterogenous

fixation strategies, and a recent systematic review suggested that the rate of non-union may be closer to 2% for percutaneous fixation of minimally-displaced fractures[38]. Patients who underwent elective screw removal reported comparable outcomes with those who did not report any complications, and superior outcomes to patients who developed non-union. Previous randomised studies have suggested that acute percutaneous fixation can lead to lower rates of non-union[15,17,39] and faster time to union[8,9] when compared with conservative treatment, but with a higher rate of complications. Five of six systematic reviews with meta-analysis have concluded that on current evidence neither method is clearly superior[12,40–44] and the large UK multi-centre SWIFFT (Scaphoid Waist Internal Fixation for Fractures Trial) supports the role of primary non-operative management, with early surgical management advocated for those cases developing a non-union[11]. It is without doubt that non-operative management is a successful treatment while avoiding the costs and complications associated with surgery. However, as with the SWIFFT study that excluded 40 patients due to a patient preference for surgery, patient centred management is key when either treatment can result in satisfactory outcomes. Our results provide evidence that when percutaneous fixation is employed and non-union is avoided, excellent long-term functional outcomes can be expected with no requirement for re-intervention for posttraumatic degenerative disease.

A further finding of this study is the high levels of HRQoL reported by patients following percutaneous fixation. There are very few studies that report on the HRQoL in relation to scaphoid fractures. Hirche et al. described HRQoL following vascularised bone grafting of scaphoid non-unions in 28 patients and the findings may be limited to that specific technique[45]. Ongoing functional impairment, pain and the necessity for a period of absence from work[46] associated with cast immobilisation or non-union would be expected to impact HRQoL. However, HRQoL is multifactorial, and may be eclipsed by general health state. Very good long-term HRQoL in this study may be a result of a young patient cohort, with minimal

general health comorbidities, who are able to return to usual activities rapidly following percutaneous fixation. It is reassuring to observe that there does not appear to be any detrimental effect on long-term HRQoL following percutaneous fixation of scaphoid fractures.

The main limitation of this study is the retrospective design and the associated number of patients lost to follow up (32%), which is a consequence of the patient population and the long-term follow-up we were aiming to achieve. This was an anticipated finding when considering the typical patient cohort of young adult males [47,48], but may have led to an under or overestimation of complication rate. The number of available radiographs was satisfactory, particularly given our local policy of destroying hard copy radiographs and our conversion to a purely electronic system in 2008. However, we employed strict inclusion and exclusion criteria for our study and when radiographs were not available, clear documentation in the medical records from the treating surgeon was utilised. Furthermore, our patient electronic records for the region and national radiographic archive were both consulted to identify any further complications, and attempts were made to contact the family physician of each of these patients, but the vast majority had moved to a different geographical location and had deregistered from their physician. Despite the attritional loss to follow up rate, this study is strengthened by the large number of patients within the cohort and long term follow up, which compares favourably with previously published studies investigating outcomes after percutaneous fixation[18–21].

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TABLES

Table 1: Comparison of PROMs between patients with and without complications.

	Non-union	Screw removal	No complications	p-value
N (%)	5 (7)	5 (7)	67 (87)	-
PRWE (median, IQR)	25.5 (8.8-59.3)	5.5 (0.5-27.3)	0 (0-6)	0.017*
QuickDASH (median, IQR)	14 (12.5-35)	2.3 (0-10.2)	0 (0-2.3)	0.001*
EQ-5D-5L (median, IQR)	1 (0.76-1)	1 (0.82-1)	1 (0.84-1)	0.901*
N satisfied (%)	4 (80)	5 (100)	66 (99)	0.244**

PRWE: Patient-rated wrist evaluation

QuickDASH: Quick version of the Disabilities of the Arm, Shoulder, and Hand score

EQ-5D-5L: EuroQol 5-dimensions score

IQR: Interquartile range

* = Kruskal-Wallis test

**= Fisher's Exact Test

Table 2: Multivariable regression analysis for predictors of PRWE score.

	B coefficient (95% CI)	p-value
Age at time of surgery (per unit increase)	0.22 (-0.03 to 0.46)	0.08
Sex		
Male	Reference category	
Female	5.83 (-1.4 to 13.1)	0.11
Socioeconomic deprivation quintile (per quintile increase)	0.42 (-1.26 to 2.11)	0.61
Complications		
No complication	Reference category	
Complication	18.73 (11.57 to 25.89)	<0.01

FIGURE LEGENDS

Figure 1: Preoperative radiograph demonstrating a minimally displaced stable fracture of the scaphoid waist.

Figure 2: Four-month postoperative radiograph demonstrating evidence of radiographic union following percutaneous fixation.

Figure 3: Radiograph demonstrating an established non-union of a scaphoid waist fracture following percutaneous fixation.