



Internal fixation with Kirschner wires is as efficient as rigid screw fixation in scaphoid fracture: long-term functional outcome

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This study aimed to compare the long-term efficacy of Kirschner wires and Herbert screw internal fixation in scaphoid fracture. A retrospective chart with radiographic review and functional follow-up was conducted for patients with the scaphoid fracture. 65 patients (40 for K-wire fixation and 25 for Herbert screw) were enrolled. The nonunion rate for K-wire fixation and screw method were indifferent comprehensively and for iliac graft subgroup. Less bone necrosis was found with K-wire fixation (2.5% vs 16%, $P=0.049$). There's no difference between groups in Mayo scores, post-operation pain and grip strength. Patients with K-wire fixation have larger range of motion on radial/ulnar deviation (35.25 ± 11.32 vs 28.00 ± 8.66 , $P=0.007$). The results support the use of Kirschner wires in the treatment of scaphoid fractures. Advantages such as high union rates and good function recovery of wrist could be expected from minimal invasion, multi-axial stable fixation.

Keywords : Scaphoid fracture ; K-wire fixation ; Herbert Screw ; Long-term follow-up ; Clinical Evaluation.

INTRODUCTION

Fractures of the scaphoid are common injuries, accounting for approximately 80 % of all carpal fractures (2). The scaphoid is a main link in the proximal row of the carpus and plays an important role in the function of the wrist (3). Therefore,

injury to this bone or its attachments might have long-term consequences.

Conservative treatment appeared to have advantages over surgical treatment due to the possibility of numerous surgical complications, but long period immobilization and consequent joint rigidity prolonged the time until patients can resume work. Furthermore, on the grounds that the proximal segment of the scaphoid is only supplied by retrograde flow (13) and large portion of cartilage surface coverage (3), high nonunion rate (ranging from 1.5 to 37 %) was observed in patients receiving conservative treatment (19, 11).

Rigid internal fixation with a Herbert screw was supposed to have biochemical advantages over other fixation methods. Promising results has been shown in literature (20,1). However, the presence of a relative large implant in the vascularized graft may increase the possibility of vascular compromise in the area of poor blood supply. An alternative immobilization technique that combines

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small-diameter temporary Kirschner wires and transarticular external fixation were used in many trauma centers (6) and believed advantageous over screw fixation by some experts (8).

There have been various results comparing the stability and fracture healing between Kirschner wires fixation and rigid internal fixation with screw (14,15,16). However, the recovery of patients' wrist function and daily activity are more concerned in clinical management. To date, few studies have been reported with complete follow-up and function determination. We hence propose a retrospective study comparing these two methods and evaluate the efficiency of Kirschner wires fixation in patients with scaphoid fracture.

MATERIALS AND METHODS

Study characteristics

After obtaining institutional review board approval. A retrospective review was conducted in patients with the diagnosis of scaphoid fracture and received surgical treatment in our hand clinic (a level-I trauma center). Inclusion criteria were: all patients who sustained a unilateral scaphoid fracture-dislocation confirmed with X-ray or CT evidence; treated surgically; who agreed to be part of this study; and followed up a minimum of 2 years. Exclusion criteria were: patients who had bilateral injuries; failed in at least 2 years' follow up.

Patient demographics

Between 1999 and 2009, 213 patients with scaphoid fracture received surgical treatment in our

department. All patients have been contacted, and 98 refused to participate in the study, 19 were lost for follow-up and 9 were excluded because they did not meet the inclusion criteria. Sixty-five patients (65 wrists) were included in this study (Table I). There were 62 men (95%) and 3 women (5%) of 33 years on average (range: 17-73) at the initial trauma. The dominant hand was involved in 31 cases. Thirty-two patients were involved in heavy manual labors. In all cases a high-energy trauma was responsible of the wrist trauma.

Surgical technique

All patients were treated surgically. Dorsal approach was used as described by Shin and Bishop (17). Chips fractures or fractures avulsions was found in 9 cases. Cartilage damage was noted in 11 cases. Stabilization of the carpus was performed with 12/10 mm K-wires through the scaphoid (in 40 cases) or a Herbert screw of 2.0 mm (in 25 cases). Ligament repair was performed in 29 cases with anchor fixation, whereas it was not possible to repair the ligament in 3 cases. A dorsal capsulodesis was performed in 19 cases. In 8 cases, a median nerve neurolysis was performed because of numbness in the median territory. Average duration of surgery was 62 minutes (range: 40-110). An external fixator (Wrist Minifixator, Aoborthofix, Haerbin, PRC) spanning the wrist was placed. The external fixator was removed 6 weeks after surgery. The Kirschner wires were removed when union was evident.

Clinical evaluation

We recorded flexion and extension and ulnar and radial deviation of both wrists immediately

Table I. — Classification according to the Herbert fracture of the study cohort

	K-wire internal fixation			Herbert screw fixation			All cases
	Simple fixation	Iliac grafting	Radial forearm fascia flap	Simple fixation	Iliac grafting	Radial forearm fascia flap	
B2	14	0	0	0	0	0	14
B3	4	0	0	6	0	0	10
B4	10	2	0	11	2	0	25
C	2	2	0	1	1	0	6
D	0	4	2	1	2	1	10
sum	30	8	2	19	5	1	65

before surgery and at every postoperative visit. Grip strength was also measured in both the affected and unaffected extremities using a grip dynamometer (EB101, Camry, Zhongshan, Guangdong, PRC). Two fellowship-trained hand surgeons (Ziping Jiang, Jianli Cui) independently evaluated all patients and imaging studies. The Mayo wrist score was calculated to assess the wrist function comprehensively.

Radiographic evaluation

Preoperative radiographic evaluation included posteroanterior, lateral, and scaphoid views of both wrists. In all patients, we applied preoperative X-ray to assess the scaphoid anatomy. Radiographic evaluation with posteroanterior and lateral radiographs was performed immediately after surgery and every 4 weeks thereafter for 16 weeks. Radiographic findings suggesting union included bony bridging at both junction sites with no adverse features, such as bony gap union. A CT-scan was obtained to assess bony healing in cases where union was uncertain on plain films. Bone graft healing was diagnosed on CT scans when bony trabeculae bridging both ends of the bone graft to the proximal and distal scaphoid were noted on 2 or more consecutive sequences in either the sagittal or coronal plane. We measured the dorsal scaphoid angle and the lateral intrascaphoid angle, defined as the intersection of 2 lines drawn perpendicular to the diameters of the proximal and distal poles, on plain films and CT scans to assess the presence of scaphoid humpback deformity. A dorsal scaphoid angle of 110° or more or a lateral intrascaphoid

angle of 35° or more indicated humpback deformity. The height-to-length ratio was also calculated on sagittal views (plain films and CT scans) of the scaphoid to rule out collapse. A ratio greater than 0.65 indicated scaphoid collapse.

Statistical analysis

Clinical and radiographic scores with follow-up data was compared with the Mann-Whitney U test for nonparametric data. In all instances, $P < 0.05$ was regarded as statistically significant. Values are presented as mean \pm SD. The Spearman non-parametric test was occupied to correlate the relationship between prognostic factors and final results. All statistical analysis was performed with SPSS 19.0 software (IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.)

RESULTS

Overall results

All surgeries went successfully and patients were discharged as scheduled. These 65 patients were reviewed with 5 years average follow-up (range: 4–117). The average time between onset of injury and surgery treatment was 8.6 months. The average delay to return to work was 6 months (range: 0–24 months). Fifty-nine out of 65 patients (90.7%) could return to their previous work whereas 5 changed their type of work (7.7%). One patient retired after the surgery.

Table II. — Clinical results of the 65 cases

	K-wire internal fixation	Herbert screw fixation	P	All cases(n=65)
Mayo score	74.78 \pm 19.13	73.40 \pm 18.30	0.709	74.25 \pm 18.68
Pain at rest/with effort (VAS)/(10 pts)	2.13 \pm 1.22/4.9 \pm 1.78	2.52 \pm 1.30/4.8 \pm 1.56	0.245/0.584	2.28 \pm 1.26/4.86 \pm 1.69
Flexion/extension ROM	125.50 \pm 11.54	127.20 \pm 11.73	0.578	126.15 \pm 11.55
Radial/ulnar deviation	35.25 \pm 11.32	28.00 \pm 8.66	0.007	32.46 \pm 10.90
Pronation/supination ROM	165.50 \pm 11.54	167.20 \pm 11.73	0.578	166.15 \pm 11.55
Wrist strength(/kg)	37.55 \pm 8.97	34.56 \pm 5.22	0.195	36.40 \pm 78.38

Clinical results

Clinical results are summarized in Table II. The Watson test was negative for all wrists.

Radiographic results

All radiographic results are summarized in Table III. Scaphoid collapse and Humpback deformity were found immediately postoperative. Union of scaphoid fracture was diagnosed 6 months postoperatively. Signs of osteoarthritis and scaphoid necrosis were identified after one-year follow up. The nonunion rates for K-wire fixation and screw method were indifferent comprehensively (10% vs 16%, $P = 0.477$) and for both simple fixation (6.25% vs 15%, $P = 0.32$) and combined iliac graft subgroups (20% vs 25%, $P = 0.84$).

Prognosis factors

Patient's age and follow-up time had no influence on the final results. Scaphoid collapse was significantly related to fracture type ($P < 0.01$) and combined iliac grafting ($P = 0.02$). Humpback deformity was correlated to cartilage damage found at surgery ($P = 0.02$). Fractures avulsion contribute to the tardive occurrence of osteoarthritis ($P < 0.01$). Fracture type ($P = 0.03$), cartilage damage ($P < 0.01$) and internal fixation method ($P = 0.05$) had influenced the happening of bone necrosis. And the nonunion of the scaphoid could be attribute to the impact of Herbert fracture classification ($P = 0.01$) and fractures avulsion ($P = 0.04$).

DISCUSSION

Scaphoid fractures are common injuries in young, active individuals. Most fractures are nondisplaced and can be treated with cast immobilization. However, fractures with displacement >1 mm can lead to nonunion and late carpal osteoarthritis (12). It is reported that early assessment and open reduction can yield better results. Therefore, displaced scaphoid fractures require anatomic reduction and rigid stabilization to optimize outcomes. The postoperative stability, bone union rate and

functional restoration are among prior concerns. In our study, radiographic images obtained at the one-year follow-up showed no noteworthy instability, the final bone nonunion at final follow-up was 12.3%, and the clinical outcome was encouraging, with an average Mayo score of 74.25 points and 51/65 patients (78.5%) showing good to excellent outcomes.

Multiple Kirschner wires were widely used and described in scaphoid fracture and trans-scaphoid perilunate fractures in the past days (1,10,9). A K-wire placement through the fracture line helped prevent from scaphoid collapse and maintain the scaphoid angle as well as lateral intrascaphoid angle by direct stabilization of the carpal bones. There has been doubts about the stability and anti rotation effect simple K-wire fixation could provide. In our experience, multi-axial K-wire fixation could provide spatial stability as Herbert screw does. Stark reported a 97% union rate in 151 scaphoid nonunions (18). The K-wire method was thought more flexible than other fixations, which makes it easier to remove sclerotic bones, and therefore promises a better bony union (7).

With the advancement of surgical facilities, screw fixation techniques have become popular for the treatment of scaphoid fractures. The rigid internal fixation with a screw has clear biomechanical advantages over immobilization with 1 or 2 K-wires, especially when combined with iliac graft. In a large study evaluating risk factors for failure after 1,2 ICSRA bone grafting, a higher failure rate was recorded among others when fixation other than screws was used to immobilize the graft (4). However, in our study, the nonunion rate was indifferent even for 2nd stage revision with iliac graft. This different could be attribute to the use of trans-articular external fixator. Although the fixator was removed 6 weeks after the operation to allow wrist motion exercises, correct position and fragment contact were maintained until union occurred. We believe that temporary wrist immobilization with an external fixator provides better support than a traditional orthopedic cast.

Inevitably the open methods require soft-tissue dissection, which could adversely affect the soft-tissue structures and influence the stability of

Table III. — Radiographic results of the 65 cases

		K-wire internal fixation	Herbert screw fixation	P	All cases (n=65)
Immediate postoperative	Scaphoid collapse	7.5% (3/40)	20%(5/25)	0.139	12.3%
	Humpback deformity	10% (4/40)	8%(2/25)	0.788	9.2%
Long-term results	Nonunion of the scaphoid	10% (4/40)	16% (4/25)	0.477	12.3%
	Osteoarthritis	10% (4/40)	8%(2/25)	0.788	9.2%
	Bone necrosis	2.5% (1/40)	16% (4/25)	0.049	7.7%

the carpal bones. The K-wire fixation requires less exposure and was easy to operate, thus less blood supply was affected during the surgery. We observed less scaphoid necrosis in the K-wire group (2.5% vs 16%, $P = 0.049$) in the up to 10 year's follow up. There's evidence multi-axial K-wire fixation could provide carpal stability at the minimal invasion, avoiding the shear rotation stress brought by Herbert screw (5).

Another advantage of K-wire fixation was that the sole residual K-wire component could be bent into a loop on the dorsal aspect of the hand, thereby facilitating postoperative care and functional recovery. In our observation, there's no significance on the Mayo scores and grid strength. However, patients receiving K-wire fixation showed a better radial/ulnar deviation ROM (35.25 ± 11.32 vs 28.00 ± 8.66 , $P = 0.007$). It is understandable and could be attributed to the less implant residual occupy and soft-tissue affection.

Several risk factors were identified in this study, which could bring hints to our analysis. Except for the fixation method, the preoperation assessment should not be ignored. The fracture type influence not only the prognosis but also the choice of fixation method. Chen concluded K-wire fixation was more suitable in the oblique fractures since screws cannot provide vivid compression effect but increase the shear force of on the fracture edges (5). The fracture should be replaced anatomically in the surgery in order to prevent nonunions. The fracture chips and sclerotic bones (in old fractures) should be removed as clean as possible to avoid osteoarthritis. And cartilage should be protected to avoid the occurrence of scaphoid necrosis in the long term.

The present study has several limitations. First, as a retrospective study, no outcome measure was designated as primary outcome. All results thus have to be regarded as exploratory and the number of the patients actually recruited was small. Therefore, given data allow no conclusions on more rare events. A prospective randomized, controlled trial is needed that compares the proposed fixation method.

Conflicts of Interest: No conflicts declared..

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