Scaphoid Excision and Limited Wrist Fusion: A Comparison of K-Wire and Circular Plate Fixation

Jeffrey A. Rodgers · Gary Holt · Edward P. Finnerty ·
Blake Miller

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Abstract The purpose of this study was to compare the clinical outcome, union rate, and complications of a consecutive series of Scaphoid excision and limited wrist arthrodesis performed by a single surgeon using distal radius bone graft and K-wires or circular plate fixation. A sequential series of ten patients (11 wrists) who were stabilized with temporary K-wires were compared to 11 patients (11 wrists) who were stabilized with a circular plate. Minimum follow-up was 1 year. One patient in the K-wire group was converted to a wrist fusion. Six of the remaining ten patients in the K-wire fixation group and 8 of the 11 patients in the circular plate fixation group returned for the following blinded evaluations: Quick DASH, analog pain scale, range of motion, grip and pinch strength, plain x-ray, and multi-detector computed tomography evaluation. One non-union occurred in the K-wire group. There were no non-unions in the circular plate fixation group. There was no difference in any of remaining measures or rate of complications. This study shows that equivalent results can be obtained using circular plate fixation compared to K-wires when equivalent bone graft source and fusion

technique are used. If K-wire removal requires a return to the OR, circular plate fixation is more cost-effective.

Keywords Wrist · Arthritis · Limited wrist arthrodesis

Introduction

Scaphoid excision and limited wrist fusion remains a time-tested procedure for the treatment of degenerative and post-traumatic arthritis of the wrist [9]. Three recent reports have suggested inferior outcome with circular plate fixation compared to “traditional” fixation using K-wires, staples, or headless compression screws [1, 4, 10]. These reports have stimulated considerable debate among hand surgeons regarding the adoption of new technology without clearly demonstrated superiority of the new device. Careful evaluation of these reports brings to light several points worthy of further evaluation.

While implicating the implant as the major cause of complications and failure, previous investigators failed to control for variables that may have significantly affected their results. These variables include the source of bone graft, surgical technique of multiple surgeons, and patient factors that may have influenced the selection of the implant. In addition, non-union was based on plain radiographs alone, while a recent study has shown that multi-detector spiral computed tomography (MDCT) is a more accurate method of determining bone healing [5]. Finally, cost implications deserve further evaluation when comparing one orthopedic implant over another.

The purpose of this study was to evaluate the clinical outcome, union rate, and complications of a consecutive series of scaphoid excision and four-corner arthrodeses performed by a single surgeon using distal radius bone graft

J. A. Rodgers (✉)
Des Moines Orthopaedic Surgeons,
P.C., 6001 Westown Parkway,
West Des Moines, IA 50266, USA
e-mail: jrogers@dmos.com

G. Holt
Roseburg Radiologists,
Roseburg, OR 97470, USA

E. P. Finnerty · B. Miller
Des Moines University,
3200 Grand Avenue,
Des Moines, IA 50312, USA

Figure 1 K-wire and circular plate fixation.

and K-wires or circular plate fixation. The cost implications of each implant will also be evaluated.

Materials and Methods

With Institutional Board approval, we contacted 21 patients who had undergone scaphoid excision and four-corner arthrodesis between 1998 and 2005 by a single hand surgeon. Only patients with at least 1-year follow-up were selected. The cohort consisted of a sequential series of 12 wrists (11 patients) that were stabilized with temporary K-wires followed by 12 wrists (12 patients) that were stabilized with a circular plate (Spider Limited Wrist Arthrodesis System; Kinetikos Medical Inc., San Diego, CA, USA).

The K-wire study group included one patient who had non-union of his limited arthrodesis and was converted to complete wrist fusion after failure of his index procedure. Of the remaining ten patients, six patients agreed to participate in the study. Eight of 12 patients in the circular plate fixation group agreed to return for follow-up evaluation.

The surgical technique for all patients was identical, as all procedures were performed by a single surgeon (JAR). The surgical approach utilized a dorsal midline incision with transposition of the extensor pollicis longus. A T-shaped arthrotomy was performed and the scaphoid was excised piece meal. The remaining cartilage surfaces of the capitate, hamate, lunate, and triquetrum were prepared using a small rongeur. No power instruments were utilized in the surface preparation. All patients in both groups received autologous distal radius bone graft harvested by removing Lister's tubercle. The lunate was reduced and pinned to the capitate in 15° of flexion using intraoperative fluoroscopy. For the K-wire group, three more K-wires were placed (Fig. 1).

For the circular plate group, the carpus was temporarily stabilized with a lunate–capitate pin, a triquetrum–hamate pin, and a lunate–triquetrum pin. The reamer for the recessed spider plate was then used to prepare the site of plate fixation. Special attention was given to the reaming process to prevent impingement of the plate on the radius during wrist extension. The circular plate was applied after surface preparation and bone graft placement. The tempo-

Table 1 Demographic comparison.

Fixation type	Postoperative (months)	Age	Sex	Diagnosis	Smoking	Workers compensation (WC)
K-wire (<i>n</i> =6)	69 (56–83)	47 (33–59)	2F, 4M	4 SLAC, 1 scaphoid non-union, 1 Preisers dz	5N, 1Y	2 WC
Circular plate (<i>n</i> =8)	30 (14–44)*	46 (23–71)	2F, 6M	6 SLAC, 1 midcarpal OA, 1 STT arthritis/SL dissociation	7N, 1Y	3 WC

Data reported as mean value (range)

**p*<0.05

Table 2 DASH score, pain rating, and physical examination comparison.

Fixation type	Quick dash	Pain rating (0–10)	Flexion	Extension	Radial dev	Ulnar dev	Grip (kg)	Key pinch (kg)	Palmar pinch
K-wire (<i>n</i> =7)	18	3 (1–6)	21 (6–37)	45 (15–57)	23 (11–30)	17 (–12–30)	27 (17–34)	8.2 (3.7–12.5)	7.0 (3.7–11.9)
Circular plate (<i>n</i> =8)	9	1 (0–4)	26 (5–60)	48 (33–63)	16 (5–27)	14 (2–20)	28 (15–46)	9.0 (3.7–10.7)	7.8 (4.1–11.1)

No statistical differences observed for any of these measures

rary K-wires were then removed (Fig. 1). All patients, except one, received two screws in each of the carpal bones. In the oldest patient in the series (71 years), it was only possible to get one screw with adequate purchase in the triquetrum. The K-wire fixation group was placed in a short-arm thumb spica cast for 6 weeks and then returned for removal of the K-wires before beginning range of motion exercises. The circular plate fixation group was given the choice of a short-arm thumb spica cast or a rigid splint to wear except to bathe for 6 weeks.

Before the final follow-up evaluation, informed consent was obtained. A certified hand therapist, blinded to the type of fixation the patient had received, evaluated the patients. Patients completed a Quick DASH evaluation and an analog pain scale. Grip strength testing consisted of three trials measured at position two on a Jamar dynamometer (Sammons Preston Rolyan, Bolingbrook, IL, USA). Key and palmar pinch was also measured. Active wrist extension, flexion, radial, and ulnar deviation were measured using a goniometer. All measurements were recorded using the JTech Tracker Computerized Objective Functional Testing System (JTech Medical, Salt Lake City, UT, USA).

We evaluated bony fusion following either spider plate or traditional K-wire arthrodesis using both plain film radiography and MDCT. Each wrist was evaluated in PA, lateral, and 45° supination and pronation oblique radiographs using standard film screen technique. CT imaging was performed on a 16-channel GE Lightspeed Series

MDCT scanner with scan data acquired in the axial plane at 0.625-mm slice thickness and reconstructed using a bone algorithm. Reformations were created on the Vitrea® 3D workstation at 2-mm thickness in sagittal and coronal planes and viewed on one megapixel Dell® monitors.

Bony union was evaluated for each modality by both authors (JR, fellowship trained hand surgeon and RGH, fellowship trained musculoskeletal radiologist) according to the technique described by Krestan et al. [5]. Union was graded by consensus using a semi-quantitative method of no, partial, or complete fusion for the four following joints: capito-lunate, capito-hamate, hamate-triquetral, and triquetrum-lunate. The absence of bridging trabeculae was graded as 0, partial joint space obliteration by bone as 1, and complete bony bridging of the prepared joint surfaces as 2 (complete bony fusion).

Data were analyzed using SPSS® 14.0. Demographic comparisons, the Quick Dash score, and pain rating were evaluated using an independent measures *t* test. The ROM and strength parameters were analyzed by a two-factor analysis of variance procedure. The factors were treatment (Spider and K-wire) and side (operated and non-operated). Pearson correlation was used to assess the relationship of the capito-lunate angle with ROM. The radiographic parameters were evaluated by assessment of the descriptive frequency distribution of the scores. In all cases, an α of 0.05 was used to determine statistical significance. Power and appropriate measures of size effect were determined where indicated.

Table 3 CT data.

CT sagittal reconstructions				
Frequency observed	Joint observed	Grade		
		0	1	2
K-wire	C–L	0	0	6
	C–H	0	0	6
	H–T	0	0	6
	T–L	0	0	6
Circular plate	C–L	0	0	8
	C–H	0	3	5
	H–T	0	0	8
	T–L	1	4	3

Grade = 0, 1 or 2 (0 = no fusion to 2 = complete fusion);
1 K-wire non-union converted to complete wrist fusion
C–L capitate–lunate joint, C–H capitate–hamate joint, H–T hamate–triquetrum joint, T–L triquetrum–lunate joint

Table 4 Capitate–lunate angle.

C–L Angle	K-wire	Spider
Mean	3.02	4.10
Median	−0.05	1.95
SD	13.90	6.37
Minimum	−8.5	−4
Maximum	30.1	15
<i>N</i>	6	8
95% CI	14.59	5.32

No statistical difference observed

Results

Study Group Demographics

The two groups did not differ significantly with regard to age, hand dominance, tobacco use, or worker's compensation status (Table 1). The mean follow-up for the K-wire group was 70.6 months, while for the spider plate group, follow-up was 29.5 months ($p < 0.05$).

Outcomes Measures and Physical Examination Data

There was no statistical difference between the K-wire fixation and circular plate fixation groups with regard to Quick Dash scores, analog pain scale, range of motion, or strength measurements (Table 2).

Radiographic Outcomes

Radiographic analysis of all patients revealed one non-union of the fusion for the K-wire group and no non-unions of the circular plate group based on plain films. When considering only those patients who returned for follow-up evaluation, all demonstrated grade 2 degree of fusion using standard x-ray analysis. The MDCT data showed more of

the circular plate fixation group patients with partial fusions of one or more joints (Table 3). The average arthrodesed position measured by the capito-lunate angle from the MDCT data for each group also did not differ (Table 4). There was no statistical correlation between capito-lunate angle and final range of motion demonstrated. None of the circular plate fixation patients suffered hardware-related complications or impingement on the distal radius.

Financial Results

The complexity of medical billing, payer mix, and lack of data source for out-of-pocket patient expenses precluded an analysis of actual cost differences for the two groups. However, Table 5 presents a comparison of billed charges (excluding any contractual discounts) comparing the cost implications of each form of fixation assuming that the K-wires are buried and require a second operative procedure for removal. This analysis assumes an ASC billing model in which operative time is not used in determining billed charges.

Discussion

To convincingly demonstrate that a particular implant is the cause for failure of an orthopedic procedure, all non-implant variables as possible need to be controlled. For an arthrodesis procedure, first and foremost, the biology needs to be respected. Previous evaluations of the Spider Plate have not controlled for this very important variable. In the study of Kendall et al. [4], the bone graft source for 94% of their patients was either the excised scaphoid (16 of 18) or allograft (1 of 18). Likewise, Vance and colleagues [10] used the excised scaphoid in 20 of 27 patients (74%) who received the Spider Plate versus only 5 of 31 (16%) patients who received traditional fixation. The remaining 26 of 31

Table 5 Cost comparison K-wire (with hardware removal) versus circular plate.

Procedure	CPT code	Surgeon (billed charge)	Anesthesia time ^a	Anesthesia (billed charge)	Facility (billed charge)	Implant cost	Total
K-wires							
Limited wrist fusion with autograft	25825	2,090	2	770	2497	4	5,361
Scaphoid excision	25210	1,530			888		2,418
Hardware removal	20680	905	0.5	350	1,777		3,032
Total charges							10,811
Spider plate							
Limited wrist fusion with autograft	25825	2,090	2	770	2,497	1,061	6,418
Scaphoid excision	25210	1,530			888		2,418
Hardware removal		0	0	0	0		0
Total charges							8,836
Cost difference							1,975

^a Anesthesia time is estimated.

(84%) patients in the traditional fixation group with K-wires received autologous distal radius or iliac crest bone graft. The most recent study to evaluate the outcome of scaphoid excision with limited wrist fusion, published by Chung et al. [1], reported implant failure in 3 of 11 patients and recommended further evaluation of the biomechanic properties of the device. Interestingly, this series also utilized the excised scaphoid as the source of bone graft. While these recent papers argue that implant is the primary reason for failure of fusion, each of these studies also strongly supports the contention that excised scaphoid as bone graft is inferior to autologous bone graft such as distal radius or iliac crest.

Intuitively, one would assume that the bone graft harvested from the excised scaphoid would be inferior in quality to the metaphyseal cancellous bone of the distal radius. However, the biologic activity of scaphoid bone, as a graft material, has yet to be reported in the English literature. Schnitzler et al. [8] did evaluate the structural and cellular properties of distal radius bone histomorphometrically and compared it to iliac crest, the gold standard of graft material. While these authors found distal radius bone graft to be structurally inferior, they suggested that when compacted into a small cavitary defect, distal radial bone graft might be an equivalent alternative.

Unlike the previous cited articles (Kendal, Vance, Chung), this study also controlled for two other very important variables, surgical technique and implant selection. By studying the result of a single surgeon, variability of surgical technique was eliminated. The process of arthrodesis site preparation was identical for each group. From a technique standpoint, these groups studied differed only by the final means of bone stabilization. While implant selection for each patient was not randomized, the implant chosen was based solely on the period of time the procedure was performed. This eliminated any bias of implant selection for individual patients.

Pain relief, grip strength, pinch strength, and range of motion were not statistically different between the circular plate and K-wire groups. QuickDash scores for each group were also equivalent. These results differ significantly from previous studies that demonstrated inferior results with circular plate fixation for pain relief and overall patient satisfaction [1, 4, 10].

The overall arthrodesis rate for both groups in this study compares favorably with previous results [2, 3, 6, 7]. Unlike previous studies, none of the circular plate fixation patients experienced hardware failure or dorsal impingement.

We live in a time of double-digit healthcare inflation, and no comparison of hardware utility is complete without a careful analysis of cost implications. In this comparison of K-wire versus circular plate fixation, five of the six patients who were stabilized with buried K-wires returned to the

operating room for pin removal. Using 2006 undiscounted cost estimates for the additional OR time, surgeon's fees, and anesthesiology fees, this resulted in an additional expense of \$3,032. If the expense of the Spider Plate implant is subtracted from the cost of K-wire fixation (\$1,061), the resulting savings using an implant that does not require return to the OR for removal results in savings of \$1,975. Interestingly, with our current model of third-party payers, the greatest beneficiary of this savings is the insurer. These are the very same insurers that frequently deny payment for implants in ambulatory surgery centers.

Deficiencies of this study include incomplete patient recruitment for each group and a very small sample size. Unfortunately, it is extremely difficult for a single surgeon to perform a sufficient number of procedures to attain sufficient statistical power. A power analysis shows that if one would like to be able to detect a difference in fusion rates between two groups of 10% with 90% power, 500 patients in each group would be required. Clearly, this is not possible by a single hand surgeon in his or her lifetime.

Unfortunately, analyzing a single surgeon's results is the only way to completely control for very important technical variables. Without control of these variables, one cannot possibly demonstrate the superiority of one implant over another. We present data supporting a biologic approach to successful scaphoid excision and four-bone fusion surgery. The ultimate outcome in our opinion is independent of the implant chosen as long as suitable bone graft is utilized. The economic impact of implant selection must not be ignored.

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