Intramedullary Screw and Kirschner Wire Fixation for Unstable Scaphoid Nonunion

Raviv Allon¹ Aviv Kramer^{1,2} Ronit Wollstein^{1,2,3}

¹Ruth and Bruce Rappaport Faculty of Medicine, Technion Israel Institute of Technology School of Medicine, Haifa, Israel

²Department of Plastic Surgery, Carmel Lady Davis Medical Center, Haifa, Israel

³Department of Plastic Surgery, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, United States

Address for correspondence Ronit Wollstein, MD, Department of Plastic Surgery, University of Pittsburgh School of Medicine, 3550 Terrace St., Pittsburgh, PA 15261, United States (e-mail: ronitwollstein@gmail.com).

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Abstract

Surgical treatment of scaphoid nonunion is not always successful, often requiring stabilization and bone grafting to achieve healing. Even after intramedullary screw fixation, residual instability may still hinder union. The purpose of this study was to describe the addition of Kirschner wires (KWs) through the capitate and the lunate to supplement an intramedullary screw for temporary enhanced stability, possibly improving healing of unstable fractures. A case-control study reviewing 25 cases with addition of KWs and 19 controls was performed. Demographic and fracture information, time to diagnosis, and healing time were documented. We found no differences in population characteristics, fracture characteristics, or outcome measures between patients treated with this method and those treated with a screw alone. We had no complications related to the addition of KWs. Preoperative lunate type and scapholunate gapping was suggestive but not significantly associated with KW insertion. Addition of KWs is safe and may be considered in scaphoid nonunion in the presence of intraoperative suboptimal stability. Intraoperative stability may possibly be inferred by reviewing preoperative radiographs for signs of instability.

Keywords

- intramedullary screw
- Kirschner wires
- nonunion
- scaphoid
- stability

Introduction

Scaphoid nonunion is common and surgical treatment does not always bring about union.^{1–3} The optimal treatment for scaphoid nonunion remains controversial with multiple studies evaluating different fixation techniques, screw type, bone graft, and surgical approach.^{4–6} Since scaphoid nonunion can stem from vascular insufficiency or instability or both, surgery that addresses only one aspect, such as vascularized bone graft alone, may not address the underlying issue in some of the patients, accounting for the imperfect results reported in the literature.⁷ We have been adding fixation with two Kirschner wires (KWs), as well as bone graft from the distal radius and an intramedullary screw in an attempt to enhance stability. The reasoning behind the addition of the KW (between the scaphoid and the capitate and sometimes

also between the capitate and the lunate) is to stabilize the ligamentous forces acting on the two ununited fragments, providing temporary enhanced rigidity during the healing process. The purpose of this study was to compare our results using this method to screw fixation and bone graft without additional KW fixation.

Methods

All patients operated on for scaphoid nonunion between 2012 and 2015 in our institution were retrospectively reviewed. Patients with concomitant injuries such as a distal radius fracture or dislocation were excluded from the study. There were 44 patients eligible for the study. Out of these 44 patients, 25 were treated with a screw, bone graft, and

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KWs, and 19 (controls) were treated with an intramedullary screw and bone graft without additional KWs. Institutional review board approval was obtained prior to commencement of the study.

Our guidelines for operative treatment of scaphoid nonunion consist of a symptomatic scaphoid fracture that has not healed within 3 months of the injury. Furthermore, the patients are radiographically evaluated for healing with standard radiographs as well as a computed tomography (CT) scan. If no healing is present on any examination, the patient is referred for surgical treatment.

All patients were treated with open reduction and internal fixation with a cancellous bone graft taken from the distal radius through a dorsal approach. We did not use bone graft from the iliac crest despite the possibility for better quality graft because we wanted to avoid donor-site morbidity. Multiple studies have demonstrated the utility of this graft.⁸ All were first fixed using headless screw fixation with a screw from the Acutrak 2 system (Acumed, Hillsboro, Oregon, United States) according to the manufacturer's instructions. The intraoperative decision regarding fixation with or without supplementary KWs was made by the treating surgeon according to the degree of stability felt to be obtained following reduction, bone grafting, and insertion of the screw. This was not quantified based on the type or position of the original fracture since these were all established nonunions. An example is shown in ►Fig. 1. In some cases, after curettage of the nonunion site and reduction of the humpback deformity, there was a significant amount of bone loss. Bone graft was inserted into the gap and an intramedullary screw was used, but to retain the length of the scaphoid the screw did not compress the fragments completely. In this situation, full compression with the intramedullary screw would cause compression of the (weaker) graft, closing the gap and resulting in loss of reduction. Though there was no gross movement between the fragments, in some cases it was felt that this construct was not very stable and therefore KWs were added for additional stability.

KWs were inserted percutaneously through the proximal and distal fragments and into the capitate. Some KWs were inserted into the lunate stabilizing the scapholunate interval. The pins were cut short under the skin since they were in place for 6 weeks and we wanted to prevent pin tract infections. The pins were placed under vision and pin position was verified using the mini C arm. We did not have fragmentation though it is possible that this can occur. We suggest inserting the KWs into areas that are at a distance from any areas of fragmentation (►Fig. 1).

Patients were treated postoperatively in a thumb spica splint for a minimum of 6 weeks. The treating surgeon made the decision as to the timing of splint and KW removal during clinical follow-up. These decisions were made according to the advancement of union using serial radiographs and physical examinations. Patients were routinely seen in clinic at 2 weeks, 6 weeks, 3 months, and 1 year postsurgery.

Since the evaluation of intraoperative instability was not quantified according to any objective criteria, we retrospectively reviewed preoperative radiographs to determine if there

were any radiographic indications of associated ligamentous injuries prior to surgery. Since some of the radiographs were not perfect (not a true posteroanterior, etc.), we did not perform measurements of the scapholunate interval and only compared it to other joints in the same wrist, designating the gap as widened or normal. We evaluated lunate type since the different lunate types have been associated with different levels of stability.⁹ Lunate type was classified into lunate type 1 with a facet for the proximal capitate alone and lunate type 2 with a facet for the capitate and the hamate.^{9,10}

A chart review as well as a review of the available radiographs was performed. Demographic data included age, gender, hand dominance, occupation, smoking status, and background disease that may affect healing such as diabetes and vasculopathy. Date regarding the time from initial fracture to diagnosis of nonunion, time from diagnosis to surgery, and the treating surgeon were obtained from the chart.

The radiographic evaluation included evaluation of the initial fracture radiographs when these were available. These were assessed for location (distal proximal or waist) and the amount of displacement of the initial fracture. The nonunion was described as hypertrophic or atrophic. The primary outcome measures were healing time and stiffness (as described in the chart).

Statistical evaluation included the Student's *t*-test or the Mann-Whitney U test to compare continuous outcome variables between the two groups and the chi-square test and Fisher's exact test for categorical outcome variables.

Results

A total of 44 patients were operated on for scaphoid nonunion at our institution during the study period. There were 25 cases and 19 controls. All patients were males and their mean age was 26.9 (standard deviation [SD] = 8). out of the 44 participants, 41 were employed and only 4 were receiving workers compensation benefits. There were no significant differences in patient characteristics between the two groups (►Table 1).

►Table 2 describes the fracture characteristics of our population. We did not find any significant differences between cases and controls in regard to fracture characteristics. We did not identify any hypertrophic nonunions on plain radiographs. We had no postoperative humpback deformities.

In the group treated with added KWs, one KW was added in 6 cases (24%), two KWs in 14 cases (56%), and three KWs in 3 cases (12%). In one case, four KWs were used (0.4%). Three cases failed to unite (7%), two from the case group and one from the control group. One of these was ultimately treated with a proximal row carpectomy and one was treated with a four-corner fusion. The third was lost to follow-up. Healing time was 52.8 (SD: 16.6) days for the control group and 57.5 (SD: 13.3) days for the case group ($p = 0.318$). There were no postoperative infections or other complications. We found no significant differences in documented stiffness between cases and controls ($p = 0.671$).

In revising preoperative radiographs, we found that a radiograph that had both a lunate type 1 and a preoperative posteroanterior radiograph with a scapholunate gap was two

Fig. 1 (A) A scaphoid nonunion of the proximal pole. Preoperative posteroanterior (PA) radiograph. (B) PA radiograph of the same patient after surgical fixation with an intramedullary screw and Kirschner wires (KW). (C) PA radiograph of the same patient 6 months postsurgery. The KWs have been removed.

times more likely to have KWs inserted during surgery, though this was not statistically significant $p = 0.2$.

Discussion

Scaphoid fractures account for 50 to 90% of all carpal bone fractures in young and physically active individuals.¹¹ Most fractures will heal but approximately 5 to 15% may progress

to nonunion.^{12,13} Factors that may influence union include smoking, delay in diagnosis, fracture displacement, fracture location, and associated ligamentous injury.^{6,14,15} To date, achievement of healing remains suboptimal possibly due to residual instability.¹⁶ Ideally, treatment should restore anatomy while improving the mechanics of the wrist. Currently available techniques include internal fixation with bone grafting, vascularized bone grafting, bone stimulation, and

Table 1 Patient characteristics

	With KW (cases) N = 25	Without KW (controls) N = 19	p-Value
Age mean (SD)	27.0 (9.5)	26.8 (5.7)	0.95
Gender (male; SD)	25 (100%)	19 (100%)	
Occupation: hard labor (SD)	4 (16%)	5 (26.3%)	0.40
Occupation: sedentary (SD)	21 (84%)	14 (73.7%)	
Employment status (employed) (SD)	24 (96%)	17 (89.4%)	0.39
Dominant hand involved (SD)	13 (52%)	13 (68.4%)	0.62
Smoking	9 (36%)	10 (52.6%)	0.23

Abbreviations: KW, Kirschner wire; SD, standard deviation.

Table 2 Fracture characteristics

	With KW (cases) N = 25	Without KW (controls) N = 19	p-Value
Waist	17 (68%)	12 (63%)	0.86
Proximal pole	7 (28%)	7 (36%)	
Distal pole	1 (11.1%)	0	
Displaced (over 1 mm)	17 (68%)	11 (57.9%)	
Time to diagnosis (d; SD)	254.2 (365.0)	387.7 (801.9)	0.46
Time to surgery (SD)	148.52 (251.4)	164.7 (161.5)	0.80

Abbreviations: KW, Kirschner wire; SD, standard deviation.

Note: "Time to surgery" is the time (in days) between diagnosis and surgery.

recently plating.^{17,18} This retrospective study evaluated the effect of additional KWs fixation on healing of scaphoid nonunion. While we could not establish a clear advantage of this technique over the use of a headless screw alone, we demonstrated that this technique is safe and possibly increases the capacity of less stable nonunions to heal.

Our population, consisting of young active males, fits the profile for scaphoid nonunion.¹⁹ We had a 7% failure rate in this series, with no difference between the two methods of fixation. Our failure rate falls within the reported rates in the literature for different grafting and fixation methods. Mathoulin et al reported 95.5% union using a vascularized bone graft from the distal radius.²⁰ Hamdi et al found an 88% union rate using vascularized bone graft.²¹ In regard to the method of fixation, Pinder et al found that when used alone, KWs had an advantage over screw fixation and a higher incidence of union when used with vascularized grafts.²² Another study reported inferior results (27% union rate) using a single KW in patients undergoing a vascularized bone graft.²³

In their meta-analysis, Pinder et al did not find any advantage of one method over the other. Our study supports this analysis since we found no differences between our two groups.²⁴ A prospective randomized study with definite criteria for stability would be needed.

Limitations of this study include limitations of a retrospective study. The number of KWs used in the case group was not

standardized and the surgeon used as many as deemed necessary to obtain stability. Furthermore, the decision as to whether to add KW fixation or not was made intraoperatively by the surgeon. Therefore, a selection bias existed in which wrists that were less stable or scaphoids where it was felt that the screw fixation was less robust were preferentially treated with added KWs. Since we did not find any differences between our two groups, and taking this inherent bias into account, it is possible that the addition of KWs allowed stable healing conditions in wrists that might otherwise have gone on to fail.

We found some association between intraoperative stability as assessed during surgery and preoperative radiographs. A combination of lunate type 1 and evident scapholunate gapping may hint at intraoperative instability. Some studies have found that a lunate type 2 behaves differently and characterizes a more stable midcarpal joint.^{9,10} Though bone quality and preoperative gapping in the nonunion site likely also affect postoperative construct stability, it may be possible to advise patients prior to surgery on the likelihood of the need for additional fixation.

The definition of fracture healing, especially following surgery, has been controversial in the literature. Grewal et al evaluated union using two methods of evaluating CT scans and later used this method to evaluate different variables effect on healing time.^{25,26} We used radiographs and clinical findings such as tenderness over the snuffbox to determine union. Though the same system was used for both groups of

patients, it is possible that we misdiagnosed healing time by some weeks.

Disadvantages of adding KW fixation are the possibility of pin tract infection, increased stiffness, and the need for a second surgery. Since we buried our pins under the skin, we had no infections, but all patients required a second minor surgery to remove the pins at 6 weeks. We did not find differences in stiffness though this was a retrospective chart review and many measurements were missing.

In conclusion, this study presents an alternative method of fixation for unstable scaphoid nonunions. Although this study did not show superiority of either method, it did demonstrate that using KWs as an adjunct to screw fixation is safe and possibly allows for union when suboptimal fixation is achieved using a cannulated screw. A prospective randomized trial including a preoperative radiographic evaluation may allow for a better understanding of the indications, advantages, and disadvantages of this method of fixation.

Conflict of Interest

None.

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