Proximal Migration of Hardware in Patients Undergoing Midcarpal Fusion with Headless Compression Screws

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Abstract

Background Scaphoid excision and limited intercarpal fusion is a common surgical procedure performed for degenerative disorders of the wrist including scapholunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC) wrist deformities. Postoperative screw migration is a rare but devastating complication that can result in severe degenerative changes in the radiocarpal joint.

Questions/Purposes The purpose of this study is to report on a series of patients who developed proximal migration of their hardware following limited intercarpal fusions with headless compression screws.

Patients and Methods Four patients were identified between 2001 and 2012 who were indicated for and underwent scaphoid excision and midcarpal fusions with headless compression screw fixation and subsequently developed hardware migration with screw protrusion into the radiocarpal joint. Detailed chart review was performed.

Results Mean age at surgery was 64 years (57–69 years). All patients had the diagnosis of SLAC wrist. Mean time to detection of failure was 6 months (4–8 months). All patients demonstrated radiographic union prior to failure based on plain films. Radiographs revealed screw backout with erosion of the radial lunate facet in all patients. Calculated carpal height ratios demonstrated a drop from an average 44.2% to 39.5% at the time of hardware migration. All four patients underwent hardware removal. One patient was not indicated for any further surgery, and two patients underwent further revision surgery. All three patients reported complete pain relief. One patient refused a salvage procedure and had subsequent persistent pain.

Conclusions This study reports a serious complication of scaphoid excision and midcarpal fusion performed with headless compression screws. We advise surgeons to be aware of this potential complication and consider employing methods to reduce the risk of hardware migration. Additionally, we recommend at least 8 months of clinical and radiographic follow-up postoperatively to enable early intervention if necessary.

Level of Evidence Level IV, therapeutic study.

Keywords

- headless compression screws
- hardware failure
- SLAC wrist

Scapholunate advanced collapse (SLAC) is a chronic, degenerative condition that develops as a result of persistent scapholunate ligament instability. Scaphoid excision and

midcarpal fusion is a common surgery performed for this condition, with the primary aims of reducing pain and preserving range of motion. Multiple fixation choices are

Table 1 Patient demographics/operative details

Case	Age at Four-corner fusion (yr)	Original Diagnosis	Fixation utilized	Screw Lengths (mm)	Bone Graft Site	Time Until Radiographic Union (mo)	Time Until Presentation With Failure (mo)	Time From SEFBF Until Revision Surgery (mo)	Corrective Surgery Performed	Follow-up from Index Procedure (mo)	Outcome	Other
1	65	SLAC Watson Type II	One antegrade Mini Acutrak II screw from lunate to capitate	30	None	9	6	10	Removal of hardware	10	No pain	
2	65	SLAC Watson Type III	Two antegrade Mini Acutrak II screws; one lunate-capitate; one triquetrocapitate	24, 20	Distal radius	6	8	13	Removal of hardware; recommended radio-carpal fusion, but patient refused	19	Stiffness and pain with activities	Recommended to have total wrist fusion but refused
3	57	SLAC Watson Type II	One antegrade Mini Acutrak II screw from lunate to capitate; one 0.062 K-wire across hamate-capitate; one 0.062 K-wire across lunotriquetral	22	Distal radius	2	6	12	Removal of hardware; total wrist fusion	14	No pain	
4	69	SLAC Watson Type III	Two antegrade Mini Acutrak II screws; one capitoluminate; one hamate-triquetrum; one 0.062 K-wire across pisotriquetral	30, 30	Distal radius	3	4	4.5	Removal of hardware; proximal row carpectomy and interposition arthroplasty	6	No pain	Died of unrelated causes at 6 months post revision surgery

available and include Kirschner wires (K-wires), staples, Herbert screws, circular plating, headless compression screws, and other devices such as fixed-angle implants. Pin tract infections associated with exposed K-wires, as well as elevated nonunion rates with staples, led to decreased enthusiasm for these methods of fixation.^{1,2} Circular plate fixation has been associated with nonunions, impingement, and carpal malalignment.^{1,3-6}

Headless compression screws have been championed for their ability to provide rigid interfragmentary compression without the associated problem of hardware prominence, thus allowing early range of motion and excellent fusion rates.^{7,8} However, this procedure is not without its own set of complications. Hardware migration, including postoperative screw protrusion into the radiocarpal joint, is a rare but devastating complication that can result in severe degenerative changes in the radiocarpal joint.⁹

The purpose of this study is to report a case series of patients who developed this complication and provide management recommendations for treating surgeons.

Materials and Methods

Institutional review board approval was obtained prior to performing this study.

From 2001 to 2012, 107 patients were indicated for and underwent scaphoid excision and midcarpal fusion with headless compression screw fixation by the authors of this paper. A retrospective clinical and radiographic review was performed on a series of four patients (four wrists) who developed postoperative proximal screw migration (►Table 1). Age, handedness, race, occupation, medical his-

tory including rheumatologic diseases, smoking history, and clinical diagnosis at presentation were all reviewed. One patient (Case 1) had a revision fusion with removal of a Spider plate (Integra LifeSciences, Plainsboro, NJ), and placement of one mini-Acutrak headless compression screw (Acumed LLC, Hillsboro, OR) in an antegrade fashion from the lunate to the capitate (►Figs. 1-4). Another patient (Case 2) had two antegrade mini-Acutrak screws with one transfixing the lunate and capitate and one transfixing the triquetrum and hamate (►Figs. 5-8). Case 3 had an antegrade mini-Acutrak screw across the lunate and capitate with one percutaneous K-wire in the hamate and capitate and another percutaneous K-wire across the triquetrum and lunate to provide temporary, supplemental fixation given poor bone quality; at ~10 weeks K-wires were removed in the office (►Figs. 9-13). The last patient (Case 4) had one antegrade mini-Acutrak screw transfixing the lunate and capitate and one antegrade mini-Acutrak screw across the triquetrum and hamate with a percutaneous K-wire in the hamate and triquetrum, again to provide supplemental fixation given poor bone quality (►Figs. 14-16). In all cases, capitollunate articulation preparation, capitollunate compression with pointed reduction forceps, guide wire placement up to the distal cortex followed by power drilling and finally hand-tightened screw insertion until each screw was buried beneath the articular cartilage, as visualized by the surgeon and confirmed with intraoperative fluoroscopy. Postoperatively, all patients were immobilized in a short arm splint. At 2 weeks, dressings were removed and patients were further immobilized with either a short arm cast (in two cases) or a forearm-based custom-molded splint (in two cases). Therapy

Fig. 1 Case example 1: A 65-year-old right-handed man presented with persistent right wrist pain following failed prior four-corner fusion surgery requiring removal of hardware. (a) Anteroposterior (AP) and (b) lateral radiographs revealed partially retained hardware and evidence of a nonunion.

Fig. 2 Case example 1: Postoperative (a) AP and (b) lateral radiographs 2 weeks following revision surgery with placement of one antegrade screw across the capitolunate articulation.

Fig. 3 Case example 1: (a) AP and (b) lateral radiographs obtained 9 months postoperatively, revealing solid fusion but associated screw protrusion and early degeneration of the lunate facet.

was initiated at 6 weeks in all patients, and all patients remained in removable splints until ~12 weeks postoperative. Operative variables reviewed included type of fixation, augmented fixation, screw length, tourniquet time, and surgical complications. Carpal height ratios (CHR) (►Table 2) were determined immediately postoperatively and at the time of hardware migration, utilizing the methods described by McMurtry et al.¹⁰

Results

The group consisted of three men and one woman with a mean age of 62.8 years (57–69 years). Two men were retired, one man was a funeral home owner, and the woman was a physician. None of the cases were workers' compensation related. The primary diagnosis in all four patients was SLAC (►Table 3); two patients had Watson type II SLAC and two

Fig. 4 Case example 1: Final follow-up (a) AP and (b) lateral imaging following hardware removal.

Fig. 5 Case example 2: A 65-year-old right-hand-dominant man presenting for evaluation of a 3-year history of wrist pain. He denies any history of trauma. (a) AP and (b) lateral radiographs demonstrate a Watson type III SLAC wrist.

patients had Watson type III SLAC. One patient (Case 1) had a history of psoriatic arthritis but had never required steroid treatment. No patient was on chronic steroid use. No ipsilateral comorbidities were identified. All patients denied remote or active tobacco use.

All four patients were followed after their index procedure both clinically and radiographically (►Table 4). Radiographs were obtained postoperatively at 2 weeks, 4 to 6 weeks, 12 weeks, and every 3 months after that. These time points

were modified based on clinical concern and therefore occurred more frequently in the patients who failed prior to 6 months. No intraoperative or immediate postoperative complications occurred. Average follow-up from time of index procedure was 12.3 months (6–19 months) with ongoing follow-up in two patients. One patient (Case 2) was lost to follow-up after 19 months, and another patient (Case 4) died of an unrelated cause at 6 months postoperatively. All four patients were noted to have bony fusion an average of

Fig. 6 Case example 2: Postoperative (a) AP and (b) lateral radiographs taken 2 weeks following scaphoid excision and four-corner fusion with two antegrade Acutrak screws with one transfixing the lunate and capitate and one transfixing the triquetrum and hamate. The lunocapitate screw appears long in this image but was noted intraoperatively by the surgeon to be completely seated below the articular margin.

Fig. 7 Case example 2: (a,b) Radiographs obtained 8 months postoperatively, demonstrating backout of the lunocapitate with associated degeneration of the radiocarpal joint.

5 months (2–9 months) postoperatively based on standard radiographs. Hardware migration was noted an average of 6 months (4–8 months) postoperatively. Computed tomography (CT) scans obtained in two of the patients (Cases 1, 3) confirmed bony union in the presence of hardware migration. Average time until removal of hardware was 9.9 months (4.5–13 months). All four patients had the chief complaint of wrist pain. Radiographs at the time of failure revealed screw protrusion into the radiolunate joint with subsequent

degenerative changes of the lunate facet. In all four cases, original postoperative radiographs show the screws to be buried less than 2 mm below the subchondral bone. CHR immediately post-operatively was 44.2% (range 40.4–50.3%) and dropped to 39.5% (range 36.6–46.4%) at the time of proximal migration of the hardware. These values correlated with 1.8, 2.3, 1.6, and 2.6 mm of midcarpal collapse in Cases 1 through 4, respectively. Removal of hardware was performed in all cases. Intraoperatively, the implants were well fixed, and

Fig. 8 Case example 2: The patient was recommended to undergo hardware removal and radiocarpal arthrodesis but refused. (a) AP and (b) lateral radiographs obtained 7 months following hardware removal demonstrate radiocarpal joint degeneration.

fusion was observed in all patients. Intraoperative tissue specimens were sent for culture and pathology review. In all cases, cultures were negative and pathology was negative for infection. In addition to hardware removal, two patients

underwent further surgery at that time: one patient underwent a total wrist fusion (Case 3), and one patient had proximal row carpectomy and interposition arthroplasty (Case 4). Another patient was recommended to have a conversion to total wrist fusion, but refused (Case 2). At the most recent follow-up visits three of four patients (cases 1, 3, and 4) reported complete pain relief. One patient (Case 2) reported substantial relief following hardware removal but had persistent stiffness and pain with activities.

Fig. 9 Case example 3: A 57-year-old right-handed woman presenting with complaint of right wrist pain for one year. No history of trauma. AP radiograph displayed here shows a Watson type II SLAC wrist.

Discussion

Scaphoid excision and midcarpal fusion is an effective treatment option for degenerative conditions of the wrist, including SLAC and SNAC wrist deformities. A variety of fixation options are available, including utilization of headless compression screws. Many surgeons prefer headless compression screws for the ability to obtain solid fixation while simultaneously reducing the prominence of the hardware, maintaining good union rates, and obtaining satisfactory pain relief and range of motion.^{7,8} Surgeons should be aware of the potential complications of this surgical technique. This report presents four patients with hardware complications unique to the headless compression screw system.

A review of midcarpal fusion with headless compression screws by Richards et al showed excellent fusion rates, improved wrist pain, and satisfactory range of motion in 21 patients.⁷ All patients had four-corner fusion with two Mini Acutrak II screws. A 24% complication rate was reported, and 3/21 patients (14%) developed significant hardware-related complications with loosening and backing out of the screws.⁷ The only case of nonunion occurred in one of these patients. They were initially noted to have radiographic union at the 3-month follow-up visit, but they had partial nonunion at the

Fig. 10 Case example 3: Postoperative (a) AP and (b) lateral radiographs 2 weeks following scaphoid excision and four-corner fusion. Radiographs demonstrate solid fixation with one antegrade Acutrak headless compression screw and two temporary K-wires transfixing the hamate and capitate and the triquetrum and lunate.

Fig. 11 Case example 3: (a) AP and (b) lateral radiographs obtained 5 months postoperatively. Imaging shows proximal migration of the headless compression screws, collapse of the radiolunate joint space, and degeneration of the lunate facet.

lunate and capitate at 2.5 years. Ozyurekoglu et al published a study that showed improved grip strength, range of motion, and Disabilities of the Arm, Shoulder, and Hand (DASH) scores but also reported a 9% complication rate, with two nonunions and “unacceptable screw position” in one patient; all patients

were treated with two Mini Acutrak II screws.⁸ Gaston et al retrospectively reviewed 50 patients with SLAC wrist treated with either capitoulunate (CL) arthrodesis or four-corner arthrodesis and found both had excellent results but found five cases of screw protrusion in the CL group.⁹ CL arthrodesis was

Fig. 12 Case example 3: Computed tomography (CT) (a) sagittal and (b) coronal reconstructions showing solid bony fusion approximately 5 months postoperatively at the time of hardware failure.

Fig. 13 Case example 3: Approximately 1 year from the index procedure, the patient underwent removal of hardware and wrist fusion as a salvage procedure. (a) AP and (b) lateral radiographs obtained 3 months following radiocarpal joint fusion show stable hardware and solid fusion mass.

performed with Acutrak (Acumed, Hillsboro, OR) screws in all cases; multiple different forms of fixation were performed for four-corner fusion including K-wires, Acutrak screws, AO screws, and staples. Ball et al reported their experience with retrograde placement of Synthes compression screws across the capitulum, hamatrotriquetal, and the hamatolunate articulations and did not observe any hardware-related complications.¹¹

The previously discussed publications include cases of hardware complications associated with the use of Acutrak headless compression screws; however, this study focuses solely on this complication, possible explanations for fail-

ure, and offers potential solutions to this problem. Among the literature that mentions this complication, screw back-out occurred in 9 out of 88 partial carpal fusions. No specific study has been performed to look at the true incidence of this complication. In our case series, we report a 3.7% rate of headless screw migration. In all four cases of hardware protrusion the patients subsequently developed clinically significant radiolunate joint degeneration. All four patients had further surgery of hardware removal; three out of four patients were indicated for more advanced revision surgery at that time. The uniform presenting symptom was pain.

Fig. 14 Case example 4: A 69-year-old right-handed man presented with a 2-year history of right wrist pain. He reported a wrist sprain 10 years prior, which did not require any operative intervention. Presenting radiographs demonstrated a Watson type III SLAC wrist. Postoperative (a) AP and (b) lateral radiographs demonstrate scaphoid excision and four-corner fusion with one antegrade Acutrak screw transfixing the lunate and capitate and one antegrade Acutrak screw across the triquetrum and hamate with a percutaneous K-wire in the hamate and triquetrum to provide supplemental fixation given poor bone quality.

Fig. 15 Case example 4: At approximately 8 weeks postoperatively, mild migration of the hardware was noted on the (a) AP and (b) lateral radiographs. Imaging at an outside hospital was obtained 4 months postoperatively due to persistent wrist pain and revealed hardware protrusion and early degeneration of the radiocarpal joint.

The etiology of failure in our case series is not entirely clear. At the time of revision surgery, all cases were noted to have bony fusion, and therefore nonunion is unlikely. Intraoperative pathology and cultures were negative, suggesting no infectious etiology. At the time of the original surgery, in all four cases, compression of the carpal bones was performed

prior to screw placement, and all hardware was noted to be buried beneath subchondral bone by direct visualization. Despite this, postoperative radiographs indicate that in all four cases the implants were buried less than 2 mm below the subchondral bone, and in one case the hardware appears to extend beyond the subchondral bone. The calculated CHR

Fig. 16 Case example 4: (a,b) The patient underwent removal of hardware and proximal row carpectomy.

dropped from 44.2% to 39.5% with an average overall loss in height of the capitulate fusion mass of 2.1 mm (1.6–2.6 mm) suggesting some compression/consolidation of the fusion during healing. Poor bone quality was evident in two cases, and perhaps these patients were more susceptible to consolidation. In the Gaston et al⁹ series, they presented a case of proximal hardware migration that required hardware removal following healing. We can speculate that compression/consolidation of the capitulate fusion mass during healing could have led to subsequent screw protrusion as the distal subchondral bone of the capitate abutted the screw tip and essentially pushed the screw proximally. This would also imply stripping/loosening of the proximal threads from the hard subchondral bone in the proximal lunate, but this is purely speculative and may not be necessary to allow hardware migration. The screw features reverse-cutting threads to enable hardware removal; whether spontaneous counterclockwise rotation of the screw during wrist motion may have led to proximal screw migration cannot be stated with certainty. Although a fracture was never apparent on plain films, subtle

subchondral fracture that later healed could also have potentially led to collapse and hardware migration.

Functional outcomes studies have shown good pain relief with midcarpal fusion using a variety of fixation techniques.^{5,12–15} Ongoing pain postoperatively and the return of a painful wrist following a period of improvement are therefore not expected complaints. In this cohort of patients, hardware migration developed within 8 months of surgery, and worsening pain was a strong indicator of failure. This report would suggest that surgeons should have a low threshold to continue standard clinical and radiographic follow-up when patients report persistent or recurrent pain. This would allow surgeons time to ensure union and maintenance of hardware position. We recommend at least 8 months clinical and radiographic follow-up in these patients to enable early identification of failure when present. If the diagnosis is in question, a CT scan of the wrist could be obtained to evaluate union and possible hardware loosening or migration.

Given the insufficient amount of data in the literature regarding the incidence of this complication, it is difficult to recommend for or against this particular method of fixation. When utilizing this form of fixation, some possible considerations are to undersize the screw at least 5 mm to allow for compression, countersink completely before placing the screw, and to confirm radiographically that the screw is at least 2 mm below the subchondral surface. Moreover, it is helpful to ensure maximal manual compression of the carpal bones prior to placing the implant. If a gap remains at the end of the case, the bones could potentially collapse and lead to protrusion. Other considerations would be to place compression screws from distal to proximal as described by Ball et al,¹¹ or to use other fixation such as plates, fixed-angle screw devices, K-wires, or other forms of fixation.

Table 2 Carpal height ratios (CHRs)

Case	Immediate postoperative measurement (percentage)	Measurement at failure (percentage)
1	41.5	36.6
2	40.4	37.4
3	44.4	37.5
4	50.3	46.4

Table 3 Watson Classification of SLAC

	Joints involved	Radiographic findings
I	Radioscaphoid	Narrowing and sclerosis predominantly on radial styloid tip or distal pole of scaphoid
II	Radioscaphoid	Narrowing and sclerosis extending to entire radioscaphoid joint
III	Radioscaphoid, capitolunate	Narrowing and sclerosis involving both the radioscaphoid and the capitolunate joints
IV	Pan-carpal	Progression of narrowing and sclerosis to the radiolunate joint

Table 4 Summary of radiographic data

Case	Screw length (mm)	Depth relative to proximal lunate subchondral bone (mm)	Amount of post-operative consolidation (mm)	Amount of screw protrusion (mm)	Time until radiographic union (months)	Time until presentation with failure (mo)
1	30	1.8	1.8	2.2	9	6
2	24	-1.5	2.3	2.1	6	8
3	22	1.4	1.6	1.0	2	6
4	30	1.9	2.6	0.6	3	4

Nonunion, infection, wound complications, impingement, adjacent joint disease, and hardware failure are not uncommon following midcarpal fusion, no matter the method of fixation chosen. Ultimately, surgical technique requires consideration of patient-specific factors, including compliance, smoking history, medical comorbidities (diabetes, rheumatoid arthritis, etc.), and bone quality.

Note

Each author certifies that he has no commercial associations (e.g., consultancies, stock ownership, equity interest, or patent/licensing arrangements) that might pose a conflict of interest in connection with the submitted article. No funding was necessary for this submission. This was an institutional review board-approved study.

Conflict of Interest
None

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