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CLINICAL RESEARCH

Is Arthroscopic Bone Graft and Fixation for Scaphoid Nonunions Effective?

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Abstract

Background Arthroscopic management of scaphoid nonunions has been advanced as a less invasive technique that allows evaluation of associated intrinsic and extrinsic ligamentous injuries; however, few studies have documented the effectiveness of arthroscopic treatment of scaphoid nonunions and which intraarticular pathologies coexist with scaphoid nonunions.

Questions/purposes (1) What are the outcomes of arthroscopic management of scaphoid nonunions as assessed by the proportion of patients achieving osseous union, visual analog scale (VAS) pain score, grip strength, range of motion, Mayo Wrist Score (MWS), and Disabilities of the Arm, Shoulder and Hand (DASH) score? (2) What complications are associated with arthroscopic scaphoid nonunion management? (3) What forms of intraarticular pathology are associated with scaphoid nonunions?

Methods Between 2008 and 2012, we treated 80 patients surgically for scaphoid nonunions. Of those, 45 (56%) had arthroscopic management. During that time, our general indications for using an arthroscopic approach over an open approach were symptomatic scaphoid nonunions without necrosis of the proximal fragment, severe deformities, or arthritis. Of the patients treated arthroscopically, 33 (73%) were available for followup at least 2 years later. There were five distal third, 19 middle third, and nine proximal third fractures. The mean followup was 33 months (range, 24–60 months). Union was determined by CT taken at 8 to 10 weeks after operation with bridging trabecula at nonunion site. VAS pain scores, grip strength, active flexion-extension angle, MWS, and DASH scores were obtained preoperatively and at each followup visit. The coexisting intraarticular pathologies and complications were also recorded.

Results Thirty-two (97%) scaphoid nonunions healed successfully. At the last followup, the mean VAS pain score decreased (preoperative: mean 4.5 [SD 1.8], postoperative: mean 0.6 [SD 0.8], mean difference: 3.9 [95% confidence interval {CI}, 3.2–4.6], $p < 0.001$) and the mean active flexion-extension angle increased (preoperative: mean 100° [SD 26], postoperative: mean 109° [SD 16], mean difference: 9° [95% CI, 2–16], $p = 0.017$). The mean grip strength increased (preoperative: mean 35 kg of force [SD 8], postoperative: mean 50 kg of force [SD 10], mean difference: 15 kg of force [95% CI, 11–19], $p < 0.001$). The mean MWS increased (preoperative: mean 56 [SD 23], postoperative: mean 89 [SD 8], mean difference: 33 [95% CI, 26–41], $p < 0.001$) and the mean DASH score decreased (preoperative: mean 25 [SD 18], postoperative: mean 4 [SD 3], mean difference: 21 [95% CI, 15–28], p <

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0.001). There were no operation-related complications and no progression of arthritis at the last followup. Seventeen patients had coexisting intraarticular pathology, including nine triangular fibrocartilage complex tears (seven traumatic and two degenerative), 17 intrinsic ligament tears (nine scapholunate interosseous ligament tears and eight lunotriquetral interosseous ligament tears), and five mild radioscaphoid degenerative changes.

Conclusions Arthroscopic management of scaphoid nonunions without severe deformities or arthritis was effective in this small series. Although intraarticular pathologies such as triangular fibrocartilage complex tears and intrinsic ligament injuries commonly coexisted with scaphoid nonunions, patients generally achieved good results.

Level of Evidence Level IV, therapeutic study.

Introduction

The goals of treatment for scaphoid nonunions are to achieve bone healing and to prevent arthritis of the wrist by correcting any carpal deformities [37]. Cancellous inlay bone grafting [12, 34], wedge bone grafting [7, 8, 27], and vascularized bone grafting [15–17, 29, 35] have been used to achieve these goals according to the associated carpal collapse deformity and the vascularity of proximal fragment. Union rates were reported ranging from 80% to 95% after nonvascularized bone grafting and from 40% to 100% after vascularized bone grafting [7, 12, 15–17, 27, 34, 35]. Requirements for treatment include nonunion débridement and reduction, bone grafting, and rigid internal fixation while maintaining blood supply [5, 22]. As minimally invasive approaches are gaining popularity in the treatment of scaphoid fractures, arthroscopic techniques have been used to treat scaphoid fractures and nonunions [2, 3, 18, 30, 31, 33]. All these processes could be done under arthroscopic guidance in patients with minimally displaced scaphoid nonunions with minimal sclerosis [3, 31, 32]. Arthroscopic bone graft and management of scaphoid nonunion have the same indications as the cancellous inlay bone graft [12, 34], which include symptomatic scaphoid nonunions with significant bone resorption ($\geq$ 2 mm) and cystic changes without necrosis of the proximal fragment, severe deformities, or arthritis. One of the advantages of arthroscopic management over conventional techniques is that it can confirm the presence or absence of associated intrinsic and extrinsic ligamentous injuries. Previous studies reported 42% to 83% of the associated ligament injuries in patients with acute scaphoid fractures and nonunions [2, 3, 18, 38].

Although arthroscopic management of scaphoid nonunion is gaining popular as a minimally invasive approach, most studies focused on describing the arthroscopic techniques the authors developed than the clinical outcomes they achieved [3, 31, 32]. Minimal morbidity of the arthroscopic approach for the treatment of scaphoid nonunion is supposed to result in less postoperative stiffness and increased functional outcomes. However, there is lack of information about the effectiveness and the types of complications observed with arthroscopic treatment of scaphoid nonunions.

We therefore asked the following questions: (1) What are the outcomes of arthroscopic management of scaphoid nonunions as assessed by the proportion of patients achieving osseous union, visual analog scale (VAS) pain score, grip strength, range of motion, Mayo Wrist Score (MWS), and Disabilities of the Arm, Shoulder and Hand (DASH) score? (2) What complications are associated with arthroscopic scaphoid nonunion management? (3) What intraarticular pathologies are associated with scaphoid nonunions?

Patients and Methods

Between May 2008 and January 2012, we treated a total of 80 patients with scaphoid nonunions. Among them, 45 (56%) underwent internal fixation after arthroscopic nonunion débridement and bone grafting. During that time, our indications for using an arthroscopic approach over an open approach were symptomatic scaphoid nonunions without necrosis of the proximal fragment, severe deformities, or arthritis. We retrospectively reviewed the records of all of these patients after institutional review board approval.

The preoperative evaluation included true wrist posteroanterior, lateral, posteroanterior with ulnar deviation, and oblique with 45° pronation plain radiographs. CT scans in the sagittal and coronal plains along the long axis of the scaphoid were also routinely undertaken preoperatively. MRI was only performed in cases with suspected avascular necrosis of the proximal fragment on plain radiographs. Nonunion was defined as a persistent fracture gap at least 6 months after the trauma with bone resorption and sclerotic and/or cystic changes at the fracture site visible on plain radiographs.

The indications for arthroscopic management were symptomatic scaphoid nonunions with significant bone resorption ($\geq$ 2 mm), cystic changes, and absence of necrosis of the proximal fragment (Fig. 1). The contraindications were (1) scaphoid nonunions with necrosis of the proximal fragments; (2) scaphoid nonunions with humpback deformity or dorsal intercalated segmental instability defined as lateral intrascaphoid angle $>$ 45° or radiolunate angle $>$ 10° [22]; and (3) advanced wrist

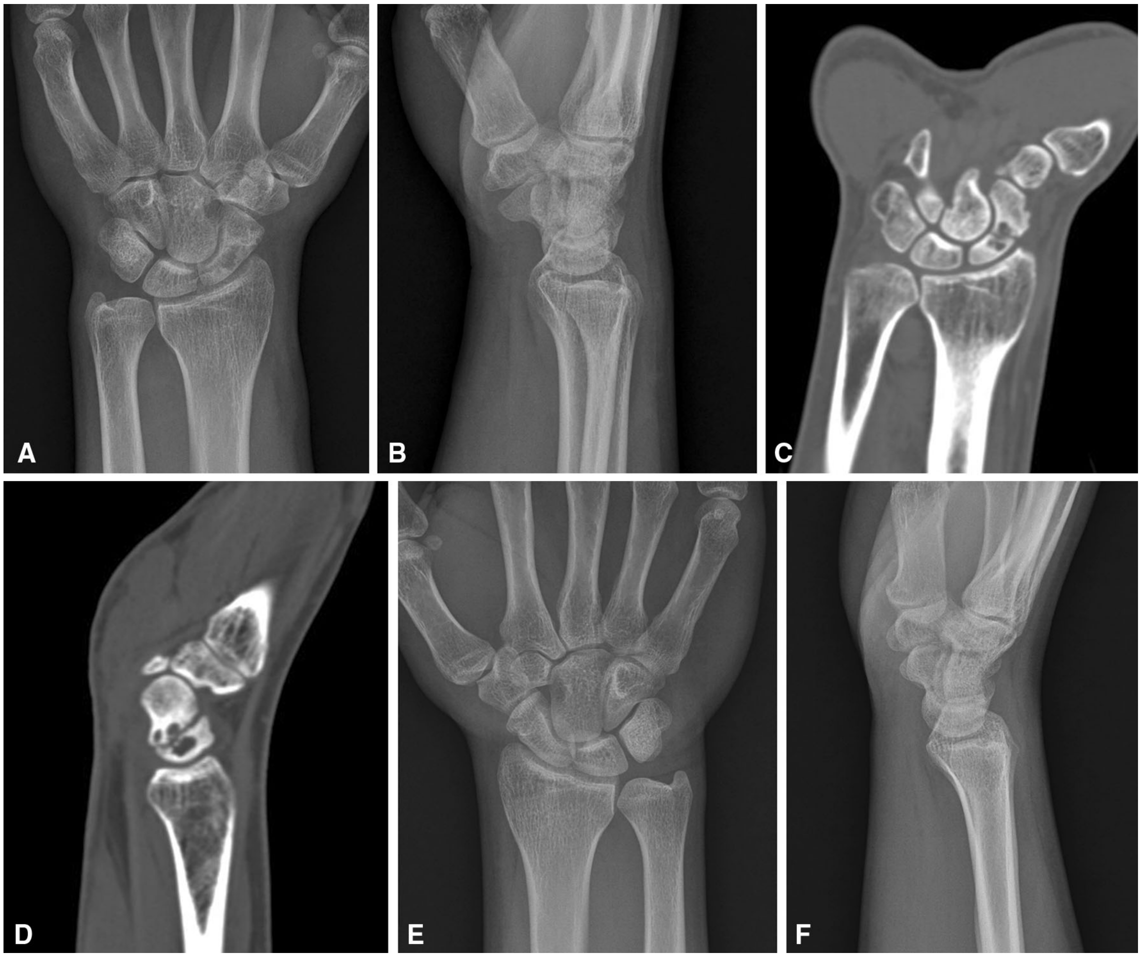

Fig. 1A–F (**A–B**) Preoperative radiographs of a 45-year-old patient show a minimally displaced scaphoid nonunion. (**C–D**) Coronal and sagittal CT scans of this patient indicate the scaphoid nonunion with cystic degeneration at the nonunion site without humpback deformity. (**E–F**) These findings are confirmed with comparison to contralateral normal radiographs.

arthritis (Stage II or higher scaphoid nonunion advanced collapse wrist).

For the purposes of this study, we excluded patients with (1) a history of previous surgery on the wrist; (2) a history of another fracture around the wrist; (3) Stage II or more scaphoid nonunion advanced collapse wrist; (4) humpback scaphoid nonunions; (5) workers compensation issues; and (6) inadequate followup (< 24 months). Based on these criteria, one patient with previous arthroscopic triangular fibrocartilage complex (TFCC) surgery, one patient with distal radius fracture history, one patient with dorsal hamate fracture history, two patients with Stage II scaphoid nonunion advanced collapse wrist, one patient with humpback nonunion, and three patients with workers compensation issues were excluded. Three of the 45 patients (7%) were lost to followup. A total of 12 patients were excluded, leaving 33 patients, all of whom were men (Fig. 2). The mean age of the patients at the time of surgery was 29 years (range, 20–58 years). The average duration of scaphoid nonunion before surgery was 30 months (range, 12–60 months). There were five distal third, 19 middle third, and nine proximal third fractures. According to the Slade and Dodds classification [31], all of our patients had Grade IV (n = 20) or V (n = 13) scaphoid nonunions. The minimum followup was 24 months (mean, 33 months; range, 24–60 months). No patients were recalled specifically for this study; all data were obtained from medical records.

Surgical Technique

Arthroscopic management of scaphoid nonunions was performed by one hand surgeon (YRC) while patients were under general anesthesia. An Esmarch bandage was used to exsanguinate the arm and a tourniquet was used. The patient's arm was suspended in an Arc Wrist Tower (Acumed®, Hillsboro, OR, USA) with 5 to 8 kg of traction.

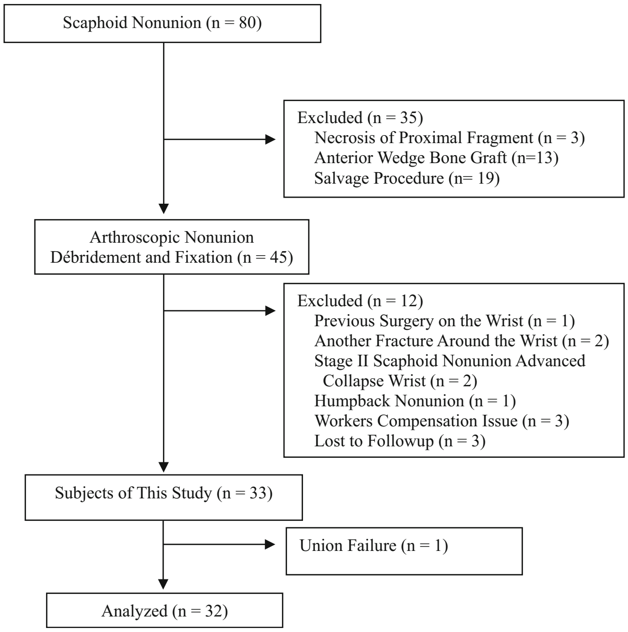

Fig. 2 A CONSORT flow diagram shows enrollment and analysis of this study.

All patients routinely underwent thorough examination of both the radiocarpal and midcarpal joints to identify any coexisting intraarticular pathologies such as loose bodies, extrinsic or intrinsic ligament integrities, and TFCC tears. For that purpose, a 3–4 portal, 6-R portal, and midcarpal ulnar portal were created sequentially, and a 1.9-mm video arthroscope was introduced through each portal. To simplify the access to the scaphoid nonunion, a working scaphotrapezial trapezoidal portal or midcarpal radial portal was made, according to the level of nonunion, under direct vision while introducing the arthroscope into the midcarpal ulnar portal. To débride the nonunion site, a fine-angled curette, motorized 2.0- or 2.9-mm shaver, and 2.9- or 3.5-mm burr were used through the working portal until healthy-looking cancellous bone was exposed at both ends of the nonunion site (Fig. 3A). After completion of débridement and curettage, the beam of a minifluoroscopy unit was positioned in the center of the wrist parallel to the floor. The nonunion site was reduced by manipulating the distal fragment with a probe or a percutaneous joystick Kirschner wire under the guidance of the arthroscopic and fluoroscopic images. One Kirschner wire was then inserted from the scaphoid tubercle to pass the nonunion site for temporary fixation (Fig. 3B). To insert a guidewire for headless screw fixation, the arthroscope was introduced in the 6-R portal. While the wrist was flexed 30° with traction, a 15-G needle was inserted percutaneously, proximally, and along the ulnar to the original site of 3–4 portal to achieve the ideal starting point for the guidewire. The point is at the most proximal tip of the scaphoid pole immediately adjacent to the attachment point of the scapholunate interosseous ligament [33]. Next, the guide pin was introduced through the 15-G needle and advanced in the radial and volar direction to pass the central axis of the scaphoid until the leading end reached the subchondral bone of the distal scaphoid pole (Fig. 3C). Then, a 5-mm transverse incision was made at the point of the prepositioned guide wire after removal of the 15-G needle and a sharp straight hemostat was used to spread the soft tissue and pierce the dorsal capsule (proximal 3–4 portal). A second wire of an equal length was placed through the proximal 3–4 portal onto the cortex of the proximal scaphoid pole and parallel to the guidewire. The difference in length between the trailing ends of the wires was equal to the scaphoid length. The screw length was selected to be 4 mm less than the scaphoid length to permit 2 mm of clearance at each end of the scaphoid. Before reaming along the guidewire, cancellous bone was harvested from the iliac crest using a trephine technique with a bone biopsy needle through a small incision. The harvested bone was cut into small chips using a small rongeur and put into the sheath of the 3.5-mm burr. The sheath packed with the harvested bone was then introduced through the scaphotrapezial trapezoidal or midcarpal radial portal into the nonunion gap under direct vision through the arthroscope in the midcarpal ulnar portal. The nonunion gap was filled with the cancellous bone by pushing the bone inside the sheath with a slightly undersized bone biopsy trocar. After complete filling of the gap, the grafted bone was packed into the defect site using a probe or a periosteal elevator (Fig. 3D). The scaphoid was then reamed to within 2 mm of the distal pole along the previously inserted guidewire with arthroscopic surveillance through the 6-R portal. In the next step, we inserted a headless compression HCS 3.0 (Synthes®, Paoli, PA, USA) or Acutrak® (Acumed®) miniscrew along the guidewire to fix the scaphoid nonunion. When the HCS 3.0 was used, we extended the skin incision 1 to 2 mm more before screw insertion to introduce the tip of the compression sleeve safely. The compression sleeve of the HCS 3.0 acts as the head of a headed lag screw and allows for surgeon-controlled compression. After completion of screw insertion, we confirmed that there was no protrusion of the screw into the joint space. If the proximal fragment was too small to insert the headless compression screw, two terminally threaded guidewires were used to fix the nonunion in a retrograde manner from the scaphoid tubercle. We confirmed that the tips of the wires arrived in the subchondral bone of the proximal fragments under fluoroscopic guidance. After all the arthroscopic procedures were completed, any loose bodies or debris within the joint were removed with the motorized shaver. In patients with an osteophyte at the radial styloid process, styloidectomy was performed with a

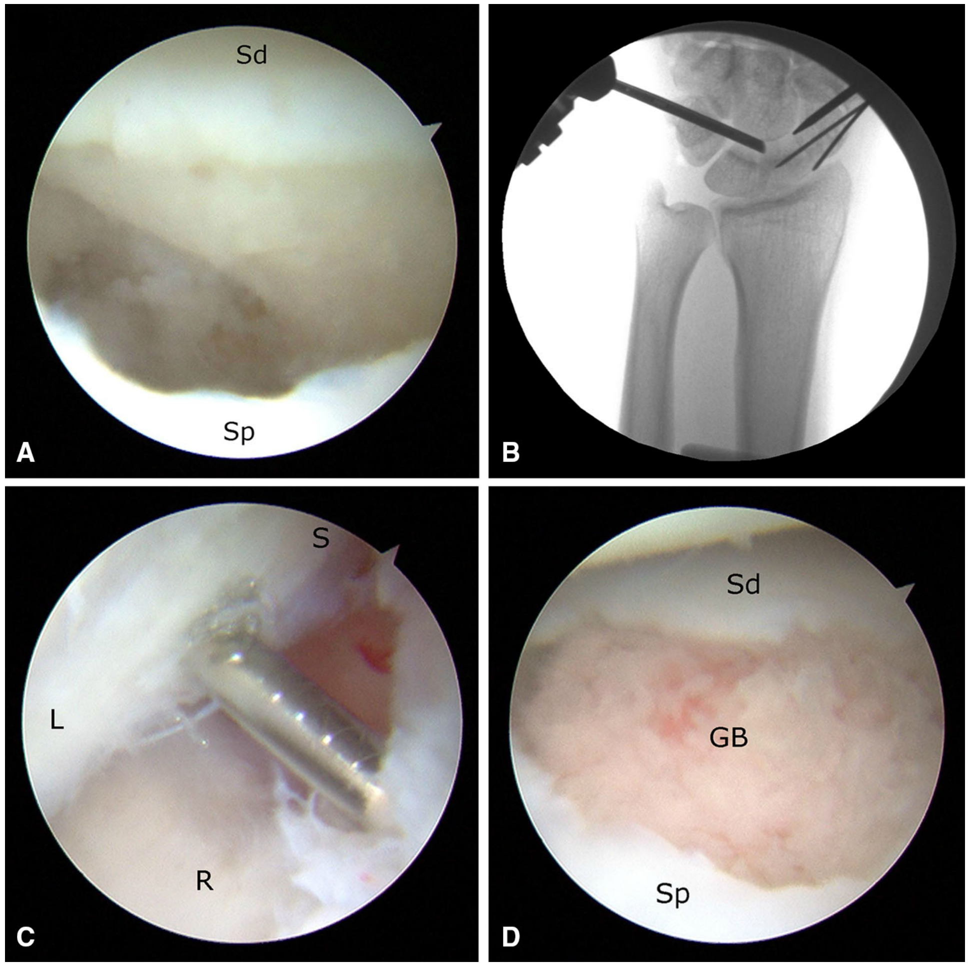

Fig. 3A–D (**A**) The scaphoid nonunion site is completely débrided using a fine curette and motorized shaver. (**B**) Then, the nonunion site was reduced by the manipulation of the distal fragment with a probe and fixed with a Kirschner wire under arthroscopic and fluoroscopic guidance. (**C**) A guidewire was inserted through the axis of the scaphoid for a headless compression screw through the proximal 3–4 portal. (**D**) A percutaneous cancellous iliac bone graft was performed through the scaphotrapezial trapezoidal portal via a 3.5-mm burr sheath and the grafted bone (GB) is packed into the nonunion site using a periosteal elevator. C = capitate; S = scaphoid; L = lunate; R = radius; Sd = distal fragment of the scaphoid; Sp = proximal fragment of the scaphoid.

2.9- or 3.5-mm burr inserted in the 1–2 portal and viewed through the 3–4 portal. The arthritic portion of the styloid (3–4 mm) was resected without sacrificing the radioscaphocapitate ligament attachment.

If present, scapholunate or lunotriquetral interosseous ligament injuries were graded using the Geissler grading system [10], and TFCC tears were classified using the Palmer system [24]. All coexisting intraarticular pathologies were treated simultaneously with arthroscopic management of scaphoid nonunions. Patients with intrinsic ligament tears or TFCC tears underwent simultaneous surgical treatment according to the grade of intrinsic ligament tears or the classification of TFCC tears.

The portals were closed with sterile strips, and a compressive dressing and a volar splint were placed, including the thumb. All patients were encouraged to initiate immediate digital exercises to reduce swelling. At the first postoperative visit 2 weeks postoperatively, a well-molded short-arm thumb spica cast that held the wrist in a functional position was applied for 6 to 8 additional weeks. In one patient who underwent simultaneous peripheral TFCC repair, the arm was placed in an above-elbow splint with the wrist in the neutral position for 4 weeks after the operation followed by the short-arm thumb spica cast. Patients were restricted from moving the wrist until a CT scan confirmed the bridging of bone at the nonunion site at 8 to 10 weeks postoperatively. Wrist motion and progressive strengthening exercises were then initiated.

Patients had regular followups at an outpatient clinic at 2 weeks, 8 to 10 weeks, 6 months, 1 year, and annually thereafter. Four radiographic views of the wrist, including the true wrist posteroanterior, lateral, posteroanterior with ulnar deviation, and oblique with 45° pronation, were obtained at each followup (Fig. 4). All patients underwent CT in the sagittal and coronal planes along the long axis of the scaphoid to confirm union at 8 to 10 weeks after the surgery to determine bony union, which was defined as consolidation of the nonunion gap (as evidenced by bridging bone formation) on at least three of the long-axis sagittal images [14]. These CT images were evaluated by two orthopedic surgeons (YRC, IHK).

One observer (BRK) not involved in the treatment performed preoperative and postoperative assessments using a VAS pain score of 0 to 10, active flexion-extension arc of

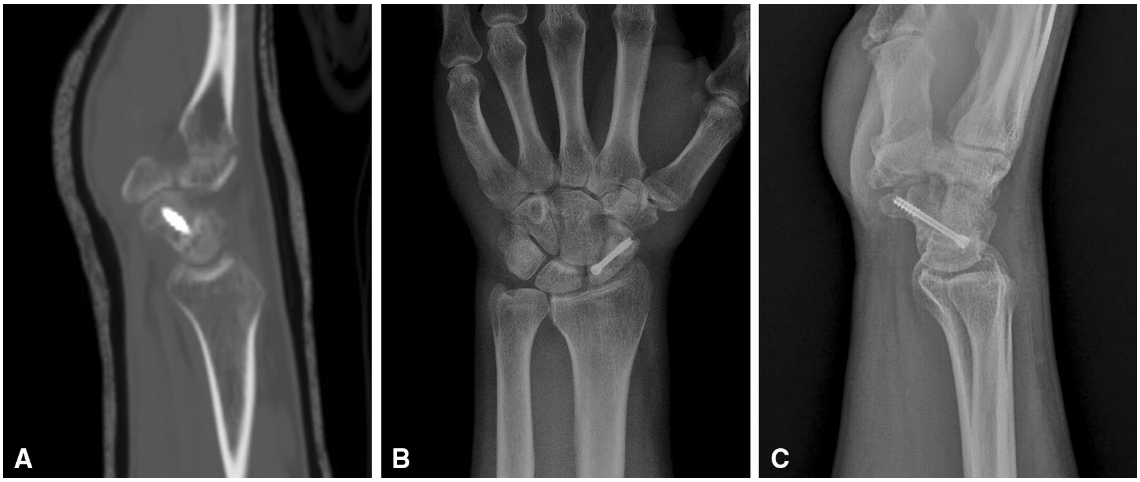

Fig. 4A–C (**A**) Sagittal CT scan taken 8 weeks after surgery shows bony union. (**B–C**) Radiographs obtained at 2 years postoperatively demonstrate solid union and no arthritic changes.

the affected wrist, grip strength, MWS, and DASH scores. Active flexion-extension arc was measured using a handheld goniometer, and grip strength was measured using a JAMA hydraulic dynamometer (Asimov Engineering, Los Angeles, CA, USA). The MWS is a commonly used wrist rating system [4]. The total score ranges from 0 to 100 points with higher scores indicating a better result. The scoring system comprises four categories of pain (25 points), assessment of active flexion-extension arc as a percentage of the opposite side (25 points), evaluation of grip strength as a percentage of the opposite side (25 points), and assessment of ability to return to regular employment or activities (25 points). The DASH questionnaire, a self-reported questionnaire introduced by Hudak et al. [13], was given to each patient preoperatively and at each followup. The questionnaire contains 30 items: 21 questions that assess difficulties with specific tasks, five that evaluate symptoms, and four more questions that evaluate social function, work function, sleep, and confidence (one for each parameter). DASH scores range between 0 and 100 with higher scores representing greater upper extremity disability. Grip strength and wrist ROM were also measured using a dynamometer (Asimov Engineering) and a standard orthopaedic goniometer. There were no missing data.

Each patient was also assessed for any operation-related complications or other complications throughout the followup period.

SPSS Statistics Version 18.0 (SPSS, Inc, IBM®, Chicago, IL, USA) was used for statistical analyses. The preoperative and postoperative clinical ranked continuous values were compared using paired t-tests including VAS pain score, ROM, grip strength, MWS, and DASH score. The level of significance was set at $p < 0.05$. To demonstrate the effectiveness of a treatment, a minimal clinically important difference in VAS scores for pain has been reported ranging from 0.9 to 1.4 [9, 19, 28] and, in DASH score, ranging from 7 to 13.5 [11, 20, 21]. However, other measurements do not have the reported minimal clinically significant differences.

Results

Thirty-two of the 33 (97%) scaphoid nonunions healed successfully. In one patient with incomplete scaphoid healing 6 months after the operation, union was achieved by revision cancellous bone grafting using a volar approach. At the last followup, the mean VAS pain score decreased (preoperative: mean 4.5 [SD 1.8], postoperative: mean 0.6 [SD 0.8], mean difference: 3.9 [95% confidence interval {CI}, 3.2–4.6], $p < 0.001$) and the mean active flexion-extension angle increased (preoperative: mean 100° [SD 26], which was 75% of that of a normal wrist, postoperative: mean 109° [SD 16], which was 82% of that of a normal wrist, mean difference: 9° [95% CI, 2–16], $p = 0.017$). The mean grip strength increased (preoperative: mean 35 kg of force [SD 8], postoperative: mean 50 kg of force [SD 10], mean difference: 15 kg of force [95% CI, 11–19], $p < 0.001$). The mean MWS increased (preoperative: mean 56 [SD 23], postoperative: mean 89 [SD 8], mean difference: 33 [95% CI, 26–41], $p < 0.001$) and the mean DASH score decreased (preoperative: mean 25 [SD 18], postoperative: mean 4 [SD 3], mean difference: 21 [95% CI, 15–28], $p < 0.001$) (Table 1).

There were no operation-related complications and no progress of arthritis at the last followup.

Table 1. Outcome measures after arthroscopic management of scaphoid nonunions

Outcome measure	Preoperative mean (SD)	Last followup mean (SD)	Mean difference (95% CI)	p value
VAS pain score (points)	4.5 (1.8)	0.6 (0.8)	3.9 (3.2–4.6)	< 0.001
Grip strength (kg of force)	35 (8)	50 (10)	15 (11–19)	< 0.001
Flexion-extension arc (°)	100 (26)	109 (16)	9 (2–16)	0.017
MWS (points)	56 (23)	89 (8)	33 (26–41)	< 0.001
DASH score (points)	25 (18)	4 (3)	21 (15–28)	< 0.001

CI = confidence interval; VAS = visual analog scale; MWS = Mayo Wrist Score; DASH = Disabilities of the Arm, Shoulder and Hand.

Seventeen patients had coexisting intraarticular pathologies: nine TFCC (seven traumatic and two degenerative), 17 intrinsic ligament tears (nine scapholunate interosseous ligament tears and eight lunotriquetral interosseous ligament tears), and five radioscaphoid degenerative changes (Table 2). Seven patients with traumatic or degenerative tears of the central disc of the TFCC underwent débridement and ablation of the torn central disc, and one individual with a traumatic peripheral TFCC tear underwent repair using an outside-to-in technique with two PDS sutures. All the intercarpal ligament tears were partial with Grades I or II according to the classification of Geissler et al. [10]. The subjects with intrinsic ligament tears underwent simultaneous débridement and ablation of loose tissues.

Table 2. Coexisting intraarticular pathologies of scaphoid nonunions

Intraarticular disorder	Number of patients
TFCC tear (Palmer type)	
IA	6
IB	1
IIC	2
SLIL tear (Geissler stage)	
I	5
II	4
LTIL tear (Geissler stage)	
I	4
II	4
SNAC stage	
I	5

TFCC = triangular fibrocartilage complex; SLIL = scapholunate interosseous ligament; LTIL = lunotriquetral interosseous ligament; SNAC = scaphoid nonunion advanced collapse.

Discussion

An arthroscopically guided approach comprising nonunion débridement, bone grafting, and rigid internal fixation in patients with minimally displaced scaphoid nonunions with minimal sclerosis has several advantages over the conventional techniques [2, 3, 18, 30–33]. Arthroscopy allows direct assessment of scaphoid fractures or nonunions and other associated soft tissue injuries, if present. It also facilitates identification of the optimal guidewire entrance point and directly visualizes the screw entrance. Previous studies reported that 42% to 83% of acute scaphoid fractures and nonunions are associated with ligament injuries [2, 3, 18, 38]. In addition, most studies reported union rates rather than clinical outcomes assessed by validated tools. We therefore investigated: (1) What are the outcomes of arthroscopic management of scaphoid nonunions as assessed by the proportion of patients achieving osseous union, VAS pain score, grip strength, range of motion, MWS, and DASH score? (2) What complications are associated with arthroscopic scaphoid nonunion management? (3) What forms of intraarticular pathology are associated with scaphoid nonunions?

There are some limitations to our study. First, it was a retrospective case study including a relatively small number of subjects, no control subjects, and relatively mild deformity patterns; studies of this design tend to inflate the apparent benefits of new treatments, because the patients were carefully chosen. Second, all of the patients in this study were men because these injuries are not common in women. Similar results would be expected in these populations. Third, because all the coexisting intraarticular pathologies were treated simultaneously with the arthroscopic management of the nonunions, it was impossible to determine whether untreated coexisting intraarticular pathologies would affect clinical outcomes of scaphoid nonunions or their symptoms. Fourth, this study had an inherent selection bias because patients with dorsal intercalated segmental instability and advanced scaphoid nonunion advanced collapse were excluded; our results would not be expected to generalize to these more challenging patterns of injury. Lastly, bony union was evaluated on CT images by two orthopaedic surgeons (YRC, IHK), who did not blind to the procedure had undergone. However, the union was also confirmed by radiographs taken at each followup. All patients who achieved bony union after arthroscopic management showed consolidation of the nonunion gap without loosening of the implants and further displacement of the fragment on those followup radiographs.

In this study, bony union was achieved in 97% (32 of 33 wrists) scaphoid nonunion cases using the arthroscopic approach that consists of nonunion débridement, cancellous bone grafting, and headless screw fixation. We believe that several factors account for the observation that the proportion of patients achieving union in our small series appeared to be as good as or better than those reported in series of nonvascularized bone grafting (80%–95%) [7, 12, 27, 33]. First, in contrast to the conventional open volar and dorsal approach, arthroscopy-guided osteosynthesis preserves the vascular structures of the scaphoid by saving soft tissue attachments. The vascular supply to the scaphoid is tenuous because the surface of the scaphoid is composed almost entirely of cartilage with minimal soft tissue attachments [31]. Second, all of our patients underwent autogenous cancellous bone grafting from the iliac crest and firm fixation with a headless compression screw. Although the iliac crest and the distal radius are commonly used as sources of bone grafts for scaphoid nonunions, the iliac crest-derived grafts seem to possess superior osteogenic properties compared with grafts from the distal radius [8].

In this study, pain relief and functional restoration were achieved as measured by outcome instruments like VAS pain score, grip strength, ROM, MWS, and DASH score. The mean grip strength in this study increased 15 kg of force (95% CI, 11–19) at the last followup. This is consistent with comparison studies that demonstrated a recovery of grip strength from 79% to 104% of a normal wrist [14, 26, 36]. The mean active wrist flexion-extension movement at the last followup was 109° and increased only 9° (95% CI, 2–16) to the preoperative angle. This small improvement might be clinically irrelevant despite statistical significance and might be because our patients maintained good preoperative wrist movement. We expected that arthroscopic management could achieve better wrist movement for patients with scaphoid nonunion than conventional open surgery; however, the flexion-extension angle measured at the last followup was similar to other studies (98°–116°) [25, 26, 36]. As pain, grip strength, and wrist movement improved, all of our patients who achieved bony union showed functional improvement assessed by MWS and DASH score like other studies [3, 25].

Complication rates after wrist arthroscopy were reported ranging from 1.2% to 5%, which included superficial or deep infection, extensor tendon injury, superficial sensory neurapraxia, dorsal wrist ganglion, stiffness, or complex regional pain syndrome [1, 2, 6, 23]. Although we reported no complications after arthroscopic management of scaphoid nonunions, it seems to be from our small number of cases. Complications during or after arthroscopic wrist surgery might be unusual; however, surgeons should be aware of the potential complications related to wrist arthroscopy to decrease the likelihood of each of these complications.

In our study, 52% of our patients had coexisting intraarticular disorders, and our results were similar to previous studies, which reported 42% to 83% of the associated ligament injuries in patients with acute scaphoid fractures and nonunions [2, 3, 18, 30, 38]. General rules of treatment for coexisting ligament injuries are the following: débridement for partial intrinsic ligament tears and débridement and fixation for complete tears; and débridement for Type 1A TFCC tears and repair for Type IB TFCC tears [2, 3, 18, 30, 38]. Shih et al. [30] and Wong et al. [38] reported lower functional scores in patients with coexisting soft tissue injuries; in contrast, in this study, patients with coexisting ligament injuries showed similar outcomes to patients without those injuries. This discrepancy seems to be attributed to the degrees of soft tissue injuries. Our patients had only partial intrinsic ligament tears. However, we think that the clinical relevance of the partial ligament tears and their treatments seem to be uncertain on functional outcomes.

Based on the proportion of patients who achieved osseous union and the assessment of pain, ROM, and subjective outcome performed at the last followup, this small series suggests that scaphoid nonunions without dorsal intercalated segmental instabilities or late scaphoid nonunion advanced collapse wrists can be managed successfully with an arthroscopic technique. Although intraarticular pathologies such as TFCC and intrinsic ligament injuries commonly coexisted with scaphoid nonunions, patients generally achieved good results. Further studies may involve clinical research to investigate whether the coexisting ligament injuries should be treated simultaneously when managing scaphoid nonunions or not. In addition, a prospective randomized study for open and arthroscopic treatment for scaphoid nonunions should be followed to evaluate the advantages and disadvantages of one technique over the other.

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