Distal Scaphoid Excision in Treatment of Symptomatic Scaphoid Nonunion: Systematic Review and Meta-analysis

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Abstract

Background: Current treatment options for persistent scaphoid nonunion are limited to salvage procedures such as proximal row carpectomy (PRC) or 4-corner fusion (4CF). Several small studies have demonstrated that distal scaphoid excision may provide a simpler alternative with faster recovery. The purpose of this study was to determine the efficacy of distal scaphoid excision as a treatment option for symptomatic scaphoid nonunion. **Methods:** The MEDLINE and PubMed databases were searched for the use of distal scaphoid excision in scaphoid nonunions. Studies included reported on either the functional or patient-centered outcomes following distal scaphoid excision for symptomatic scaphoid nonunion. **Results:** Six articles described the outcomes of 70 patients with an average of 11.7 patients per study. Functional outcomes including flexion-extension arc, radial-ulnar deviation, and grip strength improved by an average of 98.95%, 58.96%, and 131.08%, respectively. Patient-derived outcomes included the Modified Mayo Wrist Score, which improved by 92.6%, and the Disabilities of the Arm, Shoulder and Hand, which improved by 137.17%. An average of 68.75% of patients experience complete relief of pain with 20.83% of patients experiencing pain with strenuous activity. The average postoperative visual analog scale (0-10) was 0.71. On average, 93.33% of patients returned to work with an average time of return being 6.89 weeks. Complete satisfaction was reported by 87.80% of patients. Complications included progression into 4CF or PRC and newly developed midcarpal arthritis. **Conclusions:** Given favorable outcomes, our analysis suggests that distal scaphoid excision may be a favorable, low-risk treatment for scaphoid nonunion without eliminating more extensive options such as 4CF and wrist arthrodesis.

Keywords: distal scaphoid excision, SNAC wrist, scaphoid nonunion, salvage treatment, outcomes, hand

Introduction

The scaphoid is the most commonly fractured carpal bone, accounting for approximately 60% to 70% of carpal fractures and 11% of all hand fractures.^{5,8,10} While nonunion rates of all fractures are estimated at 5%, scaphoid fractures have a nonunion rate of approximately 15.5%, which is the highest rate in any fracture.²⁷ Complications of scaphoid nonunion include pain, stiffness, decreased grip strength, loss of motion, and radiocarpal arthritis between the distal fragment and the distal radius. Furthermore, nonunion can progress into scaphoid nonunion advanced collapse (SNAC), which results in midcarpal arthritis in both symptomatic and asymptomatic nonunions.^{13,25} Current management of symptomatic scaphoid nonunions following failed bone grafting includes 4-corner fusion (4CF) with scaphoid excision and proximal row carpectomy (PRC).^{4,18} However, these salvage procedures are associated with complications that can include hardware failure or prominence with soft-tissue irritation, stiffness, and worse functional outcomes.^{11,16} In addition,

4CF and PRC both eliminate part or all of the midcarpal joint, and if revision surgery is required in the future, total wrist arthrodesis and arthroplasty are the only options.

Distal scaphoid resection for the treatment of long-standing scaphoid nonunion was proposed as an alternative to traditional salvage procedures by Malerich et al in 1999.¹⁵ In addition, Ruch et al reported achieving satisfactory clinical outcomes using the arthroscopic technique of distal scaphoid resection.¹⁹ Excision of the distal fragment has multiple proposed advantages including: (1) minimal morbidity; (2) early return to preoperative activity; (3) relief of pain; and (4) improvements to preoperative range of motion, functional score, and grip strength. Several additional

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studies evaluating the efficacy of distal scaphoid excision have shown improvements in functional outcomes including flexion-extension arc, radial-ulnar deviation, grip strength, and pain.^{6,7,14,15,19,20,23,26} Pain was assessed based on the studies reported patient-centered outcomes including the relief of pain; visual analog scale (VAS); Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire; and the Modified Mayo Wrist Score (MMWS). These upper extremity functionality scores allow for a comprehensive assessment of patient-reported pain, resumption of activities of daily living, and patient satisfaction.^{2,9,12,22}

With the limited number of surgical options available in the management of SNAC wrists, a comprehensive review of the literature is needed to assess the efficacy of distal pole excision. Therefore, we systematically reviewed all studies that utilized distal scaphoid resection for the treatment of symptomatic scaphoid nonunion. The purpose of this study was to determine the effect of distal scaphoid resection for symptomatic scaphoid nonunion on functional outcomes.

Materials and Methods

A systematic literature review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.¹⁷ A review of PubMed and MEDLINE databases was conducted to identify studies that utilized distal scaphoid resection for the management of persistent symptomatic scaphoid nonunion. Search terms included “distal scaphoid resection,” “distal scaphoid excision,” and “scaphoid AND resection.” The title and abstract of each article that resulted from the database search were evaluated for eligibility with the authors and institutions of each manuscript blinded. The references of the articles that were selected for full-review were reviewed to identify any additional studies that may have been missed in the initial database search.

We included studies that reported on either the functional or patient-centered outcomes following distal scaphoid excision for symptomatic scaphoid nonunion. Studies that were excluded were those with less than 6 months of follow-up, non-English studies, those without full-text available, those that performed distal scaphoid excision for the treatment of other conditions aside from symptomatic scaphoid nonunion, those that utilized any form of wrist or carpal arthrodesis in conjunction with scaphoid excision, and those that did not provide individual patient data. The search protocol and article review were completed by 3 reviewers.

A total of 246 studies were identified following this comprehensive literature search. After carefully evaluating these 246 studies, a total of 9 studies were found that described distal scaphoid resection for symptomatic nonunion. Of those studies excluded, 2 did not provide individual patient data and 1 study was in German. Articles that

met the inclusion/exclusion criteria were selected for full-text review.

The data from the studies included were compiled into an electronic spreadsheet and analyzed. Data collected included number of patients, average age, male-to-female ratio, length of follow-up, grip strength, flexion-extension arc, ulnar-radial deviation arc, presence/progression of degenerative wrist arthritis, and patient-centered outcomes such as VAS, DASH, and MMWS. Furthermore, radiographic findings such as radiolunate angle, carpal height ratio, and presence of degenerative joint disease other than styloscapoid were recorded. Last, we assessed postoperative relief of pain, duration before return to work, patient-reported satisfaction, and reported complications. When an article was found with missing data relevant to outcomes of the meta-analysis, these were excluded for the analysis of those outcomes but still included for those of which the data were still available (ie, if a study reported on flexion-extension arc but not grip strength, that study was included in the pooled analysis of flexion-extension arc but excluded from the pooled analysis of grip strength). Similarly, if a study reported on an outcome but did not include individual patient data, those studies were excluded from the pooled analysis. The pooled median values and the 95% confidence intervals (95% CIs) for functional outcomes such as flexion-extension arc, radial-ulnar deviation, and grip strength were calculated. Pooled means and 95% CIs as well as paired *t* tests and unpaired *t* tests were used to analyze patient-centered data such as patient satisfaction, relief of pain, and functional scoring scales (ie, MMWS). Statistical significance was defined as $P \leq .05$. Patients who underwent salvage procedures such as 4CF, PRC, and wrist arthrodesis following distal scaphoid excision were excluded from the meta-analysis.

Results

Included Study Characteristics

Results from our electronic database search are demonstrated in Figure 1 and Table 1. The overall characteristics of these studies are listed in Table 2. Ninety-six percent of patients included in the study did not require subsequent salvage procedures within the follow-up periods. Functional and radiographic measures of outcome varied slightly between studies but largely focused on range of motion, grip strength, radiolunate angle, and presence of midcarpal arthritis (Table 1). Patient-derived outcomes reported included DASH, VAS, MMWS, return to work, and satisfaction.

Functional Outcomes

All studies (100%) assessed at least 1 of the 3 functional measures, both preoperatively and postoperatively (Table 1). Together, 6 studies assessed flexion-extension arc in 66

Figure 1. Selection process for articles included in this systematic review.

patients. The average percentage improvement from preoperative measures to the time of follow-up was 98.95% (95% CI: 78.21%-119.70%; Figure 2). Two studies (33.33%) involving 10 patients measured radial-ulnar deviation. The average percentage improvement from preoperative measures was 37.97% (95% CI: 16.98%-58.96%; Figure 3). Finally, 5 studies (83.33%) including 53 patients assessed grip strength. The average percentage improvement from preoperative measures was 131.08% (95% CI: 98.56%-163.61%; Figure 4).

Patient-Reported Functionality

Four studies (66.67%) assessed functionality both preoperatively and postoperatively (Table 1). The MMWS was the most commonly utilized score. It was used by 3 studies (50%) that included a total of 19 patients (Table 1). The average MMWS improved from a preoperative average of 46.32 preoperatively (95% CI: 36.93-55.70) to a postoperative average of 89.21 (95% CI: 85.60-92.83). These changes represented a 92.6% improvement in MMWS ($P < .0001$;

Table 1. Studies Included in This Systematic Review.

Reference	Level of evidence	Study design	No. of patients	Functional outcome(s) reported	Patient-derived outcome(s) reported	Radiographic outcome(s) reported
Ruch et al ¹⁹	IV	Case series	3	Flexion/extension, radial-ulnar deviation, and grip strength	MMWS, time and % return to work, and satisfaction	DISI
Malerich et al ¹⁵	IV	Case series	19	Flexion-extension arc, radial-ulnar deviation, and grip strength	% return to work, relief of pain, and satisfaction	Carpal height ratio, radiolunate angle, and degenerative joint disease other than stylosaphoid
Soejima et al ²³	IV	Case series	9	Flexion-extension arc and grip strength	MMWS, % return to work, and relief of pain	Carpal height ratio, radiolunate angle, and degenerative joint disease other than stylosaphoid
Ruch and Papadonikolakis ²⁰	IV	Retrospective review	13	Flexion-extension arc	DASH, relief of pain, and % return to work	Radiolunate angle, capitulate angle, and DISI
Malerich et al ¹⁴	IV	Case series	19	Flexion-extension arc, radial-ulnar deviation, and grip strength	VAS and satisfaction	Carpal height ratio, radiolunate angle, and development of midcarpal arthritis
Youssef and Abdel-Fattah ²⁶	IV	Case series	7	Flexion-extension arc, radial-ulnar deviation, and grip strength	VAS, MMWS, time and % return to work, and relief of pain	Radiolunate angle, capitulate angle, and DISI

Note. MMWS = Modified Mayo Wrist Score; DISI = dorsal intercalated segment instability; DASH = Disabilities of the Arm, Shoulder and Hand; VAS = visual analog scale.

Table 2. Overall Study Characteristics.

Study demographics	
Number of studies	6
Number of patients	70
Average number of patients per study	11.7
Average age, y	40.8
% Male	90
Duration of nonunion, y	11.2
Length of follow-up, y	6.5

Table 3). One study (16.67%) utilized the DASH score with 12 patients. The average DASH score improved from an average of 60.08 preoperatively (95% CI: 69.19-50.98) to an average of 25.33 postoperatively (95% CI: 36.32-14.34). This change demonstrated an improvement of 137.2% in DASH score ($P < .0001$; Table 3).

Return to Activity

Five studies (83.33%) involving a total of 45 patients assessed the percent of patients who returned to work following

Figure 2. Percent improvement in flexion-extension arc.

the procedure (Table 1). On average, 93.33% of patients returned to work following the procedure (95% CI: 89.96%-100.7%; Table 3). Two studies (33.33%) involving a total of 9 patients reported on the time from surgery to return to work. On average, patients returned to full duty work after 6.88 weeks (95% CI: 5.03-8.75; Table 1).

Figure 3. Percent improvement in radial-ulnar deviation.

Figure 4. Percent improvement in grip strength.

Pain

Five studies (83.33%) assessed postoperative changes in pain through one of 2 measures (Table 1). Two studies (33.33%) utilized the VAS pain scoring system, a 0 to 10 system in which 0 represents no pain and 10 represents severe pain. In these studies, involving 24 patients, preoperative pain was 4.71 (95% CI: 3.19-6.24) and postoperative pain was 0.71 (95% CI: 0.47-0.95). These changes represented an 84.97% improvement ($P < .0001$; Table 3). Five studies (83.33%) involving 48 individuals reported the degree to which patients experienced pain relief, either as complete relief, pain with strenuous activity, or pain at rest. Across these 5 studies, an average of 68.75% of individuals had complete relief of pain (95% CI: 55.50%-82.00%), 20.83% reported pain with strenuous activity (95% CI: 32.44%-9.22%), and 10.42% reported pain at rest (95% CI: 19.15%-1.68%; Table 3).

Satisfaction

Three studies (50%) reported patient satisfaction. Of the 41 patients reported, 87.80% (95% CI: 77.77%-97.95%) of patients were satisfied with the procedure (Table 3). The most common reason for dissatisfaction with the procedure was postoperative pain.

Complications

Our systematic review of the literature showed minimal complications following distal scaphoid excision. In the Malerich et al case series that included a mean of 15 years of follow-up, 2 patients underwent further surgical intervention. The first of these 2 patients elected to undergo wrist arthrodesis due to subluxated midcarpal joint with noteworthy midcarpal arthritis preoperatively.¹⁴ The second patient was a 60-year-old man with diabetes, heavy smoking history, avascular necrosis of the proximal pole, and scapholunate diastasis who underwent PRC.¹⁴ Soejima et al reported that newly developed degenerative arthritis occurred at the proximal scapholunate-capitate articulation in 1 patient who had a type II lunate.²³ The presence of midcarpal arthritis was noted by some articles included but was not indicated to effect long-term outcomes.

Radiographic Findings

Two studies (33.33%) including a total of 24 patients reported on radiolunate angle. The average preoperative radiolunate angle was 23.88 (95% CI: 20.32-27.43) and postoperatively increased to 28.92 (95% CI: 25.72-32.11). This represented a 21.12% increase in angle ($P = .0443$). One study (16.67%) involving 17 patients reported on revised carpal height ratio, which decreased 4% from 1.42 preoperatively (95% CI: 1.40-1.45) to 1.38 postoperatively (95% CI: 1.36-1.40; $P = .0155$). One study (16.67%) reported on capitulunate angle but found no significant difference between a preoperative average of 14.31 (95% CI: 10.24-18.38) and a postoperative measure of 15.77 (95% CI: 11.87-19.67; $P = .62$). Finally, one study (16.67%) described a patient's scapholunate advance collapse (SLAC) stage and found that only 1 patient (7.69%) had progressed from their preoperative SLAC stage at the time of follow-up.

Discussion

This article aims to bring together the collective data of a relatively small number of studies reporting the outcome of distal scaphoid excision as a bone and motion preserving salvage procedure for persistent symptomatic scaphoid nonunion. Scaphoid nonunion typically occur in younger patients, and persistent nonunion SNAC wrists pose a challenge. Despite good medium-term results, surgeons are

Table 3. Patient-Derived Outcomes.

	Postoperative	% Improvement	P value
MMWS	89.21 ± 8.04	92.6	<.0001
DASH	25.33 ± 19.43	137.17	<.0001
% Return to work	93.33 ± 25.23		<.0001
Time to return to work (weeks)	6.89 ± 2.85		
VAS	0.708 ± 0.606	84.97	<.0001
% Complete relief of pain	68.75 ± 46.84		
% Pain with strenuous activity	20.83 ± 41.04		
% Pain at rest	10.42 ± 30.87		
% Satisfaction	87.80 ± 33.13		<.0001

Note. MMWS = Modified Mayo Wrist Score; DASH = Disabilities of the Arm, Shoulder and Hand; VAS = visual analog scale.

apprehensive to perform a PRC or a 4CF particularly on younger patients. In theory, distal scaphoid excision offers shorter recovery times, minimal morbidity, relief of pain, and improvements in both functional and patient-derived outcomes. Furthermore, it provides these benefits while preserving other salvage options of PRC, 4CF, and wrist arthrodesis if necessary.

In this systematic review of the literature, 6 studies containing 70 patients with symptomatic scaphoid nonunion were analyzed. Our analysis demonstrated that distal scaphoid excision provides patients with significant improvements in all functional outcomes reported compared with other salvage procedures such as PRC and 4CF. When examining the functional outcomes of these salvage procedures, a systematic review by Mulford et al found a 4.2% improvement in flexion-extension arc in PRC and a 9.9% decrease in flexion-extension arc following 4CF.¹⁸ Saltzman et al reported on available literature and found that flexion-extension arc decreased in both 4CF and PRC, 6.6% and 7.1%, respectively.²¹ Our analysis of the individual patient data determined that distal scaphoid excision provides an average of 98.95% improvement from preoperative measures. Mulford et al found that radial-ulnar deviation improved 18.5% following 4CF and 17.1% following PRC. Similarly, Saltzman et al found a 20% improvement in radial-ulnar deviation following 4CF and a decrease of 13.5% following PRC. In comparison, our review demonstrated that distal scaphoid excision provided patients an average of 37.97% improvement in radial-ulnar deviation. Finally, Saltzman et al demonstrated that 4CF and PRC provide patients a 17.5% and 19.6% improvement in grip strength, respectively. Our analysis demonstrated a 131.08% improvement in grip strength postoperatively.

Patient-derived outcomes of PRC and 4CF have been well documented in the literature as well. When comparing PRC and 4CF on SNAC and SLAC wrists, Dacho et al reported a postoperative VAS score of 1.2 and 1.1, respectively.⁴ In a randomized clinical trial, Aita et al reported that postoperative VAS for PRC was 2.3 and 2.9 for 4CF.¹ In our

analysis, VAS following distal pole excision was found to be 0.71 postoperative, an 84.97% improvement. MMWS was not included in the reviews conducted by Saltzman et al or Mulford et al; however, Dacho et al detailed a postoperative MMWS of 68 following 4CF and 57 following PRC.⁴ In contrast, the average MMWS score of 89.21 was found in our review of distal pole excision. Postoperative DASH score following salvage procedures was found to be 28 for 4CF and 21 for PRC.²¹ These results are comparable to the 25.33 average found in our review; however, only 1 study that was included in this review reported DASH score. Similar numbers of patients were found to be satisfied when comparing our review with Mulford et al, in which 80% of PRC patients, 90% of 4CF, and 87.8% of distal scaphoid excision patients were satisfied.

One clear benefit to distal scaphoid excision is the rapid return to preoperative activity level. Due to the minimally invasive nature of the procedure and 2-week duration in the cast, patients were able to return to activity much earlier than reported for PRC and 4CF. As summarized by Saltzman et al, patients undergoing 4CF were placed in a short arm cast for between 6 and 9 weeks and those undergoing PRC for 3 to 4 weeks before gradual strengthening exercises.²¹ Our analysis demonstrated that patients on average were able to return to full duty work in under 7 weeks. Furthermore, a higher percentage of patients were able to return to work following distal scaphoid excision. Return to work was observed in 93.55% of patients in our analysis. Of patients who underwent PRC, return to work was reported by Aita et al at 69.23%; 86% by Cohen and Kozin; and 80% in the study by Tomaino.^{1,3,24} Of those who underwent 4CF, these same studies reported return to work at 57.14%, 86%, and 100%, respectively.^{1,3,24}

The quality of this review, as with any systematic review, is limited by the studies that were included for analysis. Limitations of our study include the use of solely observational and retrospective studies (level IV evidence). The absence of comparative studies, cohort studies, and randomized controls results in an inherent selection bias based on physician

preference for candidate patients. Furthermore, the lack of articles reporting individual patient data, and heterogeneity of outcome measures, reporting and scoring, making objective conclusions more difficult to make. Standardization of these reporting measures would allow for better analysis of outcomes following treatment. While these results are promising, more studies are needed to adequately power a large cohort. Alternatively, a study comparing interventions with good sample size may help answer that question.

Chronic scaphoid nonunion and progression into SNAC is a well-documented condition with significant impact on patients' well-being regardless of presenting symptoms.²⁵ The literature suggests that distal scaphoid excision outperforms PRC and 4CF in almost all measures reported, including range of motion, grip strength, MMWS, VAS, return to work, relief of pain, and patient satisfaction. However, there is a complete lack of well-designed trials directly comparing these methods. Further research is needed to assess the long-term sequelae of distal scaphoid excision in larger cohorts of patients. This assessment, along with direct comparisons with PRC and 4CF, will lead to a more comprehensive understanding of the outcomes following distal scaphoid excision for symptomatic scaphoid nonunion.

Overall, the conclusions drawn by each of the 6 studies reviewed (Table 1) were similar, and included favorable results and substantial improvement across all functional and patient-centered outcomes. Importantly, this procedure does not disrupt the proximal carpal row and allows for PRC, 4CF, and wrist arthrodesis if necessary. Thus, distal scaphoid excision should be considered as a less invasive treatment option that can significantly improve the quality of life of patients with symptomatic scaphoid nonunions. In conclusion, our meta-analysis, despite its limitations and low case numbers, would support the use of distal scaphoid excision for SNAC wrists as a simpler and less invasive alternative to other commonly utilized salvage procedures such as 4CF and wrist arthrodesis.

Ethical Approval

This study is exempt from institutional review board approval.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

Informed consent was obtained when necessary.

Declaration of Conflicting Interests

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