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Arthroscopic Wrist Debridement and Radial Styloidectomy for Advanced Scapholunate Advanced Collapse Wrist: Long-term Follow-up

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Abstract

Background: Symptomatic stage 2 or 3 scapholunate advanced collapse (SLAC) wrist is aggressively treated with salvage procedures, such as proximal row carpectomy or partial wrist fusion with resultant pain relief but limited motion. We hypothesize that arthroscopic synovectomy, radial styloidectomy, and neurectomy will preserve wrist motion, relieve pain, and delay or avoid salvage procedures. **Methods:** We evaluated outcomes in 13 wrists through questionnaires and 11 of these through additional physical examination at a mean follow-up of 5.0 years. Eight wrists were stage 2 and 5 were stage 3. Data at final follow-up included mobility/strength measurements, subjective outcome scores (Disabilities of the Arm, Shoulder, and Hand [DASH] and visual analog scale [VAS] pain), patient satisfaction, and return to work statistics. **Results:** Patients had an average flexion-extension arc of 88.0° in the treated wrist and an average grip strength that was 95.0% of the contralateral side. No patients required revision surgery at follow-up. The 13 wrists reported an average DASH score of 16.4 and mean VAS pain score at rest and with activity of 17.9 and 31.6, respectively. All patients working prior to the procedure (n = 8) were able to immediately return to work. In all, 84.6% of patients were satisfied. **Conclusions:** The procedure studied may have advantages in relieving pain, while preserving wrist motion for SLAC stage 2 or 3 disease. This procedure does not preclude future salvage procedures in those patients with severe disease who prefer to maintain wrist motion for the short term. Patients experience good functional outcomes with the majority experiencing a reduction in pain with the ability to return to work.

Keywords: scapholunate advanced collapse, wrist arthroscopy, denervation, motion sparing, radial styloidectomy

Introduction

Scapholunate advanced collapse (SLAC) is the most common osteoarthritis of the wrist and is characterized by a pattern of arthritis associated with long-standing disruption of the scapholunate ligament.²² Watson et al described the stages of pathophysiological progression.²³ Several surgical procedures such as proximal row carpectomy (PRC), 4-corner fusion (4CF), and total wrist arthrodesis (TWA) have been described to treat SLAC wrist and provide reliable pain relief while sacrificing range of motion (ROM) and strength, thus causing functional disabilities for patients.^{1,3,17,20,21}

With the rise in retirement age, disability created by SLAC wrist and its treatment is no longer acceptable by patients who wish to preserve motion and function.⁶ One study found that patients receiving TWA for SLAC wrist

were on average 58 years old.¹⁵ For patients of this age with manual and skilled labor occupations or hobbies requiring minimally limited wrist motion, the functional disabilities created by TWA and reconstructive procedures may cause patients to either accelerate retirement or endure wrist pain until they have reached the common retirement age of 65.¹⁵ Furthermore, as life expectancy has risen, average retirement age has similarly increased.⁶ This trend is expected to continue, and the duration patients must endure wrist pain may be similarly lengthened. Consequently, for patients

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with advanced SLAC wrist who desire pain relief, but wish to avoid TWA or wrist reconstruction, our senior author (M.P.R.) offers a combination of procedures that include arthroscopic debridement, synovectomy, radial styloidectomy, and partial denervation via the anterior and posterior interosseous nerves (AIN/PIN) to relieve pain while preserving function. The procedure may be indicated for patients with adequate motion and predominantly radial styloscaphoid impingement pain.

We hypothesize that the procedure in question is a safe and reliable means to relieve pain and improve function in patients presenting with advanced SLAC wrist. The purpose of this study was to assess the procedure's long-term outcomes. The primary outcomes measured included objective wrist ROM and strength measures, as well as subjective functional, pain, and patient satisfaction scores. Secondarily, rate of incidence of salvage procedures was also assessed.

Materials and Methods

After obtaining institutional review board approval (IRB-AAAE9813) for this study, 15 patients (7 male, 8 female), representing 16 wrists, were identified with the diagnosis of advanced SLAC wrist (stage 2 or 3) who were treated between January 2001 and December 2015 with a combination of wrist arthroscopy, synovectomy, radial styloidectomy, and/or AIN/PIN wrist denervation. Study inclusion criteria were limited to patients who initially failed nonoperative treatment and subsequently elected to undergo the combination of procedures either with or without AIN/PIN neurectomy. Three patients were lost to follow-up and thus excluded, leaving 12 patients (5 male, 7 female, 13 wrists) who were enrolled. Ten patients (11 wrists) were evaluated in the clinic for physical examination of both wrists and completed study questionnaires. Two patients (15.4%; 2 wrists) were unable to return for evaluation but completed mail-in questionnaires. Each patient's initial diagnosis of advanced SLAC was confirmed by preoperative radiographic findings and findings at arthroscopy.

The underlying common procedure for all of the study patients was wrist arthroscopy, synovectomy, and arthroscopic radial styloidectomy. Neurectomies were not performed in patients who denied undergoing that portion of the procedure. Standard radial, ulnar, and midcarpal arthroscopic portals were marked. A 2.7-mm 30-degree-angle-viewing arthroscope was inserted with a blunt trocar into the 3-4 portal and 4-5 portal, and a thorough inspection of the radiocarpal and capitolunate joint was performed. Motorized shavers allowed debridement of the synovitis and chondral fraying in the radiocarpal and midcarpal joints. Attention was then turned to the arthroscopic radial styloidectomy, for which an arthroscopic burr was utilized, as shown in Figure 1. The burr was used to remove 3 to 4 mm of the radial styloid and recontoured the styloid in such



Figure 1. Arthroscopic photographs representing the articular side of the radial styloid before and after radial styloidectomy was performed.

a manner so that there was no impingement as the wrist was placed into full flexion and radial deviation. The joint was copiously irrigated and suctioned to remove all debris. The arthroscopic portals were closed with 5-0 nylon suture.

Having completed the arthroscopic portion of the procedure, attention was then directed to the neurectomies for those patients who did not deny receiving one. A 4-cm dorsal longitudinal incision was created proximal to the distal radioulnar joint and over the interosseous space between the radius and the ulna. The retinaculum between the fourth and fifth compartments was incised. The tendons were retracted, and the PIN was identified in the floor of the fourth extensor compartment and resected over a course of 3 cm. The interosseous membrane was incised, and the AIN was identified and resected over a course of 3 cm. Considerable variation is present in the anatomy of the AIN, and the authors' preferred method of approach has been previously published.⁹ Importantly, preservation of innervation of the pronator quadratus was desired and achieved by tracing the AIN distally to within 2 cm of the ulnar head and then incising the AIN over a course of 3 cm. Following surgery, the patients were permitted to advance activities as tolerated with no postoperative immobilization necessary. Formal hand therapy was not prescribed.

Table 1. Patient Demographics and Treatment Details.

Patient ID	SLAC grade	Treated wrist	Age at surgery, y	Occupation (R/NM/M/S)	Follow-up time, y	Neurectomy
IND	2	ND	75	R	7.9	No
ID	2	D	76	R	6.4	No
2	2	ND	71	S	7.1	Yes
3	2	D	44	S	5.9	No
4	2	D	73	R	5.2	No
5	2	D	68	S	2.6	Yes
6	2	ND	71	S	1.9	Yes
7	2	ND	62	R	1.1	No
Mean (SD)			67.5 (9.8)		4.8 (2.4)	
Range			44-76		1.1-7.9	
8	3	D	45	M	8.3	No
9	3	D	56	M	7.3	No
10	3	ND	63	R	5.3	Yes
11	3	ND	47	NM	4.8	Yes
12	3	D	68	S	1.1	Yes
Mean (SD)			55.8 (8.9)		5.3 (2.6)	
Range			45-68		1.1-8.3	
Grades 2/3 combined						
Mean (SD)			63.0 (11.0)		5.0 (2.5)	
Range			44-76		1.1-8.3	

Note. SLAC = scapholunate advanced collapse; D = dominant hand; ND = nondominant hand; R = retired; NM = nonmanual labor; M = manual labor; S = skilled; SD = standard deviation.

All patients completed the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, a validated functional outcome measure to assess overall upper-extremity disability, with a score range of 0 (best) to 100 (worst).¹⁰ This questionnaire was chosen over a wrist-specific questionnaire because studies that assessed the procedures of PRC, 4CF, and TWA commonly used the DASH, and thus, using the DASH in this study would allow for the results to be more comparable.¹⁸ Patients also completed a visual analog scale (VAS) to grade pain at rest (VAS-R) and with activity (VAS-A).¹² A VAS score was also obtained asking patients to rate the degree of limitation in wrist function postoperatively (VAS-F). VAS-R/VAS-A scores ranged from 0 (no pain) to 100 (maximal pain). VAS-F was analogously assessed on a scale from 0 (no functional limitation) to 100 (maximal functional limitation). Additional binary (yes/no) questions evaluated whether patients were able to return to work following the procedure, whether they were satisfied with the results of the procedure, whether they were able to return to activities of daily living (ADL), and whether they felt they had an improved ability to perform ADL following the surgery. Patients' occupations were also obtained and were classified as retired, nonmanual labor, manual labor, or skilled labor.

Wrist ROM was measured by aligning a standard goniometer with the dorsal aspect of the radius proximally and the fifth metacarpal distally and having patients flex and

extend their wrists. Radial and ulnar deviation were assessed by aligning the goniometer with the medial aspect of the ulna proximally and the medial aspect of the fifth metacarpal distally, and asking patients to deviate their wrists. Grip and pinch strength were measured as an average of 3 values of maximum grip and pinch on a Jamar dynamometer (Clifton, New Jersey).

Kolmogorov-Smirnov test was used with $\alpha = 0.05$ to verify that all outcomes with continuous variables were normally distributed. Differences between variables were analyzed for significance using independent 2-sample *t* tests. A *P* value less than .05 was considered significant.

Results

Patient demographics and a description of the corresponding index procedures are shown in Table 1. Mean age at the time of the index procedure was 63.0 ± 11.0 years (range: 44-76 years), and mean time of follow-up for all patients was 5.0 ± 2.5 years (range: 1.1-8.3 years). Eight wrists were staged as SLAC 2 and 5 as SLAC 3. For the 10 patients (11 wrists) seen for physical examination, average follow-up time was 5.3 ± 2.4 years (range: 1.1-7.9 years). Six patients elected to undergo AIN/PIN neurectomy as part of the index procedure.

Detailed results of subjective outcome measures (DASH, VAS-A, VAS-R, and VAS-F) for all patients can

Table 2. Subjective Outcome Measures Organized by SLAC Grade.

SLAC grade	DASH	VAS-R	VAS-A	VAS-F	RTW	Return to ADL	Improved ADL	Procedure satisfaction
2								
Mean (SD)	14.7 (11.1)	15.0 (18.0)	32.3 (30.2)	16.4 (25.2)				
Range	0.8-33.0	0.0-48.0	0.0-84.0	1.0-82.0				
Count	—	—	—	—	4/4	7/8	7/8	7/8
3								
Mean (SD)	18.6 (23.6)	22.6 (41.2)	30.6 (33.0)	26.9 (29.1)				
Range	2.8-50.0	0.0-98.0	8.0-85.0	11.0-85.0				
Count	—	—	—	—	4/4	4/5	4/5	4/5
Grades 2/3 combined								
Mean (SD)	16.4 (14.7)	17.9 (26.2)	31.6 (30.9)	20.4 (27.2)				
Range	0.8-50.0	0.0-98.0	0.0-85.0	1.0-85.0				
Count	—	—	—	—	8/8	11/13	11/13	11/13

Note. SLAC = scapholunate advanced collapse; DASH = Disabilities of the Arm, Shoulder, and Hand; VAS = visual analog scale; RTW = return to work; ADL = activities of daily living; SD = standard deviation.

Table 3. Objective Outcome Measures Organized by SLAC Grade.

SLAC grade	Wrist range of motion (degrees)		Strength (%CTL side)	
	Flexion-extension arc	Radial-ulnar deviation arc	Grip	Key pinch
2				
Mean (SD)	91.1 (20.0)	52.0 (11.3)	88.5 (31.1)	99.1 (28.0)
Range	50-117	42-70	30-130.7	76.1-166.6
3				
Mean (SD)	81.0 (20.0)	31 (17.1)	112.3 (40.8)	106.7 (9.4)
Range	60-108	24-55	67-166	100-120
Grades 2/3 combined				
Mean (SD)	88.0 (19.8)	46.0 (16.0)	95.0 (35.7)	101.1 (24.6)

Note. SLAC = scapholunate advanced collapse; CTL = contralateral; SD = standard deviation.

be found in Table 2. Table 2 also lists patients' abilities to return to their previous occupation and ADL, if patients felt they had an improved ability to return to ADL, and if patients were satisfied with the procedure. All 8 patients working at the time of the index procedure were able to return to work following the procedure. Eleven of the 13 wrists were able to return to ADL without difficulty, with all 11 reporting an improved ability to carry out ADL with the wrist after the procedure. The 2 patients who were unable to return to ADL without difficulty reported the cause as pain at the extremes of flexion and extension, and that they compensated by either relying on their contralateral wrist more or using a splint for painful activities. Patients reported being satisfied with the procedure in 11 of 13 wrists. The patient who had the procedure done in both wrists was dissatisfied with the outcome in the non-dominant wrist. All manual and skilled laborers were able to return to work. A paired *t* test revealed no significant difference between follow-up DASH, VAS-R, VAS-A, or

VAS-F scores for study participants with initial diagnosis of SLAC stage 2 or SLAC stage 3 ($P = .29$). Similar analysis showed no statistical difference in these scores between patients with or without denervation ($P = .5$).

ROM was preserved in both SLAC stage 2 and SLAC stage 3 patients showing a flexion-extension arc of motion of 91.1° (20°) and 81° (20°), respectively, as seen in Table 3. At follow-up, ulnar deviation was significantly higher in the SLAC stage 2 group (mean: 36.0°) when compared with SLAC stage 3 (mean: 18.0°) and was the only statistically significant difference among ROM or strength measurements between these groups ($P = .04$). Grip and key pinch strength were within 12% of the contralateral normal side and in some cases exceeded the strength of the contralateral extremity.

A subgroup of 5 of these patients had previous follow-up that included DASH, VAS-R, and VAS-A scores at an average of 1.6 years after their index procedure and again at an average of 5.2 years as part of the final follow-up associated

with this study. The mean DASH, VAS-R, and VAS-A scores were 17.2, 10.3, and 30.5, respectively, at 19 months and progressed to 20.7, 27.8, and 42.3 at 62 months, respectively. A paired *t* test showed no statistically significant difference in any scores between these 2 follow-up time points.

At the time of follow-up, none of the included wrists had undergone a revision procedure.

Discussion

Advanced-stage SLAC wrist significantly impairs patient function and has traditionally been treated with PRC and 4CF.^{18,19,21} However, these procedures significantly alter wrist kinematics and impair wrist ROM, imposing significant lifestyle burdens on patients with physically demanding hobbies or manual/skilled labor avocations. Furthermore, advanced disease may require TWA but results in the most drastic of ROM deficits.⁸ Given that pain is often the biggest driving factor for patients seeking surgical treatment, it is not surprising that the majority of patients are satisfied with these procedures, despite the limitations on wrist ROM secondary to the procedures. Our results have shown that arthroscopic debridement, synovectomy, radial styloidec-tomy, and a partial wrist denervation provide immediate and long-term satisfactory pain relief to SLAC patients while also maintaining wrist ROM.

At an average of 5 years after surgery, patients reported VAS-R and VAS-A scores of 17.9 and 31.6, respectively. This exceeds the pain relief, as measured by the same scale, provided by PRC and 4CF as shown in the literature by Dacho et al who studied a similar group of patients with an approximate follow-up of 3 years (Figure 2).⁵ Comparison of pain amelioration by these salvage procedures found by other studies is difficult due to differences in methods used to quantify pain.¹⁸ In comparison with long-term outcome studies focusing on TWA, our postoperative pain results are similar, with the largest outcome study of the TWA procedure for SLAC wrist reporting a VAS-A score of 35 at follow-up for TWA patients.⁸

Furthermore, 100% of patients who were working prior to having the procedure were able to rapidly return to work without restrictions. Notably, 2 of these patients were surgeons and one was an active duty police officer. All reported being completely satisfied with the procedure, and overall, the procedure had an 85% satisfaction rate with patients. The 2 patients who reported being dissatisfied cited the uncertainty of the longevity of the procedure as the cause of this dissatisfaction. However, they indicated that if presented with the same situation, they would still undergo the index procedure because it delayed undergoing a salvage procedure.

At minimum, the goal of this described procedure was to delay the need for salvage operations such as 4CF, PRC, or TWA so that patients could continue working and maintain

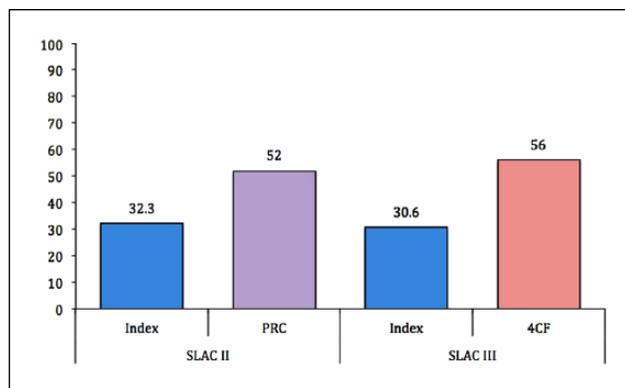


Figure 2. Long-term visual analog pain scale outcomes of index procedure compared with PRC and 4CF for SLAC stage 2 and 3 patients, respectively, as studied by Dacho et al.⁵

Note. PRC = proximal row carpectomy; 4CF = 4-corner fusion; SLAC = scapholunate advanced collapse.

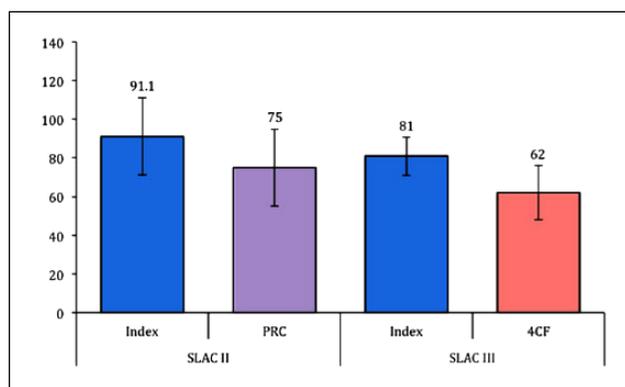


Figure 3. Flexion-extension arcs (degrees) at follow-up of SLAC stage II and III patients receiving index procedure compared with systematic review results of Saltzman et al for patients receiving PRC and 4CF for patients of equivalent SLAC stages.¹⁸

Note. PRC = proximal row carpectomy; 4CF = 4-corner fusion; SLAC = scapholunate advanced collapse.

their active hobbies such as golf or tennis. In comparison with studies reporting ability to return to work and patient satisfaction with PRC and 4CF, it appears that this arthroscopic procedure produces more favorable results in this regard, but comparison between multiple studies is limited due to variability in reporting methods of this variable.¹⁸ In the work of Dacho et al, it was found that 66% of patients receiving 4CF were satisfied and 77% of those receiving PRC were satisfied with their procedure.⁵

Satisfaction rates and return to work rates seen in this study surpass those of salvage procedures. This is likely due to both pain relief and the preservation of wrist ROM with our procedure. Figure 3 demonstrates that wrist ROM exceeded the values of 4CF and PRC reported in a recent systematic review.¹⁸ In addition, grip strength, as defined as

a percentage of the contralateral side, in the index procedure (95%) exceeded the values of these procedures as well (PRC = 67%, 4CF = 74%). Consequently, it is not surprising that the average DASH scores at follow-up of the patients in our study were within the normative values for people of the patients' ages and superior to scores reported in the same systematic review of the salvage procedures.¹¹ The low VAS-F scores, averaging 16.4 and 26.9 for SLAC stage 2 and 3 patients, respectively, at long-term follow-up only serve to further augment this result. This cannot be overlooked when the surgeon is faced with the middle-aged patient with an active lifestyle and career who requires adequate wrist ROM to maintain quality of life.

Pain in advanced-stage SLAC wrist is often focal to the point of impingement at the radial styloid with the scaphoid, and thus, it is the authors' belief that the radial styloidectomy is the component of this procedure that affords the best functional and pain outcomes.²³ As has been shown in prior biomechanical studies, a 3- to 4-mm resection is sufficient to reduce impingement without damage to the surrounding soft tissue or causing instability, while providing improved ROM.¹⁶ In the previous century, reports of adverse outcomes following radial styloidectomy were reported, but since the advent of advanced arthroscopic techniques, research has begun to show this styloidectomy as safe and reliable.^{2,13,14,16} Neurectomy and synovectomy are thought to augment the immediate pain relief patients often describe, but a more precise analysis of the mechanism of pain relief cannot be elucidated by this study.

In contrast to studies focusing on PRC and 4CF, our study found that none of the patients receiving the index procedure required a salvage procedure by the time of follow-up. We believe that this can partly be attributed to total denervations not being a component of our procedure. Total denervations are associated with postoperative neuroma or hematoma formation, and it is this potential complication that contributed to the avoidance of this procedural component and thus possibly a reduced salvage rate as well.⁴ Although the nature of this study prohibits concluding the precise cause of the reduced rate of salvage procedures, this result still provides convincing evidence that at minimum our procedure can delay salvage procedures for a clinically relevant period of time.

This is a retrospective study and includes all of the associated limitations of that methodology. Only one level 1 randomized trial exists comparing 4CF with PRC, with a mean follow-up of 1 year.⁷ All other studies comparing the salvage procedures are level 2 or lower.¹⁸ The heterogeneity of patients' choices regarding components of the procedure also limits the utility of the results. Furthermore, while the average follow-up time of 5.0 years is longer than that of studies comparing 4CF and PRC, this still remains a limitation with respect to describing this procedure as a definitive treatment option for stage 2 or 3 SLAC wrist. The results

regarding the subset of patients who were eligible for a longitudinal analysis provide potential support for the hypothesis that patients may still progress to the point of needing a salvage procedure, but this cannot be definitively concluded from the present study.

Arthroscopic debridement, synovectomy, radial styloidectomy, and AIN/PIN neurectomy should be considered in the treatment armamentarium for the treatment of stage 2 and 3 SLAC wrist. This arthroscopic approach preserves function, strength, and ROM. This motion-sparing procedure is aimed at the subset of patients who wish to return to work or hobbies as it may delay salvage operations by a meaningful amount of time and at best may serve as a definitive solution.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all patients for being included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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