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ORIGINAL ARTICLE
Hand

Scaphocapitate Arthrodesis for Wrist Deformities: A Systematic Review

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Background: Scaphocapitate arthrodesis (SCA) is a described technique for chronic wrist pathology such as Kienbock disease and carpal instability. The technique aims to preserve motion, while maintaining carpal height, preserving the radioscaphoid articulation, and offloading the lunate. Limited case series evaluate the outcomes of this previously described technique. We aim to determine if the collective, updated literature on outcomes of SCA support its continued application by the wrist surgeon. Furthermore, we investigated if any technical variations offer an advantage in improving patient-reported outcomes after SCA.

Methods: A literature search was performed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Articles selected for critical review were examined for patient demographic data, functional outcomes, radiographic outcomes, and complications. A qualitative analysis was then performed to synthesize the available date.

Results: A total of 18 unique articles published between 1991 and 2022 were identified, representing a total of 285 individual cases of SCA. Nonunion rate ranged 0%–22%. Preoperative visual analog scale pain scores ranged from 3.2 to 10, whereas postoperative visual analog scale pain scores ranged from 0 to 4. Patient-reported outcomes are reported by validated instruments, including the Disabilities of the Arm, Shoulder, and Hand, QuickDASH, Patient-rated Wrist Evaluation, and Mayo Wrist Score.

Conclusions: SCA is a viable treatment option for patients with Kienbock disease. SCA offers reliable improvements in patient pain, grip strength, and patient-reported outcomes. *(Plast Reconstr Surg Glob Open 2024; 12:e6205; doi: 10.1097/GOX.0000000000006205; Published online 3 October 2024.)*

INTRODUCTION

Scaphocapitate arthrodesis (SCA) is a motion-preserving wrist salvage technique for chronic wrist pathology that would otherwise result in progressive arthritis and collapse and arthrosis.[1] The procedure involves de-cortication of the articular surface at the scaphocapitate articulation and stable fixation through a variety of techniques such as K-wires, screws, or staples. The goals of the technique are to maintain carpal height, preserve the radioscaphoid articulation, and offload the lunate.[2,3] SCA is most often used to treat Kienbock disease and scapholunate instability.[1,4] In Kienbock disease, idiopathic necrosis of the lunate results in carpal collapse and arthrosis, where patients experience debilitating pain and limitation in range of motion.[1,4] In the case of chronic scapholunate ligament instability, SCA offers improvement in radioscaphoid congruence to alleviate pain and loss of range of motion.[5]

The technique was first described for the treatment of scaphoid nonunion by Sutro and Helfet.[6,7] Pisano et al described the use of SCA for Kienbock disease as well as scapholunate instability.[8] The SCA technique, and several technical variations, have subsequently been well-described in the literature. However, these studies largely consist of low-volume case series with limited follow-up and heterogenous study methodology and outcome measures. Given these limitations, our authors aimed to perform a systematic review of the literature to provide an updated and more complete account of this surgical

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Received for publication July 8, 2023; accepted August 12, 2024.

DOI: 10.1097/GOX.0000000000006205

Disclosure statements are at the end of this article, following the correspondence information.

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technique. Our investigation aimed to answer the clinical questions of whether the literature supports the efficacy of this technique, and whether variations on the technique provide advantages in terms of patient-reported outcomes.

METHODS

A literature search was performed using the established Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The PubMed, Google Scholar, and Web of Science electronic databases were used to conduct this study. We used the following search terms: scaphocapitate arthrodesis or fusion, intercarpal arthrodesis or fusion, limited intercarpal arthrodesis or fusion.

The resulting articles were then screened by our authors by title and abstract to ensure relevance to the topic. Given the use of multiple databases, duplicates of the same article were first excluded. The search was further refined with inclusion criteria: English language, full text available, correct surgical intervention and studies on human subjects. We added the additional exclusion criteria of cadaver-based studies and author replies or responses. Articles selected for critical review were examined for patient demographic data, functional outcomes, radiographic outcomes, and complications. A qualitative analysis was then conducted to synthesize the available data.

RESULTS

The initial literature database search produced 781 titles. After systematic application of inclusion and exclusion criteria, a total of 18 unique articles published between 1991 and 2022 were identified as appropriate for the present study. (**See figure, Supplemental Digital Content 1,** which depicts the flow diagram of our systematic approach. **http://links.lww.com/PRSGO/D535**) The articles contained a total of 285 individual cases of SCA. The majority of articles reported on the technique for the indication of Kienbock disease (n = 15, 88.2%), while three articles reported on its use in scapholunate instability (n = 3, 18%). The average patient age ranged from 24 to 44 years, while the average follow-up ranged from 0.7 to 25 years. Table 1 represents a summary of the articles included in the present review and the outcomes available for qualitative analysis.[1,2,5,8–22]

The majority of authors used an open approach (n = 14, 78%), whereas four articles discussed the use of wrist arthroscopy (n = 4, 22.0%). Fixation techniques varied and included the use of K-wire, headless compression screws, circular plate, and staples. Autologous bone grafting was performed in the majority of cases from the distal radius or iliac crest (n = 14, 78%). Prophylactic styloidectomy was not routinely performed but was described in two articles (11%). Subtotal and total lunate excision was discussed in the technique in 10 articles (56%). The published case series demonstrated average healing time ranging from 7.2 weeks to 14 weeks.[2,5,11,17,21] Eleven of the case series reported complete fusion in all patients (0% nonunion rate).[1,2,11–13,15,17–22] In the remaining six articles, nonunion rates ranged from 10% to 22%.[5,8–10,14,16]

Takeaways

Question: Does the collective, updated literature on outcomes of scaphocapitate arthrodesis support its continued application by the wrist surgeon, and do any technical variations offer an advantage in improving patient-reported outcomes after scaphocapitate arthrodesis?

Findings: In terms of functional outcomes, the literature is consistent in demonstrating that scaphocapitate arthrodesis is effective at treating pain and improving grip strength. Pain scores improved from 3.2–10 to 0–4 across the reviewed studies with most studies noting statistical significance.

Meaning: Scaphocapitate arthrodesis is a viable treatment option for patients with advanced Kienbock disease and carpal instability, offering reliable improvements in patient pain, grip strength, and patient-reported outcomes.

Pain Outcomes

Visual analog scale (VAS) pain scores were used as an outcome measure in the majority of case series. Preoperative VAS pain scores ranged from 3.2 to 10. Postoperative VAS pain scores ranged from 0 to 4. The majority of these demonstrated statistically significant improvements in VAS pain score.[2,5,9,10,12,14–18] Pain outcomes are summarized in Table 2.

Range of Motion

Pre- and postoperative range of motion data was available in the majority of articles, as summarized by Table 3. Improvements were reported to be variable with both increases and decreases in motion noted. Postoperative extension ranged from −24% to 74% compared with preoperative measurement while postoperative flexion ranged from −36% to 82%. Ulnar deviation and radial deviation were reported to decrease in all but one study, with postoperative ranges reported at −50% to 29% and −37.5% to 67%, respectively. Studies by Collon et al, Goyal et al, Luegmair et al, Ozdemir et al, Rhee et al, and Teng et al, reported statistically significant results.[10,12,15,17,19,21]

Grip Strength

Postoperative grip strength ranged from 10 to 40 kg, representing a 3%–217% increase compared with preoperative values. Studies by Charre et al, Collon et al, Goyal et al, Meena et al, Ozdemir et al, Park et al, Rhee et al, and Teng et al noted statistically significant improvements in grip strength.[9,10,12,16–19,21] Grip strength data are further summarized in Table 4.

Patient-reported Outcomes

Patient-reported outcomes were reported by validated instruments including the Disabilities of the Arm, Shoulder, and Hand (DASH), QuickDASH, Patient-rated Wrist Evaluation (PRWE) and Mayo Wrist Score.

Table 1. Summary of Articles Included in Systematic Literature Review

	Year	No. Patients	Age (y)	Average Follow-up (y)	Indication	Nonunion Rate (%)	ROM	Grip Strength	PROM
Budoff et al[1]	2005	2	31.5	1.5	Kienbock stage IIIB–IV	0	Y	Y	N
Charre et al[9]	2018	17	36	10.7	Kienbock stage IIIA–IV	5.9	Y	Y	Y
Collon et al[10]	2020	18	29	5.8	Kienbock stage IIIA–B	22.2	Y	Y	Y
Deletang et al[5]	2011	31	43	5	Scapholunate Instability	13	Y	Y	Y
Ertem et al[11]	2016	11	28.9	1.2	Kienbock stage IIIA–IV	0	N	N	Y
Goyal et al[12]	2020	11	24	1.5	Kienbock stage IIIA–B	0	Y	Y	Y
Iorio et al[2]	2014	10	41.6	1.1	Kienbock stage IIIA–B	0	Y	N	Y
Leblebicioglu et al[13]	2003	16	36 versus 26	12.8	Kienbock stage IIIA–B	0	Y	Y	Y
Luegmair et al[14]	2014	10	35	8.8	Kienbock stage IIIB–IV	10	Y	Y	Y
Luegmair et al[15]	2013	20	43	10	Scapholunate instability	0	Y	Y	Y
Meena et al[16]	2022	23	30	8.1	Kienbock stage IIIA–B	9	Y	Y	Y
Ozdemir et al[17]	2017	9	33.2	1.4	Kienbock stage IIIB	0	Y	Y	Y
Park et al[18]	2022	39	44	3.3	Kienbock stage IIIA–IV	0	Y	Y	Y
Pisano et al[8]	1991	17	32	1.9	Kienbock stage II–IV Scaphoid nonunion Scapholunate instability	6	Y	Y	N
Rhee et al[19]	2015	27	41	5	Kienbock stage IIIA–IV	0	Y	Y	Y
Sennwald et al[20]	1995	11	30	3	Kienbock stage II–IIIB	0	Y	Y	N
Teng et al[21]	2022	12	32	0.7	Kienbock stage IIIA–B	0	Y	Y	Y
Wren et al[22]	2022	1	30	35	Kienbock stage II	0	Y	Y	Y

Average postoperative DASH scores ranged from 19 to 28. The study by Meena et al provided the only average preoperative DASH score of 27.[16] Average postoperative QuickDASH values ranged from 19 to 46.1, compared with preoperative values of 27–69.3. Average postoperative PRWE score ranged from 23 to 65, compared with the only average preoperative value, 44, reported by Meena et al. Mayo wrist scores demonstrated improvement, and were reported with average postoperative values ranging from 69.5 to 80, compared with preoperative values ranging from 59 to 66.6. In cases where subjective patient satisfaction was reported, 81%–100% of patients were satisfied with their outcome postoperatively.[19,22]

Radiographic Outcomes

Progression of osteoarthritis was reported in ten studies (56%). The rate of osteoarthritis at the radioscaphoid articulation ranged from 0% to 50% of patients.[5,8,10,11,14,15,18–20,22] Midcarpal arthritis was noted in one study at a rate of 6%.[5] Rhee et al reported that 19% of patients developed radioscaphoid impingement symptoms requiring secondary styloidectomy.[19] Average preoperative radioscaphoid angles ranged from 55 to 68 degrees, whereas postoperative values ranged from 43 to 58 degrees. These decreases were statistically significant in studies by Collon et al, Goyal et al, Meena et al, Park et al, and Rhee et al. Scapholunate angles preoperatively ranged from 33 to 756 degrees as reported by Collon et al, Meena et al, and Ozdemir et al.[10,16,17] These angles were reduced postoperatively to a range of 28–55 degrees, a statistically significant reduction. Carpal height ratio remained largely stable with preoperative values ranging from 0.48 to 0.66 compared with postoperative values of 0.45–0.68. Modified carpal height ratio was alternatively reported. Similar stability between preoperative and postoperative values was found, with ranges from 1.40 to 1.47 and 1.18 to 1.34, respectively. Studies by Meena et al and Rhee et al noted statistically significant decreases in modified carpal height ratio.[16,19]

Table 2. Pain Outcomes

	Year	VAS (Preoperative)	Subjective
Budoff et al[1]	2005	—	Activity related pain improved to minimal pain level in 2 of 2 patients
Charre et al[9]	2018	2.4 (4.2)*	
Collon et al[10]	2020	4, 1 at rest (8)*	Pain free-mild (11), moderate (4), severe (4) after SCA
Deletang et al[5]	2011	0–1.5/10	50% of patients pain free after SCA
Ertem et al[11]	2016	—	—
Iorio et al[2]	2014	2.8 (6.6)*	—
Leblebicioglu et al[13]	2003	—	—
Luegmair et al[14]	2014	1 (3.2)	—
Luegmair et al[15]	2013	1.5 (3.2)*	—
Meena et al[16]	2022	4 (7)*	—
Ozdemir et al[17]	2017	1.44 (7.67)*	—
Park et al[18]	2022	1.1 (4.1)*	—
Pisano et al[8]	1991	—	—
Rhee et al[19]	2015	—	20 improved, 6 unchanged, 1 worse after SCA
Sennwald et al[20]	1995	—	Pain resolved in 10 of 11 patients
Teng et al[21]	2022	—	—
Wren et al[22]	2022	2–9/10	

*Indicates statistical significance ($P < 0.05$).

Table 3. Wrist Range of Motion

	Year	Extension (Preoperative)	Flexion (Preoperative)	Ulnar Deviation (Preoperative)	Radial Deviation (Preoperative)
Budoff et al[1]	2005	30–70 (60)	10–40 (10)	10–25	5
Charre et al[9]	2018	35 (40)	30 (35)	20 (25)	12 (13)
Collon et al[10]	2020	46 (36)*	45 (35)*	20 (32)*	10 (20)*
Deletang et al[5]	2011	39	41	32	11
Goyal et al[12]	2020	36 (45)*	35 (51)*	15 (19)*	12 (18)*
Iorio et al[2]	2014	31	22	9	13
Leblebicioglu et al[13]	2003	Open: 170 (94) total arc Arthroscopic: 199 (84) total arc		—	—
Luegmair et al[14]	2014	45 (59)	39 (46)	25 (26)	16 (17)
Luegmair et al[15]	2013	51 (63)*	36 (50)*	29 (34)	12 (14)
Meena et al[16]	2022	46 (35)*	45 (30)*	20 (30)*	10 (18)*
Ozdemir et al[17]	2017	27.78 (23.89)*	40.56 (32.22)*	—	—
Park et al[18]	2022	71.4 (74.3) total arc		34.0 (35.6)	
Pisano et al[8]	1991	42 (44.2)	32 (50)	24 (28)	10 (15.9)
Rhee et al[19]	2015	36 (47)*	30 (44)*	23 (32)*	11 (15)
Teng et al[21]	2022	57.58 (33)*	31 (17)*	50 (30)*	4.25 (3.33)
Wren et al[22]	2022	35	45	10	30

*Indicates statistical significance ($P < 0.05$).

Complications

Complications most commonly reported were nonunion rate and progression to osteoarthritis. Complex regional pain syndrome was reported in studies by Charre et al, Deletang et al, Iorio et al, Luegmair et al and Rhee et al, with rates of 11.8%, 5.4%, 20.0%, 5.0% and 7.4%, respectively.[2,5,9,15,19] Two cases of ulnar translation of the carpus were noted by the two case reports presented by Budoff et al.[1] Conversion to total wrist arthrodesis was reported by Deletang et al and Rhee et al, with rates of 6.5% and 7.4%.[5,19] Charre et al reported on pin site infections treated with K-wire removal and antibiotic therapy in 11.8% of patients.[9]

DISCUSSION

The SCA technique offers an option to maintain mechanical support to the carpus while preserving grip strength and range of motion where nonoperative management strategies have failed. Based on our systematic review, the technique is overall a viable and effective surgical treatment option for Kienbock disease and chronic scapholunate instability. The present study represents the most inclusive and only systematic literature review of the SCA technique to our knowledge. The literature review by Siegel and Ruby in 1996 included one study on SCA by Pisano et al, but also included a discussion on other intercarpal arthrodesis techniques.[23] Stewart et al similarly reviewed the literature broadly on intercarpal arthrodesis in 2014, but did include five articles on SCA.[24] They similarly concluded that the available literature suggests SCA is a viable treatment option.[24]

From a technical perspective, methods of fixation varied widely amongst the articles including K-wire, compression screws, staples, and plating techniques. Given the

Table 4. Grip Strength

	Year	Dynamometer Grip Strength (kg) (Preoperative)	Comparison to Contralateral (%) (Preoperative)
Budoff et al[1]	2005	10	—
Charre et al[9]	2018	25.8 (16.2)*	74 (45)
Collon et al[10]	2020	30 (20)*	—
Deletang et al[5]	2011	32.5	-19
Ertem et al[11]	2016	—	—
Goyal et al[12]	2020	26.1 (19.5)*	—
Iorio et al[2]	2014	—	—
Leblebicioglu et al[13]	2003	23 (11)—open 30 (13)—arthroscopic	—
Luegmair et al[14]	2014	—	64 (53)
Luegmair et al[15]	2013	—	60 (57)
Meena et al[16]	2022	32 (20)*	—
Ozdemir et al[17]	2017	—	71 (33.7)
Park et al[18]	2022	23.6 (19.2)*	—
Pisano et al[8]	1991	29	74
Rhee et al[19]	2015	24 (19)*	—
Sennwald et al[20]	1995	—	-28
Teng et al[21]	2022	40 (12.6)*	—
Wren et al[22]	2022	15.9	-35

*Indicates statistical significance ($P < 0.05$).

limited case series and lack of comparative studies, there is insufficient support for superiority of any one technique. There is also insufficient evidence regarding the necessity of use of bone grafting for SCA. Although the majority of authors reported routine use of bone graft, the four studies that did not use bone graft in their technique reported a 0% rate of nonunion.[2,11,21,22] Prophylactic radial styloidectomy is another variation that was reported in two articles.[5,15] Given the return to the operating room for interval styloidectomy was 19% in one study,[19] consideration should be given to including a styloidectomy at the time of SCA.

SCA demonstrated an acceptable rate of union in both open and arthroscopic variations. Only one study by Leblebicioglu et al provided a direct comparison between open and arthroscopic techniques.[13] Here, the authors report on average shorter operative times (99 minutes), shorter length of hospital stay (1.6 days), and faster return to work (6 weeks) using the arthroscopic technique. Open procedures had an average operative time, hospital stay and return to work period of 153 minutes, 3.6 days, and 15 weeks, respectively. These differences were statistically significant.[13] Teng et al also reported that operative time and hospital stay were significantly shorter in their case series of arthroscopic SCA. However, the authors compared their arthroscopic series to their historical experience with the open technique without objective data points.[21]

In terms of functional outcomes, the literature is consistent in demonstrating that SCA is effective at treating pain and improving grip strength. Pain scores improved from 3.2–10 to 0–4 across the reviewed studies, with most studies noting statistical significance. This decrease in pain is also clinically significant in the context of determination of a minimal clinically importance difference (MCID) and substantial clinical benefit in hand surgical procedures of 1.6–1.9 and 2.2–2.6, respectively.[25] Grip strength was similarly improved across studies postoperatively, often with statistical significance.[9,10,12,16–19,21] The literature is inconsistent in range of motion outcomes, with studies finding alternately improvement and worsening of wrist flexion, extension, ulnar deviation and radial deviation. Statistically significant increases as well as decreases in range of motion were reported in the reviewed literature. Patient-reported outcomes by DASH, QuickDash, PRWE, and Mayo Wrist Scores were improved, but only Ertem et al and Meena et al demonstrated both statistical and clinical significance using QuickDash (MCID 15.9) and PRWE (MCID 11.5), respectively.[11,16,26,27]

In cases where radiographic radioscaphoid angles were reported, the postoperative values were restored to the normal range (30–60 degrees). The scapholunate angles were also restored to the normal range (30–60 degrees) in all but one article, where an average postoperative scapholunate angle of 28 degrees was reported. Radiographic carpal height ratio remained largely stable postoperatively within the normal range (0.45–0.6), where reported.[9,10,12,14,18] However, the statistically significant change in modified carpal height ratio by Meena et al demonstrated progression of carpal collapse outside of the normal range (1.52–1.62).[16] Given the limited pre- and postoperative radiographic findings and variable follow-up periods, it is difficult to make conclusions on radiographic findings based on the available literature.

Although the reviewed literature demonstrates good outcome of SCA, we acknowledge that alternatives exist. Alternative surgical treatment for Kienbock disease or scapholunate instability include scaphotrapeziotrapezoid arthrodesis (STT), proximal row carpectomy (PRC) and total wrist arthrodesis.[10] In comparison to total wrist arthrodesis, SCA, STT and PRC techniques inherently seek to preserve wrist motion. Although PRC remains a commonly performed technique, there are instances where

SCA may be preferred such as in the case of a chondral defect of the capitate. In addition, SCA offers preservation of carpal height, offloading of the lunate and preservation of radioscaphoid articulation, whereas PRC does not.[2] STT fusion similarly aims to maintain carpal height and offload the lunate. This technique is well described, including a series by Watson et al of 800 patents over a 27-year period, which demonstrated good reliability with an acceptable complication rate and favorable progression of arthritis profile.[28] SCA in comparison, however, has been described as a technically simpler technique to perform with only one arthrodesis site.[12]

Despite the systematic approach to this literature review, there are a number of limitations. Most notable are the high degree of heterogeneity of publications and low level of evidence (level V and IV). Given the overall small number of eligible studies, we did not use a validated appraisal checklist, which represents a limitation in assessment of the quality of the included studies. All studies included were retrospective in nature, further limiting the data. There was also a lack of consistent reporting of both pre- and postoperative outcome measures for comparison. In addition, the outcome measures used by authors vary between reports. Patient demographics and disease severity was also not consistently reported in the included studies and further limits both comparison and available conclusions. Given the heterogenous methodologies of the studies included, a meta-analysis was not performed. Our authors' use of three databases to perform our literature search may not be considered exhaustive; it is possible that additional articles hosted on alternative databases were not included. No prospective studies were found in our literature review. Such prospective studies on SCA using consistent outcome measures and those comparing SCA to other intercarpal arthrodeses and wrist salvage procedures would greatly complement the existing literature.

CONCLUSIONS

SCA is a viable treatment option for patients with Kienbock disease when nonoperative management strategies have failed. SCA is well described with both open and arthroscopic techniques, with complication rates of nonunion and conversion to total wrist arthrodesis remaining favorably low. SCA offers reliable improvements in patient pain, grip strength, and patient-reported outcomes. Outcomes for range of motion remain unclear with studies demonstrating both improved and worsened range of motion postoperatively.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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