Scaphocapitate arthrodesis in late stages of Kienbock's disease

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Background
Kienbock's disease is characterized by osteonecrosis of the carpal lunate. Kienbock's disease treatment remains controversial.
Objective
To evaluate the short-term clinical and radiologic outcomes of scaphocapitate arthrodesis (SCA) in treating symptomatic late-stage Kienbock's disease.
Methods
According to Lichtman's classification, this prospective study included 21 patients with Kienbock's disease stage III. All patients underwent SCA under general anesthesia. Patients were followed up at 1 and 2 weeks, 1, 3, 6, 9, 12, and 18 months postoperative.
Results
At the end of follow-up, 33.3% of patients achieved excellent outcomes, 47.6% achieved good outcomes, and 19.0% achieved poor outcomes. Patients with excellent and good outcomes are younger than patients with poor outcomes (38.9 ± 11.0, 42.2 ± 10.1, and 54.5 ± 3.3 years, respectively). Patients in the excellent and good groups had significantly lower disabilities of the arm, shoulder, and hand score (21.7 ± 14.8, 23.5 ± 16.8, and 47.3 ± 7.4, respectively, P=0.028), significantly higher extension/flexion arc (72.1 ± 17.2, 70.3 ± 22.0, and 38.5 ± 5.1, respectively, P=0.019) and a significantly shorter time to complete union (8.4 ± 1.4, 10.7 ± 1.3, and 14.8 ± 1.9, respectively, P=0.001).
Conclusions
SCA for late-stage Kienbock's disease (stage III) was associated with significant improvements in carpal height length and grip strength postoperatively. Age, disease stage, disabilities of the arm, shoulder, and hand score, extension/flexion arc, and time to full union are critical factors in determining the prognosis of Kienböck's disease.

Keywords:
disabilities of the arm, shoulder, and hand score, Kienböck disease, scaphocapitate arthrodesis

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Introduction

Kienböck's disease, a condition medically termed avascular necrosis of the lunate, results in the loss of blood supply to the lunate bone [1]. Damage to the lunate bone's blood supply, potentially caused by repetitive stress and excessive forces, can lead to its necrosis, structural collapse, and subsequent alterations in wrist biomechanics [2].

Kienböck disease typically presents restricted movement, wrist pain, and reduced strength. It progresses predictably, involving lunate fragmentation followed by carpal instability and collapse [3].

The morphologic staging system, based on the Lichtman classification, utilizes radiographic and magnetic resonance imaging (MRI) findings to assess the severity of wrist osteoarthritis. This system exhibits low interobserver variability. The classification is divided into four stages, each with distinct radiographic and MRI characteristics. Stage 1 is characterized by normal radiographic findings, but changes in lunate signal intensity on MRI. Stage 2 features lunate sclerosis on radiography, with or without fracture lines, and a normal lunate shape. Stage 3 is marked by collapse of the lunate articular surface, with substages 3A, 3B, and 3C, which differ in terms of carpal alignment, height, and presence of coronal fracture. Stage 4 represents the most advanced stage, characterized by the combination of features from Stage 3B and radiocarpal or mid-carpal arthrosis {Goldfarb, 2003 #29}{Lutsky, 2012 #28}{Arnaiz, 2014 #27}.

Bain and Begg proposed an alternative staging system based on arthroscopic assessment of cartilage damage, ranging from stage 0 to stage 4 [4].

The goal of treating Kienböck disease is pain relief, wrist motion preservation, and preservation of grip strength {Chojnowski, 2022 #31}. Treatment of Kienböck disease depends on the stage of the disease and its causative factors. Stage I is always treated with splinting or cast immobilization. Stage II can also be treated with immobilization if necrosis is incomplete. Stages II with complete necrosis, III, and IV require 'joint-leveling' surgery {Goldfarb, 2003 #29}{Lutsky, 2012 #28}{Arnaiz, 2014 #27}.

In advanced cases of Kienböck's disease (stages III–IV), where the scaphoid bone is flexed, revascularization methods are deemed inappropriate. Alternative treatments recommended for these later stages include tendon ball arthroplasty, selective carpal fusion, removal of the proximal row of carpal bones, or denervation of the wrist [5].

Biomechanical research suggests that scaphocapitate arthrodesis (SCA) can redistribute forces exerted on the wrist, moving them from the radio lunate to the radio scaphoid joint and potentially serving as a treatment option [6].

The appropriate management of Kienbock's disease remains controversial [3]. Thus, this study aimed to evaluate SCA's short-term clinical and radiologic outcomes in managing symptomatic late-stage Kienbock's disease without lunate excision.

Patient and methods

This prospective study was conducted at Tanta University Hospital from October 2019 to June 2023 after obtaining approval from the Tanta University Hospital's ethical committee (approval code: 36264PR77/2/23). All participants gave informed consent before taking part in the research.

According to Lichtman's classification, the study included 21 patients with Kienbock's disease stage III A and B. Patients were excluded if they had arthritic radio scaphoid joint, neurovascular problems on the affected hand (hemiparesis, hemiplegia, ischemia, drop wrist), or wrist problems on the contralateral side.

Preoperative evaluation

Upon recruitment, all patients underwent careful medical history taking and orthopedic examination, which evaluated pain levels and wrist motion range, including flexion, extension, and deviation in both ulnar and radial directions, as well as supination and pronation and measured grip strength, using a sphygmomanometer [7]. Grip strength measurements were performed on both the affected and the healthy wrist. The preoperative radiological examination included anteroposterior and lateral wrist radiography, MRI, and computed tomography (CT) scans of the wrist.

The staging of Kienbock's disease was established by using the Lichtman classification system, and an independent radiologist subsequently assessed the results. The degree of scaphoid flexion was assessed using a lateral radiograph conducted before surgery. Additionally, pre-surgery measurements of ulnar variance (to evaluate if there is a correlation with the results) were obtained from a posteroanterior radiography using the distal radioulnar index, while the mean carpal height ratio was also measured.

Operative procedure

The operation was performed in a supine position with the affected arm extended on the arm radiolucent table under general anesthesia and accompanied by intravenous administration of broad-spectrum antibiotics. A pneumatic tourniquet was placed high on the affected arm and inflated to 100 mmHg above the patient's recorded systolic blood pressure to create the bloodless operative field. Sterilization of the affected arm was performed starting from the level of the tourniquet and extending distally to the fingers.

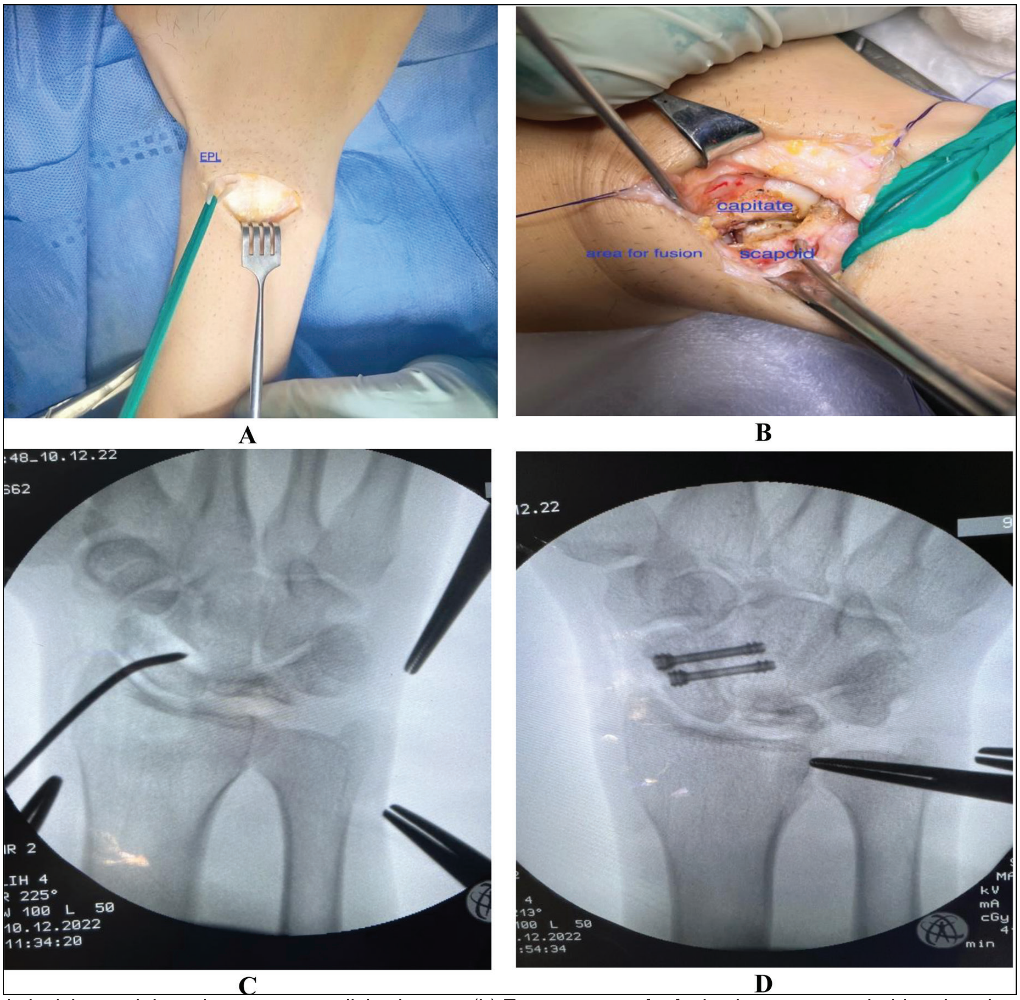
Using the universal dorsal approach of the wrist {Ciais, 2015 #30} the transverse incision followed a line running from the ulnar to the radial styloid processes, parallel to the skin creases. Figure 1a.

Another incision was made in the extensor retinaculum between the third and fourth compartments. This allowed the extensor pollicis longus and extensor digitorum muscles to be carefully detached and retracted towards the radial side. A capsulotomy with a radial-based triangular flap was performed. Rotational subluxation of the scaphoid was reduced using the C-ARM radiography device through an external 'Joystick' maneuver to restore the scaphoid extension and height, which allowed a wide surface area between the scaphoid and capitate.

The whole scaphoid from the scapholunate ligament to the distal pole was explored without interrupting the structure around. Then the articular surface between the scaphoid and the radial aspect of capitate was removed by the curate and small barre till reaching the clear subchondral bone.

Provisional stability and alignment for the fusion between the scaphoid and capitate were achieved using

Figure 1



(a) Transverse skin incision and detection extensor policies longus, (b) Exposure area for fusion between scaphoid and capitate after correction of the scaphoid flexion by Joy Stick K Wire, (c) Correction of the flexion deformity of scaphoid by K Wire, and (d) Arthrodesis augmented by 2 Herbert.

K-wires. A cancellous bone graft was obtained from the dorsal distal radius through a minor opening in the dorsal cortical bone, negating the need for an additional incision. It was used to enhance the congruency of the prepared surfaces. The distal end of the posterior interosseous was explored and cut at the most distal point using diathermy. Figure 2.

The SCA was done by two Herbert screws, one from the distal pole of the scaphoid to the body of the capitate and the other from the waist of the scaphoid to the head of the capitate, then impact the cancellous bone graft between the scaphoid and capitate raw surface. The tourniquet was released to obtain vascular hemostasis. The articular capsule and retinaculum were reconstructed, and the subcutaneous layer and skin were sutured with interrupted simple sutures without the need for drain (Fig. 1). The extremity was immobilized in a short thumb spica slap set in a slight wrist extension and a neutral position for two weeks.

Postoperative

Plain film radiography was performed in anteroposterior and lateral projection with the forearm in neutral rotation. Successful arthrodesis was determined by solid trabeculation throughout the SC articulation with no apparent gap on radiography images. The proper alignment of the scaphoid was assessed by measuring the radio scaphoid angle, which should be within the range of 30–57° after SCA.

Postoperatively, active finger motion started 1 day. After 2 weeks, the stitches were removed, and the slab was changed into a short below-elbow thumb spica to allow pain relief and decrease soft tissue edema. The short arm spica was kept for another 2 weeks. Resistance exercise started after 4 weeks.

Patients were followed-up at 1 and 2 weeks, 1, 3, 6, 9,12, and 18 months postoperative. Patients were followed-up by a range of motion (ROM), visual analog score (0=no pain, 100=maximal pain) [8], grip

Figure 2

(a) Joystick inserted on scaphoid to correct the flexion position, (b) Scaphoid in flexion position, (c) Correction of the flexion deformity of scaphoid by joystick and prepare the articular surface for arthrodesis, (d) the position of the screws in AP and lateral view, radiography of the scaphocapitate fusion (e) after 2 months, and (f) fusion after 12 months.

strength, and Mayo Modified Wrist score compared with the contra-lateral healthy unaffected wrist. A Mayo wrist pain score with four classes was utilized: no pain, mild discomfort related to climate changes or increasing effort, moderate pain that is tolerable, and severe to intolerable pain. We categorized outcomes according to the Modified Mayo Wrist Score into excellent (score of 91–100, indicating minimal pain, excellent function, normal ROM, and normal grip strength), good (score of 80–90, indicating mild pain, good function, near normal ROM, and normal grip strength), and poor (score of less than 65, indicating moderate to severe pain, poor function, limited ROM, and weak grip strength) [9].

Patients were also asked to complete the quick Disabilities of the Arm, Shoulder, and Hand (Quick DASH) [10].

Statistical analysis

Statistical analysis was performed using SPSS version 26 (IBM Inc., Chicago, IL, USA). Quantitative data were expressed as mean and standard deviation (SD) and compared among the three groups using the analysis of variance (F) test with the post hoc Tukey test. Qualitative data were presented as frequency and percentage (%) and analyzed using the χ^2 test. A two-tailed P value less than 0.05 was considered statistically significant.

Results

This study included 21 patients with Kienbock's disease, 15 males and six females, with an average age of 43.4 ± 10.8 years. The main affected side was the right side (dominant) (61.9%), and the main mechanism of injury was idiopathic (71.4%). Other baseline clinical data are shown in Table 1. Carpal height length and grip strength were significantly higher postoperative than preoperative (*P*<0.001). Table 1.

At the end of follow-up, 7 (33.3%) cases achieved an excellent outcome, while 10 (47.6%) cases achieved a good outcome, and 4 (19.0%) cases achieved a poor outcome. Comparative analysis revealed that patients with excellent and good outcomes are younger when compared with patients with poor outcomes (38.9 ± 11.0 vs. 42.2 ± 10.1 and 54.5 ± 3.3 years, respectively, *P*= 0.052). Also, it was shown that patients in the former two groups had a significantly higher frequency of cases with stage 3 disease, significantly lower DASH scores (21.7 ± 14.8 vs. 23.5 ± 16.8 and 47.3 ± 7.4, respectively, *P*=0.028), significantly higher extension/flexion arc (72.1 ± 17.2 vs. 70.3 ± 22.0 and 38.5 ± 5.1, respectively, *P*=0.019) and significantly shorter time to full union (8.4 ± 1.4 vs. 10.7 ± 1.3 and 14.8 ± 1.9, respectively, *P*=0.001). Table 2.

Discussion

This study revealed that most cases were males (71.4%), the mainly affected side was the right (dominant) (61.9%), and the primary mechanism of injury was idiopathic (71.4%).

At the end of follow-up, 33.3% of patients had excellent outcomes, 47.6% had good outcomes, and 19.0% had poor outcomes. Patients with excellent and good outcomes were younger than those with poor outcomes (38.9 ± 11.0 and 42.2 ± 10.1 vs. 54.5 ± 3.3 years). Patients with excellent and good outcomes also had a higher frequency of stage 3 disease, lower DASH scores, greater extension/flexion arc, and shorter time to full union than those with poor outcomes.

Table 1 Baseline characteristics and treatment outcome of the studied patients (*n*=21)

Male/female n	15/6	
Age (years)	43.4 ± 10.8	
Affected side, *n* (%)		
Right (dominant)	13 (61.9)	
Left (recessive)	6 (28.6)	
Left (dominant)	2 (9.5)	
The cause of Keinboch's, *n* (%)		
Idiopathic	15 (71.4)	
Others	6 (28.6)	
Ulnar variance, *n* (%)		
Negative ulna	13 (61.9)	
Neutral ulna	8 (38.1)	
Type of lunate, *n* (%)		
Type 1	7 (33.3)	
Type 2	14 (66.7)	
Lichtmans class, *n* (%)		
Stage 3 A	8 (38.1)	
Stage 3 B	13 (59.9)	
Outcome parameters		
Visual analog score	14.1 ± 13.1	
DASH score	27.4 ± 17.3	
Extension/flexion arc	64.9 ± 22.0	
Ulnar/radial deviation arc	30.6 ± 6.9	
Time of full union based on radiography	10.7 ± 2.7	
Time to return to work (weeks)	13.7 ± 2.67	
Carpal height length	Pre	Post
	0.4 ± 0.1	0.5 ± 0.1
	P value	**<0.001***
Grip strength (kg)	Pre	Post
	16.6 ± 7.01	24.7 ± 7.47
	P value	**<0.001***

Data is presented as mean±SD or frequency (%). DASH: disabilities of the arm, shoulder, and hand.

Table 2 Relation between treatment outcome and clinical variables

	Excellent *n*=7	Good *n*=10	Poor *n*=4	*P* value
Male/female n	5/2	8/2	2/2	0.53
Age (years)	38.9 ± 11.0	42.2 ± 10.1	54.5 ± 3.3	0.052
Affected side, *n* (%)				
Right (dominant)	4 (57.1)	6 (60.0)	3 (75.0)	0.65
Left (dominant)	–	1 (10.0)	1 (25.0)	
Left (recessive)	3 (42.9)	3 (30.0)	–	
Mechanism of injury, *n* (%)				
Idiopathic	4 (57.1)	9 (90.0)	2 (50.0)	0.19
Others	3 (42.9)	1 (10.0)	2 (50.0)	
Ulnar variance, *n* (%)				
Negative ulna	5 (71.4)	6 (60.0)	2 (50.0)	0.77
Neutral ulna	2 (28.6)	4 (40.0)	2 (50.0)	
Type of lunate				
Type 1	3 (42.9)	4 (40.0)	–	0.29
Type 2	4 (57.1)	6 (60.0)	4 (100.0)	
Lichtmans class, *n* (%)				
Stage 3 A	6 (85.7)	2 (20.0)	–	0.001
Stage 3 B	–	6 (60.0)	–	
Outcome parameters				
Visual analog score	13.1 ± 13.9	11.8 ± 13.3	21.5 ± 11.6	0.47
DASH score	21.7 ± 14.8	23.5 ± 16.8	47.3 ± 7.4	0.028
Extension/flexion arc	72.1 ± 17.2	70.3 ± 22.0	38.5 ± 5.1	0.019
Ulnar/radial deviation arc	32.0 ± 7.4	31.8 ± 7.0	25.3 ± 3.4	0.23
Time of full union based on radiography	8.4 ± 1.4	10.7 ± 1.3	14.8 ± 1.9	0.001

Data is presented as mean±SD or frequency (%).
DASH, disabilities of the arm, shoulder, and hand.

Kienbock's disease treatment options vary from immobilization to surgical procedures. Depending on the progression of the disease, surgical interventions might involve procedures including off-loading the lunate level of the joint, revascularizing the lunate, or employing salvage techniques [11]. Individuals with neutral ulnar variance, severe degeneration, and limited wrist arthrodesis may be considered. This includes procedures such as scaphotrapezio-trapezoid arthrodesis or SCA with preservation of the lunate. Limited wrist arthrodesis offers a motion-preserving alternative for patients with a collapsed lunate, especially when the cartilage surface is damaged or significant chondral loss on the capitate head, making proximal row carpectomy unsuitable [12]. SCA aims to reduce pressure on the lunate (if retained), maintain carpal height, and ensure proper scaphoid [13].

The controversy surrounding the decision to excise the lunate bone persists. Park *et al.* {Park, 2022 #25} and Rhee and colleagues {Rhee, 2015 #17} have presented evidence suggesting that lunate excision is not supported, corroborated by the findings of Budoff and Gable {Budoff, 2005 #26}, which demonstrated that such a procedure leads to increased stress on the radioscaphiocapitate ligament, ultimately resulting in carpal-ulnar translation. In contrast, Charre *et al.* {Charre, 2018 #22} have reported that exercising the lunate neither benefits nor harms patients. While Luegmair *et al.* {Luegmair, 2014 #12} managed SCA with or without lunate excision.

In this research, SCA resulted in good to excellent outcomes in 81.0% of patients. The results are consistent with prior studies [9,14–16]. Many studies acknowledged SCA's role in improving hand grip [17–21] and ROM [9,19,20]. In addition, the present study found significant improvement in pain as assessed by visual analog scale (VAS) in accordance with other studies [14,18,19].

This research demonstrated a substantial enhancement in grip strength following SCA, mirroring the positive outcomes of similar studies [17–21].

Regarding the ROM, the study predicted a certain degree of postoperative loss but observed improvements in flexion and extension with a mean extension/flexion arc of 64.9 ± 22.0. These findings correspond with Abodonia *et al.* [20], who reported an average postoperative arc of 65° in extension/flexion, and Charre *et al.* [19], who noted a 5° improvement postoperatively in flexion and extension. These postoperative increases can potentially be attributed to the correction of the scaphoid flexion angle achieved during surgery and biomechanical factors since the range of flexion is predominantly at the preserved radiocarpal joint. At the same time, extension predominantly occurs at the midcarpal joint.

The impact on radioulnar deviation in this study was minimal, possibly due to the early application of arthrodesis preceding the onset of carpal malalignment. Rhee *et al.* [14] supported this observation, finding an average radioulnar arch of 9º.

Lastly, regarding pain and function assessment postsurgery, the mean VAS score in the study was 1.4, which aligns with findings by Iorio *et al.* and Charre *et al.*, who reported a mean VAS score of 2.8. However, there was a discrepancy in the DASH scores; this study reported an average score of 23 points, which is consistent with the 19 points reported by Collon *et al.* [21] yet contrasts with the 38 points reported by Charre *et al.* [21].

All patients in this study had a full union; the mean time of full union based on AP and Lat radiography was 10.71 with a range from 6 to 16 (and this is with the agreement of Rhee *et al.* [14] but is with disagreement of Collon *et al.* [21] that reported four scaphocapitate joints failed to fuse.

The main limitation of the present study is the short follow-up time.

Conclusion

SCA for late-stage Kienbock's disease (stage III) was postoperatively associated with significantly improved carpal height length and grip strength. Age, disease stage, DASH score, extension/flexion arc, and time to full union are critical factors in determining the prognosis of Kienböck's disease.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Salva-Coll G, Esplugas M, Carreño A, *et al*. Kienböck's disease: preventing disease progression in early-stage disease. J Hand Surg Eur 2023; 48:246–56.

2 Asmar S, Dickson D. Kienböck's disease: pathophysiology, classification and treatment of this insidious condition. Orthopaedics and Trauma 2021; 35:208–15.

3 Kayaokay K. Scaphocapitate fusion with lunatum excision in advanced Kienböck disease: 5.3-year mean follow-up. Hand Microsurg 2023; 12:88–93.

4 Kamrani RS, Najafi E, Azizi H, *et al*. Arthroscopic lunate fossa resection arthroplasty for Kienböck's disease. J Hand Surg (Eur Vol) 2023; 48:613–8.

5 Henry M, Lundy FH, Henry GK. Matching kienböck's treatment options to specific features of each case. J Hand Microsurg 2023; 15:87–97.

6 Giddins G. The Journal of Hand Surgery (European Volume). Editorial. J Hand Surg Eur Vol 2012; 37:489.

7 Zakzouk SA. Scaphocapitate arthrodesis is a viable option in advanced Kienböck's disease. Egypt Orthop J 2014; 49:231–8.

8 Bolognese JA, Schnitzer TJ, Ehrich EW. Response relationship of VAS and Likert scales in osteoarthritis efficacy measurement. Osteoarthritis Cartilage 2003; 11:499–507.

9 Luegmair M, Saffar P. Scaphocapitate arthrodesis for treatment of late stage Kienbock disease. J Hand Surg Eur Vol 2014; 39:416–22.

10 Beaton DE, Katz JN, Fossel AH, *et al*. Measuring the whole or the parts? Validity, reliability, and responsiveness of the Disabilities of the Arm, Shoulder and Hand outcome measure in different regions of the upper extremity. J Hand Ther 2001; 14:128–46.

11 Lichtman DM, Mack GR, MacDonald RI, *et al*. Kienböck's disease: The role of silicone replacement arthroplasty. J Bone Joint Surg Am 1977; 59:899–908.

12 Moy OJ, Peimer CA. Scaphocapitate fusion in the treatment of Kienböck's disease. Hand Clin 1993; 9:501–4.

13 Sutro CJ. Treatment of nonunion of the carpal navicular bone. Surgery 1946; 20:536–40.

14 Rhee PC, Lin IC, Moran SL, *et al*. Scaphocapitate arthrodesis for kienböck disease. J Hand Surg 2015; 40:745–51.

15 Charre A, Delclaux S, Apredoai C, *et al*. Results of scaphocapitate arthrodesis with lunate excision in advanced Kienböck disease at 10.7-year mean follow-up. J Hand Surg Eur 2018; 43:362–8.

16 Bouri F, Hantouly AT, Alzobi O, *et al*. Clinical and radiological outcomes of scaphocapitate fusion in kienböck disease: A systematic review and meta-analysis. J Hand Surg Glob Online 2023; 5:435–44.

17 Pisano SM, Peimer CA, Wheeler DR, *et al*. Scaphocapitate intercarpal arthrodesis. J Hand Surg Am 1991; 16:328–33.

18 Sennwald GR, Ufenast H. Scaphocapitate arthrodesis for the treatment of Kienböck's disease. J Hand Surg Am 1995; 20:506–10.

19 Charre A, Delclaux S, Apredoai C, *et al*. Results of scaphocapitate arthrodesis with lunate excision in advanced Kienböck disease at 10.7-year mean follow-up. J Hand Surg Eur Vol 2018; 43:362–8.

20 Abodonia HEA, Elbadawy MH, Basha AA. Clinical outcome of combined scaphocapitate fusion and posterior interosseous neurectomy for stage III Kienbock's disease. Int J Res Orthop 2019; 5:1025e31.

21 Collon S, Tham SKY, McCombe D, *et al*. Scaphocapitate fusion for the treatment of Lichtman stage III Kienböck's disease. Results of a single center study with literature review. Hand Surg Rehabil 2020; 39:201–6.