Scaphocapitate arthrodesis is a viable option in advanced Kienböck's disease

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Background
Kienböck's disease remains a difficult entity to treat. Until the etiology and natural history of the disease are understood, treatment will continue to be based on attempts to decrease load across the lunate or bring a blood supply to it. There is no single procedure that could be used to treat patients with advanced Kienböck's disease.

Aim
The aim of this study had multiple facets: first, to describe a scaphocapitate (SC) arthrodesis in the treatment of stage III Kienböck's disease; second, to report the long-term results of SC arthrodesis; third, to ascertain whether SC arthrodesis provides a viable option for management of this wrist problem and whether there are significant complications.

Patients and methods
This prospective study was conducted in Damanhour National Medical Institute between December 2006 and June 2010. Eighteen patients with stage III Kienböck's disease with no evidence of arthritis of neither the upper pole of capitates nor the radioscaphoid joint were treated with SC arthrodesis using the dorsal approach. The study included five female and 13 male patients. Their age ranged from 20 to 65 years with a mean age of 38 years. The mean follow-up period was 28 months (range 18–61 months).

Results
Six of 18 (33.33%) patients had complete pain relief at rest and activity. Eight (44.45%) had mild pain on performing stressful activity with intermittent use of NSAIDs. The remaining four patients had mild pain at rest; of these four patients, two (11.11%) had mild pain and two (11.11%) had moderate pain on performing stressful activities. The latter two patients, manual workers, had to modify their level of activity. The final results were satisfactory in 14 (77.78%) patients and unsatisfactory in four (22.22%) patients. The results of this study were comparable to the results of SC arthrodesis in other series in the literature.

Conclusion
SC arthrodesis is a durable procedure that mechanically decompresses the lunate and prevents progressive carpal instability with minimal complications.

Keywords:
arthrodesis, Kienböck's disease, scaphocapitate

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Introduction

Kienböck's disease is an isolated disorder of the lunate, which occurs mainly among patients aged between 20 and 40 years and is twice more common in men than in women [1]. Kienböck's disease is an aseptic osteonecrosis of the lunate bone, followed by total carpal collapse. The first description was made 100 years ago [2]. Thus far, its exact cause and natural history remain unknown [3]. Several extrinsic and intrinsic factors have been investigated in terms of their role in the etiology of the bone necrosis [4]. Lichtman and Degnan's [5] classification of lunate changes is useful in discussing treatment.

Many operative treatment methods have been suggested for the various stages of Kienböck's disease and they can be grouped into three categories: revascularization [6–10], decompression of the lunate [11–14], and salvage procedures for pain relief [15–17]. However, little is known about their effectiveness, mainly because Kienböck's disease is not very common and a long duration of follow-up is needed to evaluate the ultimate outcome [18,19]. Scaphocapitate (SC) arthrodesis was first described by Sutro [20] in 1946 for the treatment of difficult scaphoid nonunions. Its use in the treatment of Kienböck's disease was described 45 years later in a report by Pisano *et al*. [21]. Several biomechanical studies have been published detailing the forces in the wrist resulting from various types of limited wrist arthrodesis that suggest that SC fusion results in increased axial load across the radioscaphoid joint while decreasing the joint force across the radiolunate and lunocapitate joints compared with the intact wrist [22,23]. This is the rationale for using SC fusion in the treatment of patients with Kienböck's disease and radiolunate arthritis, as a method of unloading the lunate [12].

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Aim

The goal of the current study was (i) to describe a SC fusion in the treatment of stage III Kienböck's disease, (ii) to report the long-term results of treatment of Kienböck's disease with SC arthrodesis, and (iii) to ascertain whether SC fusion provides a viable option for management of this wrist problem and whether there are significant complications.

Patients and methods

Study population

Twenty SC fusions were performed in 20 patients (15 men and five women) in the Orthopedic Department of Damanhour National Medical Institute, between December 2006 and June 2010. The mean age of the patients at the time of operation was 38 years (range 20–65 years). Eighteen patients were available for follow-up. Patients with stage III Kienböck's disease according to Lichtman's classification were included in the study [5]. Exclusion criteria were as follows: patients with extensive degenerative changes in the wrist, those with radioscaphoid joint arthritis, those with stage I, II, IV, and those with previous surgical interference. The dominant hand was involved in 13 (72.22%) patients. All women were housemaids (n = 5, 27.8%) and all men were laborers and included quarry workers (n = 6, 46.15%), carpenters (n = 3, 23.08%), soldiers (n = 3, 23.08%), and one student (7.69%). The mean duration of follow-up was 28 months (range 18–61 months).

Eleven (61.11%) patients presented with ulnar minus variance, three (16.67%) with ulnar plus variance, and four (22.22%) with ulnar neutral variance. Table 1 shows demographic data of the patients included in this study.

Table 1 Patients' demographic data

Patients	*n* (%)
Mean age (range) (years)	38 (20–65)
Sex	
Male	13 (72.22)
Female	5 (27.78)
Dominant extremity involved	13 (72.22)
Occupation	
Housemaids	5 (27.8)
Quarry workers	6 (46.15)
Carpenter	3 (23.08)
Soldiers	3 (23.08)
Student	1 (7.69)
Mean duration of follow-up (range) (months)	28 (18–61)
Ulnar variance	
Minus	11 (61.11)
Plus	3 (16.67)
Neutral	4 (22.22)

Clinical evaluation

Clinical history and examination were performed preoperatively and at the final review of each patient using the modified Mayo Wrist Score [24], which consists of pain intensity, functional status, range of motion, and grip strength, and was ranked as excellent (90–100), good (80–90), satisfactory (60–80), or poor (>60). Range of motion of both wrists was measured from a position of reference [25], with a standard hand-held goniometer. Grip strength was measured with a sphygmomanometer as described by McRae [26].

Radiographic evaluation

PA, lateral radiographs, and, in some cases, MRI were performed. The following parameters were measured:

(1) *Carpal height ratio (the carpal index)*: Carpal collapse could be quantitatively evaluated by using the carpal height ratios of both wrists; thus, the carpal collapse is equal to carpal height ratio in normal wrist minus the carpal height ratio following the pathological changes [27].
(2) *Ulnar variance*: Ulnar variance is measured on a standardized PA radiograph. A line perpendicular to the longitudinal axis of the radius is drawn at the level of the subchondral bone of the palmar lip of the lunate fossa. The distance the ulnar head extends above or below this line is the ulnar variance.
(3) Staging of Kienböck's disease for selection of stage III as the inclusion criterion according to Lichtman's classification [5].
(4) Flexion deformity of the scaphoid 'ring sign' appearance.
(5) Radioscaphoid arthritic changes to exclude wrist evolving arthritis and follow-up of cases postoperatively. Radioscaphoid joint-space narrowing was graded from 0 to 3 (grade 0 = no narrowing of radioscaphoid joint, grade 1 = mild breaking of the radius with involvement of the radioscaphoid joint, grade 2 = narrowing of radioscaphoid joint, and grade 3 = loss of radioscaphoid joint) [28].

Operative procedure

SC arthrodesis was performed under general (11 patients, 61.11%) or regional anesthesia (seven patients, 38.89%). A tourniquet was placed on the upper arm to obtain a bloodless operative field. The skin incision was a longitudinal dorsal wrist incision centered just ulnar to Lister's tubercle that extends 4 cm proximal and distal from Lister's tubercle (Fig. 1).

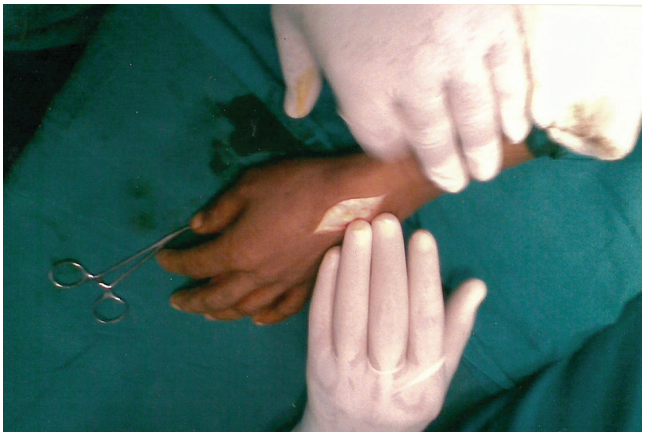
The branches of the radial sensory nerve were carefully avoided. The extension retinaculum was

incised between the third and fourth compartment. The extensor pollicis longus and extensor digitorum were released and retracted radially. A capsulotomy with a radial-based triangular flap was performed according to the method by Berger *et al*. [29]. The radiocarpal and mid-carpal spaces were evaluated for arthritic lesions, which would be a contraindication for fusion. Rotational subluxation of the scaphoid was reduced through an external 'Joy Stick' maneuver. The scaphoid and capitate were freshened down to bleeding cancellous bone (Fig. 2). Two K-wires were used to maintain the reduction and provide provisional SC fusion (Fig. 3). A cancellous bone graft was harvested through a small cortical window in the dorsal distal radius with no additional skin incision (Fig. 4) and used to improve the congruence of the freshened areas. Finally, the tourniquet was deflated and hemostasis obtained. The articular capsule and retinaculum were reconstructed. The extremity was immobilized in a short thumb spica cast with slight wrist extension and neutral to slight radial wrist deviation.

Postoperative management

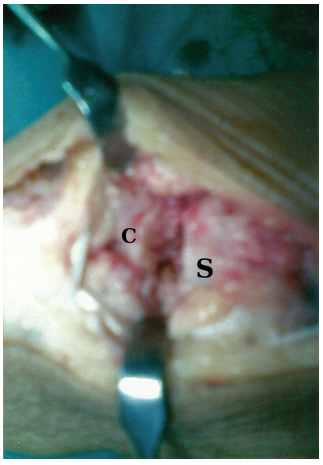
The short arm thumb spica cast was kept for 9–14 weeks after surgery, until radiographs showed a consolidation of fusion at SC joint. At this point, the cast and K-wires were removed, the patient was placed in a removable volar wrist splint, and a physiotherapy program was begun for the wrist. Protective splinting was continued for an additional 4–6 weeks. The therapy concentrates on active and passive wrist motion and progressive muscle strengthening. Recovery of maximum wrist motion required at least 6 months, and in six (33.33%) patients it continued to improve up to 12 months after surgery. Recovery of maximum grip strength took at least 12 months.

Figure 1



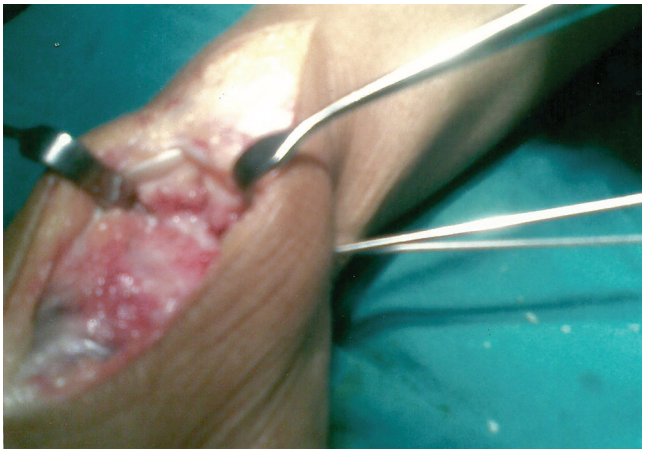
Longitudinal dorsal wrist skin incision.

Figure 2



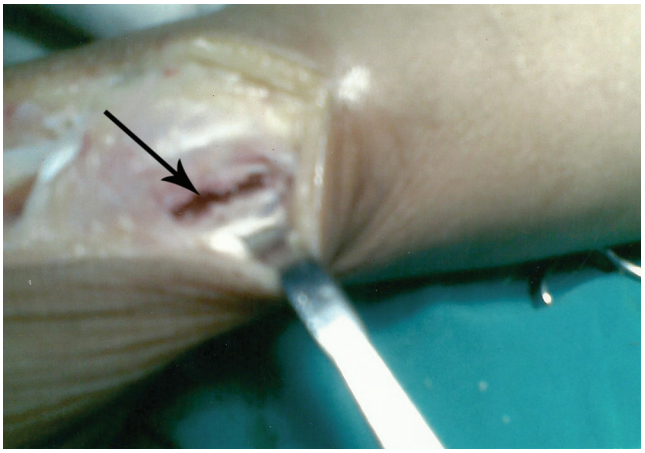
The scaphoid and capitate freshened down to bleeding cancellous bone.

Figure 3



Two K-wires used to maintain the reduction and provide provisional scaphocapitate fusion.

Figure 4



A cancellous bone graft harvested through a small cortical window in the dorsal distal radius.

Follow-up

Patients were followed-up clinically and radiologically for an average of 28 months (range 18–61 months) (Figures 5–7).

Results

Union

Union was obtained in all cases as proved by clinical examination and radiographic evaluation. On radiographs the arthrodesis had consolidated in all cases. The mean time to union was 12 weeks (range 9–14 weeks).

Pain intensity

The mean preoperative rest pain score was 52 (42–68), and the mean preoperative stress pain score was 83 (71–96); both scores improved postoperatively to 6 (0–20) for rest and to 19 (0–32) for stress. Preoperatively, three (16.67%) patients had mild occasional pain, four (22.22%) had moderate, tolerable pain, and 11 (61.11%) patients had severe to intolerable pain. Postoperatively, only two (11.11%) patients who had mild pain at rest and moderate pain during stressful activities had to reduce the level of their professional activities; however, they did not change their profession. Table 2 shows pain intensity in the studied group at the end of follow-up.

Range of motion

The mean wrist motion changed slightly. Flexion increased from 30.83 to 31.06°, extension from 38.67 to 38.61°, ulnar deviation from 21.94 to 22.72°, and radial deviation from 19.11 to 18.44°. Radial deviation was the most affected motion, whereas ulnar deviation was the least affected. However, all patients had functional range of motion for their needs (Table 3).

The improvement of range of motions was slow and very progressive over 1 year. Table 4 shows postoperative wrist motions on injured side during follow-up.

Grip strength

The mean grip strength improved from 57.17% of the normal side preoperatively to 71.57% of the normal side postoperatively. Grip strength increased and reached 71.57% of the contralateral wrist slowly and progressively over 1 year. The percentage of improvement to the normal was 8.17% at 3 months postoperatively, 12.04% at 6 months, and 16.96% at the end of follow-up (Table 5).

Carpal height ratio (the carpal index)

The mean carpal height was 0.48 preoperatively and 0.47 postoperatively. SC arthrodesis is an attractive option in stage III Kienböck's disease because it addresses the rotatory subluxation of the scaphoid, prevents proximal migration of the distal carpal row,

Table 2 Pain intensity in studied group at the end of follow-up

Level of pain	Frequency [*N* (%)]
Pain free (stress and nonstress)	6 (33.33)
Mild pain at activity	8 (44.45)
Mild pain at rest + mild pain with activity	2 (11.11)
Mild pain at rest + moderate pain with activity	2 (11.11)
Total	18 (100)

Figure 5

(a) Preoperative radiograph showing the ratio of the height of the carpus to the length of the third metacarpal reduced in this patient with Kienböck's disease. This ratio in normal wrists is 0.54 ± 0.03 [27]. The significantly reduced ratio indicates that overall carpal collapse ratio here is 0.485 (3.3/6.8) and hence it is less than 0.54. Moreover, there is ulna-minus variant. (b) One day postoperative radiograph. (c) Four months postoperative shows sound union at fusion site. (d) Thirty-six months follow-up radiograph shows preservation of wrist motion and carpal height. No arthritic changes.

Figure 6

(a) Preoperative radiograph showing stage IIIB Kienböck's disease. (b) One day postoperative radiograph. (c) Fifty-four months follow-up with good results.

Table 3 Preoperative and postoperative range of movements in the studied patients

Cases	ROM (deg.)							
	Preoperative				Postoperative at end of follow-up			
	Flexion	Extension	UD	RD	Flexion	Extension	UD	RD
1	35	37	24	18	35	42	30	15
2	34	35	20	20	32	38	22	19
3	30	42	25	19	29	41	26	18
4	30	40	21	20	28	40	21	20
5	30	40	20	19	30	40	25	15
6	25	30	23	20	35	40	25	20
7	30	35	20	18	30	35	20	20
8	35	35	30	20	35	30	30	18
9	32	35	28	20	30	35	30	19
10	30	40	17	17	29	38	18	18
11	28	37	20	19	30	35	20	20
12	30	42	19	18	30	40	19	20
13	32	43	21	20	32	41	20	19
14	29	40	25	19	30	40	25	20
15	32	45	23	20	30	40	20	18
16	30	40	19	19	30	40	18	18
17	33	38	21	20	35	39	20	20
18	30	42	19	18	29	41	20	15
Mean ± SD	30.83 ± 4.83°	38.67 ± 7.27°	21.94 ± 7.27°	19.11 ± 1.89°	31.06 ± 4.59°	38.61 ± 5.96°	22.72 ± 8.07°	18.44 ± 3.59°

RD, radial deviation; ROM, range of motion; UD, ulnar deviation.

Table 4 Evaluation of wrist motions on injured side at follow-up

Tests	3 months		6 months		End of follow-up	
	Raw mean	Percentage of value for contralateral side	Raw mean	Percentage of value for contralateral side	Raw mean	Percentage of value for contralateral side
Flexion	31.06 ± 4.59°	64.5	33.60 ± 4.89°	65.3	33.94 ± 4.94°	66
Extension	38.61 ± 5.96°	73.2	39.90 ± 6.17°	74.1	39.96 ± 6.18°	74.5
Ulnar deviation	22.72 ± 8.07°	80.3	23.60 ± 8.65°	81.2	23.72 ± 8.78°	80.2
Radial deviation	18.44 ± 3.59°	74.2	18.01 ± 3.17°	76.16	18.9 ± 3.05°	76.25

Figure 7

(a) Preoperative radiograph showing the lunate bone collapsed in the frontal plane and elongated in the sagittal plane. (b) MRI showing the avascular lunate with nonevidence of arthritis in the lunate fossa and in the capitate upper pole. (c) One day postoperative radiograph. (d) Forty-three months follow-up radiograph with grade 1 radioscaphoid joint changes according to Bain *et al.* [28].

and preserves carpal height. Table 6 shows a change in the carpal height ratio in the studied group.

Complications

In this study, the most common complication was persistent pain after surgery. Eight (44.45%) patients had mild pain on performing stressful activities. Four (22.22%) patients had only mild pain at rest. Of these four patients, two (11.11%) had mild pain and two (11.11%) had moderate pain on performing stressful activities. The latter two patients continued their work at a reduced level of activity.

Two cases of superficial wound infection occurred, which were successfully treated with oral antibiotics and daily dressing; two (11.11%) patients had mild transient paresthesia of the dorsum of the hand due to irritation of the sensory branches of the radial nerve; this responded favorably to conservative treatment. At the end of follow-up, two (11.11%) patients were seen

Table 5 Grip strength (in percentage of contralateral side) in the studied patients group at the end of the follow-up

Cases	Normal wrist (mmHg)	Affected wrist (mmHg)			Postoperative improvement 6 months (mmHg)	Postoperative improvement 1 year (mmHg)
		Preoperative	Postoperative 3 months	Improvement 3 months		
Case 1	285	205	240	35	—	25
Case 2	280	220	240	20	10	15
Case 3	290	250	250	—	10	10
Case 4	280	190	200	10	25	25
Case 5	255	195	230	35	10	—
Case 6	300	180	220	40	30	20
Case 7	275	185	225	40	15	20
Case 8	290	220	240	20	10	25
Case 9	250	200	200	—	5	30
Case 10	230	190	210	20	—	—
Case 11	265	210	210	—	25	15
Case 12	240	225	225	—	—	10
Case 13	285	225	235	10	25	15
Case 14	235	190	220	30	—	—
Case 15	220	200	210	10	—	—
Case 16	265	205	245	40	—	10
Case 17	255	185	220	35	5	15
Case 18	275	210	255	45	15	—
Mean ± SD	265.28 ± 10.27	204.72 ± 15.45	226.39 ± 8.37	27.85 ± 10.09	13.21 ± 4.71	16.79 ± 5.59
Percentages of improvement to the normal				8.17	3.87	4.92

Table 6 Preoperative and postoperative carpal height ratio in the studied group

Cases	Normal wrist	Injured wrist	
		Preoperative	Postoperative
Case 1	0.50	0.49	0.48
Case 2	0.51	0.48	0.48
Case 3	0.51	0.49	0.49
Case 4	0.52	0.45	0.45
Case 5	0.54	0.45	0.45
Case 6	0.52	0.49	0.48
Case 7	0.49	0.46	0.45
Case 8	0.51	0.49	0.49
Case 9	0.55	0.48	0.48
Case 10	0.49	0.45	0.45
Case 11	0.50	0.48	0.47
Case 12	0.52	0.49	0.48
Case 13	0.51	0.48	0.48
Case 14	0.52	0.45	0.45
Case 15	0.55	0.48	0.47
Case 16	0.52	0.48	0.48
Case 17	0.51	0.49	0.49
Case 18	0.51	0.48	0.47
Mean	0.52	0.48	0.47
SD	0.03	0.03	0.03

to have radiological evidence of grade 1 radioscaphoid degenerative changes.

Discussion

The treatment of Kienböck's disease differs based on the stage of the disease and ulnar variance. A salvage procedure should prevent advancement of the disease process and provide acceptable wrist function. Stage III is the transitional one in which the disease begins to affect the carpal structure and kinematics. At this point, the lunate is collapsed in the frontal plane and elongated in the sagittal plane, the capitates begin to migrate proximally, and foreshortening of the scaphoid (the ring sign) is observed.

The primary treatment goal for Kienböck's disease remains decompression of the lunate. SC fusion mechanically decompresses the lunate and prevents progressive carpal instability. It can successfully unload the lunate by transferring the carpal load to the radioscaphoid joint. However, load transfer to the radial column might result in degenerative arthritis of the radioscaphoid joint.

Kienböck's disease is a progressive chronic wrist disorder due to aseptic necrosis of the lunate, leading to osteoarthritis of the wrist. It usually affects young and active adults (between 20 and 45 years of age), but it is also diagnosed in children as well as in older age groups [4]. In this study, 18 patients with symptomatic stage III Kienböck's disease were treated with SC arthrodesis. The average age of patients in this work was 38 years (range 20–65 years).

It is currently the consensus that certain lunates are at risk. These lunates include those associated with a short ulna. Hulten [30] described the ulna-minus variant. He noted the presence of a short ulna in 78%

Table 7 Outcomes of this study compared with those of others

Parameters	Rongieres *et al.* [34]		Yang *et al.* [35]		This study	
	Preoperative mean	Postoperative mean	Preoperative mean	Postoperative mean	Preoperative mean	Postoperative mean
Flexion	33.3°	33.9°	30°	29°	30.83 ± 4.83°	31.06 ± 4.59°
Extension	39.6°	39.3°	41°	41°	38.67 ± 7.27°	38.61 ± 5.96°
Ulnar deviation	18.8°	17°	19°	16.94°	21.94 ± 7.27°	22.72 ± 8.07°
Radial deviation	20°	23.7°	21°	21.69°	19.11° ± 1.89°	18.44 ± 3.59°

of his patients with Kienböck's disease compared with 23% of the normal population. Since this description, a number of authors have confirmed the increased incidence of ulna-minus variance in Kienböck's disease [31]. In this study, there were 11 (61.11%) patients with ulna-minus, three (16.67%) with ulna plus, and four (22.22%) with ulna neutral.

Although the most commonly reported complication of SC arthrodesis in the literature is nonunion, in this series, all patients proceeded to union compared with two (12%) nonunions in the series of Pisano *et al.* [21] and two (18%) in the series of Zdravkovic and Sennwald [32].

In this series the occurrence of radioscaphoid arthritic change during the follow-up of patients recorded two (11.11%) patients with grade 1 according to Bain *et al.* [28] compared with 13 (43%) patients in the series of Young Szalay *et al.* [33]. This is probably due to the shorter follow-up in this study (average 28 months) compared with theirs (average 76.5 months).

As regards pain, in this study six (33.33%) patients were painless at rest and after stressful activities and eight (44.45%) patients had absolutely no pain at rest and only mild pain on performing stressful activities. The remaining four (22.22%) patients had only mild pain at rest; of these four patients, two (11.11%) had mild pain and two (11.11%) had moderate pain on performing stressful activities. The latter two patients, manual workers, had to modify their level of activity slightly but still practiced their profession. At longest follow-up, six (33.33%) patients were very satisfied, 10 (55.56%) were satisfied, and two (11.11%) patients were poorly or not satisfied. Compared with previous international literature, in series of 14 patients by Rongieres *et al.* [34], eight (57.14) patients were very satisfied, four (28.57%) were satisfied, and two (14.29%) were poorly or not satisfied. Three (21.43%) wrists were painless and only one (7.14%) wrist had no improvement. In the series of 17 patients by Pisano *et al.* [21], seven (41%) patients had pain on performing stressful activities. In the series by Zdravkovic and Sennwald [32], four (36%) patients had pain on performing stressful activities; of them two (18%) patients had to change their profession, whereas two (18%) continued their work at a reduced level of activity.

The results of this study were comparable to other series as regards the range of wrist motions Table 7.

In this series, the mean grip strength improved from 57.17% of the normal side preoperatively to 71.57% of normal side postoperatively. This was compared with 48% of the normal side preoperatively increasing to 67% postoperatively in the series of Young Szalay *et al.* [33].

In this study, the mean carpal height was 0.48 preoperatively and 0.47 postoperatively; this coincides with the results of Yang *et al.* [35].

The final results of the current study (satisfactory in 77.78% and unsatisfactory in 22.22%) compares favorably with the results of some previous studies [33–35].

The results of this study suggest that the treatment of stage III Kienböck's disease with SC fusion is a useful method of treatment that maintains the carpal height ratio, prevents carpal collapse, and retains a useful although decreased wrist range of motions.

In conclusion, the SC arthrodesis is a good option for the treatment of stage III Kienböck's disease. It achieved a high rate of satisfactory clinical and radiological results with minimal complications and preserves carpal height.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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