Capitolunate Arthrodesis for Treatment of Scaphoid Nonunion Advanced Collapse (SNAC) Wrist Arthritis

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Abstract The aim of the study was to evaluate results of capitulate arthrodesis for the treatment of post traumatic degenerative SNAC wrist disorders. A capitulate arthrodesis was performed on 12 patients, three women and nine men, of 44 years in average (28–66 years). Ten patients were manual workers; dominant side was involved in seven cases with no history of previous operation. Fixation of the arthrodesis was performed with headless compression screws. Patients were reviewed at 37.4 months of average follow up (range; 12–47 months). Mayo score equal to 82.8 points. Radiolunate and capitulate angles were decreased of 6 and 8° respectively at the final follow up radiograph compared to preoperative values. The Ten manual worker patients were able to return to their previous professional activities and the other two patients were retired but they resume their sports and recreational activities. With the advent of headless compression screws the capitulate arthrodesis gained a higher union rate, short operative time and short rehabilitation period. In the present study the capitulate arthrodesis allowed restoring a stable functional wrist in the 12 patients reviewed. It is a satisfactory therapeutic alternative to four corners fusion for SNAC wrist with osteoarthritis.

Keywords Scaphoid nonunion advanced collapse · Wrist arthrosis · Capitulate fusion · Midcarpal joint fusion · Limited wrist fusion

Introduction

The natural history of untreated scaphoid nonunion is the development a pattern of progressive wrist arthritis. This condition is known as SNAC—scaphoid nonunion advanced collapse (1). This condition affects the wrist joint in an expected manner. Initially, it is limited to the radial styloid and then it affects the radius scaphoid fossa and the midcarpal joint. Radiolunate joint is usually preserved even in advanced cases, since it is relatively spherical, which contributes to its permanent congruency (2). Pain and osteoarthritis are the cornerstone for treatment guidance, in which surgical treatment could be an option (3). For the purpose of staging osteoarthritis, Watson & Ballet classification system is of widespread use. It describes osteoarthritis as progressive stages formerly described for osteoarthritis secondary to scapholunate-advanced collapse SLAC wrist (4,5). It considers three stages, progressing from the radial styloid scaphoid interface, following to the radioscaphoid fossa and then the midcarpal joint is also affected (4). Vender and colleagues (6) established the term SNAC. In the SNAC wrist, the degenerative changes occurs in a different pattern from that seen in SLAC scapholunate advanced collapse. According to Vender (6), arthritis progresses in three stages. The first stage is: I, the interface between the radius scaphoid fossa and the fractured scaphoid distal fragment interface is affected. In Stage, II, the interface between the fractured scaphoid proximal fragment and capitate is also affected. In Stage III, radius-scaphoid, scaphoid-capitate and lunate-capitate interfaces are affected. In this system, the interface between the fractured scaphoid proximal pole and radius is not included, since it is frequently spared. Limited wrist fusions have become a well-accepted surgical procedure for patients with localized arthritis of the wrist. The overriding principle is that the arthritic painful components of the joint are fused, allowing the wrist to mobilize

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via the intact component of the joint. Central to the technique of four-corner arthrodesis is the need for a stable capitolunate fusion (7). As originally described, the hamate and triquetrum were part of the arthrodesis in order to decrease the likelihood of nonunion. Over the years, many authors have evaluated the role of an isolated capitolunate arthrodesis with or without scaphoid and/or triquetral excision to theoretically improve postoperative ROM (7–10). The present study evaluates the results of scaphoid excision and capitolunate arthrodesis with triquetrum and hamate sparing in 12 patients of SNAC wrist arthritis.

Patients and Methods

Twelve patients with SNAC wrist arthritis treated with scaphoid excision and capitolunate arthrodesis were analyzed. A full informed consent was obtained from each patient enrolled in this study. They were three women and nine men (mean age; 44 years range from 28 to 66 years). All of the patients were right handed with symptomatic seven right wrists and five left wrists. Seven patients were heavy manual workers, two patients were retired and two patients housewife (Table 1). The modified Mayo wrist score (11) (Table 2) was used to evaluate the patients' clinical condition both pre-operatively and post-operatively. This scoring system depends on evaluation of four parameters; pain, range of motion in percentage to the sound side, grip strength in percentage to the sound side, and the functional status. Each parameter was evaluated and given a score of points; 0, 15, 20, or 25 and the sum of the points given for all parameters represented the final score for each patient that was subsequently interpreted into grades; excellent, good, satisfactory, or poor. The patients' pre-operative score averaged 50.8 points (range; 45–60 points) (Table 3). A history of trauma found in seven patients, no patient had previous operation, all patients complained of

Table 2 Modified Mayo wrist score

Section 1 - Pain Intensity	
No pain	25
Mild Occasional	20
Moderate, tolerable	15
Severe to intolerable	0
Section 2 - Functional status	
Returned to regular employment	25
Restricted employment	20
Able to work, but unemployed	15
Unable to work because of pain	0
Section 3 (choose either 3a or 3b)	
3a—Range of motion (% of normal side)	
100 %	25
75–99 %	15
50–74 %	10
25–49 %	5
0–24 %	0
3b—If only injured hand examined	
Greater than 120°	25
90–120°	15
60–90°	10
30–60°	5
less than 30°	0
Section 4 - Grip strength % of normal	
100 %	25
75–100 %	15
50–75 %	10
25–50	5
0–25 %	0

wrist pain affects their daily activity and functional tasks, the pain analyzed according to visual analogue scale pain score (VAS) (12), it was average 58.1 mm (44–75 mm). Grip strength was 29.9 (13 to 40 kg) about 53 % of the sound side and the pinch grip strength was 1.13 (from 0.5 to 1.5 kg). The

Table 1 Per-operative parameters

Patient No	Age	Sex	Hand	Dominance	Occupation	Vender classification
1	32	F	R T	D	House wife	Stage III
2	45	M	LT		Manual worker	Stage III
3	28	M	RT	D	Manual worker	Stage III
4	66	M	RT	D	Retired	Stage III
5	49	F	RT	D	House wife	Stage II
6	38	M	LT		Manual worker	Stage II
7	42	M	RT	D	Manual worker	Stage III
8	39	M	LT		Manual worker	Stage III
9	36	M	LT		Manual worker	Stage II
10	65	F	RT	D	Retired	Stage III
11	47	M	RT	D	Manual worker	Stage III
12	41	M	LT		Manual worker	Stage II

F Femal; M Male; RT Right; LT Left; D Dominant

Table 3 Pre and post-operative mayo scoring

Patient NO	Pain VAS score		Functional status		Total ROM		Grip strength % of normal side		Total score	
	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
1	Moderate 65 mm	No	Able e protection	Regular employ	60 %	82 %	50 %	81 %	50	80
2	Moderate 65 mm	No	Able e protection	Regular employ	61.7 %	87.3 %	62 %	78 %	60	80
3	Moderate 50 mm	No	Able e protection	Regular employ	58.8 %	79.5 %	59.6 %	83 %	50	80
4	Moderate 60 mm	No	Able e restriction	Retired but Regular activity	62.5 %	77.5 %	40 %	79 %	45	80
5	Moderate 45 mm	No	Able e out protection	Regular employ	57.8 %	90.2 %	53.4 %	100 %	55	90
6	Mild 44 mm	No	Able e out protection	Regular employ	59 %	89.9 %	54.5 %	100 %	60	90
7	Moderate 72 mm	No	Able e restriction	Regular employ	57 %	86.8 %	51.6 %	79.4 %	45	80
8	Moderate 75 mm	Mild 4 mm	Able e restriction	Regular employ	54 %	76.9 %	52.7 %	74.5 %	45	75
9	Moderate 45 mm	No	Able e out protection	Regular employ	59.3 %	84.8 %	60 %	100 %	55	80
10	Moderate 55 mm	No	Able e restriction	Retired but Regular activity	61 %	79.2 %	25 %	72.9 %	45	80
11	Moderate 72 mm	Mild 5 mm	Able e restriction	Regular employ	60.4 %	71.8 %	52.7 %	78.3 %	45	75
12	Moderate 50 mm	No	Able e protection	Regular employ	58.4 %		65.5 %	100 %	55	90

range of motion was measured using a two-arm goniometer, the average flexion 41.6° (from 20 to 35) about 30.9 % of sound side, the average extension 32.5° (from 30 to 45) about 46 % of sound side, the average radial tilt 8.5° (from 5 to 10) about 45 % of sound side, the average ulnar tilt 17.5° (from 20 to 25) about 45 % of sound side and pronosupination was average 132.5° (from 110 to 150) about 88.3 % of sound side (Table 4). Both pre-operative and post-operative wrist radiographs were obtained in all patients in standard fashion (antroposterior, lateral and oblique views). Radiographic staging was evaluated according to Vender (6), there were four patients stage II and eight patients stage III (Table 1). In addition, the average capitulunar angle was 28.2° (from 16 to 42), the average radiolunate angle was 31.7° (18–45) and the average carpal height ratio was 0.34 from (0.23 to 0.41). The post-operative radiographs were obtained immediately after surgery, after 6 weeks, every 2 weeks until fusion healing was achieved and then every 2 months along the follow up period. All patients had uniform technique of scaphoid excision and capitulunate fusion. The average follow-up period was 37.4 months (range; 12–47 months).

Surgical Technique

The patient is placed in a supine position with the arm outstretched on a hand table with a tourniquet tire to the root of the arm. Anesthesia was regional brachial in all cases. After the operative extremity is prepared and draped in standard surgical fashion, the radiocarpal and midcarpal (capitulunate) joints are identified under fluoroscopic imaging. A line is drawn between the third and fourth extensor compartment delineating the intended surgical incision. In all cases, a partial denervation resection of the posterior interosseous nerve was performed. Total scaphoidectomy was systematic. No further palmar route was necessary for the realization of this resection. Exploring the lunate facet of the radius found no cartilage damage. Denudation of the capitate head and the distal face of lunate performed without resection, preserving convexity of the capitate and the concavity of the distal face of the lunate. The lunate was reduced on the capitate and the fusion was then set by two lunocapitate headless compression screws, occasionally in two patients the screws inserted in crossing fashion. In all cases a correction of dorsal tilt of the lunate and dorsal subluxation of the capitate was attempted (Figs. 1, 2, and 3). Cancellous bone graft taken at the expense of resected scaphoid in four cases. The wrist was immobilized with a splint for an average of 48 days (45–60 days). Hospital stay averaged 3 days (2 to 6 days) (Table 5).

Results

Mean follow up was 37.4 months (range; 12–47 months). Bone healing was achieved in 70 days average 60 to 90 days

Table 4 Pre and post-operative clinical parameters

NO	Flexion		Extension		Radial deviation		Ulnar deviation		Pronosupination		Grip strength Kg		Pinch grip kg	
	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op
1	46	20	40	30	20	7	26	20	150	130	36	22	5	1.2
2	45	25	47	35	20	10	30	15	145	130	45	31	7.6	1.5
3	45	30	46	35	20	8	35	20	150	115	43	25	7.3	1.4
4	42	25	45	30	20	7	30	20	155	130	45	24	4.2	0.5
5	40	25	50	35	20	10	26	15	155	150	35	25	4.5	1.7
6	38	20	50	35	15	8	30	25	150	125	45	23	5.9	0.8
7	42	20	45	30	15	10	30	15	150	130	42	22	6.9	0.9
8	32	25	46	35	20	5	28	15	150	125	37	25	5.8	1
9	38	25	52	30	20	9	35	15	150	150	44	21	8.4	1.4
10	46	20	47	30	20	10	30	20	150	140	31	20	3.8	0.8
11	43	25	48	30	15	9	25	15	150	150	35	29	4.7	1.3
12	46	35	53	30	20	10	35	20	155	120	46	30	6.2	1.1

(Table 5). Ten patients were able to resume their complete professional activities and the other 2 patients were retired because of retirement age but they resume their sports and recreational activities. Two patients had occasional ulnar wrist pain without clear cause, the pain was mild with no need for treatment and they returned to their prior work and activities. Two patients had a carpal tunnel syndrome at the time of review (within 47 months); an electromyography was prescribed but no patient had had surgery for carpal tunnel syndrome. The clinical analysis found that the average wrist flexion was 43.2° (from 32 to 46), the average extension was 32° (from 30 to 35), the average radial deviation 18.2° (from 15 to 20), the average ulnar deviation was 29.2° (from 25 to 35) and the average pronosupination 151.6 (from 150 to 155). The average grip strength was 40.3 kg about 81.2 % of sound side

(rang from 31 to 46 kg); the average pinch grip strength was 5.8 kg about 72.3 % of sound side (Table 4). The radiolunate angle decreased to average (−5.8) degrees (from 0 to −8), capitulate angles was also decreased to average (−3) degrees (from 0 to −6) and the carpal height ratio restored by average 0.49 from (0.48 to 0.52) (Table 6). The modified Mayo score was 82.8 (75 to 100) (Table 3).

Discussion

The scaphoid nonunion advanced collapse (SNAC) pattern is a common form of degenerative arthrosis in the human wrist (13). Degenerative changes are a result of the repetitive cycling of a malaligned carpus through its functional arc of

Fig. 1 **a** Skin incision between 3rd and 4th extensor compartments, **b** Scaphoid excision, **c** Denudation of the capitate head and the distal face of lunate, **d** Fixation of capitulate fusion by headless compression screw

Fig. 2 **a** Male patient 38 year old with SNAC right wrist stage III **a)** Posteroanterior wrist radiograph shows scaphoid nonunion with radioscapoid and scaphocapitate arthritis, **b)** Lateral wrist radiograph of the same patient shows lunocapitate arthritis and carpal collapse, **c**

and **d)** 28 month postoperative radiographs show scaphoid excision and lunocapitate fusion **b)** Photographic pictures of the same patient show range of motion 28 months post operative

motion with altered loads unevenly distributed between the carpus and distal radius. The radiolunate joint is protected because of the spherical lunate fossa of the distal radius as the lunate itself assumes a dorsiflexed position (14). The preservation of this joint offers a unique opportunity to treat wrist arthrosis while retaining radiocarpal joint motion. This treatment is accomplished by removing only the arthritic changes of the wrist, restoring the carpal alignment between the capitate and lunate, and performing a limited intercarpal fusion between these two carpal bones (15). The goals of successful surgery are twofold: to eliminate the patient's pain and to preserve as much wrist motion as possible. Surgical options include radial styloidectomy, proximal row carpectomy, distraction-resection arthroplasty (16), fascial implant arthroplasty (17), radiocarpal arthrodesis (15,18), scaphoid excision with a variety of limited intercarpal arthrodesis (16,17), total wrist arthroplasty, and total wrist arthrodesis (19). The two most popular surgical procedures performed for SNAC wrist today are proximal row carpectomy and the four-corner fusion. Proximal row carpectomy requires the preservation of the capitollunate joint and is appropriate for the treatment of SNAC stage I and II. Four-corner fusion with scaphoid excision and capitate-lunate-triquetrum-hamate arthrodesis requires only the restoration of carpal alignment and is appropriate for treatment of SNAC stages I, II, and III. These two procedures are not without their problems, however. Reports comparing these two surgeries indicate that

complications may occur in 35 % of patients, and failure (often requiring a second operation) may occur in 30 % (10,20). In the present study to avoid the complications of the four-corner fusion and improve union rates for capitollunate fusion, a limited approach and a headless compression screw fixation were used. The advent of headless compression screws offers the possibility of achieving capitollunate fusion through compression arthrodesis. The key to optimal functional outcome is the restoration of the capitate lunate alignment (21). The benefits of this procedure are improved rate of fusion, avoidance of pin track infections, omission of secondary hardware removal procedures, shorter operative time, and earlier return to work. Calandruccio and associates (18) described a technique of scaphoid and triquetrum excision and capitollunate arthrodesis using compression screw fixation. Excising an additional carpal bone (the triquetrum) is advocated here to increase capitollunate fusion rates, although this has not been proven biomechanically. The average flexion-extension arc in their series was 53°, and grip strength was 71 % of the opposite side. The pseudarthrosis rate was 14 % (2 of 14 wrists failed to achieve solid fusion) and the percentage of patients with persistent wrist pain was (21 %). Comparing results of Calandruccio and associates (18) found that there were 100 % of capitollunate fusion rate in spite of triquetrum sparing, no pseudarthrosis or delayed union in the present study; The average flexion-extension arc in this series was 75.2°, the average radial deviation 18.2°, the average ulnar

Fig. 3 **a** Male patient 36 year old with SNAC left wrist stage III **a)** Posteroanterior wrist radiograph shows scaphoid nonunion with radioscaphoid and scaphocapitate arthritis, **b)** Lateral wrist radiograph of the same patient shows lunocapitate arthritis and carpal collapse, **c**

and **d)** 43 month postoperative radiographs show scaphoid excision and lunocapitate fusion. **b** Photographic pictures of the same patient show range of motion 43 months post operative

deviation was 29.2° , the average pronosupination 151.6 and grip strength was 81.2% of the opposite side: I believed that is the advantage of rapid fusion rate, early rehabilitation, preservation of luno-triquetral motion and restoring of carpal alignment and carpal height. J. F. Slade et al. (22) treated ten patients with scapholunate advanced collapse with

percutaneous capitulunate arthrodesis without bone graft using a headless cannulated compression screw. In that series, a standard Acutrak screw was used. Arthroscopic resection of scaphoid was performed on five patients, and the remaining patients were treated with minimal exposure. At 38 months' follow-up, ten patients had solid fusions confirmed by

Table 5 Post-operative follow up and fusion healing

Paient NO	Hospital staying In days	Bone grafting	Splinting In days	Follow up period In months	Healing time In days
1	3	-	45	46	70
2	2	++	50	47	65
3	2	-	45	39	60
4	6	+++	60	43	90
5	3	-	45	36	60
6	4	-	45	42	70
7	2	++	50	37	80
8	4	-	45	45	60
9	3	-	45	12	60
10	5	+++	60	38	90
11	3	-	50	41	60
12	2	-	45	23	60

Table 6 Pre and post-operative Radiographic parameters

Patient No	Radiolunate angle		Capitolunate angle		Carpal height ratio	
	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
1	−35	−7	32	3	0.36	0.49
2	−40	−6	37	6	0.29	0.48
3	−36	−8	30	0	0.35	0.50
4	−32	−7	30	5	0.31	0.49
5	−18	0	16	0	0.42	0.51
6	−20	0	18	0	0.40	0.52
7	−35	−6	30	5	0.31	0.49
8	−45	−8	42	6	0.24	0.48
9	−19	0	16	0	0.43	0.50
10	−42	−8	38	6	0.23	0.48
11	−37	−6	31	5	0.34	0.49
12	22	−6	18	0	0.41	0.50

computed tomography scan. One patient had mild occasional pain at the radial styloid but declined treatment. The remaining patients were pain-free. All patients had a functional range of motion with a 72 flexion-extension arc, 70 radial-ulnar deviation arc, and 92 supination-pronation arc. Grip strength was 90 % of the opposite normal uninjured wrist. There were no complications and all patients returned to their prior work and avocations. The series of J.F. Slade et al. (22) supports the idea considering capitolunate arthrodesis is a valuable alternative to four corner fusion in treatment of selected post carpal instability wrist arthritis. Another point of view in spite of J.F. Slade et al. (22) treated ten patients with scapholunate advanced collapse (SLAC) wrist arthritis using arthroscopic assisted percutaneous approach, the results of the present study which used limited open dorsal approach impending the results of J.F. Slade et al. (22) all the 12 patients had solid fusions and all patients returned to their prior work and avocations.

Conclusion

Scaphoid excision, stable fusion fixation by headless compression screws, short operative time and limited surgical exposure yield a high capitolunate fusion rate with minimal morbidity which eliminates wrist pain. Preservation of lunotriquetral joint motion, restoring of carpal alignment and restoring of carpal height improve the post fusion wrist function. The lowered complication rate and improved wrist function post capitolunate fusion make it a valuable alternative to four corner fusion in treatment of selected SNAC wrist arthritis.

Conflict of Interest The author declares that he has no conflict of interest.

Ethical Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in this study.

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