

Bicolumnar Fusion as a Reliable Technique for Scaphoid Non-Union Advanced Collapse

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Abstract

Background: Scaphoid nonunion advanced collapse is a degenerative process, which follows scaphoid fracture non-union or Malunion resulting in predictable pattern of wrist arthritis. Various types of intercarpal arthrodesis have been described. Bicolumnar fusion offers arthrodesis of the lunate-capitate and triquetrum-hamate joints, but sparing of the lunate-triquetrum and capitatehamate joints. The use of cannulated headless screws allows adequate compression of properly adapted joint to unite not to use bone graft, with shorter operative time and good result compared to other methods of midcarpal fusion.

Aim of Study: Assessing clinical results of bicolumnar fusion compared to previous methods of treatment for scaphoid non-union advanced collapse (SNAC).

Patients and Methods: The study was conducted on thirty patients, with SNAC presenting to the outpatient clinic of Kasr Al-Aini hospital and El Helal hospital from June 2013 to June 2016. All patients underwent bicolumnar wrist fusion. Patients were assessed preoperatively by clinical examination, Radiographic Plain X-rays, CT scan & routine preoperative laboratory investigations. Functional outcome measured using quick disability of arm, shoulder and hand score (QDASH), modified mayo wrist score (MMWS) and visual analogue scale score (VAS).

Results: The study was conducted on thirty patients, with SNAC, 29 males and one female. The mean age was 32.33 years. 17 patients were affected on dominant hand while 13 on non-dominant hand. Only seven patients (23.3%) had history of previous surgery, nine were immobilized and seventeen did not seek medical advice. In wrist range of movement, significant difference in the mean wrist flexion range decreasing from 56° to 37° (p -value=.000). Wrist extension, show significant

difference in the mean range decreasing from 53.17° to 44.38° (p -value=.004), also radial deviation decreased from 12.67° to 9.83°. On the contrary, results showed significant increase in the mean ulnar deviation from 16.83° to 21.17° (p -value=.013) and the mean grip strength from 22.13 kg to 33.53 kg (p -value=.000). In wrist measurement, significant difference noted in all scores, MMWS (p -value=.000), QDASH (p -value=.000), and the pain on VAS (p -value=.000).

Conclusion: Bicolumnar fusion is a reliable, simple treatment for SNAC resulting in good range of movement and better grip strength, no bone graft and low complication rate.

Key Words: Bicolumnar fusion – SNAC – Wrist arthritis.

Introduction

OUR hands are a uniquely human characteristic. They have helped us throughout our evolution and even today they help us to live, work, and play.

Osteoarthritis can induce significant pain but it is most debilitating when it impacts the wrist and hands. Osteoarthritis of the wrist can result from a several different causes that can be divided into two major categories: Traumatic and nontraumatic.

Non-traumatic causes may be idiopathic carpal avascular necrosis as in Keinböck's and Preiser's diseases and congenital abnormalities as Madelung's deformity. Trauma can occur because of ligament and bone injury which causes instability and altered loading forces that can lead to joint degeneration and osteoarthritis. Intra or extra-articular fractures can also produce abnormal joint loading and arthritis [1].

A sequence of predictable degenerative changes is indicative of scaphoid non-union advanced collapse (SNAC). Nevertheless, the first injury is a

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scaphoid fracture and either nonunion or malunion. Stages of joint degeneration: Stage I is associated with arthritis localized to the distal scaphoid and radial styloid. Stage II shows radioscaphoid arthritis. Stage III shows radioscaphoid and scaphocapitate arthritis with a preserved capitolunate joint. Stage IV the capitolunate joint becomes involved [1].

Patient presents with wrist pain at the radioscaphoid joint and dorsal swelling. Diagnosis is confirmed with X-ray. Treatment for SNAC wrist includes nonsurgical management (splinting and injections), as well as surgical options like midcarpal arthrodesis, proximal row carpectomy, wrist denervation, and radial styloidectomy [1].

The treatment options for SNAC changes according to the stage of arthritis, it may be by fusion (total, limited midcarpal), proximal row carpectomy and wrist denervation. Total wrist arthrodesis was used on expense of wrist motions.

Alternative procedure as Limited wrist fusion: Capitolunate fusion was accompanied by high non-union rate. While, In four-corner arthrodesis, triquetrum and hamate were added to capitolunate fusion with good union rates and maintain near normal load transmission on radiolunate articulation. However, Bicolumnar fusion requires less exposure of the carpus than is necessary for traditional four-corner arthrodesis and also no need for bone graft that greatly simplifies the operative technique. Bicolumnar fusion is one of limited midcarpal fusion to the wrist indicated in degenerative arthritis as SNAC wrist (type II and III) [2].

Patients and Methods

The study was conducted on thirty patients, twenty-nine males and one female with scaphoid non-union advanced collapse (SNAC) presenting to the outpatient clinic of Kasr Al-Aini Hospital and El Helal Hospital from June 2013 to June 2016. All patients underwent bicolumnar wrist fusion.

Inclusion criteria: Scaphoid nonunion advanced collapse (SNAC) grade II, III.

Exclusion criteria: Scaphoid nonunion advanced collapse (SNAC) grade (I, IV), rheumatoid arthritis, deformity from gout or previous infection, active infection, radiolunate arthritis, skeletally immature.

All patients were assessed preoperatively by through history taking and clinical examination. Documenting: Age, sex, side, hand dominance, occupation, time of injury and previous surgery.

Through clinical examination of the both wrist joints including: Site of tenderness, range of motion, grip strength, Patients were analyzed for the functional outcome using quick disability of arm, shoulder and hand score (QDASH), modified mayo wrist score (MMWS) and visual analogue scale score (VAS).

All patients were assessed radiographically by Plain X-rays Posteroanterior, lateral, supination and pronation oblique views. To determine level of arthritis, fracture site, presence of sclerosis, measuring scapholunate and radiolunate angles. CT scan of the affected wrist for more detailed evaluation of the fracture geometry (stage of arthritis).

Routine preoperative laboratory investigations were performed including liver and kidney function, complete blood count, blood sugar and coagulation profile.

Surgical technique:

All patients were anesthetized by general anesthesia The patient was placed supine on operating table, prophylactic antibiotic was given. forearm was pronated & extended on an arm board; tourniquet was inflated after limb exsanguination.

A dorsal skin incision from the Lister tubercle and to the base of the third metacarpal in line with the extensor carpi radialis brevis tendon (Fig. 1).



Fig. (1): Dorsal skin incision starting from the Lister tubercle and directed to the base of the third metacarpal.

Subcutaneous dissection was done with identification of superficial branches of the radial nerve. The extensor pollicis longus tendon was released from its sheath and retracted radially with the extensor carpi radialis brevis tendon (Figs. 2,3).

The capsule was incised longitudinally down to the carpal bones including the dorsal intercarpal ligament (repaired later) from distal radius to the third metacarpal. The articular surface of the lunate fossa and lunate was inspected for exclusion of ar-

throsis. The incision is ulnarly extended, capsule was incised from the dorsal rim of the radius from radial styloid to the level of the distal radioulnar joint without opening the sheath of the fourth compartment. (Fig. 4).

The excised scaphoid was removed in a piecemeal (Fig. 5). The cartilage and subchondral bone

between the lunate and the capitate was excised using osteotome, 0.8mm K-wire was used to drill of these denuded surfaces at various location. For the best coaptation great effort was taken to keep the articular surface congruent. The same treatment was given to the joint between triquetrum and the hamate.



Fig. (2): Extensor carpi radialis brevis.



Fig. (3): Extensor pollicis longus tendon.

Fig. (4): Dissection of the dorsal capsule from distal radius.



Fig. (5): Excision of scaphoid by piece meal.

Volar translation of the capitates was also performed to correct the dorsal intercalated, and Ulnar translation of the capitate was performed to align its radial border with that of the lunate as much as possible to compensate for the loss of height experienced during cartilage and bone removal without sacrificing bony congruency.

When the wrist was extended at the level of the midcarpal joint, a K-wire was used to temporarily fixate the capitate and lunate. An antegrade headless cannulated 3-mm screw (Herbert-Whipple screw, Zimmer, Warsaw, Indiana) was then applied from the lunate to the capitates by flexing the wrist to reveal the proximal side of the lunate (Fig. 6).

The wrist's range of motion was measured prior to screw insertion to make sure that the extension range was greater than the flexion range. From the space between the second and third or third and fourth metacarpal, through the capitate to the lu-

nate, this screw can also be put retrograde. Under imaging, the screw's location was evaluated.

In the coronal plane, the hamate-triquetrum joint is oblique from the proximal radial to the distal ulnar. The extensor digiti minimi tendon was retracted, the fifth compartment's sheath was severed, and ulnar subcutaneous dissection was performed (Fig. 7). The capsule was then opened through the tendon's bed. A second screw was inserted into the distal radial portion of the hamate from the proximal ulnar aspect of the triquetrum (Figs. 8). An additional way to use this screw is retrograde, from the proximal ulnar portion of the triquetrum to the dorsal radial portion of the distal hamate. The final evaluation was conducted using fluoroscopy or C-arm (Fig. 9). Unless impingement was obvious at the time of surgery, we believed that the styloid excision was unnecessary. Following capsular repair, the skin and subcutaneous tissues were closed, and the elbow cast was placed underneath.



Fig. (6): An antegrade headless cannulated screw from lunate to capitate.



Fig. (7): Extensor digiti minimi tendon.

Fig. (8): Second antegrade headless cannulated screw from triquetrum to hamate.



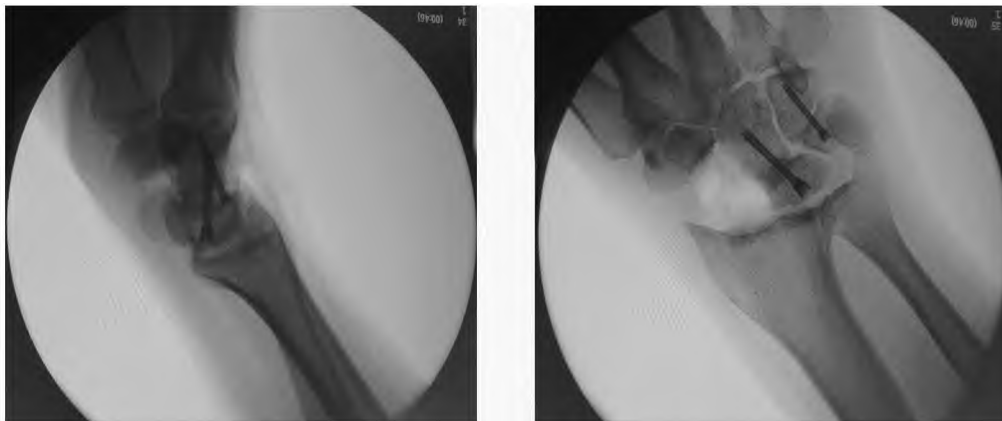


Fig. (9): C-arm guided AP and Lateral views.

Postoperative care:

Patients were discharged the day after surgery after examination for edema and inspection of capillary circulation. Achieving full range of motion of the fingers. Cast was examined for any evidence of tightness, slackness. Patients were encouraged for shoulder, elbow and finger mobilization.

Cast and stitches were removed after two weeks. A new cast was applied for 4 weeks.

Patients were assessed by the following:

Clinically: Patients were examined for range of movement by goniometer, grip strength by dynamometer, MMWS, QDASH and VAS scores.

Radiologically: X-rays in 4 wrist views for assessment of union. CT scan at time of union to confirm union.

Assessment of union:

Absence of tenderness and presence of trabeculae that cross the fusion site.

CT was performed in suspicious cases.

Late post-operative:

Patients were examined at outpatient clinic by 6, 8, 12, 24 weeks and one year (12 months) for evaluation of the functional outcome using Mayo modified wrist score, Q DASH and VAS.

Statistical methods:

The collected data was entered and analyzed using IBM SPSS Statistics (Statistical Package for the Social Sciences); version 20. The findings were expressed in terms of proportions or percentages for qualitative data and mean and standard deviation for quantitative data. Paired *t*-test was carried out to test the differences between pre and post-operative findings. $p < 0.05$ was considered as significant.

Results

Demographic data:

The mean age at the time of surgery was 32.33 years. The youngest patient in this study was (22) years old and the eldest patient was (44) years old. Twenty-nine male patients (96.7%) and one female patient (3.3%). 17 patients were affected on dominant hand while 13 on non-dominant hand. Among the thirty patients only seven patients (23.3%) had history of previous surgery, nine were immobilized and seventeen did not seek medical advice.

History of Trauma: Forced hyperextension during axial loading was found to be the main cause of fracture in twenty-three patients (76.7%) who fell on outstretched hand. Four patients (13.3%) had sports injury. Others had no clear history.

Pre-operative measurement and functional assessment:

Patients underwent pre-operative functional assessment, which were the mean wrist flexion $56^\circ \pm 11.250$, mean wrist extension $53.13^\circ \pm 12.140$, mean radial deviation $12.67^\circ \pm 7.279$, mean ulnar deviation $16.83^\circ \pm 7.484$ and mean grip strength 22.13 ± 6.564 kg. Mean Pain score on VAS was 3.57 ± 1.633 , mean mayo wrist score 50.67 ± 11.275 and mean Q-DASH quick disability of arm, shoulder and hand score 47.81 ± 19.866 .

Post-operative measurement and functional assessment:

The results are analyzed and revealed that union was achieved in all 30 cases at a mean of 9.13 ± 1.814 weeks, mean wrist flexion $37^\circ \pm 9.432$, mean wrist extension $44.83^\circ \pm 7.484$, mean radial deviation $9.83^\circ \pm 7.130$, mean ulnar deviation $21.17^\circ \pm 6.654$ and the mean grip strength 33.53 ± 7.205 kg. Mayo score showed three patients were excellent, five were good, twenty were fair and two were poor.

Mean Score 73.33 ± 11.167 , quick dash mean score 10.76 ± 11.108 and mean pain score on vas 1.03 ± 1.217 .

Complications:

Four patients (13.3%) out of 30 patients developed complications in the form of CRPS, irritation to superficial branch of radial nerve, irritation to dorsal branch of ulnar nerve and screw pack out (he underwent removal).

Analysis of pre-post functional outcome:

In wrist range of movement we found that the mean wrist flexion range decreased from 56° to 37° with significant difference (p -value=.000). In wrist extension we found that the mean range decreased from 53.17° to 44.38° with significant difference

(p -value=.004), also radial deviation decreased from 12.67° to 9.83° . On the contrary we found that the mean ulnar deviation increased from 16.83° to 21.17° with significant difference (p -value=.013) and also the mean grip strength increased from 22.13kg to 33.53kg with significant difference (p -value=.000) as shown in Table (1) and Fig. (10).

In wrist measurement we found a significant difference in all scores in which Mayo wrist score improved from 50.67 to 73.33 with significant difference (p -value=.000), the quick disability of arm, shoulder and hand score improved from 47.81 to 10.76 with significant difference (p -value=.000), and the pain on visual analogue scale score improved from 3.57 to 1.03 with significant difference (p -value=.000) as shown in Table (1) and Fig. (10).

Table (1): Showing comparison between pre and postoperative assessment and measurements.

	Preoperative		Postoperative		<i>p</i> -value
	Mean	STD deviation	Mean	STD deviation	
Flexion	56.00	11.250	37.00	9.432	0.000*
Extension	53.17	12.140	44.83	7.484	0.004*
Radial deviation	12.67	7.279	9.83	7.130	0.114
Ulnar deviation	16.83	7.484	21.17	6.654	0.13*
Grip	22.13	6.564	33.53	7.205	0.000*
MMWS	50.67	11.275	73.33	11.167	0.000*
Q-DASH	47.81	19.866	10.76	11.108	0.000*
VAS	3.57	1.633	1.03	1.217	0.000*

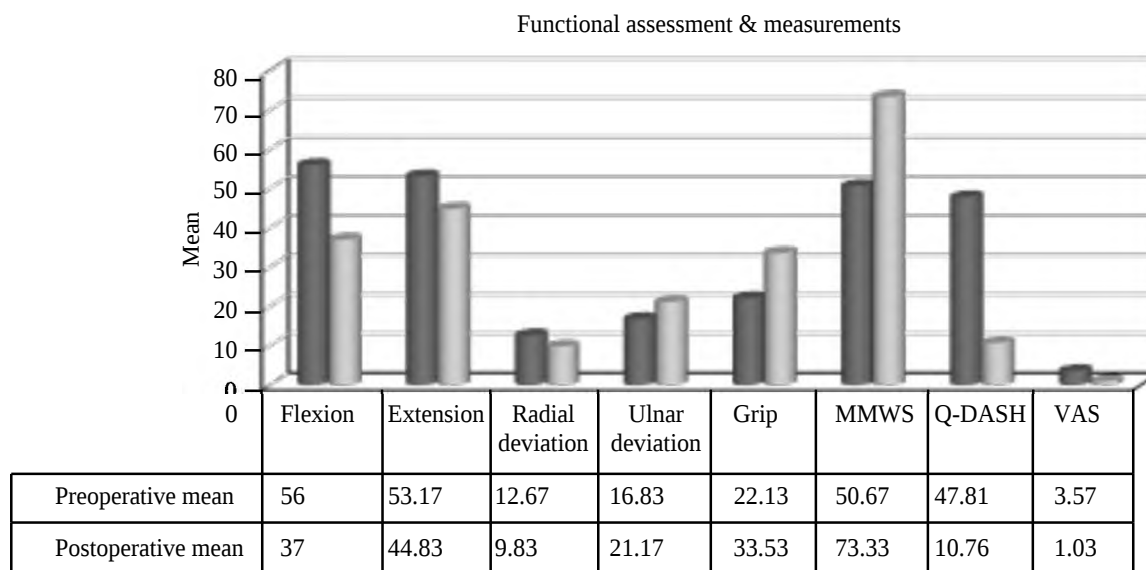


Fig. (10): Comparison of pre and postoperative functional assessment and measurements diagram.

Discussion

Scaphoid non-union advanced collapse (SNAC) pattern of wrist arthritis dates back to Watson(3) who reviewed 4,000 wrist X-rays and found degenerative wrist arthritis in 210 cases, of which the most common pattern (57%) was arthritis between the scaphoid, lunate, and radius. The majorities of scaphoid fractures unite if they are diagnosed early and treated properly.

Various types of intercarpal arthrodesis have been described to manage scaphoid non-union advanced collapse of wrist: Capitulate arthrodesis reported high non-union rate (zero%-50%) [4-8]. In Three-corner fusion Schroeder [9] reported one non-union of 13 patients 7.7%. Non-union rate improved in four-corner arthrodesis, Watson [10] described four-corner fusion in which increased bony surface area available for fusion. In bicolumnar fusion a rate of 3.7% non-union by Wang [11] and full union achieved by Mahmoud [2] and Draeger [12].

Regarding our study 30 patients underwent bicolumnar fusion with 100% union rate, which is higher than reported in literature in capitulate, three-corner fusion and four-corner fusion.

Palmer [13] showed that most activities of daily living can be achieved between 5° flexion, 30° extension, 10° radial deviation, and 15° ulnar deviation, Ryu [14] suggested that 40° flexion, 40° extension, and a range of 40° radioulnar deviation was needed.

Regarding our study, the range of motion was decreased by 34% in flexion and 15.7% in extension, radial deviation decreased by 22.4% while ulnar deviation increased by 25.7% (Average extension: 44.83°; flexion: 37°; radial deviation: 9.83° & ulnar deviation 21.17°) compared to results found in literature, our study ranges of movement decreased but allow adequate wrist movement to perform all daily living activity. And grip strength increased by 51.5%. (Grip strength 33.53 Kg) higher grip strength than reported in literature. This was consistent to results reported by Wang [11] who found 17% decrease in wrist extension, and a 25% decrease in wrist flexion compared to preoperative values, grip strength increased from 53% to 70% of opposite wrist. Similarly, Draeger [12] found that wrist extension was 43° which was 68% of opposite wrist, flexion was 46° which equal 65% of opposite wrist and grip strength was 32 kg almost 97% of opposite wrist. Also Undurraga found decrease in operated wrist extension - flexion was 69°-52° [15]. Contrary to Mahmoud [2] mean average flexion in-

creased from 45.23° to 46.36° also extension increased from 46.36° to 49.77°.

Regarding complication in our study 4 patients (13.3%) out of 30 patients developed complications in the form of CRPS, irritation to superficial branch of radial nerve, irritation to dorsal branch of ulnar nerve and screw pack out which is relatively equal to published in literature. Wang [11] reported 14.8% complication as nonunion, superficial wound infections, median nerve neuropathy, Mahmoud [2] reported 9% complex regional pain syndrome and ulnar nerve irritation.

Bicolumnar fusion lunocapitate and triquetro-hamate are fused providing uniform compression, larger surface area and larger load transmitting area (as normal ulna with triquetrum share some loads with radiolunate so it leads to longevity of the procedure). The use screws provide good compression without the need for bone graft.

Bicolumnar fusion preserves articulation between capitate and hamate and between lunate and triquetrum achieving a quicker, physiologic technique with decreased non-union rate. It is a physiologic technique preserving the ligament between lunate and triquetrum, which is important for flexion and extension of the lunate preventing dorsal wrist impingement. And quicker as it avoids unnecessary step to fuse this articulation, and provides indirect reduction of the triquetrum through the intact lunotriquetral ligament.

Conclusion: Bicolumnar fusion is reliable, simple treatment for scaphoid nonunion advanced collapse with good range of movement to perform all daily living activity, better grip strength, no bone graft and low complication rate.

Limitation to our study we need a large patient number and a long follow-up for better analysis of results.

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إلتحام ثنائى العمود كتنقية فعالة لعلاج الإنهيار المتقدم للرسغ لعدم إلتئام العظمة الزورقية

الإنهيار المتقدم للرسغ الذى يتبع سوء إلتئام أو عدم إلتئام كسر العظمة الزورقية يؤدى الى نمط متوقع من الخسونه. ففي المرحلة الأولى تكون الخسونه ما بين النتوء السفلى لعظمة الكعبرة والجزء البعيد للزورقية، وفي المرحلة الثانية يمتد الى المفصل ما بين الكعبرة والزورقية، وفي المرحلة الثالثة تستمر الخسونه لتغطى المفصل ما بين العظمتين الهلالية والرأسية، وأخيرا فى المرحلة الرابعة تمتد الخسونه ما بين كل عظيما الرسغ.

إن علاج حالات الإنهيار المتقدم للرسغ الناتج عن عدم إلتئام كسر العظمة الزورقية بعمل سمكره وتثبيت ثنائى العمود لعظيما الرسغ يوفر إلتحام ما بين عظيما الرسغ الهلالية والرأسية وما بين الخطافية والمثلثة مع الحفاظ على المفصلين ما بين الهلالية والمثلثة وما بين الرأسية والخطافية، كما إن إستخدام مسامير مجوفة بدون رأس يسمح بالإنضغاط ما بين المفصل المعد جيدا للإلتحام بدون الحاجة لإستخدام ترقيع عظام. مع توفير وقت الجراحة ونتائج جيدة بالمقارنة بالجراحات الأخرى للإلتحام.

فى الفترة ما بين يونيو ٢٠١٣ الى يونيو ٢٠١٦ بدأت هذه الدراسة لعلاج الإنهيار المتقدم للرسغ ما بعد الكسور الغير ملتئمة للزورقية. ثلاثون مريضا كانوا فى هذه الدراسة كلهم تم علاجهم بواسطة إلتحام ثنائى العمود مع المتابعة لمدة عام. فقد إستنتجنا إن الإلتحام تحقق فى كل المرضى وتم تقييمهم بواسطة المدى الحركى الوظيفى ومقياس مايو للرسغ (متوسط ٣٣، ٧٣)، مقياس الإعاقة للذراع والكتف واليد (متوسط ١٠، ٧٦) ومقياس النظير البصرى للألم (متوسط ١، ٠٣) مع مدى حركى وظيفى جيد.

وطبقا للنتائج فان إلتحام ثنائى العمود طريقة سهلة للعلاج يمكن الإعتماد عليها فى حالات الإنهيار المتقدم للرسغ الناتجة عن عدم إلتئام كسر الزورقية كما إنها توفر مدى حركى وظيفى يمكن المريض من القيام بالاعمال اليومية الحياتية وتحسن فى قوة قبضة اليد. بدون إستخدام ترقيع عظمى وبمعدلات قليلة من المضاعفات.