

Literature Review:

Modalities of Treatment for Scaphoid Nonunion Advanced Collapse

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Abstract

Background: Scaphoid nonunion advanced collapse is predictable pattern of wrist arthritis following Scaphoid fracture nonunion which disrupt the normal mechanics and movement of the wrist. Degenerative arthritis is mainly in radiocarpal and midcarpal. Many surgical interventions were described as we will discuss in this review.

Aim of Study: Is to review literature in modalities of treatment for scaphoid nonunion advanced collapse (SNAC).

Conclusion: Different operative techniques were described in literature. Four corner fusion is achieving good results, many modification was invented to simplify surgical approach, and improve union rate as capitulate, Bicolumnar fusion, three corner fusion. Proximal row carpectomy have good range of movement.

Key Words: SNAC – Bicolumnar fusion – Four corner fusion – Three corner fusion – Capitulate fusion – Proximal row carpectomy – Total wrist fusion – Wrist denervation.

Introduction

SCAPHOID non-union advanced collapse (SNAC) pattern of wrist arthritis occurs when scaphoid fracture is complicated by nonunion or malunion. Watson [1], reviewed 4,000 wrist X-rays; 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. However, failure rates as high as 15% have been reported [1].

Pathogenesis:

Arthritis can occur either after Malunion or established nonunion. Degenerative arthritis is almost inevitable after a scaphoid nonunion, and the fact that this joint degeneration can occur even after healing of the scaphoid fracture emphasizes the precise role the scaphoid plays in normal wrist kinematics [2].

If the scaphoid shape or volume is altered by nonunion and subsequent bony resorption, the process of degeneration can be initiated. Ligamentous injury can also occur with scaphoid fracture and contribute to the pathogenesis of degenerative changes. In unstable scaphoid fracture, the distal segment flexes and the proximal fragment extends under the influence of the lunate (if the scapholunate ligament is still intact). The Joint congruity between the distal radius and scaphoid and between the scaphoid and capitate is decreased [2].

Stages:

SNAC wrist are divided into four stages: Fig (1)

- Stage I: The osteoarthritis is only localized in the distal scaphoid and radial styloid.
- Stage II: The osteoarthritis is localized in the entire radioscapoid joint.
- Stage III: The osteoarthritis is localized in the entire radioscapoid joint with involvement of the capitulate joint.
- Stage IV: The osteoarthritis is located in the entire radiocarpal joint and in the intercarpal joints. It also may involve the distal radio-ulnar joint (DRUJ) [3].

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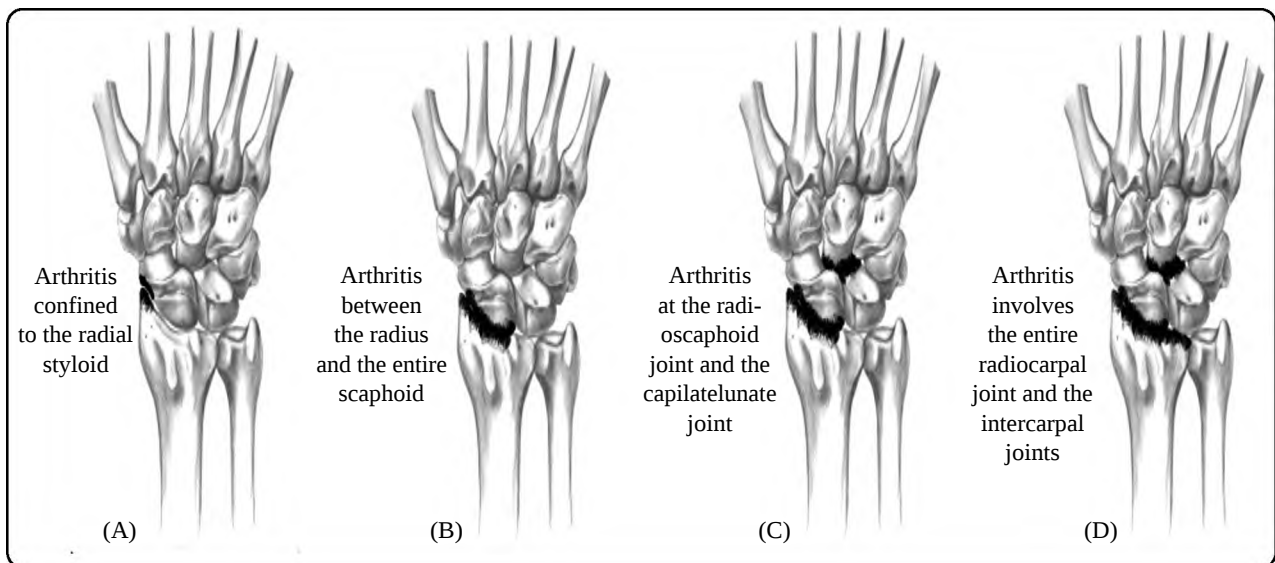


Fig. (1): With both chronic scapholunate ligament injury and scaphoid nonunions, progressive osteoarthritis can occur with (A) Stage I, affecting the radial styloid–scaphoid junction, (B) Stage II, affecting the entire radioscaphoid joint, and (C) Stage III, affecting the entire radioscaphoid joint and the capitolunate articulation, (D) Stage IV, osteoarthritis affects both the radiocarpal and intercarpal joints and may involve the DRUJ [3].

Treatment modalities:

The treatment options changes according to the stage of arthritis, it may be by fusion (total, limited midcarpal), proximal row carpectomy and wrist denervation.

Table (1): Showing treatment options according to the SNAC stage [3].

Stages	Osteoarthritis Finding	Treatment Regimen
SNAC I	Between distal Scaphoid and Radial Styloid	• Radial Styloidectomy • Wrist denervation • ORIF scaphoid with bone graft
SNAC II	In entire Radioscaphoid articulation	• Partial Scaphoid excision (distal pole) • Proximal Row Carpectomy • Mid Carpal Arthrodesis with Scaphoidectomy • Wrist denervation
SNAC III	Entire Radioscaphoid and scaphocapitate articulation	• Scaphoidectomy • Mid Carpal Arthrodesis • Proximal Row Carpectomy • Wrist denervation
SNAC IV	Entire Radiocarpal and Mid carpal joints.	• Total wrist arthrodesis

Non-operative: In medically unfit and low functioning patient only. The use of splint or cast immobilization, nonsteroidal anti-inflammatory medications, and selective intra-articular injections of corticosteroids may provide patients with improved function and decreased pain [3].

Operative:

1- Arthrodesis.

- Capitolunate arthrodesis.
- Bicolumnar fusion.
- Three-corner arthrodesis.
- Four-corner arthrodesis FCA.
- Total wrist arthrodesis.

2- Proximal row carpectomy PRC.

3- Wrist denervation.

4- Radial styloidectomy.

Treatment Modalities:

1- Arthrodesis: Various types of intercarpal arthrodesis have been described to manage scaphoid non-union advanced collapse of wrist.

• Capitolunate Arthrodesis:

Capitolunate arthrodesis Fig. (2) was used as motion preserving method to SNAC wrists. Early attempts to limit the arthrodesis to capitolunate joint were unsuccessful with high non-union rates up to 50% accompanied by complications including reflex sympathetic dystrophy, neuroma, broken k-wires, pin tract infections, prominent palpable staples and progressive radiolunate arthrosis [4].



Fig. (2): Wrist posteroanterior radiograph following Capitulum-lunate arthrodesis [4].

Previous attempts to fuse capitulum-lunate joint didn't include excision of triquetrum in addition to the scaphoid. Excision of triquetrum in addition to scaphoid will help in reduction of lunate and prevents pisotriquetral arthritis [4].

The high incidence of nonunion in earlier studies is likely thought to be a result from inadequate fixation techniques. Studies using compression techniques have demonstrated a markedly lower nonunion rate that are equal to or lower than that reported in four-corner arthrodesis. Also decreased the need of bone graft [4].

The range of movement and grip strength compared to the contralateral extremity by Kirschenbaum [5] reported flexion-extension arc 53%, radial-ulnar deviation 60%, and grip strength 61%, Calandruccio [6] reported flexion extension arc 48%, radial ulnar deviation 45% and grip strength 70%, Gaston [4] reported flexion extension arc 48%, radial ulnar deviation 60% and grip strength 70%. However, a marked difference is seen with respect to non-union rate. Earlier reports by Krakauer [7] and Kirschenbaum [5] using staples and K-wires, had non-union rates of 50% and 33%, respectively. Using newer compression techniques, the rate has been lowered to 18% Calandruccio [6], 8% by Goubier [8] and zero % by Gaston [4] using new compression technique.

• Three-Corner Arthrodesis:

Three-corner fusion Fig. (3) used for SNAC arthritis by straightforward placement of two screws from the lunate into the capitate and hamate, respectively, to maintain a readily achievable correction of the dorsal intercalated segment instability (DISI) [9].

Flexion-extension arcs 62° and grip strength was 82% of the contralateral wrist, it provided better patient-rated scores and the arc of wrist motion was more extended, with greater ulnar deviation. Motion was smoother and more closely replicated the normal axis and functional motion of the wrist [10].



Fig. (3): Preoperative (A and B) and postoperative (C, D, E) PA, oblique and lateral wrist radiographs of a male patient with radiocarpal arthritis (A) and DISI deformity (B) that developed after scaphoid Malunion. Surgical treatment consisted of an intercarpal arthrodesis using 2 screws from the lunate into the capitate and hamate, respectively, performed via a volar approach. The scaphoid and radial styloid were excised through the same volar incision and used as bone graft in the midcarpal joint [9].

• *Four-Corner Arthrodesis:*

Four-corner arthrodesis (lunate, triquetrum, capitate, and hamate) is a time tested, motion sparing salvage wrist procedure that has evolved over the past 30 years. The indications for four-corner arthrodesis FCA include radioscaphoid arthritis. The absolute contraindication for four-corner arthrodesis is radiolunate arthritis or ulnar translocation of the carpus [11].

Watson [12] described four-corner fusion in which increased bony surface area available for fusion by adding hamate and triquetrum to capitulunate fusion. Ashmead [13] in a series of 100 patients

midcarpal arthrodesis resulted in significant pain reduction and preserved a useful range of motion (33% of extension and 37% of flexion) and improved grip strength.

Four-corner arthrodesis is a biomechanically sound intercarpal fusion that results in near normal load transmission through the radiolunate articulation. The goal of four-corner fusion is a stable and pain free joint, with the lowest possible impact on final wrist range of motion [11]. Several methods of securing the four-corner arthrodesis have been described and include fixation with K wires, staples, screws, and specially designed circular plates (spider plate) (Figs. 4,5).

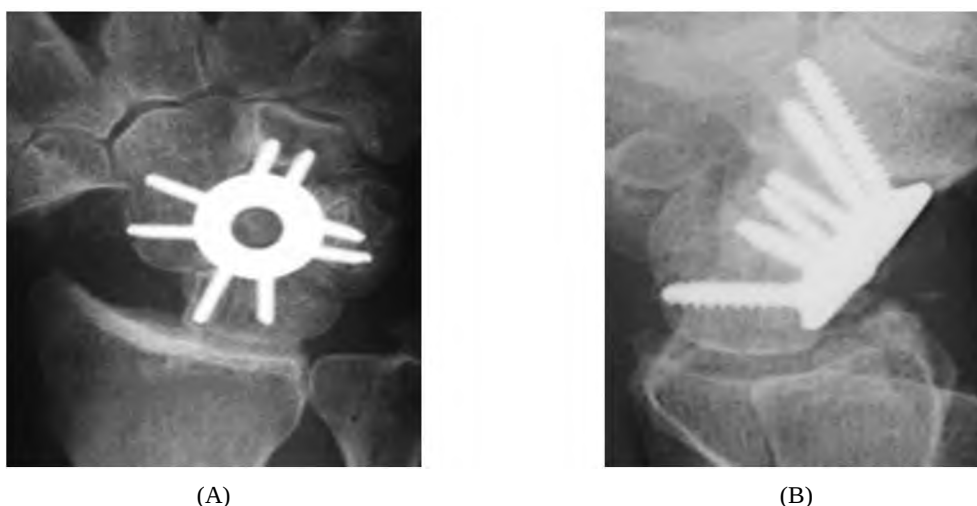


Fig. (4): Postoperative (A) PA and (B) lateral radiographs show excellent position of the carpal bones in this four- corner arthrodesis. Two screws affix each of the 4 bones being fused, and the height of the 4 bones is restored to its native position [11].

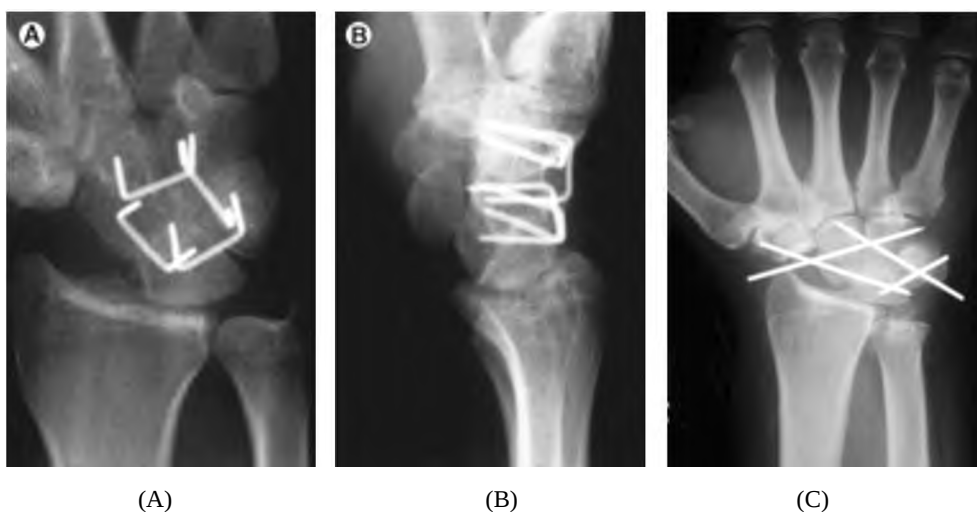


Fig. (5): (A, B) 3M Staples used in a box configuration secure the capitulunate, lunotriquetral, capitolunate, and triquetrohamate articulations. Care must be used in placing the lunotriquetral staple, because it can impinge on the dorsal distal radius. (C) k wires fixation [11].

• Bicolumnar Fusion:

Bicolumnar fusion is one of limited midcarpal fusion to the wrist indicated in degenerative arthritis as SNAC wrist (type II and III). It carry the same principles of four-corner fusion with differences in the technique involving arthrodesis of the lunate-capitate and triquetrum-hamate joints, but sparing of the lunate-triquetrum and capitate-hamate joints. The use of cannulated headless screws to achieve adequate compression and the proper coaptation of the surfaces desired for union has abolished the need for bone grafting [14].

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, the direction of screws was optional either in a retrograde or an antegrade manner. Retrograde screws are technically easier as the extension of the mid-

carpal joint can be maintained during their application; however, the point of entry of the capitollunate screw is through the carpometacarpal joint and its central application is technically difficult. Undurraga (2021) [15] used rtrograde screws to fuse capitollunate and hamate-triquetrium. So antegrade screws are preferred in both screws. (Fig. 6) [14]. Wang [16] inserted compression screw in retrograde manner from the distal dorsal capitate to proximal volar lunate then add bone graft.

In his first bicolumnar publication Wang [16] found that results were comparable to traditional four-corner fusion, range decreased by 21% in mean flexion– extension arc, Grip strength was 71% of opposite site, The average operative-sided grip strength increased by 27% and 4% nonunion rate. Mahmoud [14] found that union rate was 100%, post operative mean range of flexion-extension was increased, the mean DASH score improved.

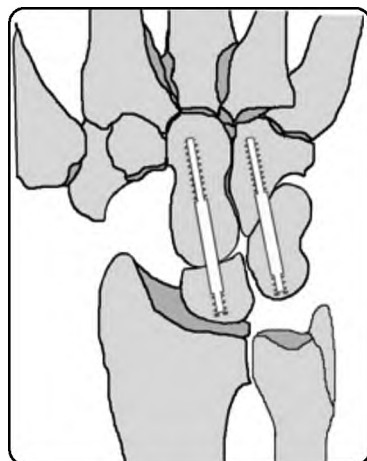


Fig. (6): Illustrative diagram showing antegrade screw's position. Postoperative radiograph (antero-posterior view) [2].



Two years later Draeger [17] found that flexion-extension arc in the operative wrist was decreased. Grip strength of the operative wrist was 97% of the contralateral wrist. Union achieved in all patients, they offer a slight technical variation to previously published reports of bicolumnar arthrodesis in that the ulnar-sided compression screw is placed from the triquetrum across the denuded triquetrum-hamate joint, and into the capitate (lunate-capitate) and (triquetrum- hamate-capitate) in a V-shaped orientation (Fig. 7). This screw placement allows for better bony purchase and may result in lower rates of nonunion. Both screws are placed in an antegrade fashion, with the ulnar screw being placed through a small percutaneous incision. This greatly simplifies the operative procedure and requires less extensive exposure for placement of both antegrade and retrograde screws [17].



Fig. (7): V-shaped orientation [17].

• **Total Wrist Arthrodesis:**

Total wrist arthrodesis is a well-established treatment for painful, advanced arthrosis and failed motion-sparing procedures, the goal is to produce a permanently stable, pain free wrist in patients who may have failed motion sparing procedures or other treatments. Total wrist arthrodesis is performed for patients who are younger than age 50, manual laborers, have a history of infection, need walking aids, or are lacking active motion of the wrist [18].

Total wrist arthrodesis provides good scores: Grip strength was 79% of opposite side. Disability of arm, shoulder and hand score was 25. Despite resolution of pain, some patients report functional limitations in activities of daily living after this procedure, which needs some adaptation to function well [19].

2- Proximal Row Carpectomy:

Proximal row carpectomy is a motion preserving salvage procedure for degenerative disorders (SNAC) of the proximal carpal row, Keinbock's

disease, failed lunate or scaphoid implants, or chronic perilunate dislocation. Contraindications include loss of cartilage either on the head of the capitate or in the lunate fossa of the distal radius.

PRC is technically a simpler procedure with a lower complication rate and greater range of motion. Wyrick [20] reported better results with proximal row carpectomy than with midcarpal fusion. Tomaino [21] reported satisfying results for both treatment options and recommended proximal row carpectomy in stage II disease and midcarpal fusion in stage III. Wall [22] have been evaluated at long-term follow-up, with satisfactory outcomes. Patients maintain approximately 68% range of motion and 72% grip strength compared with their contralateral wrist and have an average satisfaction rate of 80% (range, 26%–90%). Berkhout [23] found that PRC and Four-corner arthrodesis perform well in the long term. Proximal row carpectomy seems to result in slightly better movement of the wrist with fewer surgical complications and no need for hardware removal with a short period of immobilization (Fig. 8).



Fig. (8): (A, B) Preoperative images. Note apparent joint narrowing at capitolunate joint, dorsal intercalated segment instability, and apparent preservation of radiolunate joint. (C, D) The patient underwent PRC after inspection of joints revealed severe degenerative changes of proximal surface of lunate and relative sparing of capitolunate joint [24].

3- Radial Styloidectomy:

Radial styloidectomy may provide relief of mechanical pain from radial styloid impingement. This radio-scaphoid arthritis can develop posttraumatic including fracture of scaphoid and styloid radius and arthritis developed after SNAC wrist [25].

Open or arthroscopic excision of styloid radius may be done solely or as apart of other procedure (PRC, midcarpal arthrodesis), only 3-4mm were excised to avoid carpal instability by disrupting origin of radioscaphocapitate and long radiolunate ligaments. It is contraindicated when there is pre-existing ulnar translation of the carpus [25].

4- Wrist denervation:

The wrist joint is a common site of traumatic or degenerative disease. Chronic wrist pain still represents a challenge for hand surgeons, especially because it can affect individuals in the early stages of their work life. Furthermore, in several cases, the exact origin of wrist pain remains unknown [26].

When symptoms are so severe and the damage irreversible, these patients can be treated with conservative or surgical procedures (Fig. 9). The option of wrist denervation is a possibility when the main complaint is pain with a functional range of motion and with halting of progression of the initial pathological condition. Wrist denervation may be combined with other procedures [26].

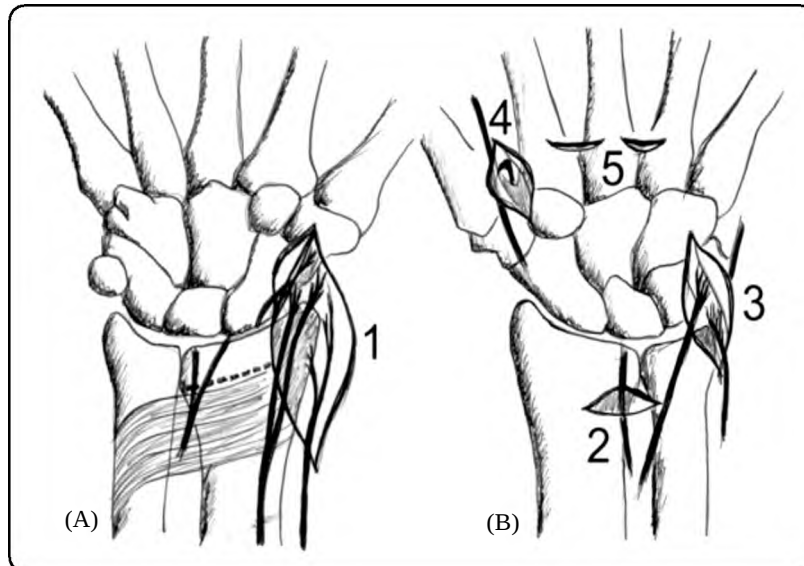


Fig. (9): Technique of wrist denervation with the 5 incisions with (A) Palmar and (B) Dorsal views. (A) Incision 1 was made on the radiopalmar side over the radius styloid between the brachioradialis and the first extensor compartment to expose the anterior interosseous nerve and the superficial branch of the radial nerve. (B) Incision 2 was made over Lister's tubercle to expose the posterior interosseous nerve. Incision 3 was made over the ulnar border of the wrist over the ulnar head to expose the dorsal branch of the ulnar nerve. Incision 4 was made dorsally at the base of the first interosseous space to expose the recurrent branch from the dorsoradial nerve of the index finger. Incision 5 was made over the base of the index-middle interosseous spaces to expose the corresponding recurrent branches [27].

5- Summarization:

To summarize the comparison between different modalities, Capitollunate arthrodesis reported high non-union rate 33% by Kirschenbaum [5] and 50% by Krakauer [7] the rate has been lowered to 18% by Calandruccio [6], 8% by Goubier [8] and ultimately 0% by Gaston [4]. In bicolumnar fusion a rate of 3.7% non-union by Wang [16] and full union achieved by Mahmoud [14] and Draeger [17]. And 12% by Undurraga (2021) [15].

In Three-corner fusion Schroeder [9] reported one non-union of 13 patients 7.7%. Non-union rate

improved in four-corner arthrodesis, Watson [12] described four-corner fusion in which increased bony surface area available for fusion. Ashmead [13] reported a nonunion rate of 3% in a series of 100 patients. Krakauer [7] reported a 9% nonunion rate in 23 patients using a combination of K-wires, staples, and headless screws. Cohen [28] reported a nonunion rate of 5% in 19 patients who had four-corner fusion with K-wire fixation and zero % in França [29]. Berkhout [23] reported 9% non-union rate 1 in 11 patients. In total wrist arthrodesis Nagy [30] found that non union rate in radiocarpal joint was 0% while in CMCJ3 was 43% non union.

Table (2): Comparison between results in literature.

Author	No.	Non-union	Range of movement	Grip strength	Diagnosis
Kirschenbaum (1993) [5]	18	33%	Extension averaged 26°, flexion 34°, radial deviation 11°, and ulnar deviation 24°	Averaged 25 kg	11 SLAC, 6 SNAC, 1 Preiser's disease
Krakauer (1994) [7]	55	50% in capitulate group 9% four-corner arthrodesis	Flexion- extension arc 50° and 28° radial-ulnar deviation	79.5% of contra-lateral side	55 SLAC 8 treated with capitulate arthrodesis and 23 four-corner fusion
Calandruccio (2000) [6]	14	18%	Flexion-extension arc 53° and radial-ulnar deviation 18°	71% of opposite side	SLAC
Goubier (2007) [8]	13	8%	35° flexion and 29° extension	22 kg	3 scaphoid pseudarthrosis and 10 scapholunate dissociation
Gaston (2009) [4]	50	0%	Flexion- extension arc 63° and radial ulnar deviation 32°	23 kg	SLAC Treated by capitulate vs. four-corner fusion

Table (3): Comparison between results in literature.

Author	No.	Non-union	Range of movement	Grip strength	Diagnosis
Schroeder (2008) [5]	13	7.7%	47% of opposite wrist	64% of opposite wrist	9 SLAC 3 SNAC 1 scaphoid Malunion
Mahmoud (2012) [14]	22	0%	Average flexion 46.36° and average extension 49.77°	—	22 SNAC
Wang (2012) [16]	27	3.7% One patient	21% decrease in mean flexion–extension arc	70% of opposite wrist	24 SLAC 3 SNAC
Draeger (2014) [17]	11	0%	43° extension and 46° flexion	32 kg	9 SLAC 2 SNAC

Palmer [31] showed that most activities of daily living can be achieved between 5° flexion, 30° extension, 10° radial deviation, and 15° ulnar deviation, Ryu [32] suggested that 40° flexion, 40° extension, and a range of 40° radioulnar deviation was needed.

In capitulate fusion flexion was 45%, extension was 52%, radial deviation was 38%, ulnar

deviation was 51% and grip strength was 71% of contralateral wrist (average flexion: 26.6, extension: 29.2, ulnar deviation: 13.6, radial deviation: 6.9, grip strength: 73.9 psi) Calandruccio [6], in three-corner fusion flexion extension range decreased from 58% to 47% of opposite wrist, grip strength increased from 59% to 64% of opposite wrist by Schroeder [9].

The earliest reported outcomes for four-corner arthrodesis was by Watson [12] They reported 10° of extension (40° opposite wrist), 50° flexion (55° opposite), 20° radial deviation (35° opposite), and 20° ulnar deviation (20° opposite). Ashmead [13] the average flexion was 32°, extension was 42°, radial deviation was 15°, and ulnar deviation was 22°. The average total flexion-extension arc of motion was 53% of that of the opposite wrist and the average grip strength was 81% of the opposite unaffected wrist. Watson [33] the average flexion-extension arc was 88° (53% of opposite wrist). The average grip was 80% of the opposite side.

Bain [34] found that average range decreased from 38° to 26° of flexion, 40° to 35° of extension and 25° to 20° of ulnar deviation but increased from 10° to 13° of radial deviation and grip strength from 27 to 28 in 2 years follow-up. França [29] found that the average decreased from 40° to 27° of flexion, 47° to 38° of extension and 21° to 18° of ulnar deviation despite increased radial deviation from 9° to 11°, grip strength remain the same 25.7kg at one year follow-up.

Berkhout [23] found average extension 36°, flexion 36°, radial deviation 16°, ulnar deviation 17° following four corner fusion.

Table (4): Comparison between results in literature.

Author	No.	Non-union	Range of movement	Grip strength	Diagnosis
Watson (1981) [12]	26 patients (28 wrists)	Not mentioned	10° of extension, 50° flexion, 20° radial deviation, and 20° ulnar deviation	–	Degenerative arthritis or posttraumatic changes
Ashmead (1994) [13]	96 patients (100 wrists)	3%	32° flexion, 42° extension, 15° radial deviation and 22° ulnar deviation	81% of the opposite side	SLAC chronic rotary subluxation of the scaphoid (63 wrists), 27 scaphoid nonunions, distal radius fracture (3), chronic perilunate dislocation (2), congenital preaxial hypoplasia (2), capitate fracture (1), and Preiser's disease (1)
Watson (1999) [33]	1077	4% in triscaphe arthrodesis 3% in SLAC	Flexion-extension arc was 88°	80% of the opposite side	798 rotatory subluxation of the scaphoid, degenerative joint disease, Kienbock's disease, midcarpal instability, traumatic dislocations, and congenital synchondrosis of the triscaphe joint 252 SLAC
Cohen (2001) [28]	19	5%	In FCA: extension 49° and flexion a 31° at the Ulnar deviation 30° and radial deviation 23° In PRC: Extension 45° and flexion 36°, ulnar deviation 24° and radial deviation 7°	FCA 38±12 PRC 34±10 kg	15 SLAC 3 SNAC 1 AVN scaphoid

Table (4): Count.

Author	No.	Non-union	Range of movement	Grip strength	Diagnosis
Bain (2010) [34]	31	9.6%	26° flexion, 35° extension, 20° ulnar deviation and 13° radial deviation	28 kg	22 SLAC 13 SNAC
França (2011) [29]	20	Zero %	In FCA 27° flexion, 38° extension, 18° ulnar deviation and 11° radial deviation In PRC 32° flexion, 40° extension, 18° ulnar deviation and 8° radial deviation.	25.7 kg	16 SNAC 4 SLAC
Wall (2013) [22]	16 patients (17 wrists)	–	66% of flexion, 50% of extension, 65% of ulnar deviation, and 22% of radial deviation	72% opposite side	5 SNAC 5 SLAC 7 Keinbock's
Berkhout (2015) [23]	20 patients (22 wrists)	9% in FCA In 8 patients	FCA: extension 36°, flexion 36°, radial deviation 16°, ulnar deviation 17° In 14 patients PRC: extension 51°, flexion 46°, radial deviation 10° and ulnar deviation 29°	–	9 SLAC 6 SNAC 3 Keinbock's 1 lunotriquetral synostosis 1 prilunate subluxation
Gauci (2020) [35]	54 patient (55 wrists)	3 in BA & 6 in 3CF	Extension decreased by 11 degree and flexion remain the same	12kg with BA and 9kg with 3CA	Radiolunate Arthritis in 4 wrist in 3CF Hamatolunate arthritis 7 wrist in BA
Undurraga (2021) [15]	23 patients (25 wrists)	12%	Extension was 41 degrees, flexion 36 degrees, and radial-ulnar deviation arc was 43 degrees	Grip strength was 39 kg	9 SNAC/16 SLAC

In proximal raw carpectomy, França [29] found that the average range decreased from 45° to 32° in wrist flexion, 42° to 40° in wrist extension, 22° to 18° in ulnar deviation and grip strength from 18.6 to 17.6 while radial deviation increased from 7° to 8° in one year follow up. Wall [22] found that there was an average of 66% of flexion, 50% of extension, 65% of ulnar deviation, and 22% of radial deviation and grip strength was 72% of the contralateral extremity in 20 years follow-up. Berkhout [23] found that mean average were extension 51°, flexion 46°, radial deviation 10° and ulnar deviation 29°.

In bicolunar fusion, Mahmoud [14] mean average flexion increased from 45.23° to 46.36° also extension increased from 46.36° to 49.77°, Wang

[16] here was a 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, Draeger [17] 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 32kg almost 97% of opposite wrist.

Gauci (2020) [35] found that bicolunar arthrodesis is durable than three-corner arthrodesis for a type I lunate and not recommend for type II lunate. three-corner arthrodesis has a increased incidence of capitulate nonunion and radiolunate arthritis.

Schroeder [9] reported dorsal impingement between the radius and the carpus due to excessive

bone graft, bone overgrowth, prominent hardware or persistent malalignment, and nonunion in three-corner fusion. Of the 431 cases reported in 8 series of four-corner arthrodesis, the overall complication rate was 13.5%. Dorsal impingement of the capitate and radius occurred in 4.4%, reflex sympathetic dystrophy occurred in 3%, superficial infections occurred in 3%, nonunions occurred in 2%, deep infections occurred in 0.5%, and deQuervain's tenosynovitis occurred in 0.5%. Only 7 failures of 4-corner arthrodesis that required conversion to total wrist arthrodesis were reported, representing a 2% incidence [11].

In proximal raw carpectomy Wall [22] found 35% failure rate 6 out of 17 patients underwent radiocarpal arthrodesis. Also stated that patients younger than age of 40 years at greater risk for eventually needing total wrist arthrodesis at a minimum of 20 years follow-up. In comparative study between PRC and FCA found as CRPS, delayed union, nonunion, and conversion to total wrist arthrodesis is higher in four-corner fusion group by Berkhout [23] and higher in proximal raw carpectomy by França [29]. In bicolunar fusion Wang [16] reported 14.8% complication as nonunion, superficial wound infections, median nerve neuropathy, Mahmoud [14] reported 9% complex regional pain syndrome and ulnar nerve irritation.

In wrist denervation It was expected that pain and functional loss increased over time but scores (DASH) improved with longer follow-up. A certain adaptation of pain perception and an avoidance of painful movements or activities during the course of chronic joint pain may serve as a possible valid explanation [27]. Rostlund [36] reported 89% improvement in 9 patients. Schweizer [27] reported 69% improvement for 71 patients. Weinstein [37] reported an 85% satisfaction rate.

Conclusion:

On that basis it is clear that four-corner fusion achieved good grip strength, pain relief and good function while proximal raw carpectomy can provide better range of movement with easier technique but weaker grip. Capitulate and three-corner fusion were established to improve the limited range of wrist movement in four-corner fusion with high non-union rates due to decreased surface area and compression. Bicolunar fusion providing uniform compression, larger surface area and larger load transmitting area leading to better union rates. Adding wrist denervation can improve results especially if pain is the main concern.

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أساليب علاج حالات الأنهيار المتقدم للرسغ لعدم إلتئام العظمة الزورقية : مراجعة علمية

ان الانهيار المتقدم للرسغ الناتج عن عدم التئام كسر العظمة الزورقية يؤدي إلى خشونة متوقعة للرسغ، ومراجعة الابحاث السابقة للعلاج وجد ان التحام رباعى العمود يحقق قوة قبضة، وتخفيف للالم ونتائج وظيفية جيدة. ولكن استئصال الصف القريب من عظام الرسغ يحقق مدي حركي احسن مع سهولة الجراحة. التحام بين الهلالية والراسية والتحام ثلاثى العمود تم استخدامهم لتحسين المدى الحركى لالتحام رباعى العمود ولكن بمضاعفات عدم التئام. التحام ثنائى العمود يحقق التئام افضل بسبب المساحة الكبيرة المتاحة للالتئام وانضغاط العظام . كما ان اضافة إزالة تعصب للرسغ يعطى نتائج افضل اذا كان الالم هو السبب الرئيسى للجراحة.