

Percutaneous Screw Fixation of Scaphoid Waist Fracture Non-Union Without Bone Grafting

Galal Hegazy¹

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Abstract The aim of the study was to evaluate results of volar percutaneous headless compression screw fixation without bone grafting in 21 patients with scaphoid waist nonunion fractures. The inclusion criteria in this series were scaphoid waist fracture nonunion with intact cartilaginous envelope, minimal fracture line at nonunion interface, no cyst or sclerosis, no avascular necrosis and normal scapholunate angle without humpback deformity. There were 17 male and 4 female patients with an average age of 23 years (range 16–45 years). All patients had radiographic examinations that included Posteroanterior, lateral, oblique and scaphoid views. Preoperative MRI to assess the cartilaginous shell and vascularity of scaphoid was done. CT scans were performed postoperatively to confirm scaphoid fracture healing. The average clinical follow-up was at 25 months (range 18–35) postoperatively. All fractures united successfully with no additional procedures. The average DASH score (disabilities of the arm, shoulder, and hand) at final follow-up was 8 (range 0–16). Percutaneous fixation for selected scaphoid nonunion can avoid the morbidity of an open approach and bone grafting.

Keywords Scaphoid fracture · Scaphoid nonunion · Bone grafting · Percutaneous scaphoid fracture fixation

Introduction

Appropriate and early diagnosis of scaphoid fractures is imperative since delay in diagnosis can lead to complications

✉ Galal Hegazy
glalhegazy@live.com; glalhegazy@Azhar.edu.eg

¹ Orthopedic Department, Faculty of Medicine, AL-Azhar University, Cairo New Cairo, Egypt

such as non-union, avascular necrosis, carpal collapse and subsequently a predictable pattern of arthrosis [7–9]. Scaphoid fractures with a delay in diagnosis, presenting more than 8 weeks after injury, have an 88 % non-union rate [6, 11, 12]. The standard method for treatment of scaphoid non union is an open approach for deformity correction, bone grafting and rigid internal fixation [4, 7, 8]. Percutaneous screw fixation has been advocated for minimally displaced acute scaphoid fractures and was recently reported for displaced scaphoid fractures [1, 5]. A few reports have described the percutaneous approach for treating scaphoid delayed unions and non-unions [3, 10]. This technique avoids devascularization of the scaphoid, division of the carpal ligaments, and providing a much more aesthetic scar [10]. Percutaneous screw fixation is indicated in early scaphoid non-unions without substantial cystic bone resorption, without appreciable collapse of the scaphoid architecture, and without clear avascular necrosis of the proximal pole also the scaphoid should be with an intact external cartilaginous shell and normal scapholunate angle without a humpback deformity [2]. The present study investigates the use of percutaneous fixation techniques, without supplementary bone grafting, in the treatment of established nonunion of the scaphoid waist fractures.

Patients and Methods

Twenty one patients with scaphoid nonunion treated with volar percutaneous screw fixation, a full informed consent was obtained from each patient enrolled in this study. The inclusion criteria in this series were scaphoid waist fracture non-union with intact cartilaginous envelope, minimal fracture line at nonunion interface, no cyst or sclerosis, no avascular necrosis and normal scapholunate angle without humpback deformity (grade 1 or 2) according to Slade and Geissler [11] classification for scaphoid non-unions (Table 1). This

Table 1 Classification system for scaphoid non-union [10]

Grade	Category	Characteristics of scaphoid non-union
1	Delayed presentation	Scaphoid fractures with delayed presentation (4–8 weeks)
2	Fibrous non union	Intact cartilaginous envelope, minimal fracture line at non-union interface, and no cyst or sclerosis
3	Minimal sclerosis	bone resorption at non-union interface < 1 mm with minimal sclerosis
4	Cyst formation and sclerosis	bone resorption at non-union interface < 5 mm, cyst formation, and maintained scaphoid alignment
5	Cyst formation and sclerosis	bone resorption at non-union interface > 5 mm and < 10 mm, cyst formation, and maintained scaphoid alignment
6	Pseudo arthrosis	Separate bone fracture fragments with profound bone resorption at non-union interface. Gross fragment motion and deformity is often present

classification is a useful guide to determine the applicability of minimally invasive procedures for scaphoid non-unions. There were 17 male and 4 female patients with an average age of 23 years (range 16–45 years). There were 15 right-sided fractures and 6 left-sided fractures. History of trauma included in 16 patients, trials of non-operative treatment was done in 14 patients in the form of short arm thumb spica for average 9 weeks (from 8 to 12 weeks). Average duration of nonunion was 6.8 months (range 4 – 8.3 months), (Table 2). Clinically all patients complained of wrist pain affects their daily activity and functional tasks, the pain analyzed according to visual analogue scale pain score (VAS) it was average 48 mm (38–70 mm). The average flexion was 60° (from

45 to 70) about 65 % of sound side, extension was 55° (from 50 to 65) about 80 % of sound side, radial tilt was 10° (from 8 to 16) about 73 % of sound side, ulnar tilt was 30° (25–35) about 90 % of sound side and pronosupination 173° (155 – 185) about 90 % of sound side. The grip strength measured using Jammer dynamometer was 62 % of sound side (range 57–75 %) (Table 3). All patients had radiographic examinations that included Posteroanterior, lateral, oblique and scaphoid views. The average scapholunate angle was 53° (from 40 to 60), average scaphoid length was 30 mm (from 28 to 31 mm), average radioscapoid angle was 65° (from 55 to 75), capitulate angle was 4° (from 0 to 6), radiolunate angle was 5° (from 0 to 10) and scapholunate gap 1.2 mm (from 1 to 2) (Table 4).

Table 2 Pre-operative patient’s evaluation

Patient NO.	Age	Sex	Affected hand	History of trauma	Non operative ttt	Duration of non union in months
1	32	F	L	+		6
2	45	M	R	+	+	6.5
3	35	M	R			5
4	42	M	R	+	+	6..5
5	16	M	L	+	+	6.3
6	32	F	R	+	+	4
7	23	F	R	+		5.4
8	25	M	L		+	6.8
9	28	M	R	+	+	5.6
10	41	M	L	+	+	5.9
11	39	M	L	+		6.2
12	21	M	R	+		6
13	29	M	R		+	6
14	27	M	R	+	+	6.3
15	28	M	R	+	+	5.2
16	37	M	R			6.3
17	43	F	R			5.3
18	29	M	R	+	+	4.7
19	30	M	L	+	+	8.3
20	34	M	R	+	+	4.9
21	28	M	R	+	+	5

Table 3 Pre-operative clinical parameters

Patient NO	VAS score	Flexion	Extension	Radial tilt	Ulnar tilt	Pronosupination	Grip % of sound side
1	55 mm	60	55	10	30	175	74
2	45 mm	65	53	16	32	170	75
3	38 mm	70	65	15	35	185	75
4	39 mm	70	65	16	35	185	75
5	46 mm	65	65	16	34	175	73
6	70 mm	45	50	8	25	155	57
7	58 mm	59	57	10	35	168	67
8	65 mm	55	60	12	28	185	65
9	48 mm	60	65	13	30	165	70
10	63 mm	50	60	8	30	160	72
11	59 mm	60	63	15	27	175	68
12	64 mm	55	60	10	30	167	59
13	70 mm	45	50	9	28	155	57
14	54 mm	60	64	14	35	173	67
15	46 mm	67	65	15	34	169	75
16	55 mm	60	55	13	38	185	68
17	64 mm	50	55	10	30	175	66
18	58 mm	60	60	15	35	169	71
19	50 mm	65	60	15	35	170	69
20	48 mm	65	58	15	35	185	73
21	66 mm	58	55	10	30	175	59

Table 4 Radiographic parameters

Patient NO	SL angle		SL gap (mm)		CL angle		RL angle		Scaphoid length (mm)		RS angle	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	50	50	1.1	1.1	4	0	0	0	28	27	65	63
2	56	52	2	2	3	0	4	0	30	29	55	60
3	52	50	1.4	1.4	5	0	3	2	30	29	75	70
4	45	45	1.5	1.5	2	2	6	3	31	30	66	65
5	57	49	1,2	1,2	0	4	0	0	29	30	58	62
6	63	60	1.3	1.3	2	6	7	4	30	32	63	64
7	65	65	1.1	1.1	0	0	4	2	30	30	73	72
8	55	53	1.1	1.1	5	0	5	0	28	29	71	70
9	50	50	1.4	1.4	6	0	6	3	30	29	58	64
10	62	60	2	2	4	3	8	2	31	29	60	60
11	59	54	1,6	1,6	0	6	5	0	30	29	65	64
12	64	55	1.9	1.9	2	2	5	2	30	27	65	67
13	61	60	1.5	1.5	5	0	7	4	30	28	56	62
14	58	56	1	1	4	0	9	5	31	30	73	70
15	45	45	1	1	3	2	0	0	29	28	62	70
16	50	50	1.3	1.3	4	3	10	7	28	32	70	64
17	58	50	1.5	1.5	0	4	4	2	27	25	62	64
18	62	60	1.1	1.1	3	2	5	3	30	28	58	59
19	59	56	1	1	2	0	3	2	31	30	61	60
20	48	45	1.1	1.1	6	0	2	0	28	30	67	65
21	60	60	1.4	1.4	5	0	0	0	28	25	63	60

Ten patients had pre-operative CT scan for more fracture study to exclude sclerosis, bone resorption, scaphoid displacement and flexion deformity. MRI study did for 8 patients to evaluate the integrity of the cartilage shell of scaphoid and to exclude avascular necrosis of proximal pole. All fractures fixed with volar percutaneous technique using 3.0 mm cannulated Herbert screw. A 20-mm screw suffices in almost all cases, with an 18-mm or 22-mm screw being used in the remaining cases. The hand is kept in a surgical dressing with a volar plaster splint for 10 days, at which time the splint and sutures are removed. The patient is placed into a molded orthoplast short arm thumb spica splint for 6 additional weeks. During this time, the splint is removed for gentle wrist motion and hygiene. When radiographic and clinical union are achieved the splint is discontinued, and all previous activities are resumed as tolerated. The post-operative radiographs were obtained immediately after surgery, after 6 weeks, every 2 weeks until fracture healing was achieved and then every 2 months along the follow up (Fig. 1).

Results

The mean follow up period 25 months (range from: 18 to 35), all fractures united successfully with no additional procedures. These fractures achieved radiographic union at an average of 4 months (range 3–6 months) post-screw fixation, in almost all cases a CT scan obtained at an average 8 months (from 6 to 10 months) post operative to confirm bone healing. The average DASH score (disabilities of the arm, shoulder, and hand) at final follow-up was 8 (range 0–16). Average wrist range of motion was extension of 75° (range 60–80), flexion 74° (range 65–90), radial tilt 17° (range 15–20), ulnar tilt 35° (range 30–45) and pronosupination 175° (range 170–185). Grip strength restored in comparison to sound side with average 98 % (95–100) (Table 5). None of the patients showed radiographic signs of osteoarthritis, osteonecrosis of the scaphoid or intra-articular screw penetration. The average Scapholunate angle 51° (range 45–65), scapholunate gap 1.2 mm (range 1–2), scaphoid length 27 mm (range 25–32), radioscapoid angle 57 (range 45–67), radiolunate angle 4

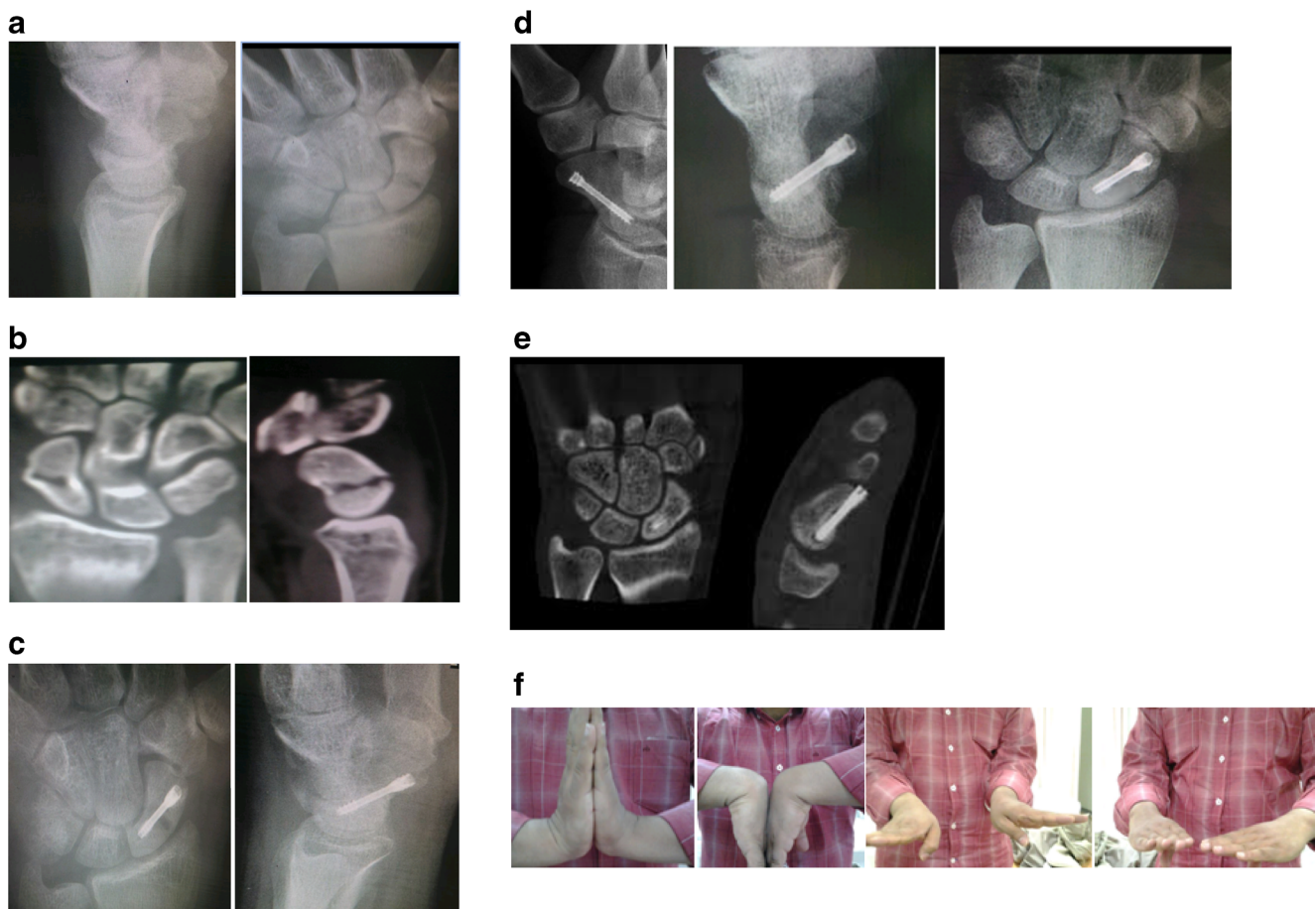


Fig. 1 **a** Posteroanterior and lateral radiographs of male patient 25 year old show scaphoid waist fracture nonunion left wrist 5 months duration. **b** Preoperative CT scan of the same patient shows no fracture sclerosis, minimal bone resorption and no humpback deformity of the scaphoid. **c** One week post operative radiographs of same patient. **d** Two months

postoperative radiographs show uniting fracture scaphoid waist of same patient. **e** Eight months postoperative CT shows united scaphoid waist fracture nonunion of the same patient. **f** Thirty one month postoperative photos shows wrist range of motion of left wrist joint

Table 5 Postoperative clinical parameters

Patient NO	Follow up (mo)	Healing time(mo)	Flexion	Extension	Radial tilt	Ulnar tilt	Pronosupination	VAS mm	Grip %
1	25	3.8	90	80	20	45	185	0	100
2	37	4.2	90	80	20	45	185	0	100
3	18	4.3	85	75	20	45	185	0	100
4	27	4	84	70	18	38	185	0	100
5	29	5.1	75	65	15	30	185	0	98
6	36	4.7	85	75	17	39	170	0	95
7	19	4.5	80	75	18	43	175	0	98
8	26	4	85	80	20	40	185	0	100
9	29	5	78	65	16	35	180	0	100
10	31	6	65	65	17	30	175	0	95
11	38	3.5	90	80	20	39	175	0	99
12	28	4.7	90	80	18	45	175	0	100
13	26	6	70	70	17	35	170	0	98
14	37	5.2	75	70	18	37	175	0	100
15	25	4	86	75	19	39	180	0	100
16	29	3.4	80	75	16	42	185	0	100
17	30	4.6	85	80	20	45	175	0	100
18	31	4.3	80	75	16	37	175	0	98
19	32	4.1	90	80	20	45	175	0	99
20	26	3.8	80	75	18	37	185	0	100
21	29	4.2	90	80	20	45	175	0	100

(range 0–7) and capitulum angle 3 (range 0–6) (Table 4). The final radiographic follow-up was recorded at an average of 12 months (range 6–21) post-procedure. There were no intraoperative or postoperative complications. All patients returned to their pre-injury level of work activity.

Discussion

Non-union of the scaphoid is generally defined as failure of radiographic evidence of union at 6 months after the injury. Anatomically, the complex three-dimensional shape, tenuous blood supply, and 80 % cartilage covering of the scaphoid make effective management of non-unions challenging. Slade and Geissler [11] proposed a progressive classification for scaphoid non-unions (Table 1). This classification is a

useful guide to determine the applicability of minimally invasive procedures for scaphoid non-unions [10]. Minimally invasive surgery is indicated in early scaphoid non-unions without substantial cystic bone resorption, without appreciable collapse of the scaphoid architecture, and without clear avascular necrosis of the proximal pole. Additional inclusion criteria for percutaneous treatment of these non-unions should be an intact external cartilaginous shell and intact and normal scapholunate angle without a humpback deformity [10]. The integrity of the cartilage shell can be evaluated by arthroscopy, as done by Slade and Geissler [11] or by a magnetic resonance imaging study. Percutaneous fixation of scaphoid fractures with cannulated screws was first performed in 1962 in Germany by Von R. Strelt via a small volar incision [12]. Recent publications report the use of percutaneous techniques in the treatment of delayed and non-unions of the scaphoid.

Table 6 Comparison of current study with previous clinical series

Study	No. of patients	% of Union rate	Average union time in weeks	ROM % of sound side	Grip strength % of sound side	Patients had post operative pain	Complication
John T. capo.et al. (2012) [2]	12	92 %	16	92 %	87 %	1	One patient need revision
Kim JK.et al. (2010) [3]	12	100 %	11	93 %	92 %	0	Non
Slade JF et al. (2003) [11]	15	100 %	14	94 %	98 %	0	Non
Wozasek (1991) [13]	33	81 %	18	-	-	6	6 patients need revision
Present study	21	100 %	14	93 %	98 %	0	Non

Wozasek and Moser [13] described 25 cases with delayed union and 8 with established non-unions treated with a percutaneous dorsal approach. Bony healing was achieved in 27 cases (81 %) after a mean postoperative time of 82 months. Slade and Geissler [11] evaluated 15 patients with a fibrous or non-union of the scaphoid treated with arthroscopic examination and dorsal percutaneous fixation with a headless screw without bone graft. Computed tomography scans were performed at approximately 4–6 weeks postoperatively and then repeated every 6 weeks until union was achieved. All 15 fractures healed with the average time to union of 14 weeks with no complications. Kim et al. [3] treated 12 patients with scaphoid waist delayed union using the volar percutaneous approach. All fractures united successfully with no additional procedures in an average 11 weeks. John T. capo et al. [2] treated 12 patients with scaphoid non-unions of an average duration of 8.7 months. They found eleven of the 12 (92 %) fractures united successfully with no additional procedures. In the current study there were 21 scaphoid waist fractures nonunion with intact cartilaginous envelope, minimal fracture line at nonunion interface, no cyst or sclerosis, no avascular necrosis and normal scapholunate angle without humpback deformity. Preoperative MRI to assess the cartilaginous shell and vascularity of scaphoid was done. CT scans were performed postoperatively to confirm scaphoid fracture healing. The average clinical follow-up was at 25 months (range 18–35) postoperatively. All fractures united successfully with no additional procedures. The average DASH score (disabilities of the arm, shoulder, and hand) at final follow-up was 8 (range 0–16). Table 6

Conclusion

Percutaneous technique avoids devascularization of the scaphoid, division of the carpal ligaments, and providing a much more aesthetic scar. Percutaneous screw fixation is indicated in early scaphoid non-unions without substantial cystic bone resorption, without appreciable collapse of the scaphoid architecture, and without clear avascular necrosis of the proximal pole. Also the scaphoid should be with an intact external

cartilaginous shell and normal scapholunate angle without a humpback deformity

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 standers.

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

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