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Original Article

Percutaneous Fixation of Recent Scaphoid Fracture by Herbert screw through the Volar Approach: A Clinical Trial

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Abstract

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Background: The scaphoid is the most frequently broken bone in the wrist, representing between 50% and 80% of all carpal fractures and about 11% of hand fractures overall. These injuries are most often seen in young, physically active individuals. The approach to treating acute scaphoid fractures varies based on several considerations, such as the degree of displacement, the fracture's anatomical location, the presence of comminution, and the patient's lifestyle or occupation. Minimally invasive fixation techniques, such as percutaneous screw fixation, are often used for stable, non-displaced fractures. This method was initially introduced by Streli in 1970.

Aim and objectives: The aim of this study is to evaluate prospectively the clinical outcome of percutaneous fixation of 15 patients with fresh scaphoid fractures by Herbert screw subjectively and objectively over 10 months using the modified Mayo wrist score [MMS] as the final postoperative evaluation.

Methods: This study involved adult patients with closed scaphoid fractures who were treated using the volar percutaneous fixation technique at Damietta Hospital, Al-Azhar University, between December 2023 and December 2024. The collected data were coded, reviewed, and entered into IBM SPSS version 20 for statistical analysis.

Results: This prospective study included 15 patients with closed scaphoid fractures. The cohort consisted of 12 males [80%] and 3 females [20%], with a mean age of 30.93 years [range: 21–50 years]. At final follow-up, 12 patients [80%] achieved excellent outcomes, while the remaining 3 patients [20%] had good outcomes according to the Modified Mayo Wrist Score [MMWS].

Conclusion: Percutaneous screw fixation offers stable osteosynthesis for non-displaced or minimally displaced scaphoid waist fractures, promoting faster bone healing, earlier return to daily activities, and reducing the risks of muscle atrophy and grip strength loss associated with extended immobilization in a cast.

Keywords: Herbert screw; Minimally Invasive; Percutaneous fixation; Scaphoid.

INTRODUCTION

The scaphoid is the most commonly fractured carpal bone, accounting for approximately 50% to 80% of carpal fractures and nearly 11% of all fractures involving the hand. These injuries are most prevalent among young, physically active individuals [1]. Approximately 80% of scaphoid fractures occur at the waist of the bone, often caused by a fall onto an outstretched hand. This mechanism transmits axial force through the scaphoid, leading to dorsal cortical failure due to compressive stress [2]. Sports involving intense wrist impact, such as football and basketball, increase the susceptibility to scaphoid fractures. These fractures are often challenging to detect and to manage due to the difficulty in achieving proper bone healing [3]. Clinically, tenderness in the anatomical snuffbox, pain when pressing on the scaphoid tubercle, discomfort with axial pressure on the thumb, and painful thumb movements are common indicators used in diagnosis [4].

When scaphoid fracture is suspected, initial wrist radiographs should include posteroanterior, lateral, oblique, and dedicated scaphoid views. If these imaging results are inconclusive but clinical suspicion remains high, MRI is the preferred modality to identify hidden fractures, bone bruises, or associated soft tissue injuries [5]. Multiple classification systems exist for scaphoid fractures, but the Herbert and Fisher system is the most widely used in clinical settings [6]. Management strategies for acute fractures depend on several variables, such as the fracture's location, degree of displacement, comminution, and the patient's lifestyle or occupational demands [7].

Stable, non-displaced fractures are commonly treated with conservative methods like scaphoid or forearm casting for 8 to 12 weeks until union occurs. However, this approach may be unpopular among younger, active patients who wish to maintain participation in sports or other demanding activities [8]. Furthermore, cast immobilization can lead to joint stiffness and reduced grip strength. Surgical intervention, typically involving open reduction and internal fixation, is the preferred method for displaced fractures due to concerns about non-union and avascular necrosis. Nevertheless, open surgery may cause complications such as extensive soft tissue disruption, injury to the anterior radiocarpal ligaments, infections, noticeable scarring, and more severe postoperative outcomes including reflex sympathetic dystrophy [9].

First introduced by Streli in 1970, percutaneous fixation is another option, primarily for treating non-displaced scaphoid fractures [10]. This technique offers several benefits, such as lower surgical morbidity, quicker recovery, preservation of the delicate blood supply to the scaphoid, and faster healing times [11]. However, the options for percutaneous entry points are limited because approximately 80% of the scaphoid's surface is covered with articular cartilage [12].

THE AIM OF THE WORK

This study aims to prospectively assess the clinical outcomes of percutaneous fixation using Herbert screws in 15 patients with recent scaphoid fractures. Both subjective and objective evaluations were conducted over a ten-month follow-up period, with the modified Mayo Wrist Score [MMS] used as the final postoperative assessment tool.

Patients and METHODS

Study Design and Population: This prospective, single arm, non-randomized clinical trial, included 15 adult patients diagnosed with closed scaphoid fractures who underwent surgical management using a volar percutaneous fixation technique. All procedures were performed between December 2023 and December 2024 at Damietta Hospital, Faculty of Medicine [Al-Azhar University], Egypt.

Sampling method: we have used a non-randomized total sampling technique in which we included all the patients that presented to our hospital in the study period, meeting our inclusion criteria and accepted to participate in our study.

Inclusion and Exclusion Criteria: Eligible patients were aged between 18 and 50 years, presenting with non-displaced or minimally displaced [<2 mm] closed scaphoid fractures, with a time from injury not exceeding two weeks. Patients younger than 18 years of age, those with open, displaced, or comminuted fractures, and cases of chronic scaphoid injury with delayed union or non-union were excluded from the study.

Ethical Considerations: All participants received a thorough explanation of the study protocol and provided written informed consent before enrollment. Patient confidentiality was rigorously upheld by using coded data entry to ensure anonymity and protect personal information. Patients were informed of their right to withdraw from the study at any time without penalty, and any unexpected risks encountered during the study were promptly reported to both the participants and the institutional ethics committee. The study received ethical approval from the Institutional Review Board of the Faculty of Medicine, Al-Azhar University, New Damietta [Approval Number: DFM-IRB 00012367-24-03-010].

Preoperative Management Protocol: At the time of hospital admission, all patients first underwent a series of baseline laboratory tests followed by a thorough physical examination and structured clinical interview. The medical history focused on identifying the nature and timing of the current injury, including the mechanism of trauma, the exact date it occurred, the date of hospital presentation, and any notable comorbidities or previous medical conditions. Additionally, a detailed personal profile was collected, capturing key demographic and lifestyle information such as smoking habits, occupational role, contact details, residential address, biological sex, and age. This comprehensive initial assessment was essential to establish an accurate clinical picture and guide appropriate management planning.

Clinical Examination: A thorough general examination was performed, including measurement of vital signs [blood pressure, heart rate, respiratory rate, and temperature] and a systemic assessment to rule out associated injuries. Local examination included inspection for deformities, skin condition, wounds, or associated soft tissue injuries; and palpation for localized temperature changes and tenderness over specific anatomical landmarks, including the anatomical snuffbox, scaphoid tubercle, and along the axis of the thumb [longitudinal compression test]. Wrist range of motion was also assessed.

Radiological and Laboratory Evaluation: All patients underwent plain radiographs of the wrist, including anteroposterior, lateral, oblique, and dedicated scaphoid views. Computed tomography [CT] was performed in cases requiring further anatomical detail or surgical planning. Baseline laboratory tests included complete blood count [CBC], liver and renal function tests, random blood glucose, and international normalized ratio [INR].

Surgical Technique: All procedures were conducted using a volar percutaneous approach, following the technique described by **Slade *et al.*** with slight modifications [13]. Under regional or general anesthesia and without tourniquet use, patients were positioned supine with the affected limb abducted on a well-padded hand table. Right-handed surgeons stood superior to the arm for optimal antegrade guide wire insertion, while the image intensifier was placed inferiorly to provide effective fluoroscopic guidance. The wrist was positioned in hyperextension with maximum ulnar deviation, and traction was applied to the thumb to aid in fracture reduction. These maneuvers repositioned the trapezium dorsally, exposing the scaphoid tubercle and shifting the scaphoid from beneath the radial styloid. Under fluoroscopy, the central axis of the scaphoid was visualized in both anteroposterior and lateral views, and its trajectory was marked on the skin using a sterile marker. A 1.1-mm guidewire was introduced percutaneously through the scaphoid tubercle, carefully advanced along the central axis toward the proximal pole, maintaining visualization in both planes. Given the scaphoid's anatomical obliquity [approximately 45° in both planes], the wire was inserted at a dorsal-medial angle of 45°, aligning with the bone's mid-axis. Once optimal guidewire placement was confirmed, a 5 mm transverse skin incision was made at the entry site, followed by blunt dissection to the distal pole. Screw length was determined using a depth gauge or matched guidewire, and a screw 4 mm shorter than the measured length was selected to prevent cortical protrusion. The guidewire was then advanced into the proximal fragment to maintain alignment during drilling. A cannulated drill was passed over the guidewire and carefully advanced across the fracture site, stopping short of the opposite cortex under fluoroscopic control. A self-tapping Herbert screw was manually inserted along the guidewire. As the screw's final threads compressed the fracture, traction on the thumb was released to enhance compression. The screw was countersunk beneath the cortical surface to prevent soft tissue irritation. Final assessment under fluoroscopy confirmed appropriate screw placement and stable fracture fixation.

Implants Used: All scaphoid fractures were stabilised using a cannulated Herbert screw. In two cases with concomitant distal radius fractures, K-wires were used for additional fixation.

Postoperative Management: The duration of immobilisation varied depending on associated injuries. Patients with ipsilateral distal radius fractures [n=2] were immobilised for six weeks. The remaining cases were immobilised for two weeks using a below-elbow slab. Active-assisted finger mobilisation was initiated immediately postoperatively. Wrist exercises were commenced at two weeks, following slab removal. Resisted and weight-bearing exercises were introduced only after radiographic evidence of fracture union.

Clinical and Functional Assessment

Early Postoperative Evaluation: Postoperative care involved inspection of the surgical wound, evaluation of hand edema, and assessment of capillary refill. Full finger mobilization was encouraged from the first day after surgery, and wrist movement was permitted as tolerated by the patient. In cases where K-wires were used for associated distal radius fractures, they were removed at six weeks postoperatively.

Radiological Assessment: Postoperative radiographic evaluation included plain X-rays to confirm adequate fracture compression, proper screw alignment, and accurate placement without breaching the scaphotrapezial joint or the dorsal cortex. Follow-up radiographs obtained at 4 and 6 weeks postoperatively and then weekly until radiological union was achieved.

Fracture Union Criteria: Union was defined as the absence of clinical tenderness over the fracture site and radiological evidence of trabecular bridging across the fracture line, confirmed on both plain radiographs and CT imaging when needed.

Late Radiological Follow-up: At six months postoperatively, radiographs were reviewed to assess implant position, carpal alignment, and to evaluate for complications such as nonunion, malunion, or post-traumatic arthritis.

Functional Evaluation: At the final follow-up, conducted six months postoperatively, all patients underwent a comprehensive clinical evaluation of wrist function. This included assessment of flexion, extension, radial and ulnar deviation, grip strength, and the ability to perform full circumduction. Grip strength in the operated hand was compared with the contralateral, non-injured side. Functional outcomes were assessed using the Modified Mayo Wrist Score [Table 1].

Data management and statistical analysis: All collected data were coded, verified for accuracy, and entered into the Statistical Package for the Social Sciences [SPSS], version 20 [IBM Corp., Armonk, NY, USA] [14]. Categorical variables were presented as frequencies and percentages, while continuous variables with a normal distribution were expressed as means, standard deviations, and ranges. For non-normally distributed continuous data, medians and interquartile ranges [IQRs] were used. Comparisons between categorical variables were performed using the Chi-square [χ^2] test. When expected cell counts were less than five, Fisher's exact test was employed. For continuous data, the independent samples t-test was used to compare normally distributed variables between two groups, and the Mann–Whitney U test was applied for non-parametric comparisons. A 95% confidence interval [CI] was used for all statistical tests. A two-tailed p-value of < 0.05 was considered statistically significant.

RESULTS

Baseline and Clinical Characteristics: This prospective study included 15 patients with closed scaphoid fractures, all managed by percutaneous fixation using a Herbert screw. Clinical and radiological assessments performed to evaluate postoperative outcomes. The cohort consisted of 12 males [80%] and 3 females [20%], with a mean age of 30.93 years [range: 21–50 years] [Table 2]. The right wrist was involved in 10 patients [66.7%], and the left in 5 patients [33.3%]. In 9 patients [60%], the injury affected the dominant hand. The most common mechanism of injury was a fall onto an outstretched hand [FOOSH], reported in 12 patients [80%], while motor vehicle accidents [MVA] accounted for the remaining 3 cases [20%]. According to the Herbert classification system, all fractures had been identified as type B2—complete waist fractures. Two patients [13.3%] had a known history of diabetes mellitus. The time from injury to surgical intervention ranged from one to 14 days. Most surgeries [11 patients; 73.3%] were performed within the first week, while the remaining four patients [26.7%] underwent surgery during the second week. Two patients [13.3%] had associated distal radius fractures. Operative time ranged from 30 to 90 minutes, with a mean duration of 60 minutes.

Follow-Up Duration Patients were followed for a period ranging from 8 to 12 months, with a mean follow-up duration of 9.92 ± 1.2 months. Follow-up continued until radiographic evidence of union and full functional recovery of the wrist were confirmed.

Clinical Outcomes: Clinical outcomes were assessed using the Modified Mayo Wrist Score [MMWS]. At final follow-up, 12 patients [80%] achieved excellent outcomes, while the remaining 3 patients

[20%] had good outcomes. No cases were classified as fair or poor, resulting in a 100% rate of satisfactory clinical outcomes [Table 3].

Pain Assessment at Final Follow-Up

Pain and Symptom Relief: By the end of the follow-up period, 12 patients [80%] reported being completely free of pain, while the remaining three patients [20%] experienced only mild, intermittent discomfort [Table 3].

Wrist Range of Motion Recovery: Twelve patients [80%] regained a flexion-extension arc greater than 120°. Two patients [13.3%] demonstrated a range of motion between 110° and 119°, while one patient [6.7%] achieved a range between 90° and 99° [Table 3].

Return to Occupational Activities and Grip Strength Restoration: All patients were able to return to their pre-injury occupational activities. Regarding grip strength, 13 patients [86.7%] recovered 90–100% of the strength compared to the contralateral hand, while two patients [13.3%] achieved recovery in the range of 75–89% [Table 3].

Factors Affecting Final Clinical Outcomes: A statistically significant correlation was identified between patient age and clinical outcomes [$P < 0.05$], while sex had no significant impact [Table 4]. Other variables, including the mechanism of injury, presence of diabetes, smoking status, and time to surgery, were not significantly associated with clinical outcomes [$P > 0.05$]. However, the presence of an associated distal radius fracture had a statistically significant negative effect on functional results [$P < 0.05$] [Table 4].

Radiological and Intraoperative Findings: Analysis revealed a significant association between central screw placement and superior functional outcomes [$P < 0.05$]. Accurate alignment of the screw along the scaphoid's central axis correlated with higher clinical scores and faster recovery [Table 4].

Radiographic Assessment of Fracture Union: Radiological follow-up involved evaluation of fracture union and the positioning of the Herbert screw relative to the scaphoid's long axis and fracture line. Union was confirmed by the appearance of trabecular bridging and increased bone density at the fracture site on both plain radiographs and CT scans.

Factors Influencing Time to Union: No significant associations were observed between union time and patient sex or age [$P > 0.05$] [Table 5]. Similarly, the presence of a distal radius fracture did not significantly delay healing [$P > 0.05$]. However, smoking was significantly associated with delayed union [$P < 0.05$]. The interval between injury and surgery was not significantly related to the time to union [$P > 0.05$]. A detailed summary of injury-to-surgery and healing timelines is provided in [Table 6].

Postoperative Complications

Screw protrusion was identified in one case, though it did not negatively affect clinical outcomes as measured by the MMWS [Table 7]. One patient with a concomitant distal radius fracture developed localized osteopenia indicative of reflex sympathetic dystrophy, likely due to immobilization. This resolved following cast and K-wire removal and physiotherapy. Another patient reported restricted wrist mobility at final follow-up, for which physiotherapy was initiated [Table 7]. No cases of nonunion, delayed union, or screw loosening were reported throughout the study period.

Table [1]: Modified Mayo Wrist Score Criteria

Category	Findings	Score
Pain Level	Pain free	25
	Occasional, mild discomfort	20
	Moderate, but manageable pain	15
	Disabling pain	0
Functional Activity	Full return to normal work	25
	Return to work with some limitations	20
	Capable of working but currently unemployed	15
	Unable to work due to pain	0
Wrist Range of motion	Greater than 120	25
	Between 100-119	20
	Between 90-99	15
	Between 60-89	10
	Between 30-59	5
	Less than 30	0
Grip strength	90-100% of the opposite hand	25
	75-89%	15
	50-74%	10
	25-49%	5
	Less than 25%	0
Overall score	90-100 excellent	
	80-89 Good	
	65-79 fair	
	Below 65 poor	

Table [2]: Patient Demographics and Clinical Characteristics

Variables	N= 15
Age [yrs.]	30.93 ± 9.36
Sex	
Female	3 [20.0%]
Male	12 [80.0%]
Side affected	
Left	5 [33.3%]
Right	10 [66.7%]
Dominant hand	
No	6 [40.0%]
Yes	9 [60.0%]
Mechanism of injury	
FOOSH	12 [80%]
M.V.A	3 [20%]
Associated medical conditions [DM]	
Nondiabetic	3 [86.7%]
Diabetic	2 [13.3%]
Time lag	
Within 1st week [1-7 days]	11 [73.3%]
Within 2nd week [8-13 days]	4 [26.7%]
Associated distal radius fractures	
Present	2 [13.3%]
Absent	13 [86.7%]
Smoking	
Nonsmokers	10 [66.7%]
Smokers	5 [33.3%]

Table [3]: Clinical outcomes after operation:

	N= 15, n [%]
Functional end results	
Excellent	12 [80.0%]
Good	3 [20.0%]
Pain intensity	
No	12 [80.0%]
Mild non frequent	3 [20.0%]
ROM	
≥120°	12 [80.0%]
From 100° to 119°	2 [13.3%]
From 90° to 99°	1 [6.7%]
Grip strength compared to the normal side	
90% to100%	13 [86.7%]
75% to 89%	2 [13.3%]

Table [4]: Factors affecting the final clinical score:

	End Result			
	Excellent	Good	Statistics	
	N [%] / Mean ± SD		Test	P
Sex				
Female	3 [25.0%]	0.00%	0.938	0.333
Male	9 [75.0%]	3 [100.0%]	0.938	0.333
Age	28 ± 7.52	42.67± 6.66	3.073	**0.009***
DM				
No	11[91.7%]	[2 66.7%]	1.298	0.255
Yes	1 [8.3%]	1 [33.3%		
Mechanism Of Injury				
FOOSH	10[83.3%]	2 [66.7%]	0.417	0.519
M.V.A	2 [16.7%]	1 [33.3%]		
Time elapsed before surgery [days]	5.5 ± 3.78	3.00 ± 0	1.114	0.285
Associated injury				
No	12 [100.0%]	1 [33.3%]	-2.406	0.0013
Yes	0 [0.0%]	2 [66.7%]		
Smoking				
No	9 [75.0%]	1 [33.3%]	1.875	0.171
Yes	3 [25.0%]	2 [66.7%]		
Position of screw				
Central	11 [73.3%]	0 [0.0%]	1.875	**0.0021**
Non central	1 [6.7%]	3 [20%]		

Table [5]: Factors affecting the union time.

	Time Of Union			
	≤ 8	**> 8**	**chi square test**	
	N [%] / Mean±SD		Test	P
Sex				
Female	2 [20.0%]	1 [20.0%]	0	1
Male	8 [80.0%]	4 [80.0%]		
Age	28.80 ± 9.24	35.20±8.98	1.276	0.224
Associated injury				
No	9 [60%]	4 [26.7%]	2.538	0.281
Yes	1 [6.7%]	1 [6.7%]		
Smoking				
No	9 90.0%	1 20.0%	7.35	**0.007***
Yes	1 10.0%	4 80.0%		
Time elapsed before surgery [days]	4.10 ± 2.73	6.80± 4.49	-5.608	0.167

Table [6]: Summary of Post-Injury and Postoperative Time Intervals.

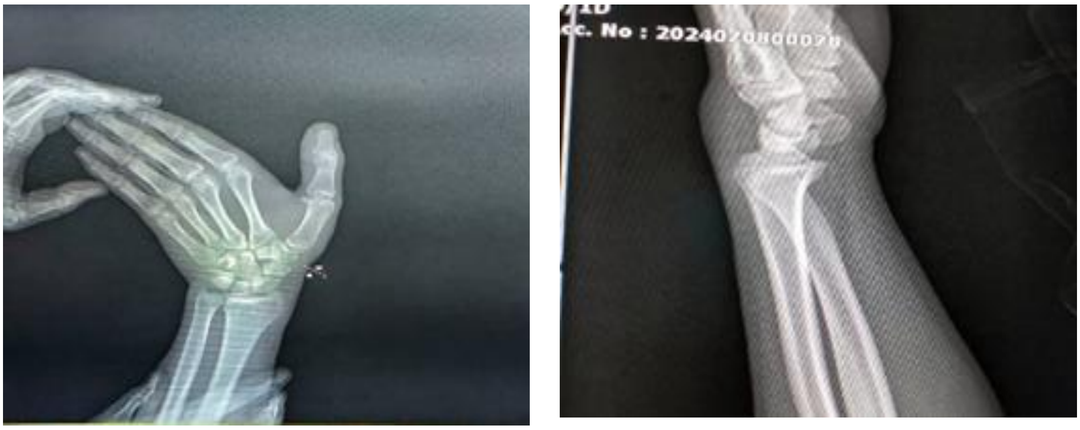
	Mean Durations	
	Mean [range]	**SD**
Time from injury to surgery [d]	5.5 [1 - 14]	3.51
Time to union [w]	7.8 [6 - 12]	1.74
Follow up time [m]	9.92 [8 -12]	1.92
Time of postoperative immobilization [w]	2.38 [2 - 6]	1.2

Table [7]: Complication after surgery

Complication	Total= 15, N [%]	Excellent	Good
Free	12 [80%]	11	1
Screw protrusion	1 [6.66%]	0	1
Reflex sympathetic osteodystrophy	1 [6.66%]	0	1
Limitation in wrist motion	1 [6.66%]	1	0

Case presentations

Case 1: Male patient, 25 years old, works as a nurse presented with pain and swelling at the anatomical snuffbox after falling on outstretched hand. X-ray showed right scaphoid fracture and the patient is right-handed. His fracture was classified as B2 [complete waist fracture] according to Herbert classification. He was treated with percutaneous Herbert screw after 1 day from the injury. The patient was immobilized for 2 weeks in volar thumb splint. Active assisted finger exercises were encouraged immediately after surgery. The slab was removed and wrist exercise initiated two weeks after the operation. Resisted or weight bearing exercise was allowed after fracture union has been established. Radiological assessment: full union was achieved at 7 weeks from fixation. Clinical assessment: Full power was restored after 7 weeks and there was no limitation of motion. Functional outcome at final follow up was excellent [100] according to MMS score **[Figurers 1-7].**



A B

Figure [1]: Pre-operative x-ray including a scaphoid view [a] and a lateral view [b] of the right wrist.

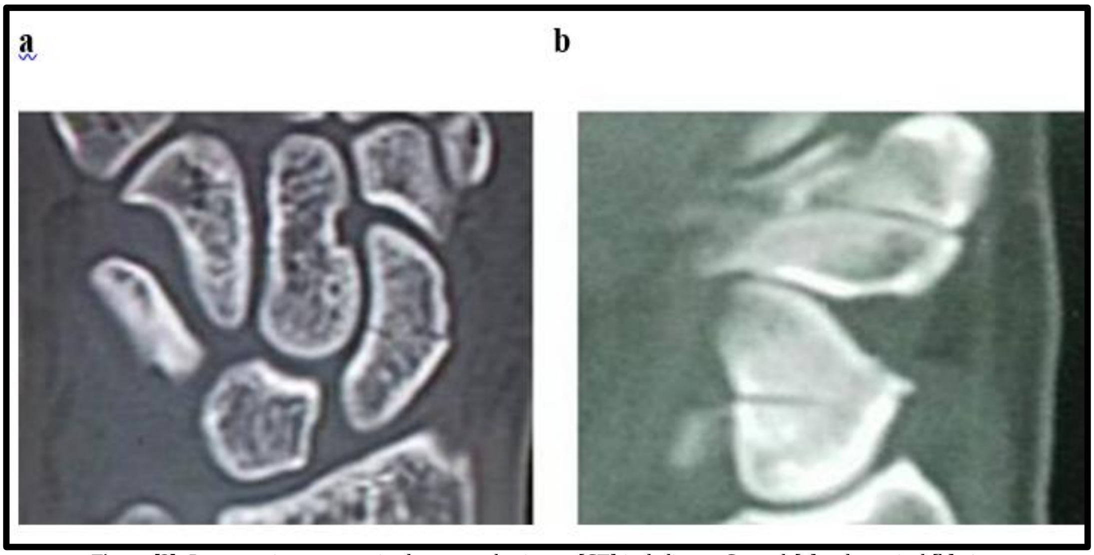


Figure [2]: Pre-operative computerized tomography image [CT] including: a Coronal [a] and a sagittal [b] view.

Figure [3]: Intra-operative pictures including: a picture during drilling [a] and another one after placement of the Herbert screw [b].

Figure [4]: Intra-operative C-arm image including antero-posterior AP [a] and a lateral view [b] of the right wrist.

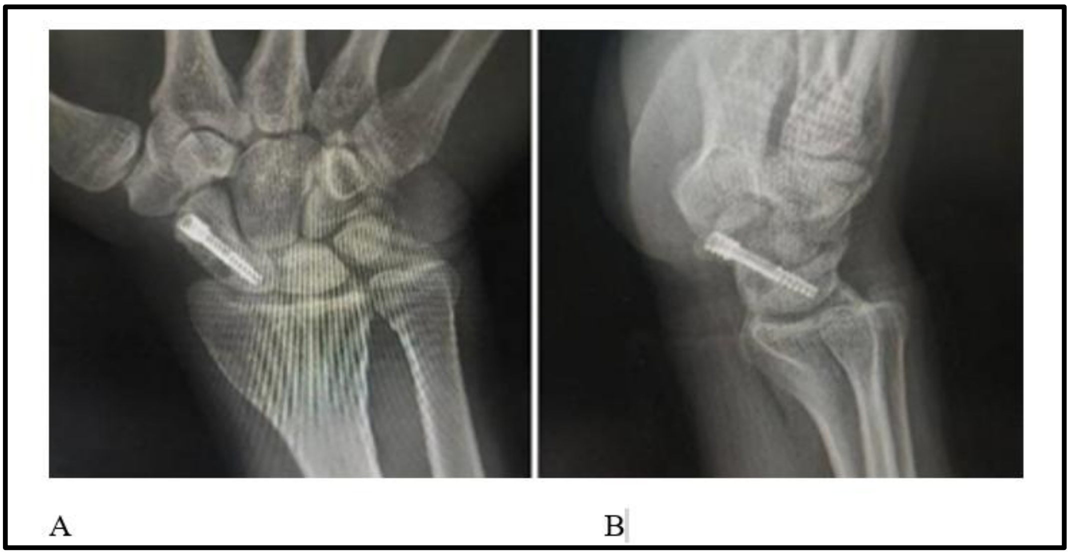


Figure [5]: Post-operative x-ray at 8 weeks of follow-up including: an antero-posterior AP [a] and a lateral view [b] of the right wrist.

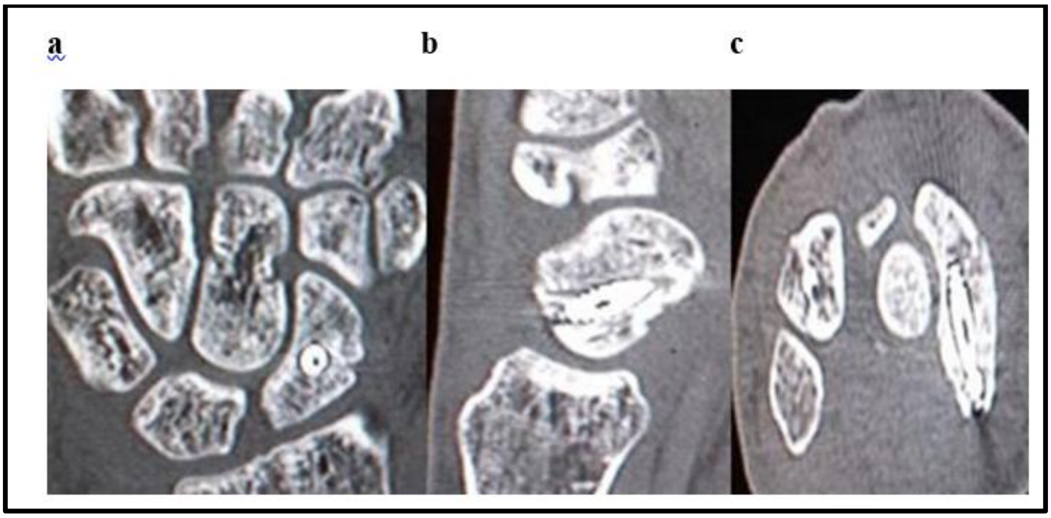


Figure [6]: Post-operative computerized tomography [CT] image at 8 weeks of follow up including: a Coronal [a] and a sagittal [b] and an axial view [c].

Figure [7]: Post-operative x-ray at12 weeks of follow-up including: an antero-posterior AP [a] and a lateral view [b] of the right wrist.

CASE [2]: Male patient, 50 years old, and works as a governmental employee presented with a history of falling on outstretched hand. X-ray showed left scaphoid fracture and he is right-handed. His fracture was classified as B2 [complete waist fracture] according to Herbert classification. He was treated with Percutaneous Herbert screw after 3 days from injury. The patient was immobilized for 2 weeks in volar thumb splint. Active assisted finger exercises were encouraged immediately after surgery. The slab was removed and wrist exercise initiated two weeks after the operation. Resisted or weight bearing exercise was allowed after fracture union has been established. Radiological assessment: Full union was achieved at 12 weeks from fixation, and screw protrusion was noted. Clinical assessment: Mild occasional pain. Range of motion [flexion & extension]: Between 90 to 99 degrees. Functional outcome at final follow up was graded as good [85] according to MMS [Figures 8-10].

Figure [8]: Pre-operative x-ray including: a Scaphoid view, a lateral view and an AP view of the left wrist.

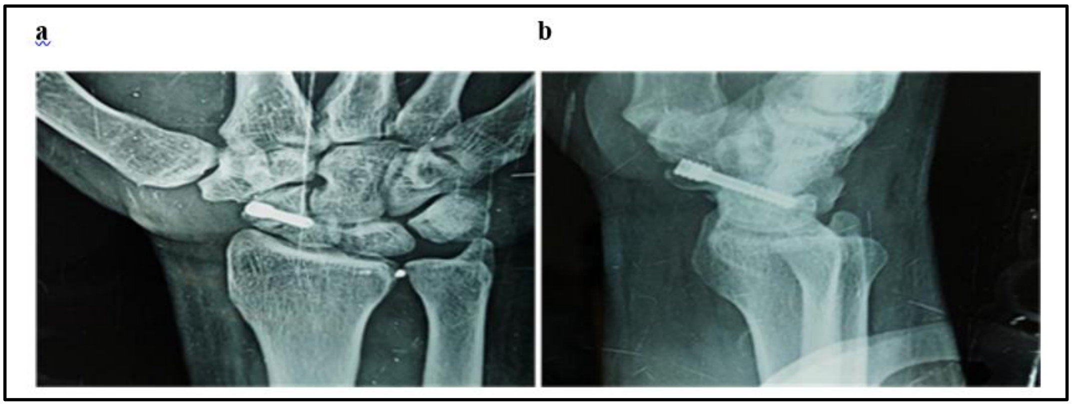


Figure [9]: Post-operative x-ray at 4 weeks of follow-up including: an antero-posterior AP [a] and a lateral view [b] of the left wrist.

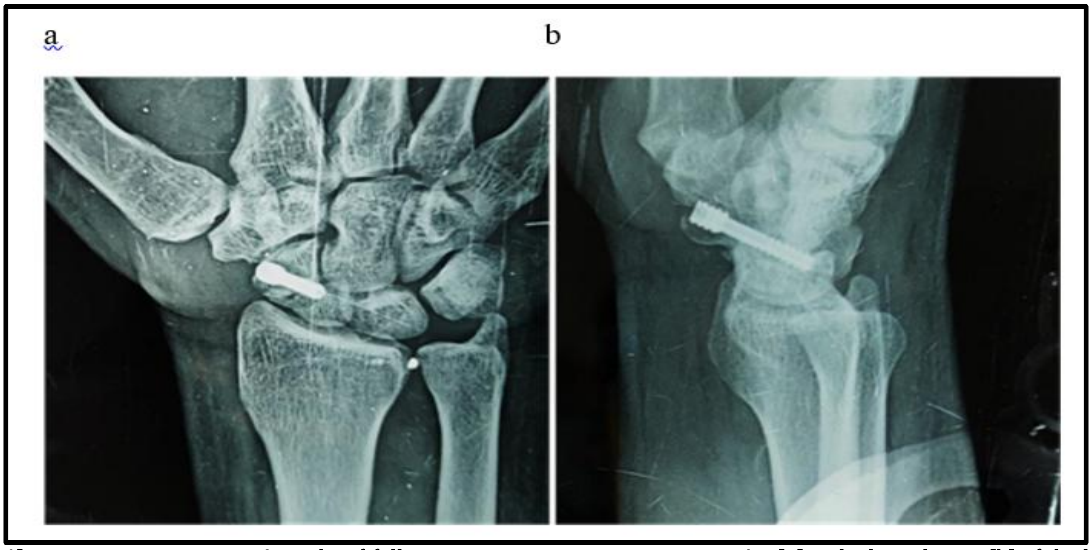


Figure [10]: Post-operative x-ray at 8 weeks of follow-up including: an antero-posterior AP [a] and a lateral view [b] of the left wrist.

DISCUSSION

Scaphoid fractures represent a relatively frequent clinical problem and are often associated with diagnostic and therapeutic challenges. These injuries primarily affect young adults and, if not managed appropriately, can lead to prolonged disability and extended time away from employment, carrying both personal and occupational repercussions [1].

Traditionally, non-displaced fractures of the scaphoid waist have been managed conservatively with immobilization, typically utilizing a long-arm cast. While this approach supports bone healing, it is often accompanied by complications such as stiffness and limited wrist mobility. Furthermore, extended periods of immobilization may carry significant socioeconomic implications, including treatment-related costs and reduced productivity [8].

The effectiveness of conservative treatment has been called into question, as multiple studies have documented a significant rate of incomplete healing or nonunion during long-term follow-up. Furthermore, patients managed with immobilization in a cast may continue to experience persistent pain, limited range of motion [ROM], and reduced grip strength [8].

Open reduction and internal fixation [ORIF] of scaphoid fractures is associated with high union rates; however, it carries the risk of disrupting intact volar ligaments, potentially compromising carpal stability. ORIF remains the standard treatment for displaced fractures and trans-scaphoid perilunate dislocations. Nonetheless, surgical trauma to the soft tissues surrounding the scaphoid—particularly given its limited vascular supply—can increase the risk of delayed healing or nonunion [9].

In response to these limitations, there has been a growing shift toward the use of percutaneous fixation for both displaced and non-displaced scaphoid fractures. First described by Streli in 1970 [10], percutaneous fixation techniques offer a minimally invasive alternative to open methods, and can be performed using either volar or dorsal approaches [11].

Adolfsson *et al*. conducted a randomized controlled trial comparing percutaneous fixation with conservative management using a long scaphoid cast in 53 patients with acute, non-displaced or minimally displaced scaphoid waist fractures. The mean patient age was 31 years. Of the participants, 25 underwent surgical fixation, while 28 received cast immobilization for ten weeks. In contrast, the fixation group wore a cast for three weeks followed by a removable splint for an additional three weeks. Fracture union in both groups was assessed via computed tomography [CT]. The results showed a significantly greater range of motion in the fixation group [$p < 0.02$], although no significant differences were found in union rates or grip strength between the two cohorts [15].

Similarly, **Bond *et al.*** performed a comparative study among military personnel with acute, non-displaced or minimally displaced scaphoid waist fractures, with a mean age of 24 years [16]. The study included 25 individuals, divided into 11 patients in the fixation group and 14 in the casting group. The casting group initially received a long-arm cast for six weeks, followed by a short cast until clinical and radiographic confirmation of union. The fixation group was treated with a short cast for 10 days, followed by a removable splint. Over a 25-month follow-up period, all fractures achieved union. However, the fixation group exhibited significantly faster healing, with a mean union time of 7 weeks compared to 12 weeks in the casting group [$p = 0.0003$], and an earlier return to full duty [8 weeks vs. 15 weeks, $p = 0.0001$].

McQueen *et al.* conducted a randomized trial to compare percutaneous fixation with conservative immobilization using a Colles' cast [excluding the thumb] in 60 patients with acute, non-displaced or minimally displaced scaphoid waist fractures. The mean age of participants was 27 years, and patients were randomly allocated to either the fixation or cast group [n = 30 each]. The cast group remained immobilized for 8–12 weeks, while patients in the fixation group began early mobilization combined with physiotherapy. Follow-up assessments were conducted over 52 weeks. The fixation group showed a significantly shorter time to union [9.2 vs. 13.9 weeks, $p < 0.001$] and returned to manual work [3.8 vs. 11.4 weeks, $p < 0.001$] and sports activities [6.4 vs. 15.5 weeks, $p < 0.001$] considerably earlier than the cast group. Despite these differences in recovery timelines, both groups achieved comparable union rates and long-term functional outcomes [17].

In a prospective case–control study, **Drac *et al.*** compared 38 patients treated with percutaneous fixation to 34 patients managed conservatively with cast immobilization. All patients had acute, non-displaced or minimally displaced scaphoid waist fractures, with an average age of 27 years and a minimum follow-up of 12 months. The study reported a significantly higher incidence of nonunion in the cast group [p = 0.024], along with poorer grip strength and range of motion outcomes [p < 0.0001]. Union was assessed using CT imaging in the fixation group, ensuring precise evaluation [18].

In a separate prospective study, **Inoue *et al.*** followed 88 patients with acute scaphoid waist fractures who were divided into two groups based on treatment preference: 46 patients underwent percutaneous fixation, and 42 were treated conservatively with a below-elbow cast including the thumb. The mean age was 26.5 years, and the average follow-up was 10 months. The fixation group demonstrated significantly faster union times [6.0 vs. 9.7 weeks, p < 0.001] and an earlier return to manual work [5.8 vs. 10.2 weeks, p < 0.001]. All fractures in the fixation group healed successfully, whereas one case of nonunion was recorded in the casting group [19].

Majeed *et al.* highlighted several drawbacks of cast treatment in scaphoid fractures, including prolonged immobilization, joint stiffness, diminished grip strength, and delayed return to manual labor. In contrast, percutaneous fixation aims to minimize disruption to the scaphoid's blood supply and surrounding soft tissue, thus enabling earlier wrist mobilization and faster resumption of manual work. According to the best available comparative evidence, percutaneous screw fixation results in an approximately seven-week reduction in time to union and facilitates return to manual work about eight weeks earlier than conservative casting, while achieving comparable union rates [20].

Despite these advantages, percutaneous fixation has limitations in managing complex wrist injuries such as trans-scaphoid perilunate dislocations. These cases often involve fracture comminution and significant soft tissue damage, necessitating open reduction and potential reconstructive procedures. Moreover, comminution at or near the intended screw entry point may preclude a percutaneous approach.

When comparing percutaneous techniques, the volar approach offers several practical benefits over the dorsal approach. These include easier identification of anatomical landmarks, wrist positioning that aids in fracture reduction, and more straightforward interpretation of intraoperative fluoroscopic images. However, the volar approach can present challenges, particularly in achieving central screw placement in proximal pole fractures. There is also a risk of injury to the volar carpal ligaments during the procedure [21].

Alternatively, the dorsal percutaneous approach offers improved access to the scaphoid's central axis, facilitating more accurate screw placement while preserving the volar carpal ligaments. Despite these advantages, this technique is not without risks. Potential complications include injury to the radiocarpal joint and extensor tendons of the thumb and index finger. Moreover, the requirement to position the wrist in flexion during the procedure can inadvertently displace a fracture that was initially non-displaced, potentially compromising alignment and healing [21].

With regard to percutaneous fixation in both recent and delayed scaphoid waist fractures, **Wozasek and Moser** reported their outcomes in a cohort of 33 patients—25 with delayed union and 8 with established nonunion—treated via a dorsal percutaneous approach. They achieved a bone healing rate of 81.8% over a mean follow-up period of 82 months. However, consistent with findings from other studies, the authors concluded that open fixation is often the more appropriate option in delayed presentations, particularly when bone grafting is necessary to promote union [22].

A study conducted in 2022 have demonstrated that open reduction and internal fixation was better compared to percutaneous screw fixation in treating nonunion scaphoid fracture [23]. On the other hand, a study conducted in 2025 on treating delayed scaphoid fractures using percutaneous screw fixation and bone marrow injection, have reported a union rate of 80% in a median time of 5.5 months with a significant improvement of pain level and hand grip [23]. Another study conducted in 2023 have reported a significant improvement of the union rates, grip strength, Mayo score, pain relief, and earlier return to activity of percutaneous screw fixation and with marrow injection in comparison to percutaneous screw fixation alone, although both are effective, in managing nonunion scaphoid fractures, and reported that percutaneous screw fixation and bone marrow injection is safe and effective [24].

Factors influencing the outcomes

In examining the factors influencing the outcomes of the current study, the demographic profile of the cohort was broadly comparable to previous findings. The mean patient age was 30.93 years, with males accounting for 80% of the study population. Injuries predominantly affected the dominant hand [60%] and falls on an outstretched hand [FOOSH] were the leading cause [80%].

These trends closely mirror the findings of **Severo *et al.*,** who studied 28 patients undergoing percutaneous scaphoid fixation. In their cohort, the mean age was 30.5 years, with a male predominance of 89.2%. Although they observed no dominant-side preference, FOOSH was similarly the most common injury mechanism, reported in 78.5% of cases [25].

In the present study, radiological union was achieved in all patients [100%], with a mean consolidation time of 7.8 weeks [range: 6–12 weeks]. Return to occupational activities occurred within 14 to 45 days, depending on the physical demands of each patient's job, while the resumption of sports activities ranged from 6 to 16 weeks postoperatively. These outcomes are consistent with prior studies reporting similarly high union rates and favorable recovery timelines.

Al-Ashhab and Elbegawi observed complete radiological union in all patients [100%] at an average of 57 days [range: 35–70 days]. The return to work varied from 18 to 40 days, with sporting activities resuming between 49 and 70 days post-surgery [26].

Likewise, **Verstreken and Meermans** documented full union in their patient cohort, with a mean healing time of 6.4 weeks [range: 5–10 weeks]. Patients resumed sedentary duties as early as four days postoperatively, and the majority were able to return to manual labor within six weeks [27].

In a comparable study by **Iacobellis *et al*.,** 33 out of 34 patients achieved union, with a mean consolidation period of 57 days [range: 35–70 days]. Their reported timelines for return to work [18–40 days] and sports [49–70 days] closely align with the findings of the current study [28].

Severo *et al.* noted radiological consolidation in 26 out of 28 patients [92.8%], with a mean time to union of 7.5 weeks. This included patients with proximal pole fractures. The average return to work occurred at approximately 7 weeks postoperatively [25].

All patients in the current study were assessed functionally using the Modified Mayo Wrist Score [MMWS]. Clinical outcomes were classified as excellent in 12 patients [80%] and good in 3 patients [20%], producing a 100% satisfactory outcome rate, with no fair or poor results.

In comparison, **Iacobellis *et al.*** [28] reported a broader range of outcomes: 30 excellent, three good, 2 fair, and 1 poor result using the same scale. **Al-Ashhab and Elbegawi** [26] documented excellent outcomes in all cases, while **Verstreken and Meermans** [27] reported 37 excellent and 4 good results among their patients. **Severo et al.** [25] observed excellent outcomes in 26 patients [92.8%] and poor results in two cases [7.2%].

Functional Outcomes: At the final follow-up in the present study, 12 patients [80%] reported being completely pain-free, while the remaining 3 patients [20%] experienced only mild and occasional discomfort. Regarding wrist mobility, 12 individuals [80%] regained flexion and extension exceeding 120°, two patients [13%] demonstrated a range between 110° and 119°, and one patient [7%] achieved a range between 90° and 99°. All participants successfully returned to their pre-injury occupational roles. Grip strength recovery was also notable, with 13 patients [87%] regaining 90–100% of the strength in the affected hand relative to the contralateral side, while two patients [13%] achieved 75–89% recovery.

These findings are consistent with those reported by **Al-Ashhab and Elbegawi** [26]**,** who observed full flexion, extension, and ulnar deviation in all patients within six weeks following percutaneous fixation. Radial deviation became symmetrical with the unaffected wrist in 12 patients by three months, and in the remaining three by four months. Mean grip strength reached 90% of the contralateral side by six weeks and improved to 98% by three months.

Similarly, **Verstreken and Meermans** [27] documented excellent range of motion outcomes in their cohort, with average wrist flexion reaching 69.8° [98% of the unaffected side], extension at 80.6° [95%], ulnar deviation at 30.9° [97%], and radial deviation at 13.6° [89%]. Grip and pinch strength were restored to 95.9% and 95.8%, respectively, compared to the contralateral hand.

Severo *et al.* reported that 92.8% of patients achieved full flexion, extension, and ulnar deviation without any reported residual pain or functional weakness. However, two patients who did not attain union displayed restricted motion, ongoing pain, and decreased grip strength [25].

Complications

In this study, complications were observed in three patients [20%]. These included one case of screw protrusion, one case of localized osteopenia suggestive of reflex sympathetic dystrophy, and one instance of reduced wrist mobility. All cases were managed conservatively with satisfactory outcomes. This complication rate aligns with those reported in the literature.

Adolfsson *et al.* and **Verstreken and Meermans** documented complication rates of 22% and 21%, respectively [15, 27]. Verstreken's complications included scaphotrapezial joint osteoarthritis and complex regional pain syndrome [27].

Iacobellis *et al.* reported both screw protrusion and one case of nonunion [28], while **Adolfsson *et al.*** observed nonunion and reflex sympathetic dystrophy [15]. **Severo *et al.*** described pseudoarthrosis in two cases [7.2%][25], and **Bedi *et al.*** reported complications such as nonunion and delayed union [29].

In the current study, all procedures were performed using the volar approach. Our clinical experience demonstrated that this approach provided easier identification of bony landmarks, allowed for stable fracture reduction during the procedure, and facilitated clearer fluoroscopic imaging. Importantly, none of the included cases were classified as Herbert type B3 [proximal pole fractures], which are typically considered more suitable for dorsal access. Therefore, the dorsal approach was not utilised in our cohort.

Findings from **Polsky *et al.*** and **Jeon *et al.*** support the notion that there are no significant differences in clinical outcomes, union times, or grip and pinch strength between volar and dorsal approaches [30, 31]. Given that all fractures in this study were located at the scaphoid waist, the volar route was more practical and preferable.

The study population was predominantly composed of young male patients, many of whom were highly motivated to return to functional activity as soon as possible. This included students preparing for academic exams and individuals seeking to minimize time away from work due to financial considerations. For patients with isolated scaphoid fractures, a short immobilization period of two weeks was sufficient, allowing an earlier return to occupational tasks. No complications related to soft tissue dissection or postoperative instability were encountered during the six-month minimum follow-up period.

Prognostic Factors

Patient age was found to have a statistically significant correlation with final functional outcomes in this study. Interestingly, no significant association was noted between age and the duration required for fracture union. This contrasts with most previously published studies, where age did not appear to significantly influence clinical or radiological results. The presence of a concomitant distal radius fracture was also associated with final outcomes. In our series, two patients presented with associated distal radius fractures and ultimately achieved good results. This finding suggests that concurrent injuries may influence both recovery trajectory and overall functional performance, underscoring the importance of comprehensive preoperative evaluation and tailored rehabilitation protocols. Smoking status was another factor found to influence the healing process. Patients who did not smoke demonstrated faster fracture consolidation compared to smokers, highlighting the negative impact of tobacco use on bone healing.

This finding is in agreement with earlier studies by **Haddad *et al.* and Iacobellis *et al.*,** both of which confirmed delayed union among smokers [29, 33]. Accordingly, patients should be counselled about the adverse effects of smoking on musculoskeletal outcomes and encouraged to cease tobacco use, particularly in the perioperative period.

Central positioning of the fixation screw within the proximal fragment of the scaphoid was significantly correlated with both favorable functional outcomes and accelerated fracture union in our study.

These results are consistent with findings reported by **Iacobellis *et al*., Verstreken and Meermans, and Al-Ashhab and Elbegawi,** all of whom concluded that achieving central screw placement, whether using cannulated or Herbert screws, has a strong positive influence on healing time and overall outcomes [27–29]. Further biomechanical support for this principle was provided by a cadaveric study conducted by **Chan *et al*.,** which demonstrated that centrally placed screws within the proximal fragment offered superior biomechanical stability compared to eccentrically placed ones [34].

In contrast, factors such as the presence of diabetes mellitus and the duration between injury and surgical intervention did not demonstrate any statistically significant effect on the outcomes in our study cohort.

Regarding surgical technique, the volar approach was used exclusively in all cases. While there is ongoing debate about whether the screw should be introduced through the trapezium, we deliberately avoided the transtrapezial route to prevent potential injury to the scaphotrapezial joint. Experimental data from cadaveric models simulating scaphoid waist fractures have shown that entering through the trapezium may allow ideal screw positioning through both poles of the scaphoid. However, this approach carries a risk of damaging the scaphotrapezial articulation. Therefore, our preference was to use an entry point that bypasses this joint to maintain its integrity. The choice of fixation hardware also remains an area of discussion. A range of implants, including Herbert screws, headless compression screws, 3.5-mm cannulated screws, and Acutrak screws, have been used in various settings. In our study, we selected the cannulated Herbert screw as the implant of choice, given its favorable biomechanical profile and capacity to be fully embedded within the bone.

Previous studies have reported varying results regarding the optimal implant type. **Shaw *et al.* and Rankin *et al.*** observed that while cannulated screws provide strong compressive force, the Herbert screw offers the added benefit of being headless, thus preserving the native scaphoid architecture without protrusion [35, 36]. Similarly, **Newport *et al.*** found that the Herbert screw delivered superior compressive force compared to other options [37]. The Acutrak screw, another widely used implant, is headless, tapered, self-tapping, and fully threaded. It combines the compression advantages of a variable pitch design with the ability to be buried entirely within the scaphoid. While **Adla *et al.*** found no statistically significant difference in compression between Herbert and Acutrak screws [38], consensus across multiple studies supports the conclusion that central screw placement, regardless of implant choice, is the most critical factor for successful fixation, rapid union, and minimal complication rates.

Conclusion: Percutaneous screw fixation represents a reliable method for stabilizing minimally or non-displaced scaphoid waist fractures. This technique facilitates accelerated bone healing and supports earlier return to occupational and athletic activities. Additionally, it reduces the risk of complications often linked to extended cast immobilization, including joint stiffness, diminished grip strength, and muscle wasting.

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