Herbert screw fixation and bone graft in non united scaphoid

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Background
Nonunion of the fractured scaphoid is a difficult surgical problem. This condition may occur in 5–10% of scaphoid fractures treated nonoperatively. Its occurrence has been attributed to delayed diagnosis and treatment, inadequate immobilization, displacement, or instability secondary to ligamentous injury. Moreover, the incidence of nonunion is greater in proximal pole fractures in which the vascularity of the proximal fracture segment is compromised. Numerous techniques have been described for the treatment of patients with scaphoid nonunions, with success rates varying from ~70 to 90%. The generally accepted surgical treatment for patients with scaphoid nonunions includes either inlay bone grafting (Russe) or iliac crest bone grafting with screw fixation, achieving successful union in ~90% of patients.

Objective
The aim of the study was to evaluate the results of the treatment of nonunited scaphoid fractures using Herbert screws and cancellous bone grafting.

Patients and methods
The study included 16 patients with established nonunion of the scaphoid that was treated using Herbert screw fixation and bone grafts. The average age of the patients at the time of surgery was 30.75 years (ranging from 24 to 38 years). The causes of injury were different, ranging from motorcycle accidents to road traffic accidents, and the majority of cases were the result of falling on outstretched hands and onto dorsiflexed and pronated wrists. Results were evaluated using the modified scaphoid outcome scoring system including assessment of pain, motion and strength of the wrist, occupation with regard to wrist injury, and overall satisfaction with the results of the operation after 12 months of follow-up.

Results
Ten patients had well to excellent results (62.5%), four had fair results (25%), and two had poor results (12.5%). The average range of radial deviation was 18°, the average ulnar deviation was 23°, and the average palmar flexion and dorsiflexion range was 33°. The strength of the power grip on the fractured wrist was lower when compared with the nonaffected wrist. In one patient (12.5%), the fracture failed to unite and hence another operation using a bone graft was required. A hypertrophied scar was observed in two patients (12.5%). Despite the small number of patients, we found that the Herbert screw fixation and bone graft technique is an ideal solution for established scaphoid nonunion.

Conclusion
Bone grafting with Herbert screw fixation is a reliable and successful technique for treating patients with scaphoid nonunions.

Keywords:
bone graft, Herbert screw, scaphoid

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Introduction

The scaphoid is covered by articular cartilage preventing fracture and callus formation [1].

Herbert and Fischer defined delayed union as nonunion of the scaphoid fracture even 6 weeks after injury and established nonunion as nonunion of the fracture even 6 months after injury [2]. Scaphoid fractures are common injuries that result from forced dorsiflexion of the wrist but can be overlooked clinically and radiologically. The time between injury and operation is the major factor predisposing to postoperative nonunion, especially nonunion in the proximal pole [3]. Causes of scaphoid nonunion are as follows: One of three patients with acute scaphoid fracture may have soft-tissue interposition, which may eventually lead to nonunion [3]; nonunion of scaphoid fractures occurs in 5–10% of patients after nonoperative treatment [4–6]; in addition, nonunion occurs because of delay in treatment, inadequate immobilization, fragment displacement, and instability [7]. A symptomatic nonunion of the scaphoid should be treated to prevent osteoarthritis of the wrist joint.

The severity of osteoarthritis is worse in cases of long-standing nonunion of the scaphoid, which is usually localized

to the region between the radial styloid process and the distal part of the scaphoid and which changes progressively to the midcarpal joint; however, the proximal fragment is unaffected. These changes occur in cases of symptomatic and asymptomatic nonunion. Osteoarthritis in cases of complicated nonunion of the scaphoid is classified into three stages: stage 1, degenerative changes in the region of the distal part of the scaphoid and the styloid process of the radius; stage 2, changes extending proximally to the radioscaphoid joint; and stage 3, changes between the scaphoid and the capitate and between the capitate and the lunate [8]. Avascularity of the proximal part of the scaphoid usually developed osteoarthritic changes, especially during the dorsal approach [9].

Blood supply to the scaphoid is primarily through the radial artery to the dorsal ridge of the scaphoid; the branches of the artery enter the scaphoid through the foramina at the dorsal ridge at the level of the waist of the scaphoid [10,11]. Subsequently, these vessels divide and run proximally and palmarly to supply blood to the proximal pole of the scaphoid [10]. Other branches provide 20–30% of the blood flow and appear from the distal palmar area of the scaphoid, arising either directly from the radial artery or from the superficial palmar branch [11,12]. The proximal pole, therefore, is dependent entirely on intraosseous blood flow. This tenuous blood supply can result in a protracted healing process after fracture, with the average healing time of an acute proximal pole fracture ranging from 3 to 6 months [13].

Nonunion may occur in 5–10% of all patients, with an even higher incidence in cases of displaced fractures. Numerous studies document the progression of nonunion to collapse and arthritis [14–16].

Radiological assessment was carried out using standard anteroposterior, lateral, and oblique views with the affected wrist in full ulnar deviation and the forearm in 30° supination. The radiological assessment included the presence of degenerative changes, carpal bone collapse, interscaphoid angle in anteroposterior and lateral views, and failure of hardware and the union. Osseous union of the scaphoid was confirmed on radiographs by the appearance of cross-trabeculation at the site of fracture at least in two views of the standard radiographs that showed trabeculation at the fracture site [2]. MRI is superior to repeated radiographs for detecting an occult scaphoid fracture [17]. Bone scans are sensitive but not specific for diagnosing a scaphoid fracture [18]. Bone scintigraphy has demonstrated 100% sensitivity and 98% specificity for a scaphoid fracture compared with ~65–70% sensitivity for plain radiography [12,19,20]. MRI is considered by many to be the gold standard for detecting scaphoid fractures, with sensitivity approaching 95–100% and specificity approaching 100% [21,22].

Patients and methods

This was a prospective study that included 16 patients with established nonunion of the scaphoid who had been treated in Zagazig University Hospital from August 2007 to December 2009. Open reduction and fixation with Herbert screws and bone grafts was performed for all patients. The patients were examined using preoperative and postoperative radiographs in anteroposterior, lateral, and oblique views. The average age of the patients at the time of surgery was 30.75 years (ranging from 24 to 38 years). The causes of injury were varied, ranging from motorcycle accidents to road traffic accidents, and the majority of cases were caused by falling on outstretched hands onto dorsiflexed and pronated wrists.

The preoperative patterns of management were as follows: neglected treatment for specific scaphoid fractures, inadequate immobilization, and adequate treatment but failure of union.

Evaluation of patients included preoperative and postoperative assessment using the modified scaphoid outcome score system developed by Robbins in 1995 (Table 1): 10 points indicated excellent results, 8–9 points indicated good, 6–7 points indicated fair, and 5 or fewer points indicated poor results [2].

Surgical technique

All patients were operated upon under general anesthesia. The volar approach was used, in which the volar aspect of the wrist joint was approached over the flexor Carpi radials tendon by incision of the capsule and scaphocapitate ligament.

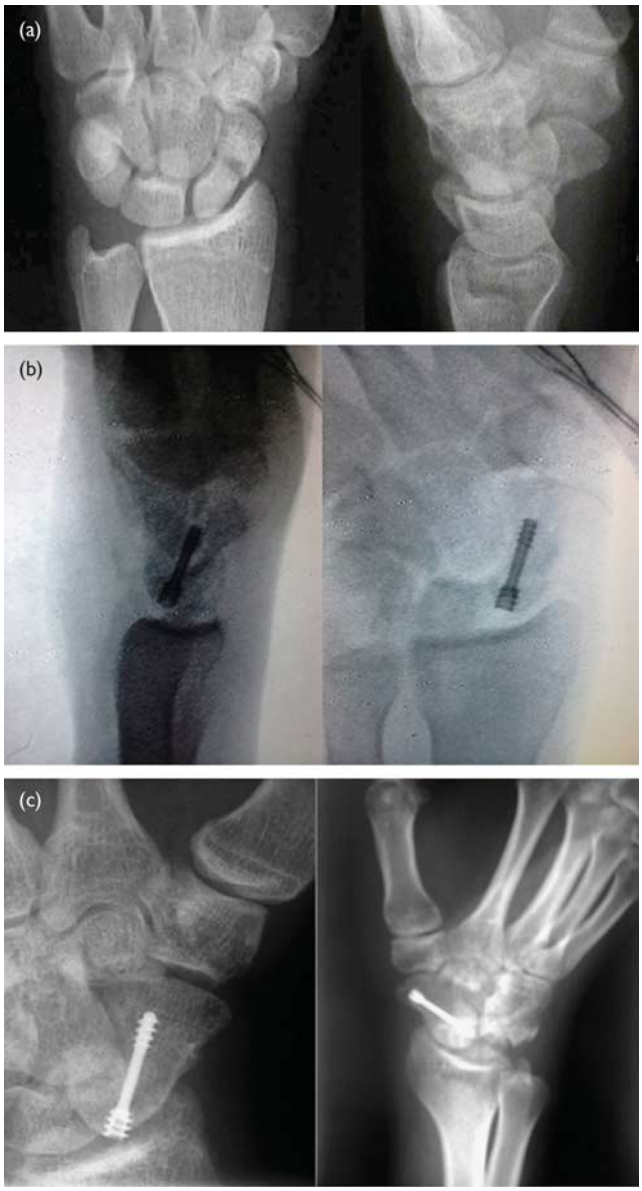
The site of nonunion was identified, fibrous tissue and sclerotic bone ends were excised, and the site of fracture was prepared for the graft taken of the cancellous bone from the iliac crest (Figs 1 and 2).

Reduction of the scaphoid was done without any step or flexion and the graft was placed. Under an image intensifier, the specific guide for the Herbert screw system was applied. Two different sets of drill bits and taps were used, as the Herbert screw has two different diameters from distal to the proximal fragment. The screw was then applied, and stability during range of flexion–extension and radial–ulnar deviation was tested, following which the capsule and the wand were closed (Table 2).

Table 1 Modified scaphoid outcome score system developed by Robbins and Ridge [2]

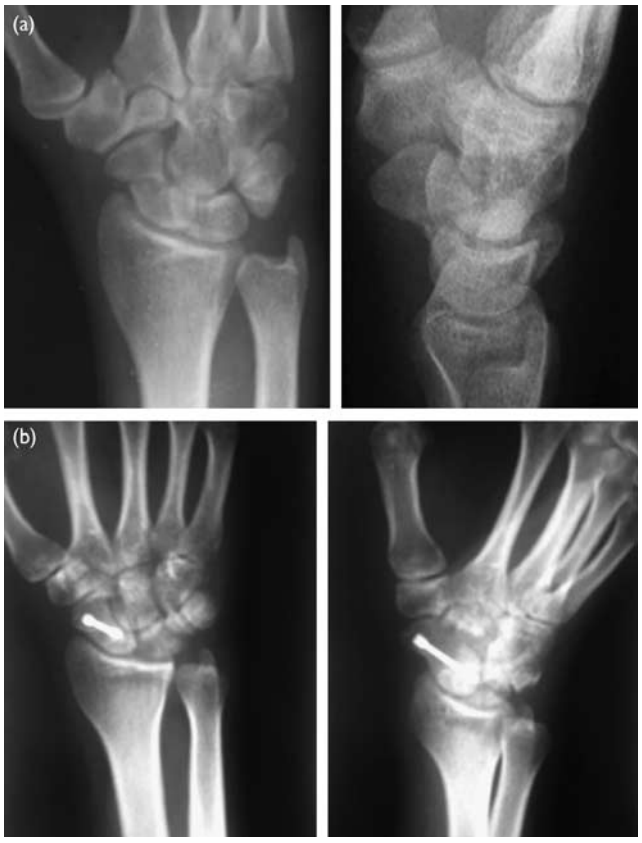
Pain	Points
No pain	4
Occasional ache	3
Ache after work or sport	2
Pain after work or sport	1
Daily pain not associated with activity	0
Motion and wrist strength	
Able to return to preinjury work	2
Unable to return to preinjury work	1
Always limits work or activity	0
Occupation (regard to wrist injury)	
Never limits work or activities	2
Occasionally limits work or activities	1
Always limits work or activity	0
Overall satisfaction with result of operation	
Improved quality of life	2
Did not change quality of life	1
Worse quality of life	0

Figure 1



Case 3: (a) preoperative and (b) intraoperative radiographs. (c) 12 months after surgery with excellent results.

Figure 2



Case 12: (a) preoperative radiograph; (b) 6 months after surgery with excellent results.

Results

According to the criteria of Radford *et al.* [2] for management of scaphoid fractures, 10 patients (62.5%) were treated with a cast for an adequate period of time but their fractures failed to unite after 6 months of treatment, and six patients (37.5%) underwent no treatment. With respect to the range of radial deviation, there was increased range of motion in relation to the study by Jiranek [23,] who used the Russe method of bone grafting, because of early active range of motion and rehabilitation. However, radial deviation decreased in relation to the nonaffected wrist in this study. In this study, the limited average range of degree of radial deviation in the operated wrist in relation to 40° in the nonaffected sides was attributed to the prolonged period of fixation in cast postoperatively and the capsular adhesions that followed the volar approach. In addition, the decrease in the strength of the power grip postoperatively resulted from the use of a cast, as well as because of delayed active range of motion and delayed rehabilitation through physiotherapy. In this study, osteoarthritic changes were observed in four patients (25%), presenting in the follow-up radiograph as subchondral sclerosis and diminished radiocarpal joint space. Union of the scaphoid occurred in 14 patients (87.5%) and persistent nonunion occurred in two patients (12.5%) who required another bone graft. The interscaphoid angle was within the normal range (25–45°) and was measured in anteroposterior and lateral radiographic views: between lines on the volar and dorsal surfaces on the lateral view and between lines on the radial and ulnar sides on the anteroposterior view. Two patients in this study had a hypertrophied scar that needed medical treatment and which improved with time. There was no failure of hardware and no collapse of carpal bones. Excellent results were observed in four patients (25%), good results in six (37%), fair in four (25%), and poor in two patients (12.5%) (Tables 3–5).

Discussion

Nonunited scaphoids can be managed in several ways – bone grafting, kirchner wire (KW) and bone graft, muscle pedicle graft, and vascularized graft – all of it aiming to achieve solid union of the nonunited scaphoid in both

Table 2 Patients data and scoring

Case number	Age (years)	Period between injury and operation (months)	Cast period (weeks)	Follow-up period (months)	Preoperative score	Postoperative score
1	28	9	6	10	4	8
2	30	12	5	6	3	10
3	25	18	9	12	3	9
4	32	24	4	13	5	6
5	38	10	No cast	10	3	10
6	33	13	No cast	9	4	9
7	24	20	6	7	2	3
8	36	12	8	6	3	6
9	30	24	No cast	7	2	3
10	32	12	12	9	4	6
11	33	20	No cast	10	3	9
12	24	13	No cast	6	3	10
13	25	18	6	13	3	6
14	28	9	10	12	5	8
15	36	10	No cast	10	4	9
16	38	20	9	6	3	10
Average	30.75	14.75		9.5	3.3	7.6

Table 3 The overall results

Results	*N* (%)
Excellent	4 (25%)
Good	6 (37%)
Fair	4 (25%)
Poor	2 (12.5%)

Table 4 Modified scaphiod score

Case number	Pain	Motion and wrist strength	Occupation (with regard to wrist injury)	Overall satisfaction with the result of the operation	Total score
1	3	2	2	1	8
2	4	2	2	2	10
3	4	2	1	2	9
4	2	1	2	1	6
5	4	2	2	2	10
6	3	2	2	2	9
7	1	0	1	1	3
8	3	1	1	1	6
9	2	1	0	0	3
10	2	1	2	1	6
11	3	2	2	2	9
12	4	2	2	2	10
13	3	2	1	1	6
14	4	1	2	1	8
15	3	2	2	2	9
16	4	2	2	2	10

Table 5 Postoperative wrist range of motion

Case No	Ulnar deviation	Radial deviation	Arc of ulnar–radial deviation	Palmar flexion	Dorsi-flexion	Arc of dorsipalmar flexion
1	20	25	45	40	45	85
2	35	30	75	45	50	95
3	25	15	40	30	35	65
4	15	10	35	25	20	45
5	30	25	55	50	40	90
6	25	15	40	40	35	75
7	15	15	30	20	25	45
8	20	10	30	15	20	35
9	35	25	75	50	40	95
10	25	15	35	15	45	85
11	15	10	40	45	20	35
12	30	25	30	20	50	45
13	20	15	45	40	35	75
14	15	10	55	30	20	45
15	25	15	30	25	25	65
16	20	30	40	40	35	90
Mean	23	18	43.75	33	33	69.68

symptomatic or asymptomatic patients and prevent osteoarthritic changes in the wrist.

In our study, we performed open reduction and internal fixation using Herbert screws and bone grafts in 16 patients with established nonunited scaphoid fractures.

On comparing the results of our study with those of the study by Warren-smith and Barton on 22 patients using Herbert screw fixation and bone graft, it was observed that the range of palmar flexion and dorsiflexion in our study decreased to 33° in contrast to 65° in the study by Warren-Smith and Barton [23].

Daly *et al.* [24] showed 96% union after treating 26 patients with nonunited scaphoid using Herbert screw and bone grafting, which exceeded the 54.5% union observed in our study using the same technique.

Treating established nonunited scaphoid fractures using the Herbert screw and bone grafting technique has many advantages when compared with bone grafting by the Ruse method:

(1) The technique allows enough fixations to achieve a union without the use of an external splint, as castings prevent or lessen postoperative stiffness and has high functional rate.
(2) It decreases the risk of osteoarthritic changes as the patient can tolerate early range of motion and rehabilitation.

However, the Herbert screw technique has the following disadvantages: the need for an expert surgeon and intraoperative fluoroscopy; destruction and comminution of small fragments; probability of distraction rather than compression with small proximal fragments; and screw serration not crossing the fracture site.

Conclusion

The positive results obtained on using a Herbert screw and bone graft in the treatment of scaphoid nonunion – namely, high rate of union and prevention of postoperative stiffness and postoperative osteoarthritis as patients can tolerate early range of motion and early rehabilitation programs – encourage the use of this technique. Decreased radial deviation postoperatively is of less significance in relation to high rate of union and hence this technique is indicated in all patients with nonunited scaphoid provided that the proximal fragment is large enough to be fixed by the threads of Herbert screws.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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