Comparative study between usage of Herbert screw versus Kirschner wires in the management of nonunited fracture scaphoid

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Purpose This study aimed to compare between the usage of Herbert screw versus Kirschner wires (K-wires) in the treatment of nonunited fractured scaphoid regarding the most effective and less complicating procedure.

Patients and methods It is a retrospective, comparative study that compared the usage of Herbert screw versus K-wires with bone graft from iliac crest in the management of patients with nonunited scaphoid fractures who were admitted in the Department of Orthopedic Surgery in Alzahraa University Hospital during the period from October 2016 to June 2018. Twenty patients were included in the study. Among them, 10 were subjected to internal fixation using Herbert screws, while 10 patients were subjected to internal fixation using K-wires.

Results Patients subjected to K-wires achieved a union rate (80%) superior to patients subordinated to Herbert screw (60%) as a method of internal fixation. Moreover, patients subjected to Herbert screw suffered more complications in the form of impingement with pain and progressive degeneration. Patients subjected to K-wires had a better functional outcome when compared with those exposed to the Herbert screw. In multivariate regression analysis, only male patients appeared to be independent predictors of time to bone healing.

Conclusion A combination of thorough impaction of iliac bone graft, and internal fixation with K-wires, and Herbert screws provides a good option for the treatment of scaphoid nonunion with superiority of K-wires regarding safety, feasibly, and outcomes when compared with Herbert screw especially in the absence of avascular necrosis of the proximal fragment.

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Keywords: Herbert screw, Kirschner wires, nonunion, scaphoid fracture

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Introduction

Scaphoid fracture is the most common form of carpal bone fractures accounting for 60% of carpal injuries owed by the anatomical characteristics comprehending brittle blood supply, low concentration of joint fluids, and deficiency of callus formation [1]. Additionally, the biomechanical features in the form of magnificent shear stress, and dislodged fragments thus contributed to the high incidence of delayed union and nonunion [2,3]. Consequently, delayed or insufficient management can also lead to scaphoid nonunion that was established after 6 months of scaphoid nonhealing [4]. Of date, without surgical treatment, 5–10% of patients developed scaphoid nonunion [5].

The lack or inadequate treatment of scaphoid nonunion will obviously progress to osteoarthritis, pseudarthrosis, and loss of the joint function [6]. The cornerstone of effective management of scaphoid nonunion is based on achieving fracture union, correction of the deformities, retrieve of the anatomical alignment, prevention of carpal collapse, restoring of the joint function, and renewal of the normal activity of the patients [7]. Thereafter, the surgical treatment may provide the optimal choice for these patients. However, the treatment of scaphoid nonunion is associated with a failure rate of 25–45% [8].

The recent tendency in the surgical treatment of scaphoid nonunion focuses on complicated reconstructive procedures such as free vascularized bone graft, and morphogenetic protein, and minimally invasive methods such as injection of bone grafts substitutes using an assisted arthroscope [9,10]. However, the evolved drawbacks and limitation of these techniques as regards the complexity of the technique, long period of immobilization, problems with inadequate graft size, and eventually, it may be inappropriate to the scaphoid due to the curved boat-shaped morphology [3]. Thereafter, the convenient management of scaphoid nonunion is still a debated

question in the literature particularly with the diversity of the fixation methods, screw types, surgical procedures, and different bone grafts [11,12].

This study aimed to compare between the usage of Herbert screw versus Kirschner wires (K-wires) in the treatment of nonunited fractured scaphoid in order to know the most effective and less complicating procedure. The comparison was performed at three time points: pretreatment, immediately after application of the procedure, and 6 months after the application of the procedure.

Patients and methods

It is a retrospective, comparative study that compared the usage of Herbert screw versus K-wires with bone graft from the iliac crest in the management of patients with the nonunited scaphoid fracture. This study was conducted in the Department of Orthopedic Surgery in Alzahraa University Hospital, Faculty of Medicine for Girls, Al-Azhar University during the period from October 2016 to June 2018 and comprehending an overall 20 participants. Among them, 10 patients were subjected to internal fixation using Herbert screw, while 10 patients were subjected to internal fixation using K-wires. IRB approval was obtained from the ethics committees of the Faculty of Medicine for Girls, Al-Azhar University. At the time of enrollment, a written informed consent was obtained from the participants with consideration to Declaration of Helsinki.

Inclusion and exclusion criteria

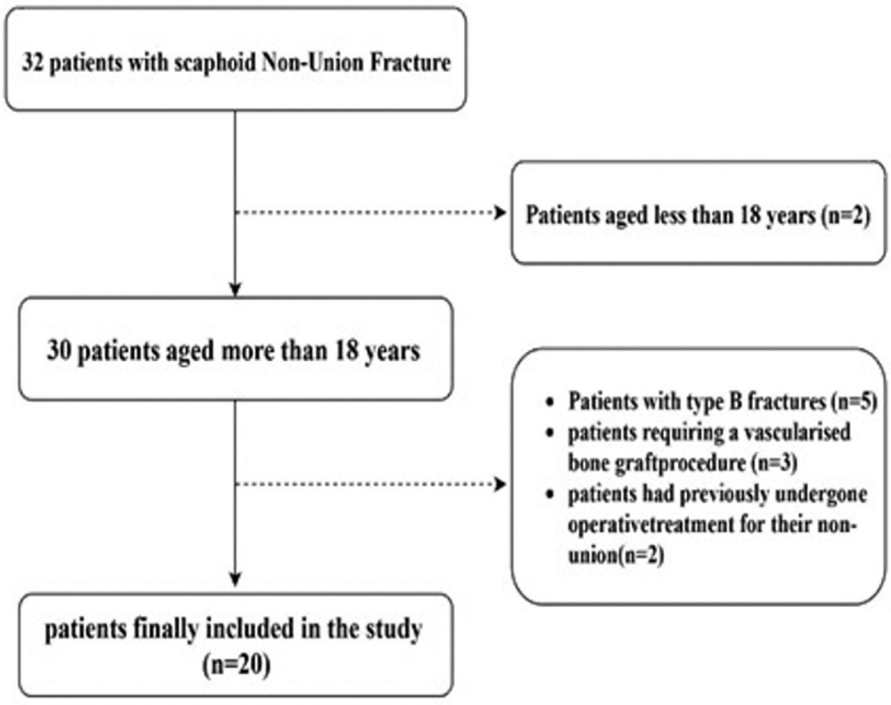
Inclusion criteria were settled to include all patients suffering from scaphoid nonunion without avascular necrosis (AVN) and aged more than 18 years. Five patients with type B fractures (acute fractures <6 weeks), as well as three patients requiring a vascularized bone graft procedure for the treatment of nonunion were excluded. Two patients had previously undergone operative treatment for their nonunion and were also excluded.

Participants with a history of systemic disorders affecting the musculoskeletal system, bone tumors, or bone infection were excluded. We also excluded participants with apparent degenerative changes in wrist bones or radiologically proven scapholunate dissociation from the study. The process of the study selection is shown in Fig. 1.

Data collection

Patients enrolled in the study were subjected to meticulous history taking comprehending the following data: age at the time of injury, sex, BMI, occupation, marital status, mode of trauma, duration between the fracture and surgical procedure, hand dominance, and associated comorbidities such as

Figure 1



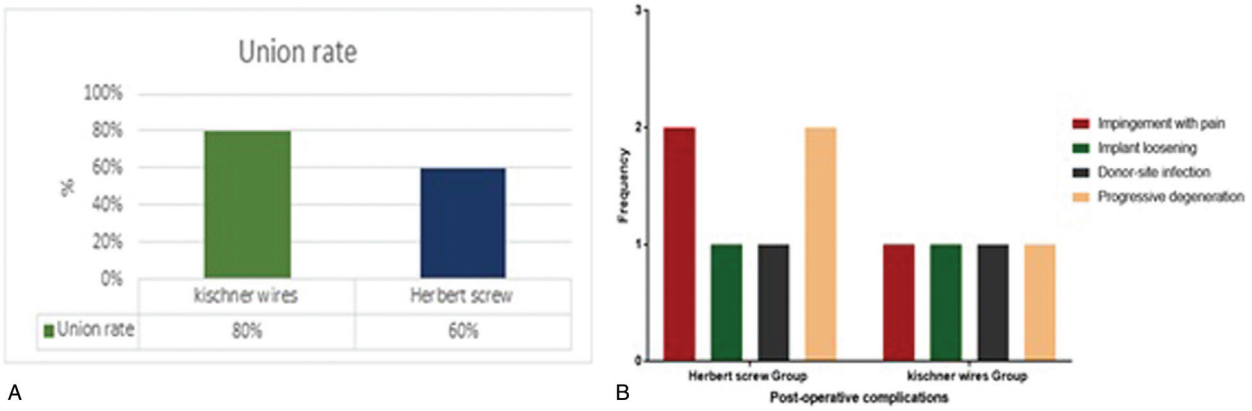
Study flowchart of the patients enrolled in the study.

Table 1 Patients' demographic characteristics

Variables	Herbert screw group (n=10) [n (%)]	Kirschner wire group (n=10) [n (%)]	P value
Age (mean±SD)	28.5±5	29.15±6	0.07
Sex (male/female)	8/2	9/1	0.19
Smoking	6	7	0.94
Type of scaphoid nonunion			
Type D2	7 (70)	8 (80)	0.21
Type D3	3 (30)	2 (20)	0.7
Type of hand dominance			
Right hand	7 (70)	6 (80)	0.31
Left hand	3 (30)	4 (20)	0.6
Mode of trauma			
FOOSH	8 (80)	6 (60)	0.31
Athletic activity	2 (20)	3 (30)	0.6
Motorcycle accident	0 (0)	1 (10)	0.73
Previous treatment			
Plaster of paris	8	9	0.8
Physiotherapy	2	1	0.2
Approach of surgery			
Volar approach	7 (70)	8 (80)	0.08
Dorsal approach	3 (30)	2 (20)	0.2

FOOSH, fall onto an outstretched hand.

Figure 2



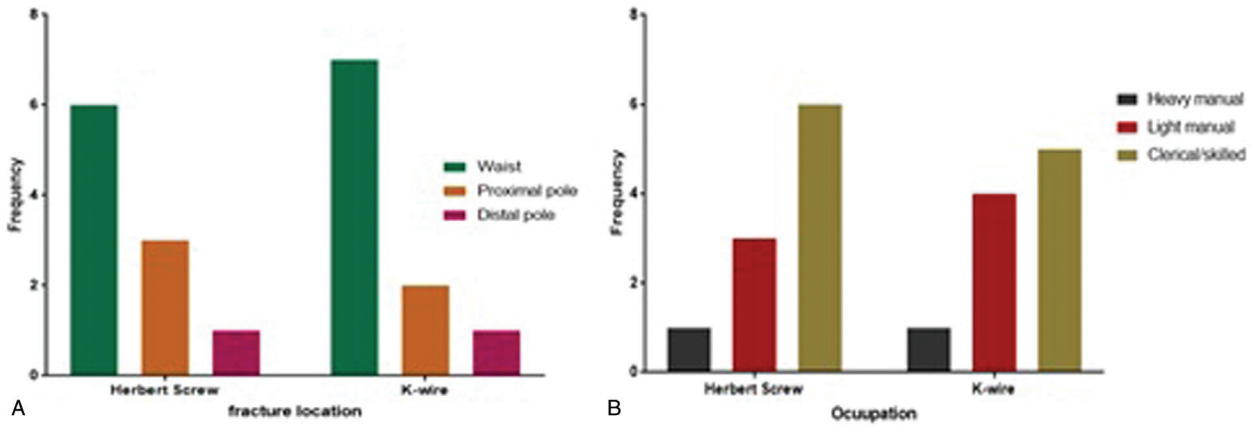
(a) Location of fracture in patients subjected to Herbert screw, and patients subjected to Kirschner wires. (b) Occupation among those subjected to Herbert screw, and patients subjected to Kirschner wires.

hypertension, smoking, diabetes, chronic renal failure, cardiac insufficiency, and previous operations. Furthermore, routine physical examination including general examination, local examination (inspection, palpation, range of motion, and Grip strength), and preoperative assessment using the American Society of Anesthesiologists score. Routine preoperative investigations included complete blood count, random blood sugar, fasting plasma sugar (FPS), coagulation profile, renal functions tests, and liver function test. Eventually, preoperative computed tomography scan, MRI, and four-shot scaphoid radiographs were taken preoperatively, and the fractures were classified according to the modified-Filan and Herbert Classification (1996) [13].

Surgical procedure

All patients were subjected to appropriate anaethesia; 15 cases were done under general anesthesia and five cases were done under brachial plexus block anesthesia. The patient is placed supine on the operating table while placing his or her arm pronated on the hand table. A tourniquet is used but inflated only to 250 mmHg. The Esmarch is not used to exsanguinate the extremity before tourniquet inflation but just elevation of the limb before tourniquet elevation. This will allow better visualization of the donor vessels during operation. The volar approach was used for the distal pole and waist scaphoid fracture nonunion, while the dorsal approach was used for proximal pole fracture nonunion. After insertion of the bone

Figure 3



(a) The union rate in patients subjected to Herbert screw, and patients subjected to Kirschner wires. (b) Postoperative complications among those subjected to Herbert screw, and patients subjected to Kirschner wires.

Table 2 The time of treatment and appearance of outcome

Variables	Herbert screw group (n=10) (mean±SD)	Kirschner wire group (n=10) (mean±SD)	P value
Delay in treatment (months)	7±2	6±1.6	0.45
Immobilization (months)	1.5±0.3	2±0.7	0.03
Time to union (months)	5±1.1	4±0.7	0.06

Table 3 The results of postoperative outcome according to Mayo score

Score	Herbert screw group (n=10) [n (%)]	Kirschner wire group (n=10) [n (%)]	P value
Excellent	5 (50)	7 (70)	
Good	3 (30)	2 (20)	0.07
Fair	1 (10)	1 (10)	
Poor	1 (10)	0 (0)	

Table 4 Multivariate regression analysis to predict the independent predictors of time to bone healing

Variables	β	95% CI	P value
Male sex	–3.23	–5.57 to 1.47	0.01
Age	0.16	–0.08 to 0.32	0.6
Fracture location	0.52	–2.27 to 2.96	0.4
Time to treatment	0.34	–0.011 to 0.001	0.56
Active smoker	0.12	–8.28 to 9.16	0.23
DM	0.34	–6.47 to 4.35	0.45
PVD	1.76	–5.98 to 2.56	0.76

CI, confidence interval; DM, diabetes mellitus; PVD, Peripheral vascular disease.

graft, which was cancellous or corticocancellous in cases of decrease in the scaphoid height, fixation was done using Herbert screw in 10 cases and K-wires in the remaining 10 cases in our study.

Figure 4

(a and b) Preoperative plain radiography of case 1.

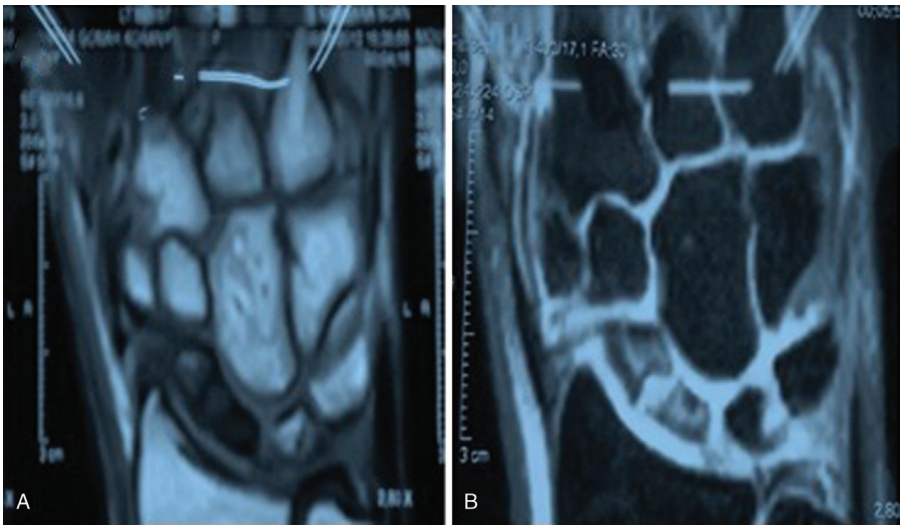
Follow-up

All patients have subjected to the optimal postoperative care such as wound care, and the cast was examined for presence of tightness, unfavorable limitation of finger movement. Furthermore, any complications were managed immediately with appropriate treatment. Moreover, serial radiological examinations every 4 weeks were performed for early examination of fracture reduction, and for early detection of any problems related to K-wires, and Herbert screw position. Consequently, for early detection of late complications, regular clinical, and radiological examinations at the time of union, after 6 months, and at the last follow-up visit. The median follow-up was 20.8 months which ranged from 8 to 28 months.

Statistical analysis

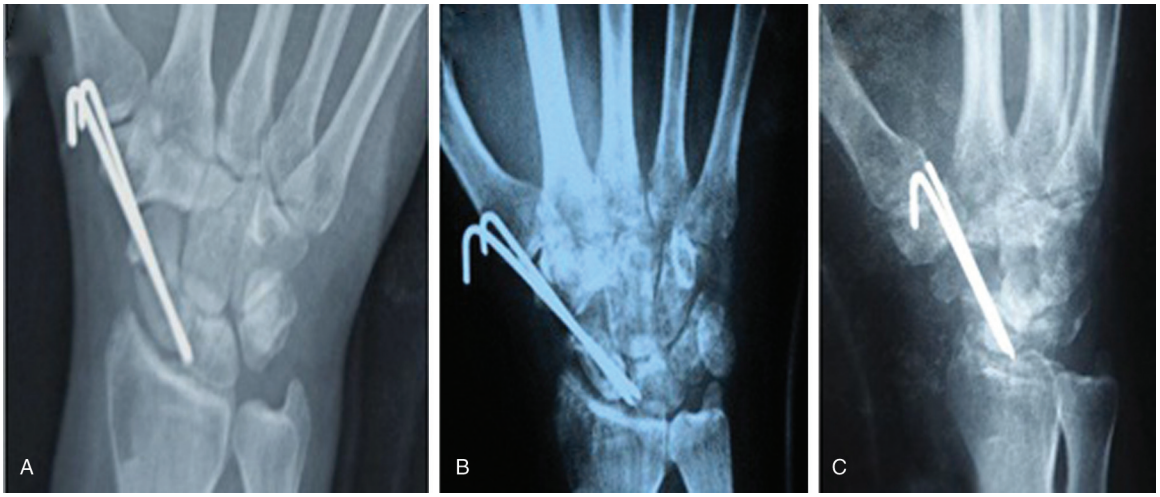
Normally distributed data were elucidated in the form of mean and SD and the particular groups were compared using Student's t-test. On the other hand, nonparametric variables were expressed as median and range, and the

Figure 5



(a and b) Preoperative MRI revealing diminished signal over the proximal fragment of the scaphoid of case 1.

Figure 6



(a) Posterioranterior radiograph early after the grafting procedure. (b and c) Radiograph 10 weeks after the grafting procedure of case 1.

difference between those groups was estimated using Mann–Whitney *U*-test. Moreover, categorical variables were elucidated as number and percentage, and compared using Fisher's exact test and χ^2-test.

Significance was established when P is less than 0.05. Analyses were performed using SPSS v.23 software (IBM SPSS Statistics; IBM Corp, Armonk, New York, USA). Figures were renovated using GraphPad Prism (GraphPad Software Inc., San Diego, California, USA) software version 7.

Results

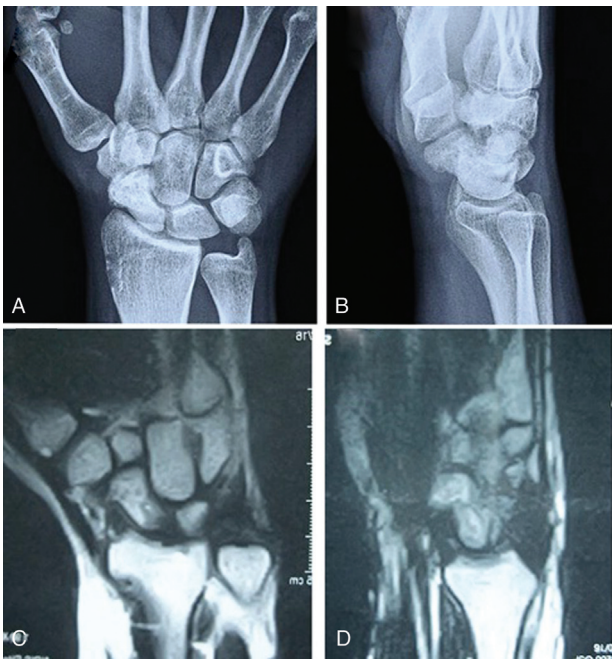
A total of 20 patients were enrolled in the study, 10 patients were subjected to internal fixation using Herbert screw, while 10 patients received K-wires as a method of internal fixation. The mean age was 28.5±5, and 29.15±6 in the Herbert screw group, and the K-wire group, respectively. Of them, 15 patients were of type D2 scaphoid fracture, while five patients were of type D3 fracture. Compulsory hyperextension during axial loading was the major cause of fracture. Fall on outstretched hand was the most common mode of trauma causing the fracture in 14 patients (eight in the Herbert screw group and six in the K-wires group), during athletic activity was found in five patients (two in the Herbert screw group and three in K-wire group), and motorcycle accident was the mode of trauma in one patient in the K-wires group. Patients demographic characteristics are summarized in Table 1.

Having the site of the fracture, the most predominant sites was the waist in 13 patients, followed by the proximal pole in five patients, and distal pole in two patients only (Fig. 2a). Moreover, 11 patients were engaged with clerical or skilled occupation while light manual work was the occupation in seven patients (Fig. 2b). The union rate was significantly higher (P=0.01) in the K-wire group (80%) than the Herbert screw group (60%), in spite of the absence of significant difference between the two procedures regarding the delayed time to treatment (P=0.45), and the time to union (P=0.06). Interestingly, there were significantly lower immobilization time in patients subjected to K-wires (P=0.03) (Fig. 3a and Table 2).

Regarding postoperative complications, only two patients in the Herbert screw group had clinical symptoms of impingement with pain and required surgical removal of the implant. Consequently, one patient in each group experienced loosening of the screw with the absence of bothersome symptoms. Otherwise, progressive degeneration was evolved in three patients. There was no evidence of adverse events at the donor site, comprehending wound infection, injury to the lateral femoral cutaneous nerve, or avulsion fracture except one incidence of superficial infection at the donor site in each group, which resolved with antibiotics (Fig. 3b).

Based on the Mayo score, functional outcomes of the two groups based on the modified-scaphoid outcome scoring system showed that no significant difference was observed between patients subjected to Herbert screw or K-wires (P=0.007) (Table 3). Furthermore, to predict the time to bone healing, multiple regression model was established to assess the independent predictor of time to bone healing and showed that male sex is the only independent predictor of time to bone healing (Table 4).

Figure 7

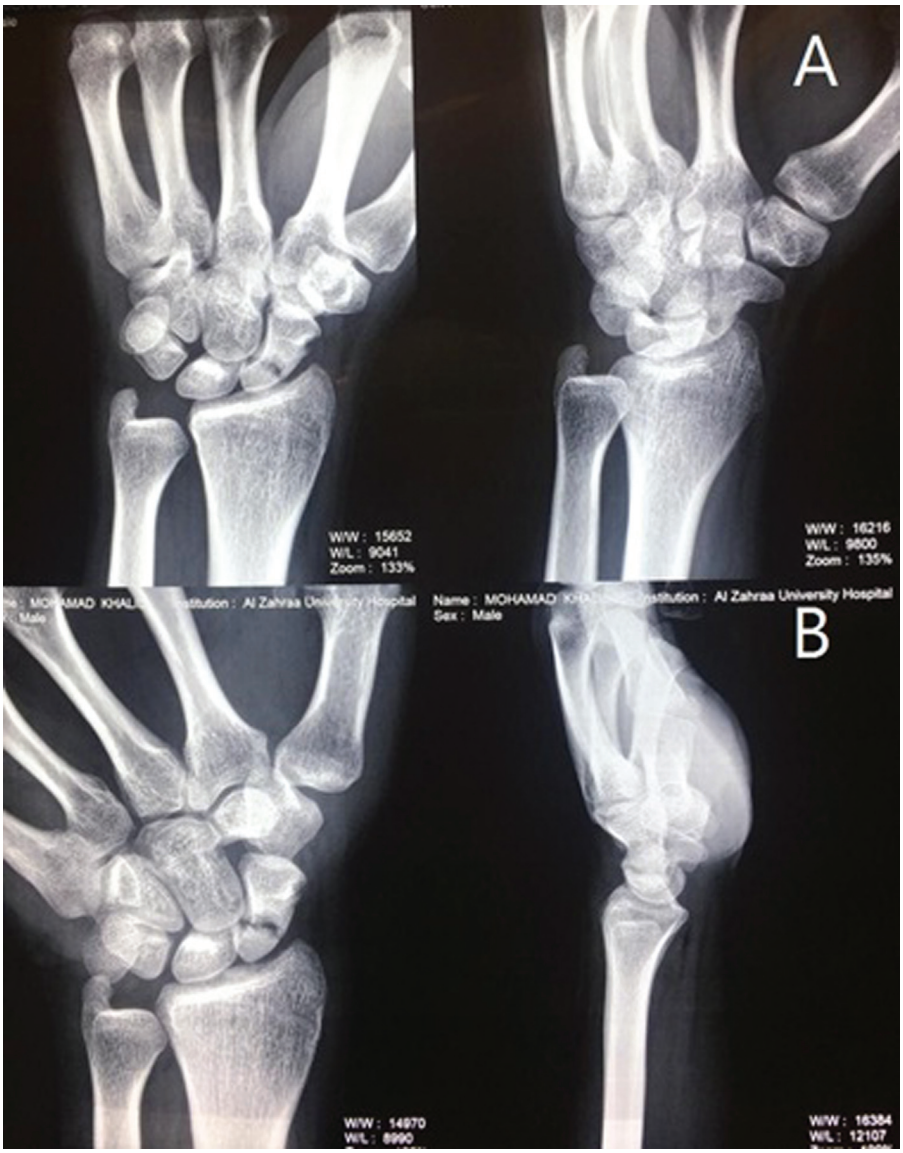


(a and b) Posterioanterior and lateral radiography 6 months after the grafting procedure with complete union of the fracture. (c and d) MRI 6 months after the grafting procedure revealing union of the fracture with improved signal over the proximal scaphoid denoting revascularization of case 1.

Figure 8

Clinical photography of the range of motion of case 1 6 months postoperatively.

Figure 9



Preoperative radiography showing scaphoid nonunion of case 2.

Case presentations

Case 1

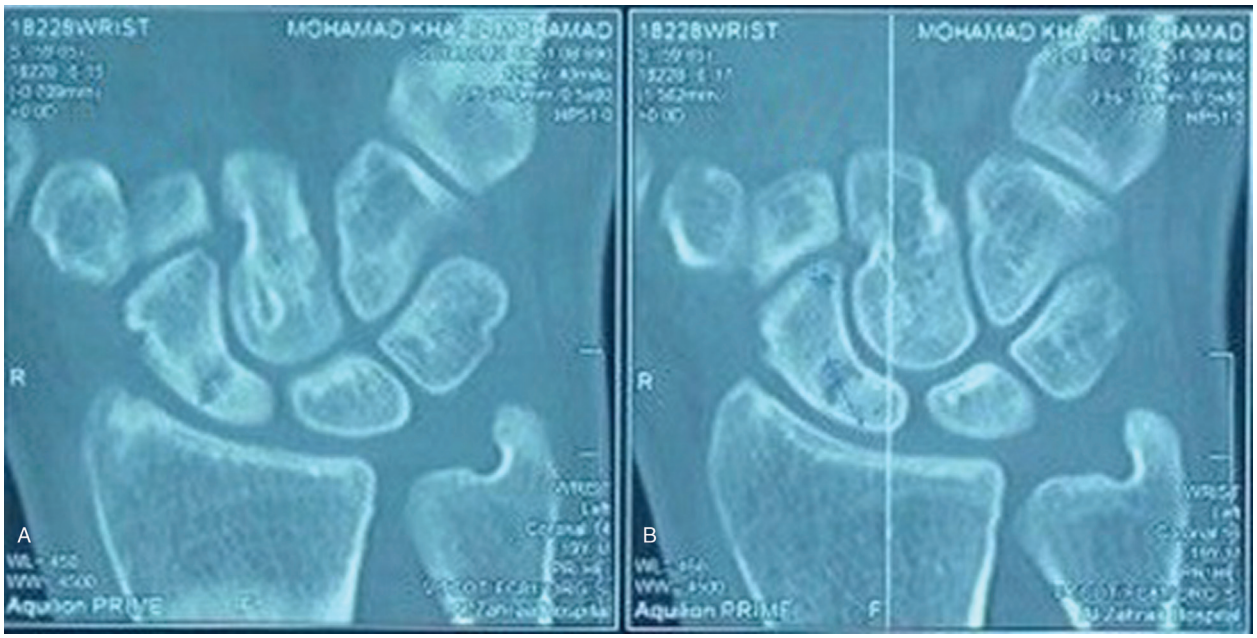
A 27-year-old male student who experienced a hyperextension injury in the wrist during football playing which resulted in scaphoid fracture. He was managed initially by cast immobilization for 6 weeks which was removed without radiography assessment. The patient experienced prolonged wrist complaint after this incident. The nonunion was of the waist fracture. The patient had vascularized bone graft (VBG) with fixation with K-wires, immobilized for 2 months in below elbow slab and after which physiotherapy, range of motion (ROM), and grip strengthening exercises were started. Complete union and full loading achieved at 12 weeks. His postoperative Mayo score improved from fair to excellent (Figs 4–8).

Case 2

A 20-year-old left-handed student was referred to our clinic with a 7-month history of persistent right radial wrist pain after a fall onto his outstretched hand during a football match. He was initially diagnosed with a proximal pole scaphoid fracture and treated with a removable short-arm thumb spica splint. Limitations of movement included inability to lift heavy objects.

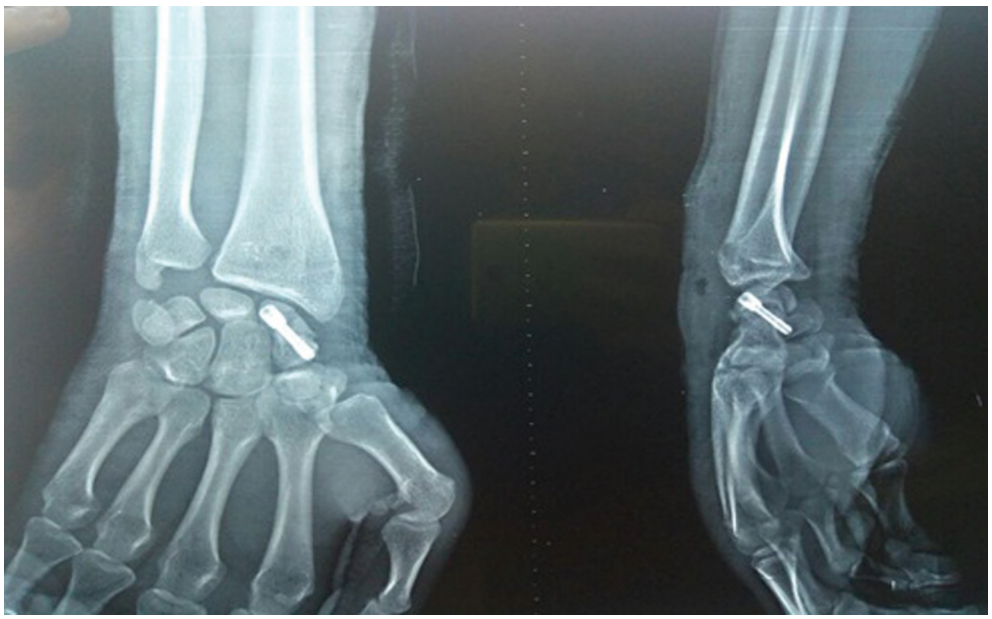
Internal fixation was done using Herbert screw with harvested bone graft from the iliac bone. Postoperatively, a short-arm thumb spica splint with the wrist in neutral position was applied for 2 weeks, followed by a short-arm thumb spica cast for another 4 weeks. At his 9-month follow-up visit, the patient was free of right wrist pain. He had full pronation and supination and a minor lack of wrist flexion and extension of 10° (Figs 9–14).

Figure 10



Preoperative computed tomography shows scaphoid nonunion with cystic formation of case 2.

Figure 11

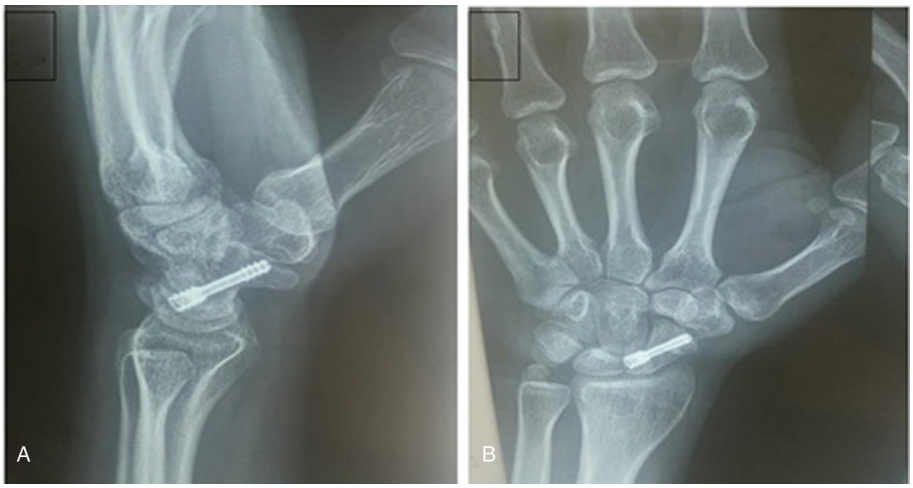


Immediate postoperative plain radiography after bone graft and internal fixation by Herbert screw of case 2.

Discussion

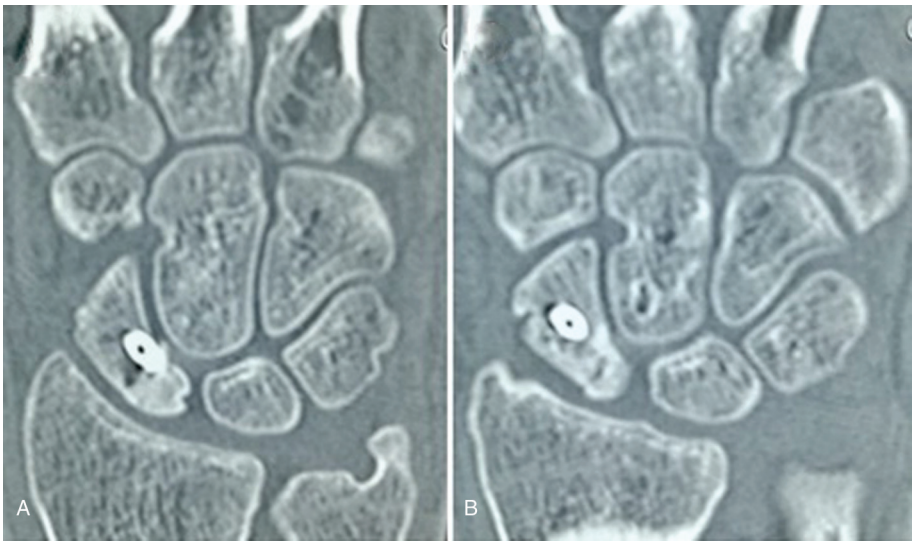
Scaphoid nonunion is one of the most difficult complication of scaphoid fracture that hinders the normal activity of the affected patients with catastrophic sequel especially with inadequate treatment. Thereafter, the established evidence in this study is crucial regarding which procedure, Herbert screw versus K-wires, had the advancement in the management of scaphoid fracture nonunion. This study brings to light that patients subjected to K-wires achieved a union rate (80%) superior to patients subordinated to Herbert screw (60%) as a method of internal fixation. Moreover, patients subjected to Herbert screw suffered more complications in the form of impingement with pain and progressive degeneration. Consequently, based on the modified-scaphoid outcome scoring system, patients subjected to K-wires had a better outcome when compared with those exposed to Herbert screw. In multivariate regression analysis, only male patients appeared to be independent predictors of time to bone healing.

Figure 12



Plain radiography after 6 months shows scaphoid partial union in case 2.

Figure 13



Computed tomography scan after 6 months shows partial union of the scaphoid in case 2.

Having the union rate, our result was concomitant with the previous result. For instance, Meisel *et al.* [6] reported that scaphoid nonunion among patients subordinated to K-wire fixation and iliac crest bone graft achieved excellent union rates when compared with other techniques published in the literature despite the large number of patients that had proximal pole fractures, which established to have a lower union rates [14]. Similarly, Stark *et al.* [15] notified that K-wires achieved high union rate (97%) with mean time to union of 17 months. On the other hand, Christodoulou *et al.* [16] exemplified that K-wires achieved a low union rate (55%) not only when compared with Herbert screw but also when compared with AO 2 mm minifragment screw.

In contrast, despite the advantages of K-wires in the management of patients with scaphoid nonunion, some adverse events may alter the safety and efficacy of K-wires such as protrusion of the wires may lead to skin irritation that deems another surgery for removal of the implants if K-wires pended over the scaphoid bone and used as a permanent method of fixation that did not occur with Herbert screw [17]. Vascularized and nonvascularized bone grafts play an important role in the enhancement of the union rate. Supportingly, Pinder *et al.* [18] conducted a meta-analysis to assess the variety of surgical procedures in the management of scaphoid nonunion and notified a high rate of union of 92%, and 88% in patients who received vascularized and nonvascularized bone grafts, respectively. Nevertheless, the union rate is not the

Figure 14

Clinical photography of the range of motion 6 months postoperatively in case 2.

only absolute criteria for assessing the advancement of either technique [13]. Thus, rejuvenation of the carpal bone anatomy, and the function should be considered.

Despite the evidence established in this study, the small sample size, the heterogeneity between the patient's characteristics, and the retrospective nature of the study may alter this evidence.

Conclusion

A combination of thorough impaction of iliac bone graft, and internal fixation with K-wires, and Herbert screw provides a good option for treatment of scaphoid nonunion with superiority of K-wires regarding safety, feasibly, and outcomes when compared with Herbert screw especially in the absence of avascular necrosis of the proximal fragment. However, high-quality RCTs are required to overcome the limitation of the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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