Dorsal percutaneous screw fixation of delayed scaphoid fractures augmented with bone marrow injection

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Background
The management of delayed scaphoid fractures in physically demanding patients remains controversial. This article discusses a simple treatment that accelerates healing and allows early mobilization.
The purpose of the study was to evaluate results of percutaneous headless compression screw fixation with bone marrow injection in scaphoid delayed-union fractures, which allows early mobilization of wrist to achieve early return to activities of daily living (ADL).
Patients and methods
A total of 20 patients (22 scaphoid) with scaphoid delayed-union fractures underwent percutaneous headless screw fixation with bone marrow injection from iliac bone. The inclusion criteria in this series were scaphoid delayed-union fractures with intact cartilaginous envelope, no sclerosis, and no avascular necrosis.
Results
The mean follow-up period as 20.4 months (range: 12–24), the average radiographic union was 7.8 weeks (range: 6–10 weeks), and the average visual analog scale score was 0.05 (range: 0–1). Average wrist range of motion was flexion of 85° (range: 75–90), extension 76.5° (range: 70–85), radial tilt 18.5° (range: 15–20), and ulnar tilt 42.5° (range: 39–45). The average grip strength was 95% (85–100%).
Conclusion
Percutaneous technique fixation for scaphoid fractures is a reliable and less harmful method and helps in early return to activity. The dorsal approach allows proper screw positioning and allows the use of hook to correct minimal displacement and gain best compression at the fracture site. Refreshing of the fracture ends by k-wire and bone marrow injection help to accelerate union with the less-invasive method. The best results of the percutaneous technique in delayed-union scaphoid fractures are achieved with intact cartilaginous envelope, no sclerosis, and no avascular necrosis.
Level of evidence
This was a level IV therapeutic study.

Keywords:
bone marrow injection, nonunion, percutaneous fixation, scaphoid fixation, scaphoid fractures

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Introduction

Fractures of the scaphoid are the most common carpus fractures and second in occurrence among fractures of the wrist [1]. Early diagnosis of scaphoid fractures is important as delay in diagnosis can lead to complications such as nonunion, avascular necrosis, carpal collapse, and subsequently, a predictable pattern of arthrosis. The standard method for treatment of scaphoid nonunion is an open approach for deformity correction, bone grafting, and rigid internal fixation [2,3]. Percutaneous screw fixation has been advocated by many authors for minimally displaced acute scaphoid fractures and now for displaced scaphoid fractures [4].

If the fracture scaphoid is neglected or misdiagnosed, nonunion will occur that progresses to radiographic and symptomatic osteoarthritis of the wrist. This will lead to morbidity and lifelong disability, especially in manual workers, in whom the wrist range of motion and hand grip are very important [5].

Patients and methods

Between April 2014 and April 2016, 20 patients with 22 scaphoid delayed-union fractures were treated with dorsal percutaneous screw fixation and bone marrow injection. A fully informed consent was obtained from each patient in this study. The inclusion criteria were

delayed-union scaphoid fracture with intact cartilaginous envelope according to Herbert classification type C, no cyst or sclerosis, and no avascular necrosis.

There were 14 males and six female patients, with an average age of 29 years (range: 20–42 years). There were 10 dominant-side fractures and eight nondominant-side fractures and two bilateral fractures. History of trauma included in 17 patients. Treatment was done in 13 patients in the form of short arm thumb spica for an average of 6.5 weeks (from 4 to 9 weeks).

The average duration of delayed union was 3.5 months (range: 2.5–5 months) (Table 1). Clinically all patients complained of wrist pain that affects their daily activity and functional tasks. The pain was analyzed according to the visual analog scale pain score (VAS).

Average VAS score preoperative was 8.02 (range: 6–10). The average flexion was 51° (from 50 to 70), extension was 63.5° (from 50 to 75), radial tilt was 10.9° (from 7 to 16), and ulnar tilt was 30.2° (25–40). The grip strength was measured by asking the patient to squeeze as hard as he could the partially inflated rolled sphygmomanometer cuff at 20 mm of mercury. The average grip strength was 61.7% of the sound side (range: 50–70%).

All patients that have a duration of delayed union from 2.5 to 3 months did computed tomography bony scan to assess union (Fig. 1).

Table 1 Patients data

Patient ID	Age	Sex	Affected side	History of trauma	Casting	Duration of delayed union in months
1	21	M	D	√	–	2.5
2	24	M	D	–	√	3
3	27	M	N	√	√	2.5
4	32	M	Bil	√	√	2.5
5	33	M	N	√	–	4.5
6	20	M	N	√	√	5
7	35	F	D	√	–	3.5
8	39	M	D	–	–	3
9	22	F	N	√	√	3
10	21	F	N	√	√	4
11	40	M	D	√	–	5
12	30	M	D	√	√	4
13	29	F	D	√	√	3
14	42	M	N	√	√	3.5
15	24	M	Bil	√	√	3
16	22	M	D	√	√	4.5
17	27	M	N	√	–	3.5
18	31	F	N	–	√	4
19	34	F	D	√	–	3
20	26	M	D	√	√	3

F, female; M, male.

Figure 1

Fracture of the scaphoid of 3-month duration. (a)/ Anteroposterior radiographic view; (b) lateral view; and (c) oblique view.

Patients were placed in a supine position after general anesthesia. A Herbert headless screw system is used. A guide wire is laid along the skin under image intensification (Fig. 2), and the skin was marked. The wrist was hyperflexed, and a small stab transverse incision was placed over the dorsal and proximal edge of the scaphoid. With a small hemostat, the stab was carefully developed until the bone was felt, to avoid injury to the extensor tendons and the superficial branch of the radial nerve (Fig. 3). A guide wire was passed along the medullary canal of the scaphoid (Fig. 4), and its position was checked meticulously from several directions with a C-arm. After guide wire placement, a cannulated drill and tap was used by hand (Fig. 5).

Bone marrow aspiration was taken from the iliac bone by an assistant while doing drilling the scaphoid (Fig. 6); about 3–5 ml was taken. Refreshing of the fracture ends was done by small k-wire under c-arm guide from snuff box, avoiding the superficial radial nerve, and then an injection is done at the fracture site and through the drill site. A small hook (Fig. 7) was used through a separate incision at the distal pool to correct alignment, prevent rotational deformity during screw insertion, and allow resistance against screw insertion to gain maximum compression (Fig. 8). Placement of the screw of appropriate length was done (Fig. 9). Suturing of the wounds was done (Fig. 10), and a splint over the wrist was placed.

The splint was removed about 2–3 weeks postoperatively. Early active range of motion was started with restriction of lifting or working with hand for 3 weeks. Then, follow-up was done at 3, 6, and 12 months postoperatively.

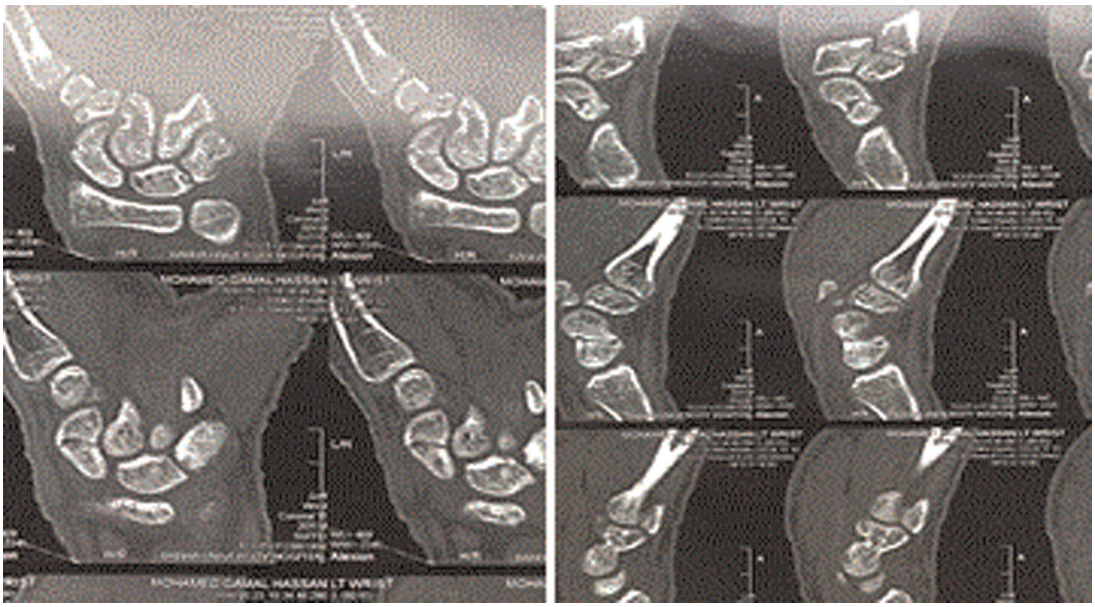
Ethical approval

All procedures performed in this study involving human participants were in accordance with the Ethical Standards of the Institutional and National Research Committee. Informed consent was obtained from all individual participants included in this study.

Figure 3

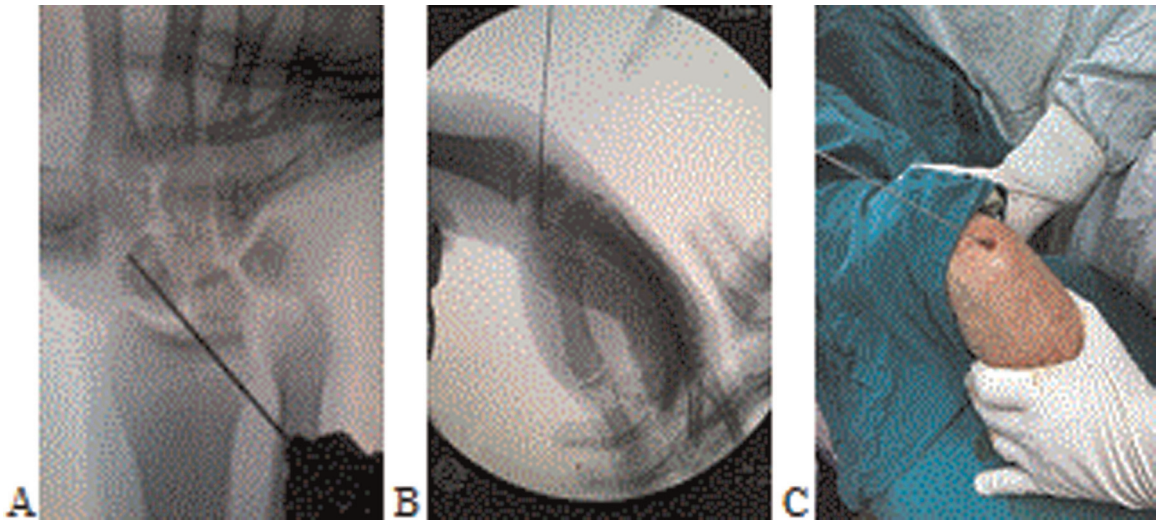
Small incision is made over dorsal approach with flexed wrist.

Figure 2



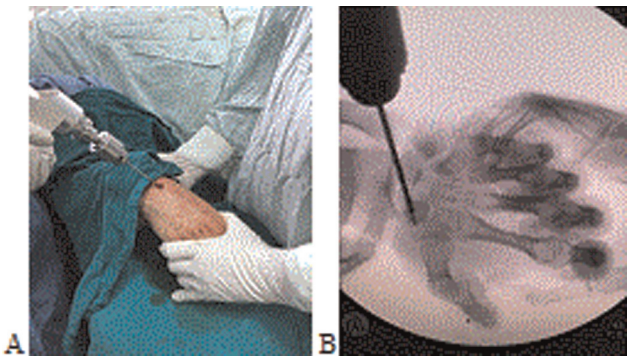
Computed tomography scan of the fracture showed: no sclerosis and no deformity with delayed union.

Figure 4



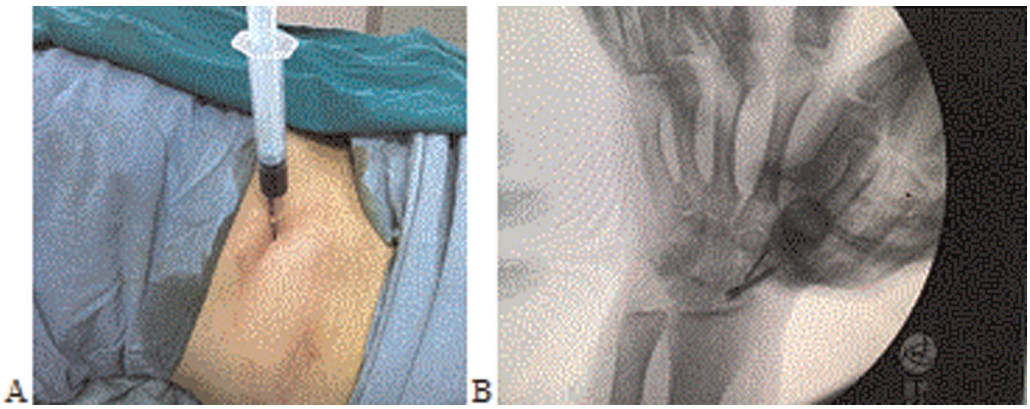
Guide wire passed along the medullary canal of the scaphoid: (a) anteroposterior view; (b) lateral view; and (c) clinical view.

Figure 5



Cannulated drill and tap is used by hand. (a) Clinical view and (b) anteroposterior view from c-arm.

Figure 6



Bone marrow aspiration and injection before and after screw insertion. (a) Clinical view and (b) anteroposterior view from c-arm.

Result

The mean follow-up period 20.4 months (range from: 12 to 24). Almost all fractures united successfully with no additional procedures, except for one fracture in the patient number 4, a 32-year-old male with bilateral fracture scaphoid, where the right side united within 8 weeks, but the left side proceeded to nonunion and

needed re-surgery with open bone graft after 9 weeks (Figs 11 and 12). These fractures achieved radiographic union at an average of 7.8 weeks (range: 6–10 weeks) postoperatively.

The average VAS score at the final follow-up was 0.05 (range: 0–1). The average wrist range of motion was flexion of 85° (range: 75–90), extension 76.5° (range: 70–85), radial tilt 18.5° (range: 15–20), and ulnar tilt 42.5° (range: 39–45).

Figure 7

A small hook.

Grip strength regained at an average of 95% (85–100%) in comparison with the other side.

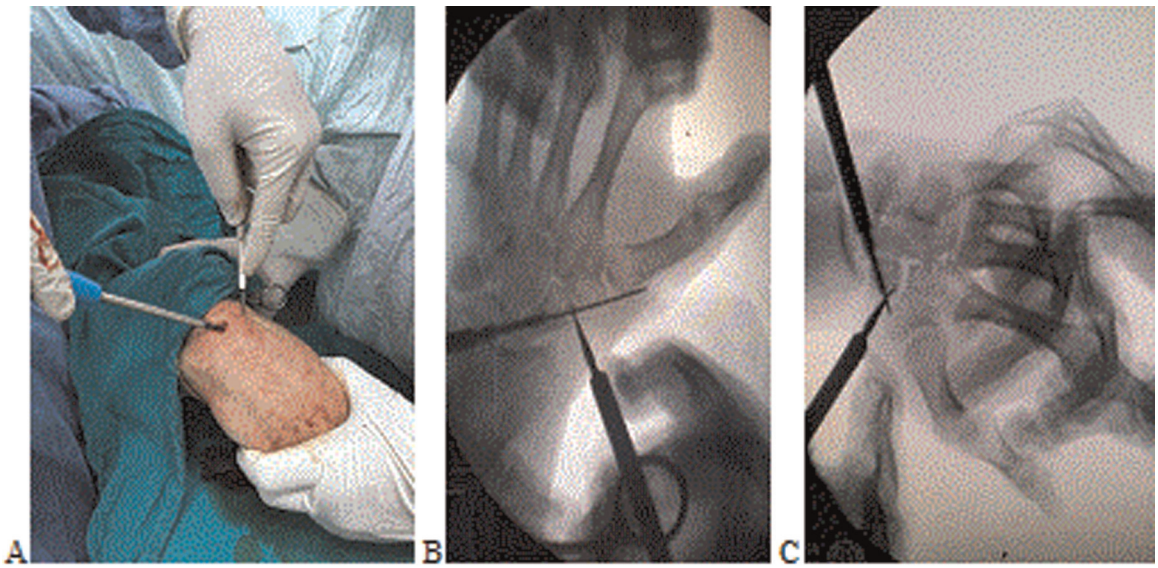
Patient number 6, a 20-year-old male, presented with left delayed united fracture since 5 months with a small cyst in the proximal part (Fig. 13). We decided to proceed with the same technique as the cyst was small and there were no other signs of nonunion or avascular necrosis (AVN) (Fig. 14).

Union was achieved at the seventh week and had satisfactory results by 11th week (Figs 15 and 16).

Complications

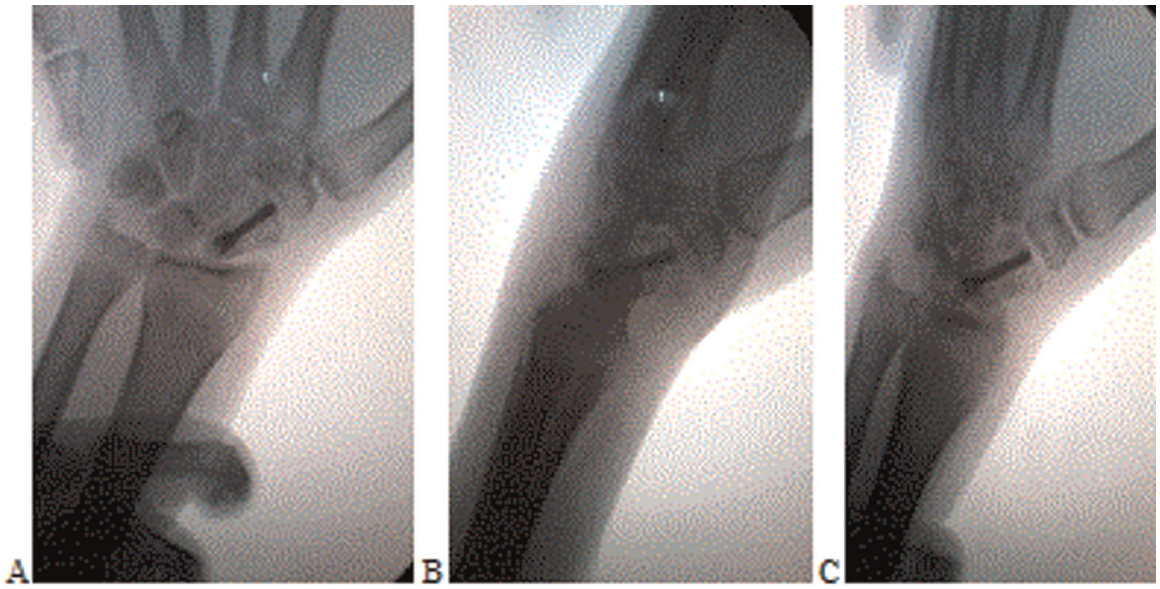
All our patients had satisfactory results. A total of 21 fractures fully united without additional maneuvers, and one fracture proceed to nonunion and need re-surgery with open graft and fixation. This fracture was in patient number 4 with bilateral fracture of the scaphoid 2.5 months ago (Figs 11 and 12). He had conservative treatment for 9 weeks in the form of short cast. Dorsal percutaneous fixation with bone marrow injection was done for the both sides. The right side united within 8 weeks, but the left side proceeded to nonunion with screw intra-articular penetration at 6 weeks postoperatively. We explain the cause of failure in union owing to improper compression in fracture site and improper screw length, as we did not use the hook in the first four cases and used manual compression from the thumb against screw insertion. However, after this case, we decided to use the hook to achieve best compression and alignment, and all cases after this modification had no complications.

Figure 8



A small hook used through a separate incision at the distal pool to correct alignment and allow resistance against screw insertion to gain maximum compression. (a) Clinical view, (b) anteroposterior view from c-arm, and (c) oblique view from c-arm.

Figure 9



Placement of the screw of appropriate length. (a) Anterioposterior view; (b) lateral view; (c) oblique view.

Figure 10

Suturing the wounds.

Discussion

Cast treatment for scaphoid fractures is considered reliable and inexpensive, but disadvantages of cast are longer immobilization time, joint stiffness, reduced grip strength, and longer time to return to manual work [6,7].

Many studies have shown that delayed and nonunion of scaphoid fractures are better to be treated with internal fixation [8]. Open approaches, either dorsal or palmar, have serious problems such as soft tissue stripping, damage to ligaments (radioscaphocapitate and radiolunate ligaments) leading to instability, injury to the already damaged blood supply leading to AVN, infection, reflex sympathetic dystrophy, painful scar formation, and stiffness [9].

So, a trend toward percutaneous fixation of scaphoid fractures became popular by many authors [10]. Comparison between palmar and dorsal percutaneous fixation has no difference in terms of union, time, and clinical outcome, and the dorsal approach allows more precise placement of the screw [9].Adolfsson *et al.* [11] compared the outcomes of percutaneous fixation alone with immobilization in a long scaphoid cast. The fixation group consisted of 25 patients. The fixation group was immobilized with a cast for 3 weeks and a removable splint for a further 3 weeks. Results showed a significantly better range of motion in the fixation group but no differences in union rate (average 10 weeks) or grip strength.

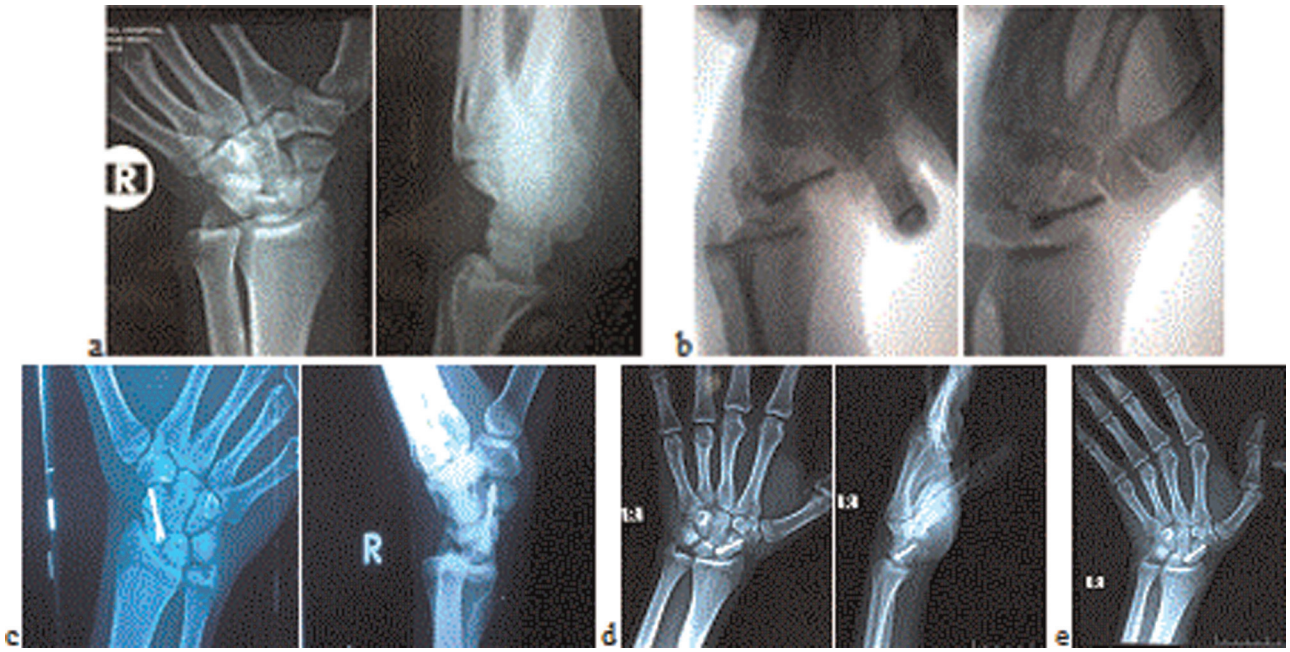
Galal [4] evaluated the results of volar percutaneous headless compression screw fixation without bone grafting in 21 patients with scaphoid waist delayed and nonunion fractures. The fractures achieved radiographic union at an average of 4 months.

Taskin *et al.* [9] evaluated 33 consecutive scaphoid delayed unions or nonunion treated by dorsal

percutaneous fixation only. Union was achieved at an average of 10 weeks.

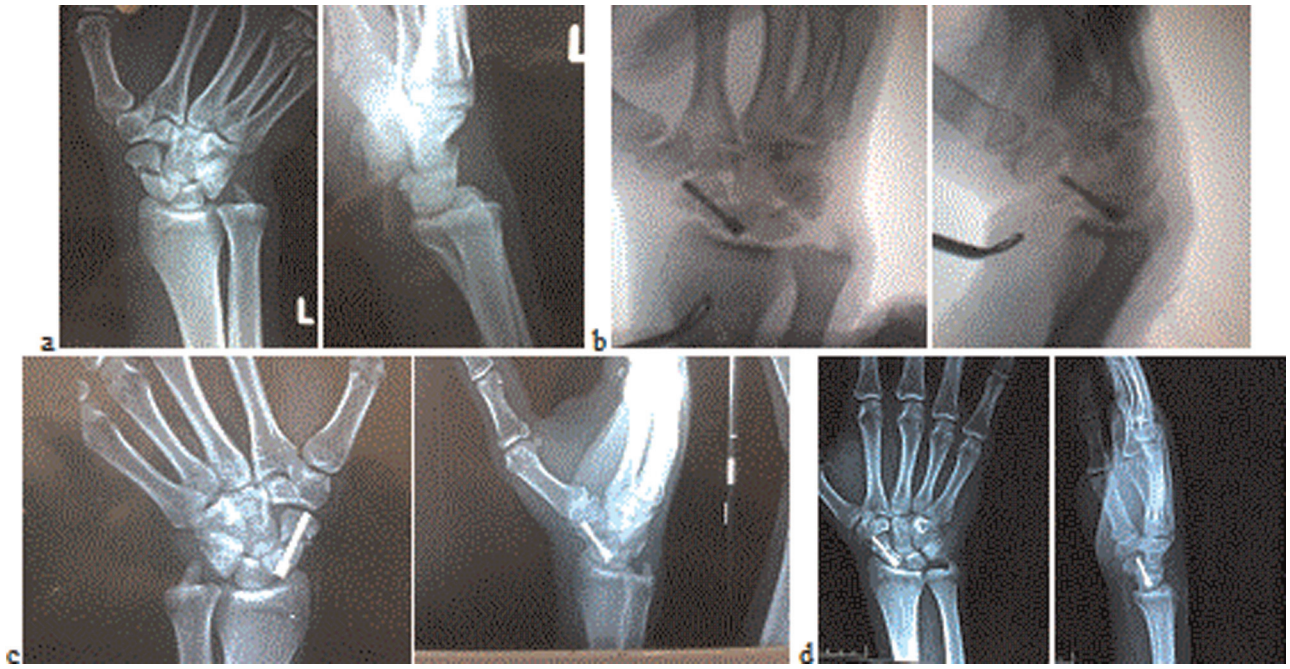
In this study, there were 22 delayed-union scaphoid fractures with intact cartilaginous envelope, minimal fracture line, no sclerosis, no avascular necrosis. We perform dorsal percutaneous fixation with refreshing fracture ends and bone marrow injection. Union achieved at an average of 7.8 weeks (6–10). The patients' satisfaction was high. Our good results were achieved through percutaneous fixation (less invasive), refreshing fracture ends, bone marrow injection

Figure 11



(a) Delayed union right scaphoid 2.5 months. (b) Intraoperative c-arm photo. (c) Four weeks postoperative: signs of union. (d) Six weeks postoperative: uniting. (e) Eight weeks postoperative: good union.

Figure 12



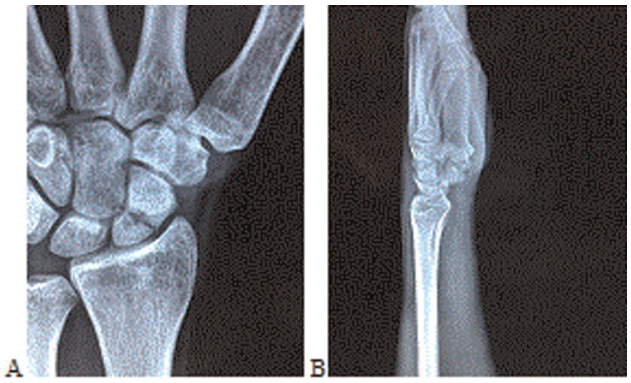
(a) Delayed union left scaphoid 2.5 months. (b) Intraoperative C-arm photo. (c) Four weeks postoperative: no signs of union. (d) Six weeks postoperative: nonunion with collapse and intra-articular screw penetration.

(accelerate healing process), use of hook while inserting the screw (good compression at fracture site), and early mobilization of wrist (decrease immobilization hazards).

Conclusion

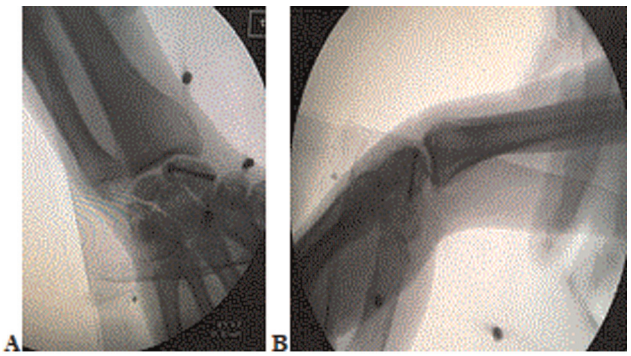
Percutaneous technique fixation for scaphoid fractures is a reliable and less harmful method and helps in early return to activity. The dorsal approach allows proper screw positioning and allows the use of hook to correct minimal displacement and gain best compression at the fracture site. Refresh fracture ends by k-wire and bone marrow injection help to accelerate union with less invasive method. The best results of percutaneous technique in delayed union scaphoid fractures are with intact cartilaginous envelope, no sclerosis, no avascular necrosis.

Figure 13



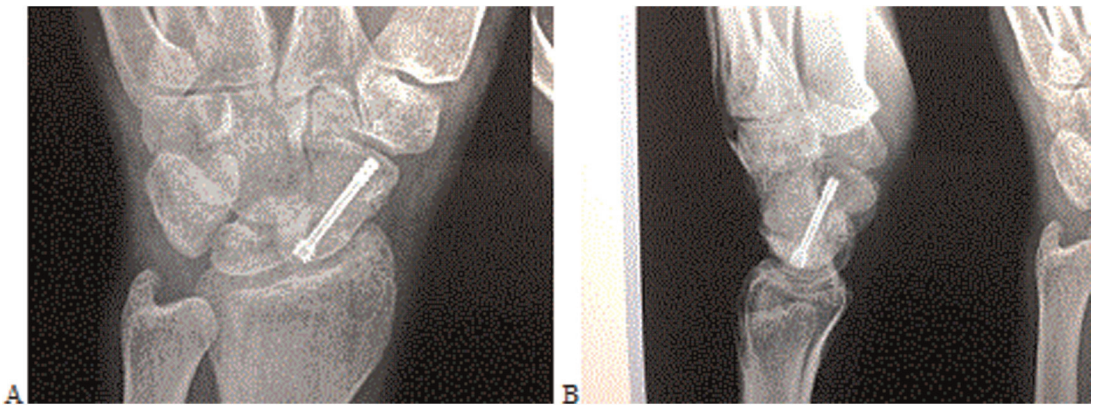
Delayed union scaphoid 5 months duration. (a) Anterioposterior view; (b) lateral view.

Figure 14



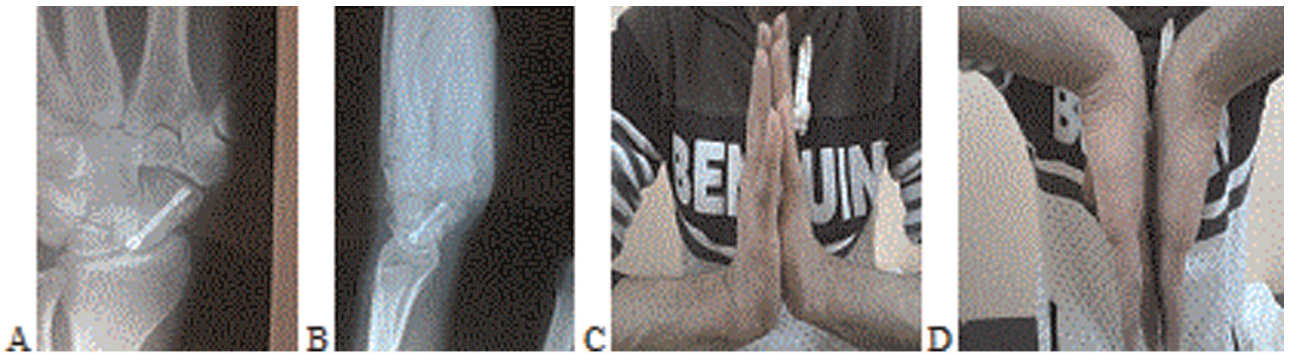
Intraoperative C-arm photo. (a) Anterioposterior view; (b) lateral view.

Figure 15



Seven-week postoperative, sound union achieve. (a) Anterioposterior view; (b) lateral view.

Figure 16



Eleventh-week postoperative. (a) Anterioposterior view; (b) lateral view; (c and d) range of motion.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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