Percutaneous screw fixation with bone marrow injection in delayed fracture scaphoid, is it effective: a randomized control study

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Background
Scaphoid is the most commonly injured carpal bone, with over two-thirds of scaphoid fractures occurring at the waist. The anatomy of the scaphoid makes these injuries susceptible to delayed unions or nonunions and can lead to significant morbidity and disability.
Aim
To evaluate the effect of bone marrow injection on bone healing in delayed presented fractures of scaphoid with percutaneous fixation via Herbert screw.
Patient and methods
Forty patients with delayed presented scaphoid fractures treated with percutaneous screw fixation and divided into two groups, group A augments the fixation with bone marrow injection, while group B suffices with fixation only.
Results
All fractures had complete union, but there is a significant acceleration in bone healing in group A than in group B with *P* value less than 0.05. This is reflected in the other results for group A, according to Mayo wrist score, we have 17 excellent and three good results, while in group B, there were 15 excellent, four good, and one patient with poor results due to nonunion that occurred.
Conclusion
The use of bone marrow is considered a simple and minimally invasive technique. It is safe and has no risk, so we recommend use of bone marrow injection with fixation of delayed presented fractures of scaphoid.

Keywords:
bone marrow aspirate concentrate, delayed union, platelet-rich plasma, scaphoid fractures

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Introduction

Scaphoid fractures are the most common carpal injuries, and their management can be challenging for the orthopedic surgeon [1].

Early and accurate diagnosis are important to improve management outcomes. These injuries are commonly missed and mismanaged. Delay of even 4 weeks for treatment will lead to significantly higher rates of delayed union and nonunion [2]. Percutaneous fixation of scaphoid fractures advocated by a lot of authors for minimally displaced acute scaphoid fractures and now for displaced scaphoid fractures, to achieve fracture stability and higher union rates than conservative methods [3].

Healing problems such as delayed union and nonunion still occur in ~15% of patients post fixation. Optimal healing potential involves an interplay of biomechanical and biological factors [4]. Bone marrow aspirated from iliac bone is rich in stem cells, growth factors, and other active substances and represents a novel osteo-inductive therapy that is valuable as an adjunct of bone healing [5].

The aim of this study is to evaluate the effect of bone marrow injection on bone healing in delayed fractures of scaphoid with percutaneous fixation via Herbert screw.

Patients and methods

Between December 2016 and May 2020 40 patients with 40 delayed presented scaphoid fractures treated with percutaneous screw fixation via dorsal and volar approaches. Ethical approval taken from our institustion with approval number Rc.43.10.2022. The patients were randomly divided into two groups, 20 fractures augmented with intraoperative bone marrow injection (group A) while others suffice by fixation only (group B). The process of randomization was done via sealed opaque envelopes in which the allocation group

was stated inside each envelope. The patients were blinded to their treatment assignment, a full informed consent was obtained from each patient in this study. The inclusion criteria were delayed presented scaphoid fractures not exceeding 6 months with intact cartilaginous envelope according to Herbert classification type A2, B1, and B2, no flexion deformity of scaphoid.

In group A, there were 15 males and five female patients with mean age of 30 years (range, 20–40 years), while in group B, there were 14 male and six females with mean age 25.5 years (range, 20–35 years).

There were 13 dominant-side fractures and seven nondominant-side fractures in group A with fracture type A2 three patients, type B1 two patients, and type B2 15 patients, while in group B were 15 dominant-side fractures and five nondominant-side fractures with fracture type A2 four patients, type B1 five patients, and type B2 11 patients. Some patients give history of cast application for weeks after injury and others do not.

All patients who have painful wrist motion affects their daily activity and functional tasks, the pain assessed according to visual analog scale pain score (VAS).

In group A, the average VAS score was 8 (range, 6–10) and in group B it was 7.9 (range, 6–10).

The grip strength assessed by squeezing as hard as a patient could partially inflate a rolled sphygmomanometer cuff at 20 mm of mercury by each hand and measure the percentage between healthy and affected sides.

Grip average in group A was 55.7% of sound side (range, 50–65%) and in group B was 56% of sound side (range, 50–70%).

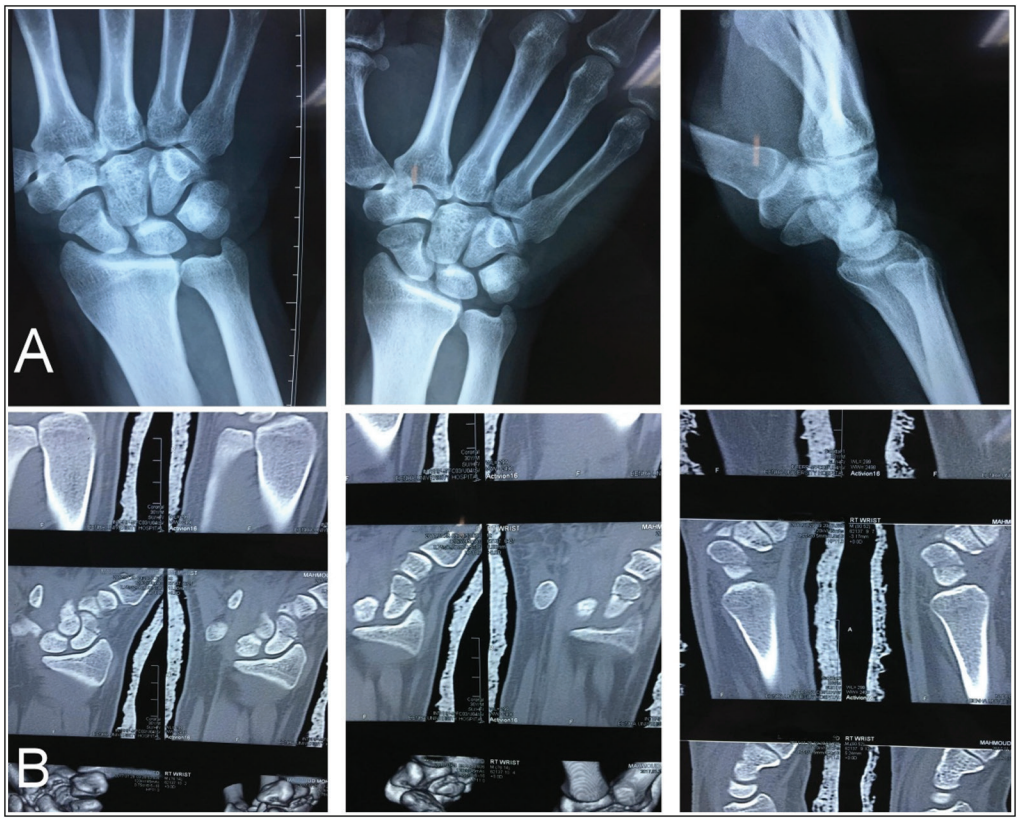
All patients included in our study in both groups have no medical problems and nonsmokers and have no special habits of medical importance.

All patients did computed tomography scan to assess fracture type and fracture gap and displacement (Fig. 1).

Surgical technique

Patients after general anesthesia were placed in a supine position. A Herbert headless screw system is used through percutaneous dorsal or volar entry according to surgeon preference, after small skin incision over the dorsal and proximal edge of scaphoid (in dorsal approach) or volar side on the distal edge of scaphoid

Figure 1



Fracture scaphoid type B1, plain radiographs and computed tomographic scan.

(in volar approach), a fine dissection done by a small hemostat till the edge of bone felt, and then a guide wire is introduced under an image intensifier. After guide wire placement, a cannulated drill is used (Fig. 2).

In group-A patients, we used bone marrow aspirated from iliac bone and injected into the fracture site via radial portal and through drilling a tunnel prior to screw insertion (Fig. 3).

Then, introducing the Herbert screw with counterpressure made by a small hook push against the distal pole of the scaphoid via separate incision, to allow good compression in the fracture site (this step done in both groups) (Fig. 4).

Postoperative below-elbow splint done that was removed by the third week and allows early range of motion without any stress on the wrist. Then, follow-up done weekly for the first 2 months and then at 3, 6, and 12 months postoperative for functional outcome assessment.

Fracture union was assessed via radiograph, computed tomography scan at 6, 9, and 12 weeks to assess trabecular continuity. Functional outcome assessed by Mayo Modified wrist score. Assessment done blind and randomly by the authors from both groups.

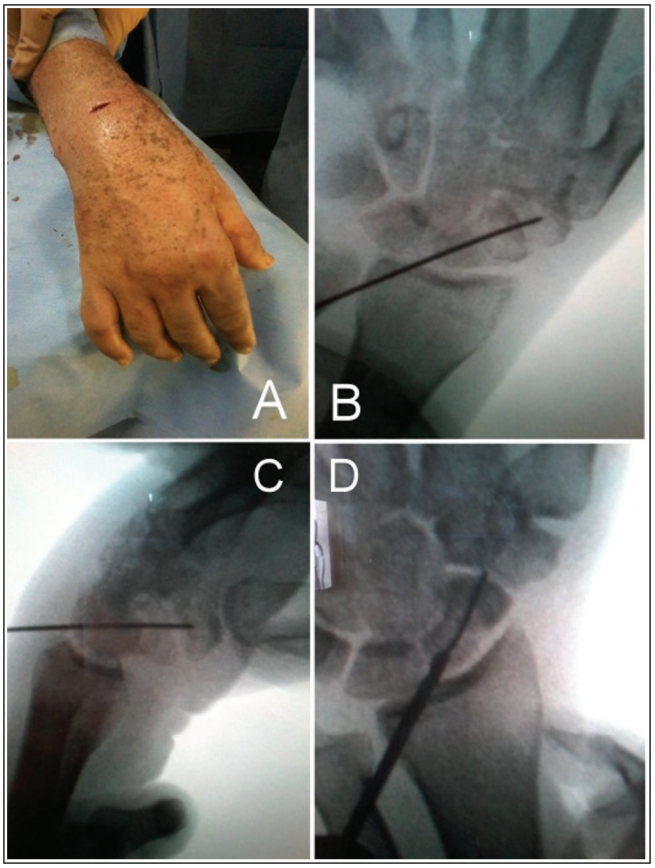
The descriptive and statistical analyses were achieved using the IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, New York, USA) with setting the level of significance at *P* value less than 0.05. The Kolmogorov–Smirnov test was used to determine whether nonparametric or parametric tests were appropriate. Student *t* distribution for sample size was used.

Results

The mean follow-up period was 11.5 months (range, 10.5–13 months). All fractures in both groups went on to clinical and radiological union, except one patient in group B. In group A, the mean time of union was 9.2 weeks (range, 7–10 weeks), while in group B, the mean time of union was 11.2 weeks (range, 8–13 weeks) (Figs 5 and 6).

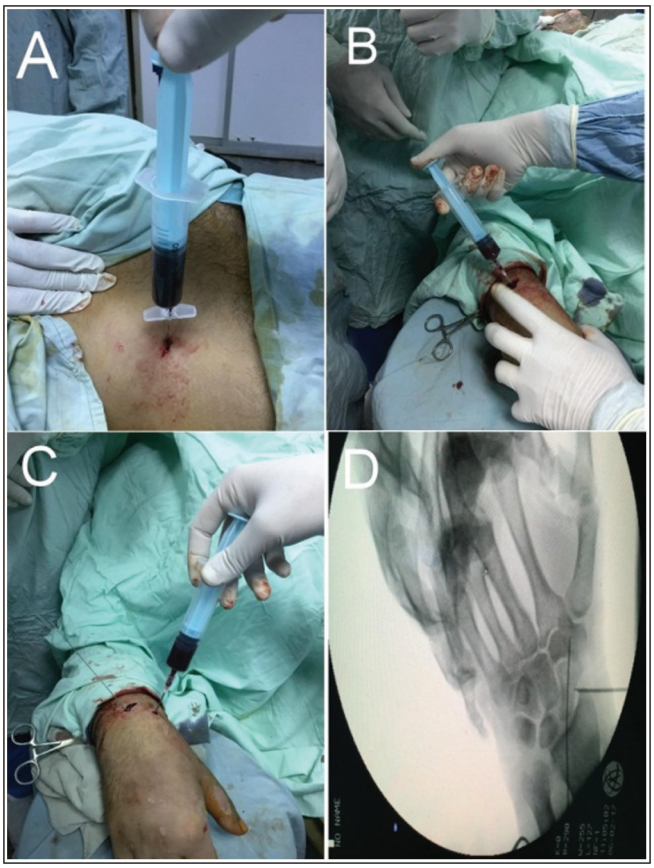
There was no statistically significant difference between both groups of patients regarding the number of cases

Figure 2



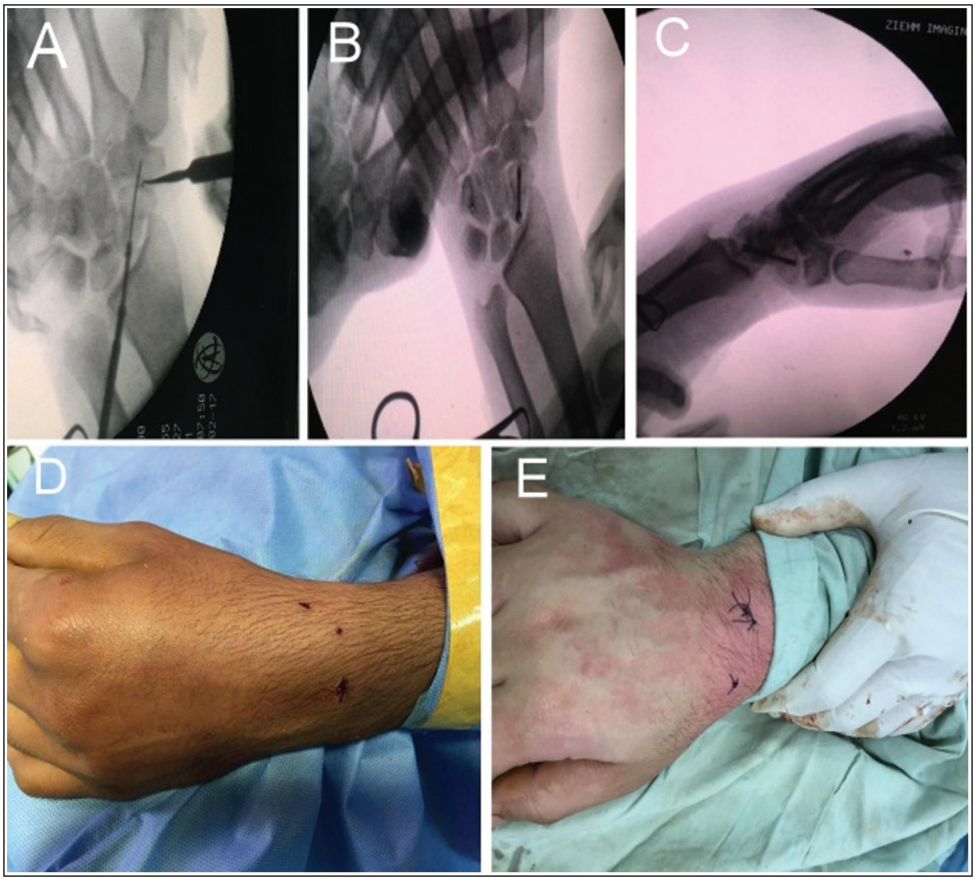
(a) Skin incision for dorsal approach. (b) Guide wire introduced under image intensifier. (c) Check guide wire position in lateral view. (d) Drilling of scaphoid with cannulated drill.

Figure 3



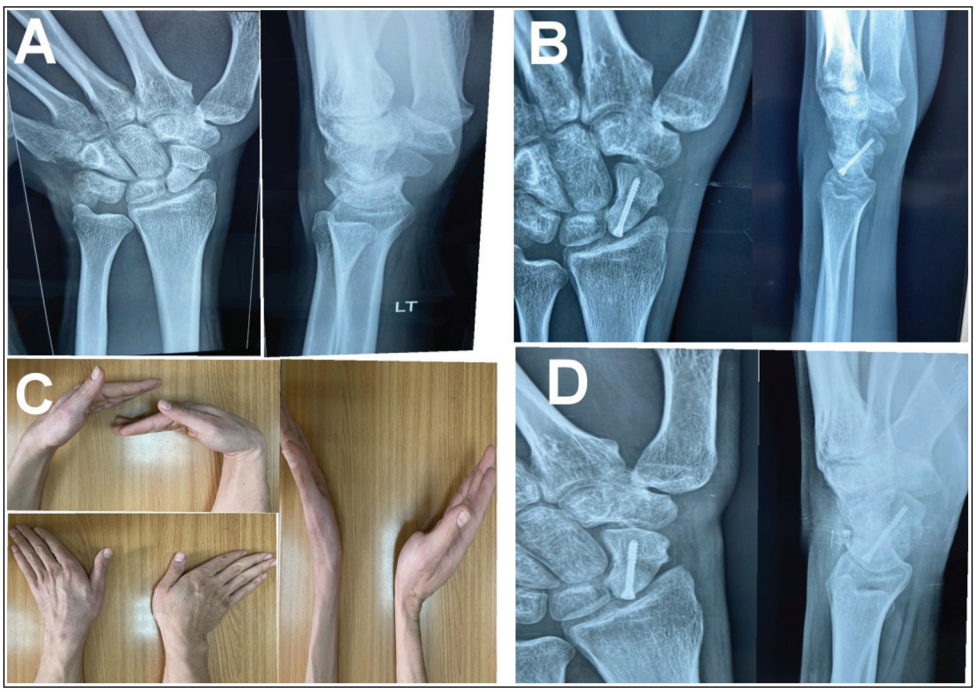
(a) Aspiration of bone marrow via trocar from right iliac bone. (b) Injection of bone marrow through drill tunnel. (c) Injection in the fracture site under (d) image intensifier.

Figure 4



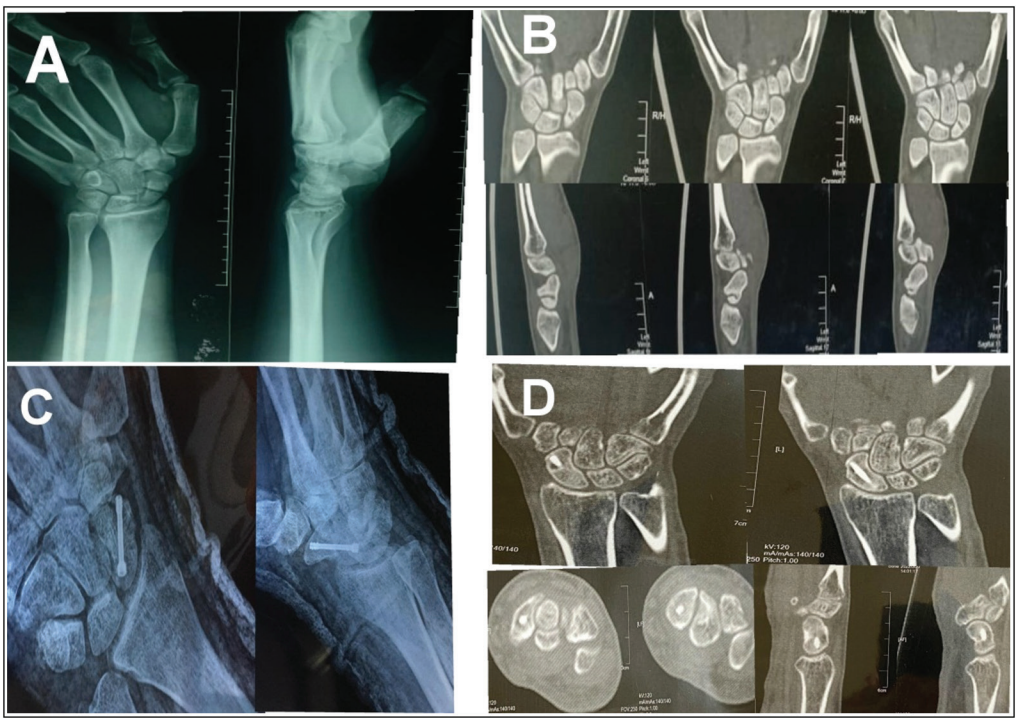
(a) Small hook push against distal pole while screw insertion. (b, c) Intraoperative check of screw position and length (P–A and lateral views of wrist). (d, e) Incisions of operation and closure by simple sutures.

Figure 5



(a) Delayed fracture scaphoid since 3 months treated by cast. (b) Four weeks postoperative using dorsal screw with bone marrow injection. (c) Wrist range of motion at 4 weeks. (d) Seven weeks postoperative show complete union with pain-free range of motion.

Figure 6



(a) Delayed fracture scaphoid since 4 months. (b) Computed tomography (CT) scan at the time of presentation. (c) Three weeks postoperative using bone marrow injection prior to splint removal. (d) CT scan at the 7th week postoperative shows complete union.

Table 1 Demographics and results of the patients

	Group A	Group B	*P* value	Total
Age (years)				
Range	20–40	20–35	NS	20–40
Mean±SD	30±2.2	25.5±2		27±3.1
Sex [*n* (%)]				
Male	15	14	NS	29
Female	5	6		11
Fracture type [*n* (%)]				
A2	3	4	NS	7
B1	2	5		7
B2	15	11		26
Time from fracture till operation	6–20	6–19	NS	
By weeks	12±2	11.8±2		
VAS score				
Range	0–4	0–5	*P*<0.05	0–5
Mean±SD	2±0.5	3±1.2		2.5±0.7
Grip strength (%)				
Range	78–95	75–90	*P*<0.05	
Mean±SD	88±2.7	81±1.5		
Union rate (weeks)				
Range	7–10	8–13	*P*<0.05	
Mean±SD	9.2±0.5	11.2±1.2		
Mayo score [*n* (%)]				
Excellent	17	15		
Good	3	4	*P*<0.05	
Satisfactory	0	0		
Poor	0	1		

VAS, visual analog scale.

and fracture type, age, sex, distribution, and follow-up periods, but there was great significance in group A according to postoperative VAS score, hand grip, and union rate in comparison with group B (Table 1).

According to screw placement, volar approach was used in 13 in group A and 15 in group B, while dorsal approach was used in seven in group A and five in group B.

Two patients in group A had mild discomfort at their iliac crest donor site, which resolved within a few days without any medications. One patient in group B did not get any signs of progressive union till 13 weeks, so open surgery and graft were done and union achieved 3 months later.

Discussion

Nonunion and delayed union are two of the common problems that usually face any surgeon dealing with scaphoid fracture healing [6].

Assessment of the scaphoid vascularity via conventional methods, such as plain radiography and bone scintigraphy, is unreliable and therefore the true incidence of proximal avascularity after a fracture is unknown. After several weeks of trauma, sclerosis of the proximal fragment develops and indicates revascularization and new bone deposition after an ischemic episode rather than ongoing avascular necrosis [7].

Conservative methods of treatment for scaphoid fractures are considered inexpensive and reliable, but have a lot of disadvantages such as long immobilization time, joint stiffness, reduced grip strength, and post cast skin problems [8].

So, the trend toward percutaneous fixation of scaphoid fractures became popular by many authors with attention to revascularization methods [9].

Most of the regenerative methods used in medicine require stem cells *ex vivo* cultivation, so this carries several risks, such as infection, high costs, and the need for two operations at least. So using bone marrow injection allows intraoperative application of mesenchymal and progenitor stem cells as a single-stage procedure [10].

The use of bone marrow to accelerate fracture healing represents a promising method of application of tissue engineering in the orthopedic field that avoids a lot of complications of the traditional bone grafting methods commonly used. Hernigou *et al*. [11] reported that hematopoietic stem cells are pluripotent and are able to differentiate; however, the number of pluripotent cells is decreased in patients who smoke or use steroids or alcohol [12].

The current study presents one-stage surgical intervention that avoids the drawbacks of the multiple-stage approaches, especially in delayed union cases, 40 patients with delayed fractures of scaphoid were divided into two groups, 20 for each group, both groups treated by percutaneous Herbert screw fixation, but in group A, an intraoperative bone marrow injection was used, while in group B, suffices by fixation only as a control.

There was a significant difference ($P<0.05$) in group A according to union rates, grip strength improvement, Mayo score, pain relief, and return to activity in comparison with group B. These differences related to early union rates in group A that allow early rehabilitation programs and return to activity of daily living.

Several studies with different revascularization enhancement methods for delayed scaphoid fractures were done. A study by Tomasz *et al*. [10] on seven patients with delayed scaphoid fractures treated by bone marrow aspirate concentrate injection and plaster splint for 8 weeks, they achieved union rate about 12 weeks with mild decrease in wrist range of motion till 4 months post cast removal.

Another study done by Mohsin and Shankar [13] using platelet-rich plasma injection with percutaneous screw fixation, shows union rate about 9 weeks, they used ex-vivo centrifuge of patients' blood sample and re-inject in the fracture site, which have high risk for infection. Another study by Mekaouche and Merabet [14] on 12 patients with delayed scaphoid fractures using commercially available device such as the two-step centrifugation Arthrex ACP system with percutaneous screw fixation, their results were in line of our results, they achieved union rate (7–10 weeks) with good results but with expensive cost of commercial platelet-rich plasma.

Taskin *et al*. [15] evaluated 33 consecutive scaphoid-delayed unions or nonunion treated by dorsal percutaneous fixation only. Union achieved on average 11 weeks.

The present study has some limitations such as single-center study and uses one modality for bone regeneration enhancement, so our recommendation is to make a multicenter cohort study in the future and use many different modalities.

Conclusion

The use of bone marrow is considered a simple and minimally invasive technique. The bone marrow injection is safe, as the material injected is autogenous, so there is no risk of disease transmission or immune reaction. When compared with iliac bone grafting, there is no additional surgical incision, and no donor site morbidity with less hospital stay, and when used with percutaneous screw fixation of delayed presented scaphoid fracture, it gives good results and plays a significant role in accelerating fracture healing. So, we recommend use of bone marrow injection with fixation of delayed presented fractures of scaphoid.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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