International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2016; 2(3): 108-112

www.orthopaper.com
Received: 21-05-2016
Accepted: 24-06-2016

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Functional outcome of minimally invasive percutaneous Herbert screw fixation with cancellous bone graft in delayed union or non-union scaphoid fractures with minimal sclerosis

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Abstract
The best treatment for scaphoid nonunion fractures is still controversial. The objective of this article is to report our clinical experience in the treatment of patients with scaphoid fracture with delayed union or non-union with minimal sclerosis using percutaneous cancellous bone graft and Herbert's screw and to study the functional outcome with an average of one year follow-up. We reviewed 35 patients treated with percutaneous cancellous bone graft and Herbert's screw fixation from October 2012 to January 2016. Preoperative clinical manifestations and postoperative results were assessed by radiography, and functional results, including grip force, range of motion of the wrist joint, and Cooney's scoring chart, were evaluated. The union rate was 91.42%. The average grip power, as well as wrist flexion and extension were significantly improved. Using Cooney's scoring system, 28(80%) patients were rated excellent and 4(11.42%) good. For successful union, anatomical reduction with cancellous bone grafting and Herbert's screw fixation is definitely a reliable option. This method leads to a satisfactory functional outcome.

Keywords: Functional, invasive percutaneous, bone, scaphoid, sclerosis.

Introduction
Scaphoid fractures are the most common fracture of the carpal bones and account for 60% carpal injuries [13, 19]. Due to anatomical properties including tenuous vascular supply, joint fluid dilution, and the inability to form callus, as well as biomechanical properties, such as high shear stress and displacement of fragments, delayed unions and non-unions are not uncommon. Delayed treatment and an inadequate period of fixation are also responsible for scaphoid nonunion [15, 16]. It is known that the non-union rate of scaphoid fracture is 5–10% with non-surgical treatment [7, 14, 17]. Established nonunion, if left untreated, will progress to osteoarthritis and impair the function of the wrist joint [15, 17, 18]. Therefore, in most instances, non-unions of the scaphoid are managed by surgery. However, the treatment of scaphoid non-unions is troublesome, with reported failure rates between 25% and 45% [13, 21]. The key points of successful surgery for scaphoid non-unions include achieving union of the fracture, correcting the deformities, restoring anatomical alignment, and recovering the function of the wrist [20]. Barton and Warren-Smith used Herbert's screw fixation and bone graft, which yielded satisfying results with better functional results than those obtained with bone graft alone [22].

AIMS
The study was undertaken in a Prospective manner to evaluate the functional outcome of treatment of patients with post-traumatic scaphoid fracture with delayed union or non-union with minimal sclerosis using percutaneous cancellous bone graft and Herbert's screw.

The objectives of this study were
- To study the result of percutaneous cancellous bone graft and Herbert's screw in of patients with scaphoid delayed union or non-union with minimal sclerosis in terms of maintaining of anatomy radiologically.
- To assess healing or union of fracture clinico-radiologically.

- Counteracting the per-operative and post-operative complications.
- Assessment of functional outcome by Cooney's Score.
- Comparison of results with standard literature.

Materials and Methods
In this prospective interventional study, a total of 35 patients with delayed union or nonunion with minimal sclerosis scaphoid fracture were included in the study between October 2012 and January 2016. Written informed consent was obtained from all subjects prior to the study. All subjects between the ages 18 and 50 years, who had a waist scaphoid fracture (fracture in the middle third of the scaphoid bone) with delayed union or non-union with minimal sclerosis were included. Subjects with a history of systemic disorders affecting the musculoskeletal system, bone tumors, or bone infection were excluded. We also excluded subjects with apparent degenerative changes in wrist bones, or radiologically proven scapholunate dissociation from the study. Parameters for analysis were obtained through case records as well as radiographic records including plain radiograms, CT scans and MRI if available. The following variables were determined for each patient: age at injury, gender, hand dominance, mechanism of injury, acute management of the fracture if any, other associated injuries, and eventual healing of the fracture. Postoperatively, a short arm splint was used for two weeks, which was exchanged for a thumb spica after removal of the stitches for an additional month. Routine roentgenography including AP, true lateral, and ulnar deviation views for evaluation of the union was undertaken monthly. We assessed osseous union based on the continuity of the trabeculae on both poles of the fracture. A questionnaire regarding pain, joint stiffness, satisfaction with the operation, and Cooney's scoring chart (Table 10) were used. The subjective results were evaluated by physical examination and radiographs. Range of motion of dorsiflexion, palmar flexion, and ulnar deviation were recorded.

Operative technique
Patients were placed in a supine position after either brachial block or general anaesthesia. The wrist was flexed and ulnarly deviated for proper scaphoid view and a small stab transverse incision was placed over the dorsal and proximal edge of scaphoid. With a small haemostat, the stab was carefully developed until the bone was felt, in order to avoid injury to extensor tendons and superficial branch of radial nerve.The starting position for the guide wire was the proximal pole of the scaphoid 2mm from the scapholunate margin. On the lateral view the wire must be directed to the scaphoid tuberosity earlier identified. The volar end of the wire exits from the radial base of the thumb, a safe zone devoid of tendons and neurovascular structures. A depth gauge was used for identifying an approximate scaphoid size. The screw selected should provide for 2 mm clearance between the end of the screw end and the scaphoid cortex, hence screw length was calculated by substracting 4mm from the measured scaphoid length. Drilling was done for a path 2 mm short of the opposite scaphoid cortex with a cannulated drill over the guide wire, then an appropriate size of cannulated screw was advancedunder c-arm guidance to within 1-2mm of the opposite cortex (Fig. 4). Postoperatively, a short arm splint was used for two weeks, which was exchanged for a thumb spica after removal of the stitches for an additional month. Routine roentgenography including AP, true lateral, and ulnar deviation views for evaluation of the union was undertaken monthly. We assessed osseous union based on the continuity of the trabeculae on both poles of the fracture, following which active exercises were promoted.

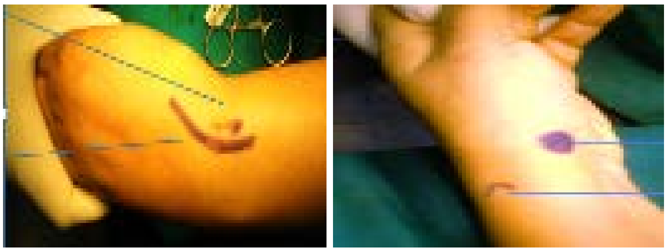

Fig 1: (Identification of landmarks; a-lister's tubercle, tendon of EPL; b-scaphoid tuberosity, radial styloid process)

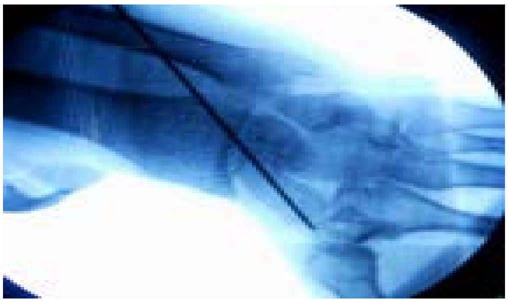

Fig 2: (Identification of central axis of scaphoid)

Fig 3: (wrist is flexed and ulnarly deviated)

Fig 4: (Guide wire placement)

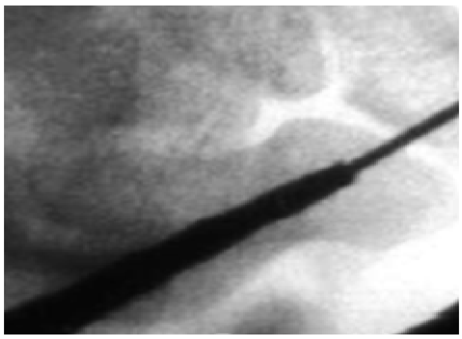

Fig 5: (Reaming)

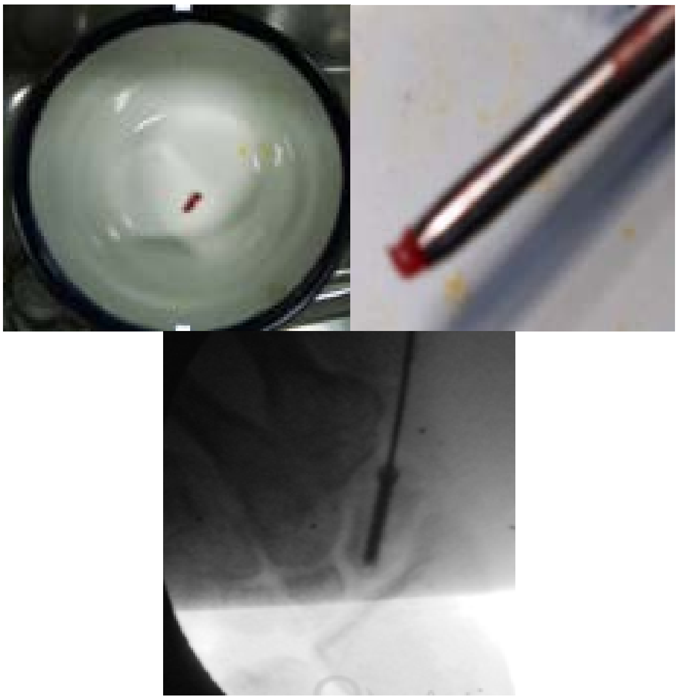

Fig 6: (Bone-graft harvested from iliac crest with help of jamshedi needle and percutaneously placed at fracture site, insertion of screw)

Results -

All fractures were united successfully without any additional procedures. At the latest follow-up (mean-12; range -6 to 28 months after the operation), patients were evaluated by the criteria of Cooney *et al*. [9]. By this criteria, pain, range of motion, grip strength and return to regular employment were evaluated and all patients had good or excellent results. This means that all patients returned to their employment without pain but with slight decrease (10% compared to the uninjured side) in range of motion or grip strength in 13 patients. In nine patients both grip strength and range of motion were comparable to the normal wrist. Radiological examination at the latest follow-up revealed no signs of AVN or humpback deformity. Only one patients had clinical symptoms of impingement with pain and required surgical removal of the implant. Loosening of the screw was noted in one patients, but there were no bothersome symptoms. Three patients with progressive degeneration were noted in our studies. There was no complication at the donor site, including wound infection, avulsion fracture, or injury to the lateral femoral cutaneous nerve, except one incidence of superficial infection at donor site, which resolved with antibiotics. Thirty-two of the 35 patients (91.42%) returned to their original work and 3 patients (8.57%) changed to jobs with lighter loading. The average duration until a patient went back to work was 4 months (range 3–7 months).

Table 1: Age distribution.

Age distribution in years	Number	%
18-30	9	25.71
31-40	21	60
41-50	5	14.28
Total	35	100

Table 2: Sex incidence.

Sex	No of Cases	%
Male	30	85.71
Female	5	14.28
Total	35	100

Table 3: Mechanism of injury.

Mechanism of Injury	No of Cases	Percentage
RTA	27	77.14
Accidental Fall	8	22.85
Total	35	100

Table 4: Side of the affected scaphoid.

Side	No of cases	Percentage
Right	29	82.85
Left	6	17.14
Total	35	100

Table 5: Time interval of operation from injury.

Time Elapsed (Days)	No. of Cases	Percentage
20-40	9	25.71
41-60	15	42.85
61-80	6	17.14
81-100	5	14.28
TOTAL	35	100
Mean time of interval 45days		

Table 6: Associated injury

Associated Injury	No. of Cases	Percentage
Ipsilateral Both Bone FA #	1	2.85
Ipsilateral Colle"S	3	8.57
Galleazea #	2	5.71
Contralateral Both Bone Forearm Fracture	1	2.85
Chest Injury	1	2.85
Ipsilateral Radius #	1	2.85
Head injury (Concussion)	1	2.85
Total	10	28.57

Table 7: Duration of surgery

Duration of Surgery (Minutes)	No. of Cases	%
<60	6	17.14
60-90	24	68.57
90-120	3	8.57
120-150	2	5.71
Total	35	100
Mean time required 72minutes		

Table 8: Exposure of radiation from C-arm machine in seconds

Exposure of Radiation From C-Arm	No.of Cases	%
60-90	29	82.85
90-120	5	14.28
120-150	1	2.85
Total	35	100
Mean Exposure Of Radiation 85.5 Sec		

Table 9: Complications

Complications	No.of cases	%
Impingement with pain	1	2.85
Implant loosening	1	2.85
Donor-site infection (superficial)	1	2.85
Progressive degeneration	3	8.57

Table10: Cooney's Score

	Excellent (≥90)	Good (80-89)	Satisfactory (65-79)	Poor (<65)
At 10 wks	3	27	2	3
At 14 wks	24	6	2	3
At 18wks	27	5	0	3
At 24wks	27	5	0	3
At 36wks	28	4	0	3
At 1yr	28	4	0	3

Table 10: Time taken for union.

Union Time	No. of Patients	Percentage
By 10 weeks	3	8.57
By 14 weeks	24	68.57
By 18 weeks	5	14.28

Discussion

Studies have shown that delayed or nonunion scaphoid fractures should be treated by internal fixation [1]. However, open approaches, either dorsal or palmar, have some certain problems including soft tissue stripping, damage to ligaments, especially 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 [1-6, 8, 10-12]. For these reasons, there has been a trend towards percutaneous fixation of such fractures [2-5]. AVN is the most important complication of scaphoid fractures and occurs due to the disruption of precarious blood supply [1, 8], and the risk for AVN increases if the fracture is left untreated [1]. For this reason, this risk should be eliminated before attempting to fix the fracture. 1, 8). If radiograph or MRI shows normal intensity, or minimal sclerosis, fractures can be fixed safely percutaneously with cancelous bonegraft. The result of our series is comparable with others in that 32 of the 35 patients (91.42%) returned to their original work and 3 patients (8.57%) changed to jobs with lighter loading. The average duration until a patient went back to work was 4 months (range 3–7 months).Reaming of the scaphoid in preparation for the screw creates an opportunity to establish bleeding of the bony surfaces [5], which along with cancelous bone graft enhances the rate of union. The major limitation of the present study is the lack of a control group, so the results cannot be compared with the other treatment modalities including palmar percutaneous fixation, open reduction or conservative treatment. Another important limitation is the retrospective design of the study and these prevent more definitive conclusions. Nevertheless, dorsal percutaneous screw fixation for scaphoid delayed or non-union with minimal sclerosis seems a reasonable treatment.

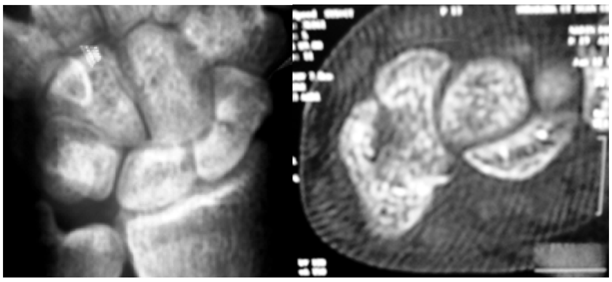

Fig 7: (at presentation) CT-scan

Fig 8: (Immidiate post-operative)

Fig 9: (10wks post-op)

Fig 10: (14wks post-op)

Fig 11: (ROM at final follow-up)

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