Dorsal percutaneous screw fixation of delayed scaphoid fractures augmented with bone marrow injection
*Eslam A. Tabl, MD and **Wael A. Kandel, MD

* (lector of orthopaedic surgery Benha university) .
** (Assistant professor of orthopaedic surgery, Benha university)

Abstract

Background Management of delayed scaphoid fractures in physically demanding patients remain controversial. This article discuss simple treatment accelerate healing and allow 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 and allow early mobilization of wrist to achieve early return to ADL.

Methods: Twenty 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 fracture delayed-union with intact cartilaginous envelope, no sclerosis, no avascular necrosis.

Results: Mean follow up period 20.4 months (range: 12 to 24), average radiographic union was 7.8 weeks (range 6–10 weeks), average VAS 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), ulnar tilt 42.5° (range 39–45). Average grip strength was 95% (85–100%).

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

Keywords: Bone marrow injection; non-union; percutaneous fixation; scaphoid fixation; scaphoid fractures.

LEVEL OF EVIDENCE: Therapeutic study, Level IV

Introduction

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

If the fracture scaphoid is neglected or misdiagnosed, non-union will occur progress to radiographic and symptomatic osteoarthritic of the wrist. This will lead to morbidity and lifelong disability especially in manual workers in which the wrist range of motion and hand grip are very important 5.

Patients and methods

Between April 2014 and April 2016 a twenty patients with 22 scaphoid delayed-union treated with dorsal percutaneous screw fixation and bone marrow injection, a full informed consent was obtained from each patient in this study. The inclusion criteria were scaphoid fracture delayed-union with intact cartilaginous envelope according to Herbert classification type C, no cyst or sclerosis, no avascular necrosis.

There were 14 males and 6 female patients with an average age of 29 years (range 20–42 years). There were 10 dominant side fractures and 8 non-dominant side fractures and 2 bilateral fractures. History of trauma included in 17 patients, treatment was done in 13 patients in the form of short arm thumb spica for average 6.5 weeks (from 4 to 9 weeks).

Average duration of delayed-union was 3.5 months (range 2.5 – 5 months), (Table 1). Clinically all patients complained of wrist pain affects their daily activity and functional tasks, the pain analyzed according to visual analogue 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), ulnar tilt was 30.2° (25–40). The grip strength measured by asking the patient to squeeze, as hard as he could, the partially inflated rolled sphygmomanometer cuff...
at 20mm of mercury. Grip average was 61.7% of sound side (range 50–70%).

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

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 skin marked. The wrist was hyperflexed and a small stab transverse incision was placed over the dorsal and proximal edge of scaphoid. With a small hemostat, the stab was carefully developed until the bone was felt, in order to avoid injury to extensor tendons and superficial branch of radial nerve (Fig 3), Guide wire passed along the medullary canal of the scaphoid(Fig 4). Position checked meticulously from several directions with C-arm. After guide wire placement, cannulated drill and tap is used by hand (Fig 5).

Bone marrow aspiration taken from iliac bone by assistant while doing drill to scaphoid (Fig 6), about 3 to 5 cc taken. Refreshing of fracture ends done by small k-wire under c-arm guide from snuff box avoid superficial radial nerve then injection done in fracture site and through drill site. A small hook (Fig 7) used through separate incision at 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 (Fig 9). Suturing the wounds (Fig 10) and splint over wrist done. Splint removed about 2-3 weeks post-operative, early active range of motion started with restriction of lifting or working with hand for 3 weeks. Then follow up done at 3,6,12 months post-operative.

**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** Informed consent was obtained from all individual participants included in this study.

**Table 1:** Patients Data

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Age</th>
<th>Sex</th>
<th>Affected side</th>
<th>History of trauma</th>
<th>Casting</th>
<th>Duration of delayed union in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>M</td>
<td>D</td>
<td>✓</td>
<td>-</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>M</td>
<td>D</td>
<td>-</td>
<td>✓</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>M</td>
<td>N</td>
<td>✓</td>
<td>✓</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>M</td>
<td>Bil</td>
<td>✓</td>
<td>✓</td>
<td>2.5</td>
</tr>
<tr>
<td>5</td>
<td>33</td>
<td>M</td>
<td>N</td>
<td>✓</td>
<td>-</td>
<td>4.5</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>M</td>
<td>N</td>
<td>✓</td>
<td>✓</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>35</td>
<td>F</td>
<td>D</td>
<td>✓</td>
<td>-</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>39</td>
<td>M</td>
<td>D</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>22</td>
<td>F</td>
<td>N</td>
<td>✓</td>
<td>✓</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>F</td>
<td>N</td>
<td>✓</td>
<td>✓</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>40</td>
<td>M</td>
<td>D</td>
<td>✓</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>M</td>
<td>D</td>
<td>✓</td>
<td>✓</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>29</td>
<td>F</td>
<td>D</td>
<td>✓</td>
<td>✓</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>42</td>
<td>M</td>
<td>N</td>
<td>✓</td>
<td>✓</td>
<td>3.5</td>
</tr>
<tr>
<td>15</td>
<td>24</td>
<td>M</td>
<td>Bil</td>
<td>✓</td>
<td>✓</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>22</td>
<td>M</td>
<td>D</td>
<td>✓</td>
<td>-</td>
<td>4.5</td>
</tr>
<tr>
<td>17</td>
<td>27</td>
<td>M</td>
<td>N</td>
<td>✓</td>
<td>-</td>
<td>3.5</td>
</tr>
<tr>
<td>18</td>
<td>31</td>
<td>F</td>
<td>N</td>
<td>-</td>
<td>✓</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>34</td>
<td>F</td>
<td>D</td>
<td>✓</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>26</td>
<td>M</td>
<td>D</td>
<td>✓</td>
<td>✓</td>
<td>3</td>
</tr>
</tbody>
</table>
Fig. 1: fracture scaphoid of 3 months duration, A / Ap x-ray view  B / lateral view  C / oblique view

Fig 2: C.T. scan of the fracture showed: no sclerosis, no deformity with delayed union.

Fig. 3: Small incision is made over dorsal approach with flexed wrist
(Fig 4): Guide wire passed along the medullary canal of the scaphoid, A) Ap view B) lateral view, C) clinical view.

Fig. 5: Cannulated drill and tap is used by hand. A) clinical view B) Ap view from c-arm.

Fig. 6: Bone marrow aspiration and injection before and after screw insertion. A) clinical view B) Ap view from c-arm.

Fig. 7: A small hook
Fig. 8: Small hook used through separate incision at distal pool to correct alignment and allow resistance against screw insertion to gain maximum compression. A) clinical view B) Ap view from c-arm. C) oblique view from c-arm.

Fig. 9: Placement of the screw of appropriate length. A) AP view, B) lateral view, C) oblique view.

Fig. 10: Suturing the wounds.
**Result:**
Mean follow up period 20.4 months (range from: 12 to 24), almost all fractures united successfully with no additional procedures, except one fracture in patient number 4, a male 32 years old with bilateral fracture scaphoid, right united within 8 weeks but left side proceed to non-union and need re-surgery with open bone graft after 9 weeks (Fig.11&12). These fractures achieved radiographic union at an average of 7.8 weeks (range 6–10 weeks) post-operative.

The average VAS score at final follow-up 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), ulnar tilt 42.5° (range 39–45).

Grip strength regained in comparison to other side with average 95% (85–100). Patient number 6, a male 20 years old presented with left delayed united fracture since 5 months with small cyst in proximal part [Fig. 13]. We decide to proceed with same technique as the cyst was small and no other signs of nonunion or AVN. [Fig 14]

Union achieved with 7th week and satisfactory results by 11th week [Fig. 15, 16]

![Fig. 11: a) Delayed union Rt scaphoid 2.5 months. b) Intraoperative c-arm photo. c) 4 weeks post operative: signs of union. d) 6 weeks post operative: uniting. e) 8 weeks post operative: good union](image1.png)

![Fig. 12: a) Delayed union Lt scaphoid 2.5 months. b) Intraoperative c-arm photo. c) 4 weeks post operative: no signs of union. d) 6 weeks post operative: nonunion with collapse and intra-articular screw penetration](image2.png)
Figure 13: Delayed union scaphoid 5 months duration, A) AP view, B) lateral view

Figure 14: Intraoperative C-arm photo, A) AP view, B) lateral view

Figure 15: 7 week post operative, Sound union achieve, A) AP view, B) lateral view

Figure 16: 11th week post operative, A) AP view, B) lateral view, C&D) range of motion
Complications:

All our patients have satisfactory results, 21 fractures fully united without additional maneuvers, and one fracture proceed to non-union and need re-surgery with open graft and fixation. This fracture was in patient number 4 with bilateral fracture scaphoid 2.5 months ago (Fig.11, 12). he had conservative treatment for 9 weeks in form of short cast, dorsal percutaneous fixation with bone marrow injection done for both sides, right side united within 8 weeks, but left side proceed to non-union with screw intra-articular penetration at 6 weeks post-operative, we explain that the cause of failure in union due to improper compression in fracture site and improper screw length, as we didn’t use the hook in first 4 cases and use manual compression from the thumb against screw insertion, but after this case we decide to use the hook to achieve best compression and alignment and all cases after this modification have no complications.

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

A lot of studies shown that delayed and nonunion of scaphoid fractures better to be treated by 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 that a trend towards 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 allowing more precise placement of the screw 9.

Adolfsson et al 11, compared outcomes of percutaneous fixation alone with immobilization in a long scaphoid cast, fixation group consisted of 25 patients, 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 Hegazy 4, evaluate results of volar percutaneous headless compression screw fixation without bone grafting in 21 patients with scaphoid waist delayed & nonunion fractures, fractures achieved radiographic union at an average of 4 months.

Taskin Altay et. al. 9, evaluated 33 consecutive scaphoid delayed unions or nonunion treated by dorsal percutaneous fixation only. Union achieved in average 10 weeks.

In the current study, there were 22 scaphoid fractures delayed-union 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 in average 7.8 weeks (6-10). Patient’s satisfaction was high, Our good results achieved through: percutaneous fixation (less invasive), refreshing fracture ends and bone marrow injection (accelerate healing process) use hook while inserting the screw (good compression at fracture site), early mobilization of wrist (decrease immobilization hazards).

Conclusion

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

Conflict of Interest

The author declares that he has no conflict of interest.

References:


