ABSTRACT

Objectives: We aimed to compare the functional and radiological results of a volar or dorsal percutaneous approach for acute scaphoid waist fractures treated with headless cannulated compression screw.

Methods: Acute fractures with less than 10 days of injury time, nondisplaced or minimally displaced fractures (<2 mm), and fractures at the scaphoid waist were included in the study. A single type of compression screw (3.5 mm, headless, cannulated, and full threaded) was used in all patients. Postoperatively, a short arm palmar splint with thumb support that held the wrist in a neutral position was applied to all patients for 2 weeks.

Results: Nineteen patients were operated with the dorsal approach (group 1), and 17 patients were operated with the volar approach (group 2). There were 17 men and 2 women in group 1, and 16 men and 1 woman in group 2. The mean age of group 1 was 28.1 (range: 18-38) years, and the mean age of group 2 was 27.2 (18-39) years. Union was obtained and radiological consolidation was achieved in all patients in the study and there were no statistically significant differences between the groups in terms of wrist movements, grip and pinch force, or functional scores.

Conclusions: We think that both volar and dorsal percutaneous approaches in acute scaphoid waist fractures are effective and reliable methods with similar clinical and functional results, and are thus a suitable alternative to each other.

Key words: Acute scaphoid fracture, headless compression screw, internal fixation, navicular, percutaneous fixation

Introduction

Scaphoid fractures constitute 50-80% of all carpal bone fractures. They occur predominantly in young active men and are most commonly due to hyperextension trauma to the wrist [1]. Union with cast treatment is obtained in 80-90% of acute nondisplaced scaphoid fractures. However, long-term immobilization can lead to problems such as muscle atrophy, joint stiffness, and a decrease in grip strength [2].

Percutaneous screw fixation was first reported by Steli in 1970 [3]. During percutaneous surgical procedures, limited soft tissue dissection is performed and...
theoretically chance of fracture union increases, rigid fixation is provided, early mobilization is allowed, and fewer complications are seen. Both volar and dorsal percutaneous approaches have resulted in high union rates and are widely used today for the treatment of acute scaphoid fractures [4,5]. However, there is no consensus regarding which percutaneous approach (volar or dorsal) is optimal to treat acute scaphoid waist fractures.

In this study, we aimed to compare the functional and radiological results of a volar or dorsal percutaneous approach for acute scaphoid waist fractures treated with headless cannulated compression screw.

Patients and Methods

We retrospectively studied a cohort of patients with acute scaphoid waist fracture who, between 2014 and 2018, underwent screw fixation with a dorsal or volar percutaneous approach, had a follow-up of at least 1 year, and replied to the last control call. The study protocol was approved by the Institutional Review Board of our hospital (2019/79), informed consent were obtained from all patients. Acute fractures with less than 10 days of injury time, nondisplaced or minimally displaced fractures (<2 mm), and fractures at the scaphoid waist were included in the study. Patients with pathologic fractures, open fractures, additional injuries in the same extremity, and degenerative wrist arthrosis were excluded from the study.

Thirty-six patients met the selection criteria and were included in the study. Every patient underwent computerized tomography (CT) to support preoperative diagnosis and to assess the configuration of the fracture. The fracture classification was made according to the Herbert and Fisher classification (table 1) [6]. The mean time between injury and surgery was 3.5 (range: 1-8) days in the dorsal approach group (group 1) and 3.7 (range: 1-9) days in the volar approach group (group 2). The selection of the surgical approach was made in accordance with the surgeon's personal preference. In our clinic some surgeons prefer to use only dorsal percutaneous approach, others prefer to use only volar approach for scaphoid waist fractures.

Surgical Technique

Among the 36 patients studied, 15 were operated under general anaesthesia and 21 under axillary block anaesthesia. In the dorsal approach, a 0.5 cm longitudinal incision was made distal and ulnar to the Lister tubercle. Blunt dissection was made until the scaphoid proximal pole. Extensor tendons and superficial branches of the radial nerve were protected. The wrist was flexed, then under fluoroscopy control, a 1 mm Kirschner (K) wire was centrally inserted from dorsal to volar and from ulnar to radial. The K-wire came out from the skin at the distal base of the thumb, and the K-wire was retracted until the scaphoid proximal pole. The wrist was extended, and the central position of the K-wire was confirmed by fluoroscopy. Next, the K-wire was pushed back into a proximal position, and the scaphoid was drilled over the K-wire with a 2.7 mm drill. The fracture line was passed, the opposite cortex was not passed. The screw length was measured from the drilled hole with another K-wire. A screw 2 mm shorter than the length measured with the K-wire was selected. Compression was achieved in the last round of the screw. The head of the screw was buried in the cartilage (Figure 1).

Table 1. Herbert and Fisher classification.

| Type A (Acute stable fractures) |
|----------------------------------|
| A1: fractures of tubercle         |
| A2: undisplaced ‘crack’ fracture of wrist |

| Type B (acute unstable fractures) |
|-----------------------------------|
| B1: oblique fractures of distal third |
| B2: displaced or mobile fractures of waist |
| B3: proximal pole fractures       |
| B4: fracture dislocations of carpus |
| B5: comminuted fractures          |

| Type C (delayed union) |
|------------------------|
| Type D (established non-union) |
| D1: fibrous non-union |
| D2: sclerotic non-union (pseudoarthrosis) |
Volar versus dorsal percutaneous screw for scaphoid fractures

In the volar approach, with the wrist hyperextended, a 0.3 cm incision was made over the scaphoid tubercle after determining the site of entry with a K-wire under fluoroscopy control. The transtrapezial approach was not used to avoid damaging the scaphotrapezial joint. The scaphoid distal pole was exposed by blunt dissection. A K-wire was inserted from volar to dorsal and from radial to ulnar. After verifying that the K-wire was in the central position, the screw length was measured with an equivalently long K-wire, and a screw 2 mm shorter than the length measured with the K-wire was selected. Then, the K-wire was sent proximally to the radius, for not to come back after drilling. Next, the screw was inserted after drilling with 2.7 mm drill. Compression was achieved in the last rounds of the screw. The head of the screw was buried in the bone (Figure 2).

A single type of compression screw (3.5 mm, headless, cannulated, and full threaded, Suzhou Youbetter Medical Apparatus Co., Ltd., Jiangsu, China) was used in all patients. Among the 36 patients studied, 3 received 18 mm screws; 18 received 20 mm screws, and 15 received 22 mm screws. All patients were discharged one day after the surgery. Postoperatively, a short arm palmar splint with thumb support that held the wrist in a neutral position was applied to all patients for 2 weeks. After 2 weeks, the sutures and splint were removed and wrist movements (active and passive), as well as wrist rehabilitation, were started. Strengthening exercises were started 6 weeks postoperatively, and sports activities were allowed after the 12th postoperative week. The fracture union was evaluated according to the presence of cortical trabeculation in the radiographs [3]. A goniometer was used to evaluate wrist movements, and a Saehan hydraulic hand dynamometer (Saehan Corporation, Changwon, South Korea) was used to measure the patient’s grip strength. A pinch gauge was used for...
A 20 year old man presented with left scaphoid fracture. A-B: posterio-anterior X-ray and CT scan demonstrated scaphoid waist fracture, volar percutaneous approach was applied. C-D: posterio-anterior and oblique X-rays show fracture union and satisfactory alignment, E-F: clinical images of patient.

key pinch strength measurements. The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, as well as the Mayo wrist score and the VAS (Visual Analogue Scale) score, were used for functional evaluation and we asked the smoking status [7-9].

Statistical Analysis

Mann-Whitney U and Student’s t-tests were used to compare parameters between the two groups. Wilcoxon Signed Rank tests were used for intragroup comparisons of non-normally distributed parameters. The Pearson’s chi-square test was used to compare qualitative data. P<0.05 was considered statistically significant.

Results

Nineteen patients were operated with the dorsal approach (group 1), and 17 patients were operated with the volar approach (group 2). The mean follow-up period was 21.5 (range: 12-36) months for group 1 and 22.7 (range: 12-38) months for group 2. There were 17 men and 2 women in group 1, and 16 men and 1 woman in group 2. The mean age of group 1 was 28.1 (range: 18-38) years, and the mean age of group 2 was 27.2 (range: 18-39) years. The right side was affected in 20 patients, and the left side was affected in 16 patients. There were no patients with bilateral fractures. The trauma mechanism was a fall in 30 patients, a ball impact during a sports activity in 3 patients, and a traffic accident in 3 patients. The dominant extremity was affected in 22 patients (61.1%). According to the Herbert and Fisher classification system, in group 1, patients had type A2 (4 patients), type B1 (7 patients), and type B2 (8 patients) fractures; while in group 2, patients had type A2 (4 patients), type B1 (5 patients), and type B2 (8 patients) fractures. In group 1, 7 patients smoked, and in group 2, 8 patients smoked. A detailed analysis of the patients is shown in table 2.

Union was obtained and radiological consolida-
| Table 2. Summary of medical and demographic informations of patients. |
|---------------------------------------------------------------|
| **Group 1** | **Group 2** | **p** |
| Number of patients | 19 | 17 | 0.287 |
| Mean time between injury and surgery (day) | 3.5 (1-8) | 3.7 (1-9) | 0.748 |
| Mean age (range) | 28.1 (18-38) | 27.2 (18-39) | 0.689 |
| Gender (n, %) | | | 0.543 |
| Men | 17 (89.5 %) | 16 (94.1 %) | |
| Women | 2 (10.5 %) | 1 (5.9 %) | |
| Side (n, %) | | | 0.765 |
| Right | 11 (57.9 %) | 9 (52.9 %) | |
| Left | 8 (42.1 %) | 8 (47.1 %) | |
| Trauma mechanism (n, %) | | | 0.579 |
| Fall | 17 (89.5 %) | 13 (76.5 %) | |
| Traffic accident | 1 (5.3 %) | 2 (11.8 %) | |
| Sports injury | 1 (5.3 %) | 2 (11.8 %) | |
| Fracture Classification (Herbert and Fisher) (n, %) | | | 0.895 |
| A2 | 4 (21.1 %) | 4 (23.5) | |
| B1 | 7 (36.8 %) | 5 (29.4 %) | |
| B2 | 8 (42.1 %) | 8 (47.1 %) | |
| Smoking status | | | 0.535 |
| Smoking | 7 | 8 | |
| Nonsmoking | 12 | 9 | |
| Length of screw | | | 0.218 |
| 18 mm | 2 | 1 | |
| 20 mm | 11 | 7 | |
| 22 mm | 6 | 9 | |
| Dominant hand | | | 0.790 |
| 12 (63.2 %) | 10 (58.8 %) | |
| Mean operation time (minute) (range) | 31.0 (20-50) | 29.7 (20-45) | 0.623 |
| Mean follow-up time (month, range) | 21.5 (12-36) | 22.7 (12-38) | 0.861 |
| Mean DASH score (range) | 2.49 (0-9) | 2.76 (0-10) | 0.686 |
| Mean grip strength (kg) | 43.1 | 42.0 | 0.790 |
| Mean key pinch strength (kg) | 7.59 | 8.06 | 0.869 |
| Mean wrist flexion (degree) | 71.5 | 72.6 | 0.663 |
| Mean wrist extension (degree) | 73.6 | 75.8 | 0.275 |
| Mean wrist radial deviation (degree) | 17.1 | 16.4 | 0.638 |
| Mean wrist ulnar deviation (degree) | 25.7 | 26.1 | 0.824 |
| Mean VAS score | 1.3 | 1.1 | 0.686 |
| Mean Mayo wrist score | 91.5 | 93.5 | 0.763 |
tion was achieved in all patients in the study, no patient had tenderness on the fracture line upon palpation. No statistically significant difference was found between the groups in terms of age, gender, sides, trauma mechanism, smoking status, Herbert and Fisher classification, surgery waiting time, follow up time, or length of the screw (p>0.05). When we evaluated the DASH, Mayo, and VAS scores, the wrist flexion and extension, the radial and ulnar deviation degrees, and the grip and key pinch strength, no statistically significant difference was found between the groups (p>0.05) (table 2). Radial deviation was significantly lower in both groups when compared with healthy side (table 3). None of the patients experienced implant irritation, migration, hardware loosening, or hypertrophic scarring, and no implant was removed from any patient. Also, none of the patients had infection, tendon damage, or avascular necrosis. Reflex sympathetic dystrophy was observed in one patient in group 2 and was healed with conservative treatment. One patient in group 1 developed transient superficial radial nerve neuropraxia postoperatively; the patient was placed on observation and complete recovery was observed by the 16th postoperative week.

Discussion

Scaphoid fractures are frequently seen in young men [10]. Accordingly, in our study, the mean age of the patients was 27.7 (range: 18-39), and they were predominantly male (91.7%). Although high union rates with conservative treatment have been reported for non-displaced and minimally displaced scaphoid fractures [11], closed percutaneous methods have been developed in order to decrease the complications caused by long immobilization and to reduce the time to return to work of the young male population.

There are two approaches in percutaneous screw applications: the volar and the dorsal approach. In the volar approach, the entry point is easier to find and the risk of radiocarpal ligament and tendon injury is low. On the other hand, in the volar approach, the superficial palmar arch and the median nerve recurrent branch may be damaged. In the volar approach, the screw is inserted at the wrist extension and the fracture is reduced better in wrist extension. In the dorsal approach, surgery is performed in wrist flexion and the thumb and finger extensors, the radial nerve sensory branch, and the posterior interosseous nerve are at risk. Gürbüz et al. treated 13 b-type scaphoid fractures with a dorsal percutaneous approach and screw fixation and 14 b-type scaphoid fractures with volar percutaneous approach and screw fixation; union was achieved in all fractures and they found similar clinical and functional results among the groups [5]. Polsky et al. applied cannulated compression screws to 16 scaphoid fractures using a dorsal approach and to 10 scaphoid fractures using a volar approach; they obtained 80% union in the dorsal group and 81% union in the volar group, and they found similar clinical results in both groups [12]. Jeon et al. applied Herbert screws (Zimmer, Warsaw, ...
IN, USA) to 19 scaphoid fractures using a volar approach and to 22 scaphoid fractures using a dorsal approach; they obtained similar union rates and functional results in both groups and emphasized the need to insert the screw parallel to the long axis of the scaphoid and perpendicular to the fracture line [13]. Drac et al. treated 42 scaphoid waist fractures with a volar percutaneous approach and 38 with a limited dorsal approach; one nonunion developed in both groups. They found no statistically significant difference between the groups in terms of wrist movements, but they reported that the grip force was better in the volar group than in the dorsal group. They found the two techniques to be comparable [14]. In our study, union was obtained in all patients in both groups, and there were no statistically significant differences between the groups in terms of wrist movements, grip and pinch strength, or functional scores. In our study, a 0.5 cm incision was made distally from the Lister's tubercle before inserting the K-wire to reduce the risk of tendon, nerve, and vessel injury in group 1. In group 2, after a 0.3 mm incision was made, a blunt dissection was performed and a K-wire was inserted from the scaphoid distal pole. In both groups, the screws were buried in the bone. No screw penetration of the joint was seen, and no screw extraction was made.

The choice of screw is also important in the treatment of scaphoid fractures. In a biomechanical study comparing scaphoid screws, it was emphasized that although better compression was achieved with conventional cannulated screws, they were big. They pointed out that the Herbert screw (Zimmer, Warsaw, IN, USA) is embedded in the bone and is most advantageous with its compatibility [15]. In another biomechanical study comparing mini bone screws, the mini-Acutrak screw (Acumed, Inc., Beaverton, OR) and the Herbert screws (Zimmer, Warsaw, IN, USA) were shown to have similar compression [16]. In our study, we used a single type, headless, full and variable threaded, self-tapping, cannulated, compression screws. We think that the 3.5 mm screws we used provided sufficient stability. We buried the screw head into the bone in all cases, and no patient had screw irritation.

Many authors use radiographs for evaluation of union in scaphoid fractures. Trabecula and sclerosis in the fracture line are evaluated in favor of union. However, due to the shape, size and orientation of the scaphoid, it is difficult to say confidently union. In addition, if the x-rays are not in the same plan as the fracture line, there will be overlap and accidentally considered as trabeculation [17,18]. With CT, evaluation in multiple planes can be done and trabecular architecture is better evaluated. There is documented evidence of union, if there is a bridging bone in the fracture line in the CT scan. In addition, union should be supported with clinical findings such as lack of tenderness in the fracture line and functional return [19]. In our study, we evaluated the union radiographically, accordingly, we observed trabecula and sclerosis in the fracture line in all patients, none of the patients had tenderness in the fracture line and functional return was observed in all patients. So we did not use CT to avoid giving extra radiation and charging additional costs.

After percutaneous screw application, we found high union rates in scaphoid waist fractures and low complication rates, we think that the percutaneous method is an effective and reliable treatment method. With this technique, complications of prolonged immobilization are avoided and an earlier return to work and sports activities is achieved. The retrospective design of the study and the selection of the surgical technique according to the surgeon's choice were the main limitations of our study. According to our personal experience, screwing between anatomical structures is difficult in the dorsal approach, and since the cartilage surface is drilled, this may lead to degenerative changes later in time. Therefore, long-term follow-up is required to understand this. In the volar approach, some minimally displaced fractures were reduced in hyperextension position. Therefore, minimally displaced fractures
may benefit from being treated with a volar approach. In addition, we think that screw heads should be deeply buried in the bone, that the scaphoid counter-cortex should not be drilled, and that the screw should not pass through the joint.

Finally, we think that both volar and dorsal percutaneous approaches in acute, nondisplaced scaphoid waist fractures are effective and reliable methods with similar clinical and functional results, and are thus a suitable alternative to each other.

**Conflict of interest statement**

The authors have no conflicts of interest to declare.

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