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Internal fixation of acute scaphoid proximal pole & waist fractures using the dorsal mini open technique without bone grafting

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Abstract

The navicular bone of the hand is the most frequently fractured bone among the carpal bones, and if not treated well, it may result in nonunion. Dorsal, volar open, or percutaneous approaches can be used in surgical treatment. We aimed to evaluate the results of internal fixation of scaphoid fractures with the dorsal mini-open technique. Patients with acute proximal and waist fractures who have been treated with cannulated compression screws with a dorsal mini open approach without grafting between 2015 and 2020 were included. Functional outcomes were analyzed with the DASH questionnaire and MAYO wrist performance scores and compared with the contralateral wrists. The mean age of the patients was 35.6 ±10.8 years (range 20-55), seven were proximal, and 13 were waist fractures. The mean time to surgery was 16±7.3 days (range 5-30) and the mean follow-up time was 47.5±20.2 weeks (range 20-84). The mean DASH score at the last follow-up was 5.9±3.3 points (range 2.5-11.7), and the Mayo wrist performance score was 96.8±5.2 points (range 85-100). In one proximal pole fracture, cracking occurred on the cartilage surface at the screw insertion site but consolidated without any additional intervention. The mean time to union was 8.5±1.2 weeks (range 7-11). Waist region fractures consolidated faster than proximal pole fractures (p=0.002). No significant difference was found between the fracture site and mid-term functional results. Complications like proximal cartilage fractures during the embedding of the screw head or prominence of the screw head can be avoided with the dorsal mini-open technique which is a safe and effective method.

Keywords: Acute scaphoid fractures, dorsal, mini open, limited incision, bone graft, extensor pollicis longus

Introduction

The navicular bone of the hand is the most frequently fractured bone among the carpal bones, with a rate of 50% to 70%, and it usually occurs as a result of falling on the open hand in radial deviation [1]. Difficulties may be experienced in diagnosing with direct X-ray at the first application, and if not treated well, it may result in nonunion [2,3]. It has been shown that if the time elapsed between the treatment of the fracture and the day the fracture occurred is more than four weeks, the rate of nonunion increases by 40% [4]. The fact that 80% of its surface is covered with cartilage, the vascular entrances are in the non-articular region on the dorsal and volar sides, and especially the proximal region is fed with retrograde blood flow are the main causes of nonunion that occurs after waist or proximal pole fractures [1,5].

Long-term plaster treatment is generally accepted for waist region fractures without displacement. However, despite proper casting, nonunion can be seen in the waist and proximal fractures [2]. In addition, studies have been published recently showing that

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surgical treatment prevents both financial loss and limitation of movement compared to long-term casting, even in non-displaced waist and proximal region fractures [6–8].

Dorsal, volar percutaneous, or open approaches can be used in surgical treatment. In the dorsal percutaneous approach, the extensor tendons, especially the extensor pollicis longus (EPL) tendon are at risk [9]. We hypothesized that with the dorsal mini open technique, we should minimize the risk of tendon injuries and the entrance point on the proximal pole can be visualized and protected while inserting screw. There are few studies on the treatment of acute fractures using the dorsal mini-open technique [10–12]. Only one of them have used ligament sparing technique [11], and our study will be the next study which aimed to evaluate the results of internal fixation of the scaphoid fractures with the dorsal mini-open ligament sparing technique.

Material and Method

Approval for this retrospective cohort study was obtained from the local ethics committee of our hospital (Decision No: 125 Date:01.07.2020) and informed consent was obtained from the patients. Patients who underwent surgery for scaphoid fractures between 2015 and 2020 were examined. Of these, patients with proximal and waist fractures who have been treated with cannulated compression screws with a dorsal mini open approach without bone grafting were included in the study. Functional outcomes were analyzed with the DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire and MAYO wrist performance scores and compared with the contralateral wrists [13,14]. Wrist movements were measured with a goniometer and recorded. Grip strength was measured with a Jamar (Jamar, Clifton, NJ) dynamometer and was calculated with 10% correction in non-dominant hands [15]. Since the comparisons were made with the intact hand, bilateral cases or patients with any previous wrist movement limitation were excluded from the study. Fractures older than six weeks were not included in the study because the study was planned on newly formed fractures.

Surgical technique

While the patient was lying in the supine position under regional block anesthesia with a pneumatic tourniquet on the upper arm, a hand table was used to work on. A longitudinal 1.5cm incision was made just distal and ulnar to the lister tubercle from the dorsum of the wrist directing the third metacarpal. Only the distal part of the EPL tendon sheath was opened, and the tendon was protected on the radial side. The joint capsule was opened longitudinally on the same line as the incision, and the scapholunate joint was made visible. The fracture line was not opened and the scaphoid bone was not explored completely. Only the proximal pole of the scaphoid bone was seen, and the entry point of the headless cannulated screw was determined by flexing the wrist to 60 degrees. Then, the guide wire was advanced by controlling it on the fluoroscopy device (Figure 1). As putting the wrist in a neutral position to see the anteroposterior wrist X-ray would bend the guide wires, the elbow was flexed to make the wrist parallel to the ground (Figure 2). This way radiographs were obtained at anteroposterior, lateral, and 30 degrees pronation, and the central location of the guide wire was confirmed. A second wire was used to prevent rotation. Before drilling, screw length was measured with equal-sized K-wires, and a screw 4mm shorter than the measured one was used. Osteosynthesis was achieved with mini headless cannulated compression screws (HCCS, TSTOrthopedics, Turkey) in waist region fractures and micro headless screws in proximal fractures. Grafting was not applied. After pulling the guide wires and controlling the movement, the capsule and EPL sheath were closed with absorbable sutures, and the subcutaneous tissue and skin were closed. A short arm splint was made, sutures were removed two weeks later. A removable wrist splint was given for waist fractures after two weeks. For proximal fractures, the duration of the short arm splint was extended to one month. Joint range of motion exercises was started while the splint was removed. Patients were called for follow-up at 15-day intervals after surgery.

Figure 1. Screw insertion site can be seen after flexing the wrist to 60 degrees

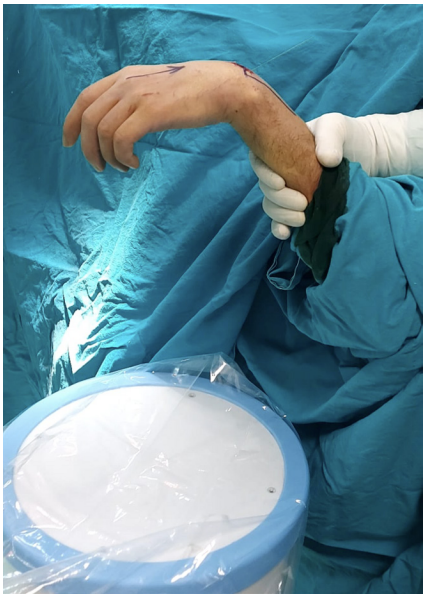

Figure 2. Elbow was flexed to make the wrist parallel to the fluoroscopy device

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Statistical analysis

The normal distribution of the data was analyzed with the Shapiro-Wilk test using the SPSS 25.0 (SPSS Inc, IBM, Chicago, IL) program. A T-test was used to compare the postoperative range of motion with the intact side. The Mann-Whitney U Test was used to compare the union times with the fracture site. The p-value for the significant difference was accepted as <0.05.

Results

Twenty of 25 patients, 16 male and four female, could be reached. Seven fractures were in the proximal scaphoid region, and 13 were in the waist region. The demographic data can be found in Table 1. The mean time to union was found to be 8.5±1.2 weeks (range 7-11) and there was a statistically significant difference between the proximal and waist region fractures regarding the time to union (p=0.002, Table 2). No complications such as guide wire breaking, neuropraxia, hypertrophic scar, infection, tendon rupture, and nonunion were encountered. In one proximal pole fracture, cracking occurred on the cartilage surface near the screw insertion site while the headless screw was fully embedded into the bone. However, no statistically significant difference was found between the fracture site and mid-term functional scores.

Table 1. Demographic Data

	Mean	Standard Deviation	Minimum	Maximum
Age "Years"	35.65	10.840	20	55
Time from fracture to surgery "Days"	15.95	7.097	5	30
Follow-up time "weeks"	47.55	20.242	20	84
Final DASH score	5.875	3.3312	2.5	11.7
Final Mayo wrist score	96.75	5.200	85	100
Final Extension	64.70	4.566	55	73
Opposite side Final Extension	71.50	2.838	68	78
Final Flexion	77.05	4.019	70	85
Opposite side Final Flexion	79.20	3.847	72	85
Grip Strength	38.25	5.730	28	47
Opposite side Grip Strength	38.05	4.751	27	44

Table 2. Comparison of fracture consolidation time according to fracture location

Fracture localization	Mean Time to consolidation "weeks"	Std. Deviation	Significance p
Proximal	9.57	1.27242	0.001802
Waist	7.92	.75955	

Discussion

In this study we showed that there is no need to open the fourth and second dorsal extensor compartments to explore the scapholunate area with the dorsal mini open technique. Also, complications like screw prominence or entry site fracture can be avoided while protecting dorsal ligaments and tendons.

An uncontroversial area in the treatment of acute scaphoid fractures is the necessity of surgical treatment of proximal pole fractures [16–19]. Nonunion problems are frequently encountered in scaphoid proximal region fractures.Vascularity is thought to be related to this situation. For this reason, Megerle et al. reported that they performed intra-operative bleeding control in the surgical treatment of proximal pole non-unions. They have applied vascularized grafts to those without bleeding, and conventional bone grafts where they could detect bleeding [20]. In non-displaced acute fractures, it was advocated that surgical fixation without using grafts and without bleeding control is sufficient [16,21,22]. In proximal region fractures, unlike the waist region, standard 4 mm cannulated compression screws are not recommended due to the small area to be inserted, as there is a risk of fragmentation of the proximal pole [16]. In our study, all acute proximal region scaphoid fractures were surgically treated, and fixation was performed with 2.5 mm micro headless cannulated compression screws without using grafts.

The surgical treatment of acute waist fractures is controversial [23]. The indication for surgery is usually decided by evaluating the initial displacement and stability of the fracture. While fragmentation of the fracture, an intra-scaphoid angle of more than 35 degrees on the lateral radiograph, and perilunate injury indicates that the fracture is not stable, there are different opinions regarding the amount of displacement [1,11,12,16]. Classically, the presence of a 1mm gap is considered unstable. At the same time, Clementson et al. have classified it as "minimal" if the amount of displacement is less than 0.5mm,

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moderate if the amount of displacement is between 0.5 and 1.5mm, and advanced if the amount of slippage is ≥1.5mm [1,10,11,16]. While they recommended surgical treatment for those with severe displacement and conservative treatment for those with minimal displacement, they reported that fractures of the waist region with moderate displacement could be treated conservatively. However, casting may be required for up to 10 weeks [16]. And even with slight displacement, the presence of a separate cortical fragment on the radial side of the scaphoid bone or the accompanying rupture of the scapho-lunate ligament is still considered unstable [24,25]. The relative surgical indication is mentioned in young active patients and patients unsuitable for long-term cast treatment, as surgery may shorten the time to return to work [7,11,26]. In our study, scaphoid waist region fractures with a displacement of 0.5mm or more were fixed by using the dorsal mini-open technique with 3.3 mm mini headless cannulated compression screws without opening the fracture line.

It has been reported that computed tomography (CT) scan should be used in preoperative planning to determine the amount of displacement and to evaluate the stability [1,27]. On the other hand, Müller et al. recommended CT scan to evaluate postoperative screw placement and to diagnose nonunion [28]. The study of Herbert and Filan showed that there might be no symptoms after stable fixation without any sign of union on direct radiographs [19]. In an examination conducted for the treatment of nonunion cases, Tada et al. divided the fracture line into three types as; linear, cystic and sclerotic or displaced type, and they reported that CT examination is required for this distinction [22]. They emphasized that graft should be used if there is a cyst or sclerosis in the CT examination. In our study, all patients had a CT scan for preoperative planning, and as the study was conducted on acute fractures no cyst or sclerosis was detected. Since union findings were detected in the direct radiographs in the postoperative follow-ups, examination with CT scan was not required after the operation.

Dorsal and volar, percutaneous or open approaches can be used in the surgical treatment of acute scaphoid fractures [1,29]. The route to be chosen is also related to the localization of the fracture and the surgeon's preference [26]. While the dorsal approach is preferred in proximal fractures, there is no consensus in waist fractures [10]. In the dorsal open approach, the blood supply to the scaphoid bone is disturbed, while in the volar approach, the scaphotrapezoid joint may be damaged. In addition, for the screw to be inserted into the center of scaphoid bone, it might pass through the trapezium in the volar approach, and tendon ruptures may be encountered when it is applied entirely closed in the dorsal approach [9,10,12].

Martus et al. reported in 2005 that tendon damage could be prevented with a limited dorsal approach [10]. According to this technique, with a 3 cm dorsal incision, the third, fourth and second extensor compartments are opened starting from the distal of Lister's tubercle, and the capsule is opened in an inverted T shape to explore the proximal scaphoid. They have investigated 18 acute waist fractures with less than two weeks between injury and surgery, which has displacement of less than 1 mm with no ligament injury, and they have found union within eight weeks in 17 patients and did not encounter any significant complications [12]. They did not report the nonunion case as a significant complication because of the short follow-up period and the continuation of the treatment for that patient. The mean DASH score was found to be 6.12 in their follow-ups. Our study was also planned on acute fractures but also included proximal region fractures. It is similar to the study of Martus et al. as union was detected in 20 patients, and the mean DASH score was 5.9.

Dodds et al. described the dorsal mini-open technique with ligament-sparing arthrotomy and presented their comparative study with the percutaneous dorsal approach [11]. They reported that they used a 1.5 cm incision in this study, which included patients with a displacement of 1 mm or more, and patients who needed early movement. They explained the technique as opening only the distal of the third compartment and radial side of the fourth compartment and then opening the capsule longitudinally to reach the proximal scaphoid. They observed minor complications that did not make a statistically significant difference in both groups, but functional results were not evaluated in their study. They recommended using the ligament-sparing surgical technique because they found it safe [11]. On the other hand, our study is similar to that of Dodds et al. in terms of incomplete opening of the EPL tendon sheath and incision size. We did not open the fourth compartment and functional scores were also evaluated in our study.

In the study by Bushnell et al., in which a closed dorsal percutaneous approach was used as described by Slade et al., they reported that the complications of percutaneous techniques are higher than expected [9,30]. In this study of 24 patients involving only waist region fractures, the time between trauma and surgical intervention extended up to 10 weeks. The significant complications they encountered were one nonunion, three screw irritation, and one proximal region fracture in the postoperative period. We think that the irritation due to the incomplete embedding of the screw head in the proximal scaphoid and the damage caused by drilling in the radio-scaphoid joint can be prevented with the mini-incision used in our study.

In our study, one major complication was observed in a patient with a proximal pole fracture. Cracking was observed in the cartilage area at the edge of the screw during tightening, immediately after the screw was embedded. The compression was stopped as soon as it was observed. Since the entry point of the screw was visible, fragmentation of the proximal region was prevented, and as stable fixation was ensured, the screw was not changed, or loosened. After a one-month standard splint period, movements were initiated, and no additional intervention was required for this patient. The pre-operative and post-operative

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images of this patient can be seen in figures below (Figure 3).

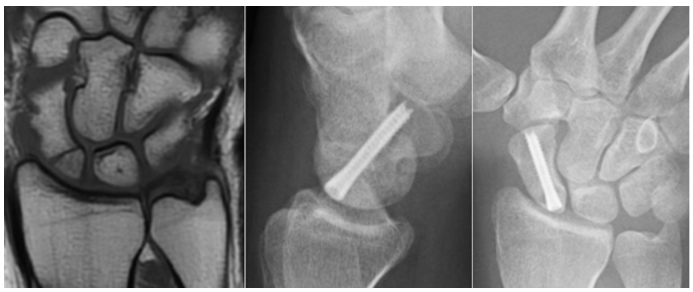

Figure 3. Images of one patient's pre-operative and 3 months after operation

In both studies using the dorsal mini-open technique, only waist fractures were examined, and therefore, the time between the union and fracture location was not investigated [11,12]. Severo et al. used the volar technique in 24 waist fractures and the dorsal percutaneous technique in 4 proximal region fractures [8]. Failure was detected in one dorsally approached fracture, since the head of the screw was not embedded in the bone. In our study, such a complication was not encountered since this region was visualized while the screw was placed. The same study reported that the waist region fractures consolidated earlier than the proximal region, which is consistent with our study.

There are some limitations of our study. First limitation is; it was arranged retrospectively and as a result the data was collected from the records of the patients and therefore, we couldn't perform a comparison between the pre- and post-operative functional outcomes. Also, no comparison with an alternative treatment method was made in the current study. Another limitation is, the union times were not evaluated with CT scan but it is not a routine recommendation. Finally, the sample size of cases was relatively small.

Conclusion

With the dorsal mini-open technique, the screw insertion site can be visualized between the third and fourth dorsal compartments without complete opening of these compartments. As a result, complications such as proximal cartilage fractures during the embedding of the screw head or irritation because of a prominent screw head can be avoided. The dorsal mini-open technique is safe and effective for proximal and waist region scaphoid fractures.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
Approval for this retrospective cohort study was obtained from the local ethics committee of our hospital (Decision No: 125 Date:01.07.2020) and informed consent was obtained from the patients.

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