RESEARCH ARTICLE

Closed K-wire Fixation for the Treatment of Perilunate Dislocation and Trans-Scaphoid Perilunate Fracture Dislocations without Ligamentous Repair: Short Term Follow-Up

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Abstract

Background: The purpose of this study was to evaluate the treatment outcomes of perilunate dislocations (PLDs) and transscaphoid perilunate fracture dislocations (TSPLDs) treated with operative volar approach without ligament repair or reconstruction.

Methods: A total of seven patients (10 hands) were studied during 2017-2018. We fixed scaphoid fractures thorough a volar approach and 3 k-wires were inserted to stabilize the scaphoid to the adjacent bones. We evaluated patients' range of motion by VAS and grip strength, sensitivity assessment, and radiographs. Mayo and DASH scores were also recorded for wrist evaluation.

Results: All fractures united well. The mean Mayo wrist score was 81.5. Five patients scored good and excellent results (90-100). Excellent DASH scores (<20) were observed in 4 patients and there was no poor DASH score (>50).

Conclusion: Treatment of PLDs and TSPLDs with k-wire and screw fixation using a volar approach and without any ligament repair or reconstruction results in minimal manipulation and has favorable short-term outcomes.

Level of evidence: II

Keywords: Bone wire, Joint dislocations, Ligament, Lunate bone, Transscaphoid perilunate fracture dislocation

Introduction

Perilunate dislocation (PLD) and perilunate fracture dislocations are complex types of wrist instabilities, resulting from high energy injuries such as motor vehicle accidents, falls from height, and extreme athletic activities that constitute about 10% of all carpal injuries, while scaphoid fractures, associated with dislocation of capitate from the lunate, referred to as transscaphoid perilunate dislocations (TSPDs) are observed in 61% to 65% of these types of injuries (1, 2).

Perilunate injuries can result in poor functional results, if left untreated, and patients may have mild to moderate dysfunction even after treatment (3). Although closed treatment was historically advocated for these injuries, early treatment with open reduction and internal fixation is the recommended treatment choice (4). Nonetheless, the best surgical approach is still controversial and varies based on surgeon's preference, interval after injury, location, degree, and pattern of dislocation (5). Dorsal approach, volar approach, or combination of dorsal and volar approaches have been suggested

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in different studies; and recently minimally invasive methods of screw fixation under fluoroscopic guidance or arthroscopic assistance have been introduced (6-10).

Although open reduction and internal fixation methods allow for direct anatomic reduction and appropriate fixation of most injured components, it has several complications such as inevitable soft tissue, cartilage, tendon, ligament, and vascular injuries, carpal instability and traumatic arthritis, while evaluation of osteochondral and ligamentous lesions is also difficult that may result in imperfect carpal reduction and residual instability (5, 11, 12). In spite of discussions about different surgical approaches, we believe that individualized approach for different groups of patients can guide us to the best management for each patients. As TSPD is generally a rare condition, reporting new cases can help surgeons on a better treatment choice. Thus, in this study, we aimed to evaluate patients with PLDs and TSPLD, treated with operative volar approach without ligament repair and reconstruction, and assess the short-term results in these patients.

Materials and Methods

In a 1.5-year period (January 2017 - June 2018), 15 patients with wrist injuries were diagnosed and treated in orthopedic service at Imam Hossein hospital, Tehran, Iran. The injury was as follows in fifteen patients:

- Seven people with unilateral and eight with bilateral injuries;
- Including 8 PLDs and 15 TSPLDs;

Three patients were excluded due to associated injuries (including ankle fracture, radius fracture, elbow dislocation and 2 phalangeal fractures) and 5 patients were excluded from the study as they did not agree to participate in this study or refused clinical and radiological follow-up evaluations.

Finally, 7 patients with 6 TSPLDs and 4 PLDs signed the written informed consent for their participation in this study and completed the follow-ups. The study protocol was approved by the Medical Ethics Committee of Shahid Beheshti University of Medical Sciences (#:IR.SBMU.REC.1396.005).

All cases were diagnosed at the time of their first visit by radiographic assessment (standard anteroposterior and lateral plain radiography of wrist joint). All patients were treated with closed reduction and splinting under adequate sedation within the first 24-48 hours, the time spent on primary stabilization of multiple trauma patients resulted in up to a maximum of 42 hours' delay, followed by elective surgical intervention within 3 days; all closed reductions were successful. All operations were performed by one orthopedic hand surgeon. Two patients including three wrists revealed signs of carpal tunnel syndrome at the time of initial evaluation, all resolved after successful closed reduction. All injuries were closed without fractures of capitate or triquetrum. Herzberg et al. (13) classified perilunate dislocations and fracture-dislocations into two stages. In stage I injuries lunate stays in place under the radius articular surface and capitate displaces either dorsally or volarly with respect to lunate. While, in stage II injuries lunate dislocates dorsally or volarly, which is subdivided into stages IIA and IIB when scaphoid is rotated less than 90 and more than 90 degrees respectively. In this study, according to classification of Herzberg et al for PLDs and fracture-dislocation, all cases were classified as stage II, and in TSPLDs, scaphoid fracture was involved the proximal third in two and scaphoid waist in four patients. Clinical and radiological assessments of patients are summarized in [Table 1].

Surgical Technique

All operations were conducted under general anesthesia, and all patients received prophylactic antibiotic before surgery. The arm was prepped and draped on the hand table with the patient in supine position; pneumatic brachial tourniquet was fastened. A volar approach was used with internal fixation of scaphoid fracture with Herbert screw. The incision was centered over the scaphoid's tubercle and curved distally in to the base of thenar eminence; the flexor carpi radialis was exposed and retracted ulnarly; the radial artery was protected; the dorsal sheath of flexor carpi radialis was incised longitudinally; and pericapsular fat was divided; the anterior capsule of wrist was incised longitudinally to display the anterior surface of scaphoid. Fibrin and clots were removed from the fracture surface and after exposing the distal fragment of the scaphoid and the capitate head by traction on the hand, the proximal fragment was pushed dorsally and the distal fragment was pulled volarly. The fracture was then reduced and the scaphoid fracture was fixed with a screw (Herbert: Zimmer, Inc). For intercarpal fixation in patients with SLD or TSPLD, we fixed the scaphoid bone to the lunate via a single 1mm k-wire; secondly, after the confirmation of the alignment between lunate and radius under fluoroscopy, we achieved the desired alignment between lunate and triquetrum by lunotriquetral joint fixation with the second 1mm k-wire. Finally, we used the same sized k-wire to stabilize the scaphocapitate joint [Figure 1]. We performed all the mentioned steps under fluoroscopic guidance. No ligamentous repair or reconstruction was required. After inserting the wire into the wrist bone, one end of each wire was placed outside the skin so that it could be removed easily in the future. Finally, the skin was closed as routine. For pure perilunate dislocation, the same pinning technique was applied under fluoroscopy without any open surgical ligamentous repair. Then the wrist was immobilized with long arm cast for 8.8 weeks (Min 7 and Max 11 weeks). The k-wires and splint were removed afterwards; physiotherapy of the wrist with gentle movements started, and heavy manual activities were avoided for at least three months.

Assessments

Outcome was assessed for each patient on the last follow-up visit at mean of 11.7 months after surgery (Min: 9 and Max: 15). For the objective assessment of range of motion, grip strength, and sensitivity assessment, radiographs were evaluated by the orthopedic specialist. Wrist range of motion was measured using a goniometer according to the American Medical Associations guidelines;

sensitivity assessment by two-point discrimination, and grip strength by Jamar dynamometer according to values for age and sex.

Subjective assessments were performed by a 10-point Visual Analogue Scale (VAS) (1 indicated no pain and complete satisfaction, while 10 indicated the worst pain and complete dissatisfaction). The patients were also asked about the pain they experienced using their hand for daily activities.

Radiologic evaluation consisted of scapholunate angle, radiolunate angle, capitolunate angle, carpal height ratio, and size of scapholunate gap. These assessments were recorded in absolute degrees in bilateral cases and percentage of value for the contra-extremity in unilateral cases, immediately after surgery and on final follow-up.

The patients were also evaluated by two orthopedic scores used for wrist evaluation including Mayo wrist score and disabilities of the arm, shoulder and hand (DASH) score (14). The Mayo wrist score was evaluated for overall functional recovery, interpreted as excellent (90-100), good (80-90), satisfactory (60-80), and poor if below 60. The DASH scores were interpreted as excellent (<20) and poor (>50).

Results were presented by mean and standard deviation (SD) as well as minimum and maximum values. Statistical analyses for radiological evaluation were

Table 1. Clinical and radiological characteristics of patients

No of case	No of patient	Wrist	Age (year)	Occupation	Cause	Associated Fracture	Injury	Herzberg Classification	Time to close reduction (hr)	Treatment	Length of immobilization (weeks)	Length of follow-up (month)
1	1	L*	24	Factory worker	Fall	Scaphoid	Drorsal PLFD	II	8	Herbert Screw+K-wire	9	12
2	2	L*	20	College Student	Accident	non	Dorsal PLD	II	10	K-wire	7	9
3	3	R*	35	Office job	Fall	Scaphoid	Drorsal PLFD	II	30	Herbert Screw+K-wire	11	14
4	3	L	35	Office job	Fall	non	Dorsal PLD	II	30	K-wire	8	14
5	4	L*	23	Construction worker	Fall	Scaphoid	Drorsal PLFD	II	42	Herbert Screw+K-wire	9	15
6	5	R*	30	Factory worker	Fall	non	Dorsal PLD	II	18	K-wire	7	12
7	5	L	30	Factory worker	Fall	Scaphoid	Drorsal PLFD	II	18	Herbert Screw+K-wire	10	12
8	6	L*	44	laborer	Fall	Scaphoid	Drorsal PLFD	II	28	Herbert Screw+K-wire	11	9
9	7	R*	22	Student	Sport	Scaphoid	Drorsal PLFD	II	20	Herbert Screw+K-wire	9	10
10	7	L	22	Student	Sport	non	Dorsal PLD	II	20	K-wire	7	10

*dominant hand; MVA: Motor Vehicle Accident

Figure 1. AP and Lateral wrist radiograph of patients Number 6 after surgery. Intercarpal fixation is performed in scapholunate, lunotriquetral and scaphocapitate joints without ligamentous repair.

performed using Student's paired t-test. *P-value<0.05* was considered as statistically significant.

Results

Participants' characteristics

Injuries were unilateral in 4 patients and bilateral in 3 (all on the dominant hand). Among the three participants with bilateral injuries, the cause was falling from altitude in form of sport injury (Bungee jumping) or labor injury. Three people suffered unilateral wrist injuries due to motorcycle accident or falling from height.

All patients were men with mean age of 28 years (range: 20-44 years). Of 7 patients, 4 were manual workers and 3 were holding office jobs. The mean follow-up time was 11.7 months (range: 9-15 months). Injuries occurred due to motor vehicle accidents in 1 patient and falling from height in 6 patients among which one was port injury during bungee jumping.

Subjective Assessments

All patients expressed on final follow up that they were satisfied with the surgical outcome; one patient complained of pain for light daily activities and others indicated satisfactory pain relief. The mean pain score based on VAS was 2.1 at rest (range: 1-4) and 2.8 with stress (range: 1-6). All patients were able to return to their previous jobs, 5 without any restrictions and 2 with certain restrictions, able to do only lighter activities.

Objective Assessments

With a mean follow-up of 12 months (range: 9-15), the mean healing time of scaphoid fractures was 11.3 weeks (range: 8-14 weeks). The mean combined wrist flexion-extension arc was 115.5° (range: 100-135°) for all injured wrists, unilateral cases showed 87% of the contralateral wrist. The mean flexion-extension arc of the contralateral wrists was 135° (128-148°). The mean combined supination and pronation was 160° (range: 135-175°) for all injured wrists and unilateral cases showed 90% of contralateral wrists (mean of 160° for contralateral wrist, range: 150-185°). Follow-up radiographs and range of motion of two patients are provided in Figures 2 and 3.

The mean grip strength on Jamar dynamometer was 30.9 kg. The patients achieved an average of 85% grip strength of the uninjured side for unilateral cases and 83% for bilateral

Figure 2. Post-Operative follow-up radiographs of patient Number 4 and his final range of motion.

cases for sex and age matched scores of dynamometer. The two-point discrimination was normal in all cases. Clinical characteristics of the patients and examinations of our series are summarized in [Tables 1; 2].

Radiologic Evaluation

The final follow up radiographs were compared with initial post-surgical radiographs [Table 3]. Although the mean revised carpal height ratio decreased on final follow-up, it was not statistically significant; also there was no significant difference between scapholunate, radiolunate, and capitolunate angles and the increased scapholunate gap on final follow-up was not significantly different from the initial assessment.

Figure 3. Post-Operative follow-up radiographs of patient Number 1 and his final range of motion.

Table 2. Functional outcomes of patients

No of case	VAS Score	flexion-extension arc (% Contralateral)*	Supination-Pronation (% contralateral)*	Grip strength, kg(%)**	Mayo Wrist Score	DASH Score
1	1	125(90%)	165(90%)	32.8(89%)	95	6.7
2	1	135(92%)	175(94%)	33.2(93%)	95	4.2
3	3	105	160	29.1(80%)	75	23.3
4	2	113	168	31.2(83%)	75	23.3
5	3	120(88%)	155(89%)	30.3(85%)	70	31.7
6	1	118	160	31.6(86%)	90	10.3
7	2	105	150	30.9(84%)	85	10.3
8	4	100(78%)	130(87%)	28.1(74%)	65	34.2
9	2	110	163	31.8(85%)	80	18.3
10	2	120	172	30.7(80%)	85	18.3

* Percent of contralateral in unilateral cases;** percent of contralateral hand for unilateral cases and percent of matched scores for age and sex for bilateral cases

Table 3. Comparison of post-surgical and the last follow-up radiological indices

	Immediately after surgery	Last follow-up	*Pvalue*
Revised Carpal Height Ratio(o)	1.49±0.2	1.46±0.1	0.12
Scapholunate Gap(mm)	1.43±0.35	1.61±0.43	0.09
Scapholunate angle(o)	50.3±6.8	52.2±7.4	0.57
Capitolunate angle(o)	11.3±3.4	10.4±4.1	0.39
Radiolunate angle(o)	7.2±7.5	7.1±8.3	0.73

Outcome Scores

The mean Mayo wrist score was 81.5 (range: 65-95) with excellent results in two patients, good results in three patients, and satisfactory results in two patients. The mean DASH score was 18.06 with excellent results in four patients and >20 in three patients, while there was no poor DASH score (>50) among patients.

Complications

There were no malunion and all the fractures united. None of the patients had radiographic evidence of early arthritis. One patient had carpal tunnel symptom. No other complications like pin tract infection and avascular necrosis of scaphoid or lunate were detected during our follow-up period. No patient required any additional surgery, except k-wire removal.

Discussion

PLDs and TSPLDs are uncommon injuries with high rate of treatment failure and poor surgical outcome with difficult diagnosis, classification, and treatment; however, treatment algorithm has progressed for these injuries and different methods of open reduction with single or combined methods and various types of fixation, closed reduction with percutaneous pinning, and arthroscopic evaluation have been proposed (5). Although open reduction with internal fixation has become the gold standard treatment for perilunate injuries, Stanbury et al. stated in a review article that comparison of the results of different approaches was not possible due to the lack of sufficient prospective randomized trials (15). We believe that the reason of unclear ideal surgical approach and controversies on different approaches is the fact that there is no ideal surgical approach for all patients and the decision for surgical approaches is largely dictated by the individual surgeon's experiences. The authors of this article believe that the key to a good clinical result in treatment of perilunate dislocation or fracture dislocation is not only restoration of proper alignment of carpal bones, but also, maintenance of this restoration and individualized approaches based on injury's severity and pattern, mechanism of injury, and the extent of bone, ligament, and cartilage damage can result in best surgical outcome.

In this study we reported a series of PLDs and TSPLDs treated with volar approach with k-wire fixation and without ligament repair and reconstruction. Temporary carpal fixation with k-wires is necessary for successful ligament healing. Some have suggested that ligament repair for treatment of TSPLDs is not necessary and adequate healing of perilunate ligaments can be achieved even without direct ligament repair, especially if carpal alignment is restored and maintained (16). Knoll et al. assessed the importance of ligament repair by dorsal approach for screw fixation of scaphoid and confirmed that their technique did not adversely affect the outcome, but, could not lead to a better wrist function (6). However, operative treatment is important because untreated dislocations lead to poor results including post traumatic arthritis, decreased range of motion, and chronic carpal tunnel syndrome. Also, abnormal carpal mechanism can decrease function and lead to arthritis, but we believe that open procedure with minimum manipulation of the joint structure and avoiding extra procedures can lead to proper alignment and maintenance of carpal bone alignment (17). Park et al. stated that adequate stabilization of acute scapholunate or lunotriquetral ligament injuries can be obtained by an accurate reduction and pinning with no effort to repair the torn ligaments (18). Adkinson et al. also suggested that the maintenance of an anatomic position is sufficient to restore perilunate ligamentous integrity without individual ligament repair (19). In fact, ligament structures of the joints are generally believed to heal adequately when properly approximated and protected for sufficient time. This concept can also be applied to perilunate injuries.

In our study volar approach was used by surgeon's preference and the results showed favorable outcomes with no cases of malunion, no radiographic evidence of early arthritis, and no complications like pin tract infection and avascular necrosis of scaphoid or lunate or any requirement of additional surgery, except k-wire. Volar approach is believed to allow control over the median nerve and carpal tunnel decompression, visualize damage to perilunate dislocation, easier reduction of the fractured scaphoid, access to distal scaphoid fracture, better exposure of carpus, and easier repositioning of perilunate dislocation (5, 12, 20). Malovic et al. also commented that advantages of volar approach include decreased adhesion to flexor compared to extensor tendons, using dorsal approach and lower incidence of avascular necrosis (21). In line with the above-mentioned reports our results showed the appropriateness of volar approach with minimal complications.

In this study, we assessed the wrist range of motion of patients both subjectively and objectively, in line with Kremer et al. who stated that clinical results based on outcome scores are not necessarily correlated with the patients' individual perception of disability and the best tool to measure this important information is the DASH questionnaire (4). Another remarkable finding in this study is that three (out of seven) patients suffered bilateral injury due to a fall from height; nevertheless, bilateral TSPLDs and PLDs are extremely rare as stated before (22, 23). However, as a referral center in the country, we encountered this high rate of bilateral injuries most probably due to fear of mismanagement in the stellate centers (24). Fortunately, all patients managed to return to a satisfactory level of activity in daily living during our one-year follow-up. The mean Mayo wrist score in our study was 81.5 (range: 65-95) with excellent results in two patients, good results in three patients, and satisfactory results in two patients. The mean DASH score in our study was 18.06 with excellent results in four patients and >20 in three patients, but there was no poor DASH score (>50) among patients. Malovic et al. reported 43 cases undergoing volar approach with screw fixation for scaphoid fractures via guidewire and temporary k-wires used for fixation and reported a mean Mayo wrist score of 87 with all patients returning to their previous jobs (21). In the present study, as well, all patients returned to their previous job, five without any restrictions and two with certain restrictions, able to do only lighter activities. The mean wrist extension-flexion was 85% of contralateral wrist and grip strength was 87% of contralateral at final follow-up in our report, which was higher than that reported by Malovic et al. (75%) (21). The Mayo wrist scores of the present study was even higher than the study by Wong et al. who used a minimally invasive management for TSPDs (mean Mayo score of 80 with three excellent and two poor results) (9). Although less invasive methods are believed to have better results for management of PLDs or TSPLDs (10, 18), we believe that all perilunate injuries cannot be managed by one general approach.

The limitations of current study include lack of longer-term follow-up, absence of comparison of the results (with other procedures with and without ligament repair or with other patients), and nonrandomized patients' selection.

A prospective cohort of procedures and longer-term follow-up can assure the results.

Based on this report, the treatment of PLDs and TSPLDs with k-wire and Herbert screw fixation using a volar approach without any ligament repair or reconstruction and minimum manipulation and no extra procedures can have favorable short-term subjective, objective and radiological results and minimal complications.

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