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Dr. Mansoor Ahmad Tali
Senior Resident, Department of Orthopaedics, Government Medical College, Srinagar, Jammu and Kashmir, India

Dr. Mudasir Nazir Bhat
Senior Resident, Department of Orthopaedics, Government Medical College, Srinagar, Jammu and Kashmir, India

Dr. Imtiyaz Hussain Dar
Professor, Department of Orthopaedics, Government Medical College, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Dr. Mansoor Ahmad Tali
Senior Resident, Department of Orthopaedics, Government Medical College, Srinagar, Jammu and Kashmir, India

Closed K-Wire fixation for the treatment of Perilunate dislocations and Trans-scaphoid Perilunate fracture-dislocations without ligamentous repair: Short term follow-up

Dr. Mansoor Ahmad Tali, Dr. Mudasir Nazir Bhat and Dr. Imtiyaz Hussain Dar

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Abstract
Introduction: Perilunate injuries are rare and often caused by high-energy trauma. Despite surgical treatment, there can still be a high incidence of functional dissatisfaction and post-traumatic arthritis. The aim of this study was to evaluate the short term follow-up outcomes of perilunate dislocations (PLDs) and transscaphoid perilunate fracture dislocations (TSPLDs) treated with closed k-wire fixation without ligament repair or reconstruction.
Materials and Methods: This observational study was carried out on 12 patients diagnosed with perilunate dislocations (PLDs) and transscaphoid perilunate fracture dislocations (TSPLDs) treated with closed k-wire fixation without ligament repair or reconstruction to evaluate the short term follow-up outcomes. At the final follow-up clinical assessment was done by ROM, VAS score for pain, DASH questionnaire for Disabilities of the Arm, Shoulder and radiographs were evaluated with regard to incidence and time to scaphoid union and the lunotriquetral gap.
Results: The mean wrist movement (flexion-extension) and grip strength rates were 79.9 % and 80.2 %, respectively. The mean active flexion-extension arc was 115° (range 90^0 to 130°). The mean combined supination and pronation was 165^0 (range 135-180^0) for all injured wrists. At the final follow-up evaluation, the average SL gap was 1.4 (range, 1 to 2.7) mm. The mean SL and CL angles were 48.3° (range 40 to 75°) and 4.7° (range 2 to 12°) respectively. The mean grip strength on Jamar dynamometer was 32.9 kg. The patients achieved an average of 87% grip strength of the uninjured side. At the latest follow-up, mean post-operative VAS score for pain was 2.73 (range 0-4). The mean post-operative DASH scores was13.08 with excellent results in 7 patients.
Conclusion: The treatment of PLDs and TSPLDs with k-wire fixation 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.

Keywords: Wrist, Perilunate dislocations, fracture-dislocations, reduction, fixation, herzberg classification.

Introduction
Perilunate dislocations and perilunate fracture dislocations are devastating injuries to the wrist and are a subcategory of the carpal instability complex. Perilunate injuries were first described by Joseph Francois Malgaigne [1] and pose as a type of carpal instability complex [2]. The ligamentous and bony structures around the lunate are severely damaged. Perilunate injuries account for approximately 2% of all hand injuries. These injuries generally occur in young patients after high-energy trauma [3].
Perilunate dislocations are high-energy injuries caused by a fall from a height, motor vehicle accidents or sporting injuries. Depending on the severity and direction of the injury, it has been shown that there are a number of different injury types, ranging from perilunate fracture-dislocation to a full lunate dislocation [4-7]. The direction of the perilunate dislocation is dorsal in 97% of the patients, with 10% being open injuries and 65% being accompanied by carpal and distal radial fractures [4].

The literature lacks any consensus regarding the modality of treatment. Notably, poor results have been observed with non-operative treatment methods [8, 9] Perilunate injuries can result in poor functional results, if left untreated, and patients may have mild to moderate dysfunction even after treatment [10]. Although closed treatment was historically advocated for these injuries. However, several studies have reported acceptable results with open reduction and internal fixation through a dorsal surgical approach, a volar approach or a combination of both of both have been suggested in different studies [11]. Recently minimally invasive methods of screw fixation under fluoroscopic guidance or arthroscopic assistance have been introduced [12-16]. 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 [17, 18].

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 patient. Thus, in this study, we aimed to evaluate the short term follow-up outcomes of patients with perilunate dislocations (PLDs) and transscaphoid perilunate fracture dislocations (TSPLDs) treated with closed k-wire fixation without ligament repair or reconstruction.

Materials and Methods

This observational study was carried out to evaluate the short term follow-up outcomes of patients with perilunate dislocations (PLDs) and transscaphoid perilunate fracture dislocations (TSPLDs) treated with closed k-wire fixation without ligament repair at Govt. Hospital for Bone and Joint surgery, Barzulla an associated Hospital of Govt. Medical College Srinagar. In this study a total of 11 patients diagnosed with perilunate dislocations and fracture-dislocations from May 2020 to April 2022 were enrolled. Inclusion criteria were: any patient of >18 years age, patients with perilunate dislocations (PLD) and perilunate fracture dislocations (PLFD). The patients with collagen disease, rheumatoid arthritis, osteomalacia and patient who received proximal row carpectomy were excluded from the study.

A perilunate injury was diagnosed after standard postero-anterior and lateral plain radiographs of the wrist joint at their initial presentation. Injuries were classified according to the Herzberg classification (Table 1). Patients were immobilized with a short arm splint until surgery.

Surgical technique

All surgeries were performed under local anesthesia. In acute perilunate dislocations a closed reduction was performed. Gentle traction was used prior to the reduction attempt. For a dorsal perilunate dislocation longitudinal traction followed by volar flexion of the wrist with volar pressure on the capitate was done. Once reduction was complete PA and lateral views of the wrist were obtained to assess carpel alignment.

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. No ligamentous repair or reconstruction was required. Finally, the skin was closed and wrist was immobilized with long arm cast.

Post-operative protocol

In the postoperative period, all the patients sustained 6 weeks of wrist immobilization. Physical rehabilitation was started afterwards. Total time of therapy was stated on an individual basis. After 6 weeks, a removable splint is used for another 3-4 weeks with compliant patients before the removal of k-wires was performed. Removal of the k-wires after 10 weeks was done under fluoroscopy followed by mobilization of the wrist. Depending on the radiographic appearances, progressive mobilization and strength training was started after 10 weeks and removal of k-wires.

Assessment

A review of the median nerve function, wrist extension/ flexion, wrist radial/ulnar deviation, pro/supination, grip strength, and power strength was evaluated using a Jamar dynamometer. Wrist range of motion was measured using a goniometer according to the American Medical Association guidelines. Radiographs were evaluated with regard to incidence and time to scaphoid union and the lunotriquetral gap at the time of surgery and at follow-up examination. Visual Analogue Scale (VAS) for pain (0 -10) was applied and data from preoperative period were reviewed. Global hand function was evaluated using Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (0 - 100). The postoperative complications were identified through clinical and radiological assessment.

Results

The mean age of the patients was 32 (19-53) years. There were 9 (75 %) male patients and 3 (25 %) were female patients in this study. The mode of trauma was road accidents in 4 (33 %) and falls in 8 (67 %) patients. All patients were with unilateral fracture. The right wrist was injured in 7 (58 %) patients and the left wrist in 5 (42 %) patients. Most of the injuries 8 (67 %) were fracture-dislocations. Perilunate injuries were most commonly associated with radial styloid (51.85%) and scaphoid (44.44%) fractures of the same wrist. According to Herzberg staging, 6 (50 %) patients were stage 2A, 4 (33 %) patients were stage 2B and 2 (17 %) patients were stage 1 (Table 1).

The average time between injury and surgery was 4 (range, 0 to 7) days. In this study the mean follow-up was 11 (range 9-13) months, the mean healing time of scaphoid fractures was 10.4 (range 7-13) weeks.

In this study, no permanent pain was reported by any of the patients. One patient reported occasional pain and two patient experienced occasional pains during daily activities. At the

final follow-up, these three patients reported no pain. The mean wrist movement (flexion-extension) and grip strength rates were 81.7 % and 82.3 %, respectively. The mean active flexion-extension arc was 115° (range 90^0 to 130°). The mean combined supination and pronation was 165^0 (range 135-180^0) for all injured wrists

Table 1: Demography of patients

Characters	No. of patients	Percentage
Gender		
Male	9	75
Female	3	25
Age group		
18-30 Years	3	25
31-50 Years	7	58
>50 Years	2	17
Mode of injury		
Road traffic accidents	4	33
Fall	8	67
Side		
Right	7	58
Left	5	42
Injury type		
Perilunate dislocations	4	33
Perilunate fracture dislocations	8	67
Herzberg stage		
1	2	17
2A	4	33
2B	6	50

In this study, 1 (8 %) of patients had scaphoid non-union. At the final follow-up evaluation, the average SL gap was 1.4 (range, 1 to 2.7) mm. The mean SL and CL angles were 48.3° (range 40 to 75°) and 4.7° (range 2 to 12°) respectively. The mean grip strength on Jamar dynamometer was 32.9 kg. The patients achieved an average of 87% grip strength of the uninjured side.

At the latest follow-up, mean post-operative VAS score for pain was 2.73 (range o-4). The mean post-operative DASH scores was13.08 with excellent results in 7 patients. Time to return to work was 5.00months by mean.

Discussion

Perilunate dislocations and fracture-dislocations are extremely complex injuries that carry a guarded prognosis, even when the most adequate surgical treatment is performed. As a spectrum of a rare injury, multiple lesion patterns are expected and several options are available for their management. 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 [19]. 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 [20]. 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. We 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, it was found that perilunate injuries were mainly in the form of fracture-dislocations in young, actively working men, and the most common concomitant injuries were radial styloid and scaphoid fractures of the same extremity. Furthermore, in the follow-up, the wrist active joint range of motion and grip strength was lower compared with the uninjured extremity. Young patients had less resting pain and the time duration until their return to work was longer in those with scaphoid fractures. It is possible to achieve optimal functional treatment results in perilunate injuries affecting hand function and activities of daily living with accurate diagnosis and timely treatment.

In this study, the patients with perilunate dislocations and perilunate fracture dislocations were treated 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 [21]. 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 [22]. 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 [23]. In this study, 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.

In this study, the range of motion of the wrist joint was reduced in 4 directions and the grip, and pinch grip strengths were reduced relative to the unaffected side, similar to the results of the previous studies. The flexion-extension range of motion was 81.7% and grip strength was 82.3 % of the unaffected side. In previous studies, results showed that the flexion-extension range of motion was 57%-80% of the unaffected side, and grip strength ranged between 71%-87% of the unaffected side [24]. Wrist flexion range was significantly lower in patients with work-related injuries. It has been reported that the range of motion, grip strength, and functionality outcomes were affected more in work-related perilunate injuries [25-28].

Our first aim was to describe clinical and functional results at final follow-up of surgical treatment. Mean postoperative VAS score for pain was 2.73. 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 [27]. Mean postoperative DASH score was 13.08 with excellent results in 58 % patients. This is quite a low value when comparing to literature [27, 29].

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.

Conclusion

In conclusion, perilunate injuries are very complex lesions which characteristically have a guarded prognosis. Loss of function is expected, but efforts to perform a prompt and adequate treatment are helpful to avoid worst results. As clinical and radiological outcomes are not imperatively related, it is important to percept how patients are dealing with their sequelae behind the radiographs to decide when to escalate treatment options.

The treatment of PLDs and TSPLDs with k-wire fixation 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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