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Outcomes of Perilunate Dislocation and Perilunate Fracture Dislocation After a Minimum 1-Year Follow-Up Following Open Reduction and Internal Fixation Via the Dorsal Approach: A Retrospective Study

Phanumas Muennoi, MD, Thananit Sangkomkamhang, MD, PhD

Department of Orthopedic Surgery, Khon Kaen Hospital, Khon Kaen, Thailand

Purpose: This study aimed to review and evaluate the functional and radiographic outcomes of patients with perilunate injuries after a minimum 1-year follow-up following open reduction and internal fixation with or without ligament repair.

Methods: This retrospective study included patients with perilunate injuries who underwent open reduction and internal fixation with or without ligament repair at our hospital between 2013 and 2021 with a minimum 1-year follow-up.

Results: Of the 22 enrolled patients, 18 and 4 exhibited perilunate fracture dislocation and perilunate dislocation, respectively. The mean follow-up period was 15.3 (12–20) months. The mean age of the patients was 30.5 ± 10.2 years. Notably, 20 (90.9%) and 2 (9.1%) patients were males and females, respectively. The mean flexion/extension angles were 67.2°/76.2°. The mean ulnar deviation/radial deviation was 25.4°/13.8°, and the mean pronation/supination was 85.6°/88.3°. As secondary outcomes, the mean grip strength was 80% of the uninjured side, modified Mayo wrist score was 73.6 (1 excellent, 6 good, 11 fair, and 4 poor), and visual analog scale during the activities of daily living (ADL) was 0.59. For radiographic outcomes, the mean scapholunate angle (SL angle) was 50.4°, SL gap was 2.43 mm., and carpal height ratio was 0.50. Four and nine patients had an incongruent Gilula's line and arthrosis, respectively.

Conclusions: Satisfactory results can be achieved with open reduction and internal fixation using a dorsal approach. Although some patients had abnormal radiographic findings, the radiographic outcomes may not correlate with the functional outcomes.

Keywords: perilunate dislocation, perilunate fracture dislocation, modified Mayo wrist score, scapholunate angle, carpal height ratio

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Correspondence to: Phanumas Muennoi, MD
Department of Orthopedic Surgery, Khon Kaen Hospital, Khon Kaen, Thailand
E-mail: phanumasmuennoi@gmail.com

Perilunate injuries, encompassing perilunate dislocation (PLD) and perilunate fracture dislocation (PLFD) (Figure 1), are uncommon injuries[1,8] and usually occur in young patients due to severe injuries owing to traffic accidents, work-related injuries, or sports injuries[6,8]. The diagnosis of these injuries requires specialized expertise and supervision, and misdiagnosis may lead to delayed treatment and poor outcomes[14].

At present, open reduction is recommended to treat such injuries to re-align the bone and evaluate injuries to other structures, such as ligaments, cartilage, and carpus[2-8]. Open reduction offers the advantage of realigning the bone to its anatomical position and repairing of the ligaments. However, the techniques and outcomes of open reduction remain debatable[2-7,9-13]. In addition, complications such as joint stiffness and osteoarthritis of the wrist may arise from various treatments.

Therefore, this study aimed to evaluate the functional and radiographic outcomes of patients with perilunate injuries treated via open reduction and internal fixation using a dorsal approach.

Objective

To study the functional and radiographic outcomes of patients with PLD and PLFD after a minimum 1-year follow-up following dorsal approach surgery.

(A) (B) (C) (D)

Fig. 1 Radiographic images of a patient with trans-scaphoid perilunate fracture dislocation (A, B) and trans-radial and ulnar styloid perilunate fracture dislocation (C, D).

MATERIALS AND METHODS

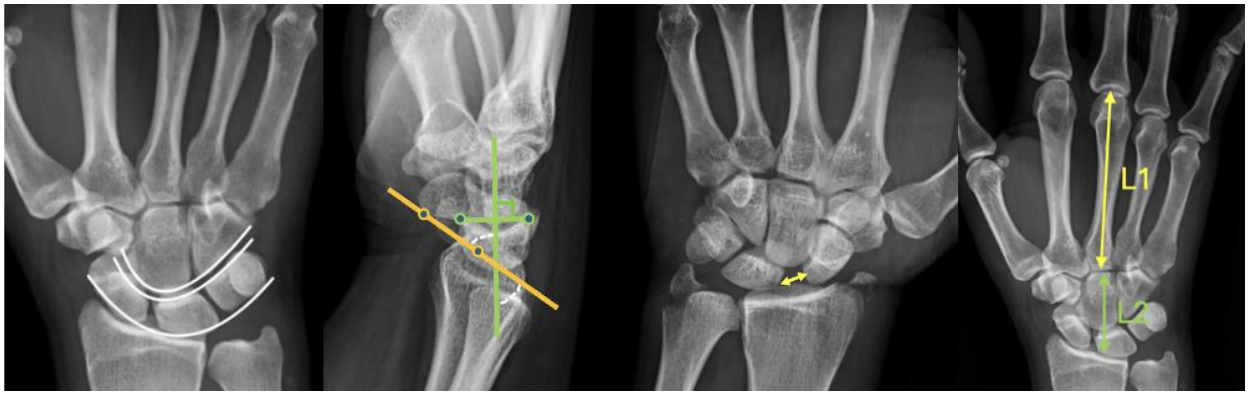
Study Participants

Patients diagnosed with PLD and PLFD who underwent dorsal approach surgery from 2013 to 2021 and were followed up for at least 1 year were enrolled in this study. The inclusion criteria were as follows: (i) patients aged between 18 and 60 years and (ii) patients who underwent surgery within 6 weeks after the injury date. The exclusion criteria were as follows: (i) patients with injuries in the hand and wrist on the same side, affecting the movement of the hand and wrist and (ii) patients with multiple injuries, such as a brain or nerve injury, that affect hand and wrist movement. This study was approved by the Human Research Ethics Committee of our hospital (research project code: KEXP64085, dated December 7, 2021).

Methods

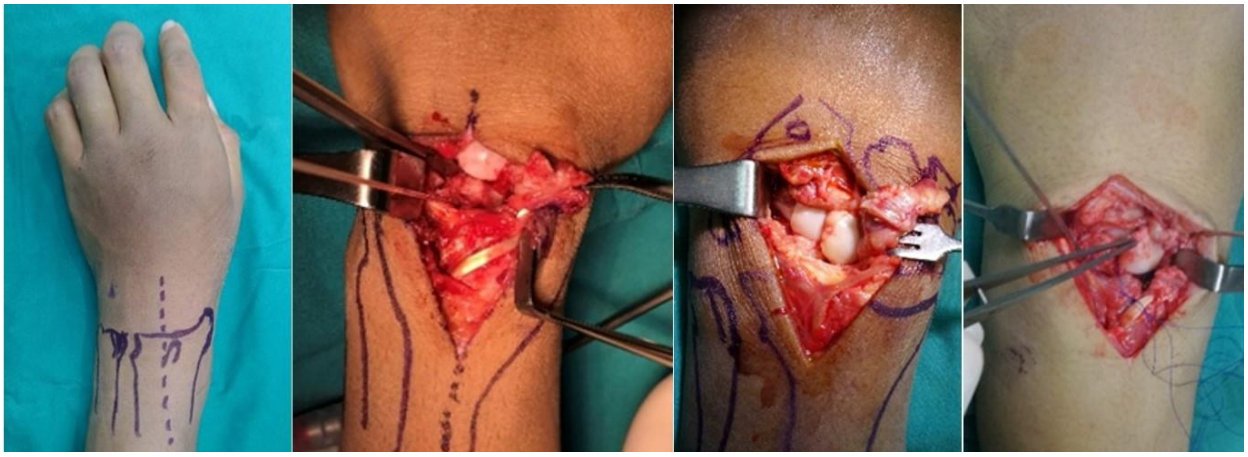
This retrospective study enrolled patients diagnosed with PLD and perilunate fracture dislocation who underwent open reduction and internal fixation via the dorsal approach from 2013–2021. Data were divided into the following two parts: (i) information from the medical records, including demographic data; information about the injury, diagnosis, follow-up period, and preoperative period; and functional outcomes such as range of motion, grip strength, modified Mayo wrist score, and visual analog scale. (ii) Information on the radiographic outcomes (Figure 2) of the injured carpal bones obtained from the infinite radiographic computer program of the PACS at our hospital. The following parameters were measured: scapholunate angle (SL angle), SL gap, Gilula's line,

carpal height ratio, and joint arthrosis. Outcomes were measured after internal fixation and volar plaster slab removal (approximately 12 weeks), and the mean follow-up time was 15.3 months (12–20 months).



(A) (B) (C) (D)

Fig. 2 Trajectory of the Gilula's line (A), measurement of the SL angle (B), SL gap (C), and carpal height ratio (L2/L1) (D).



(A) (B) (C) (D)

Fig. 3 Surgical technique. Surgical incision on the wrist (A), 3rd extensor compartment was retracted (B), ligament splitting arthrotomy (C), transosseous suture for SL repair (D).

Surgical Technique

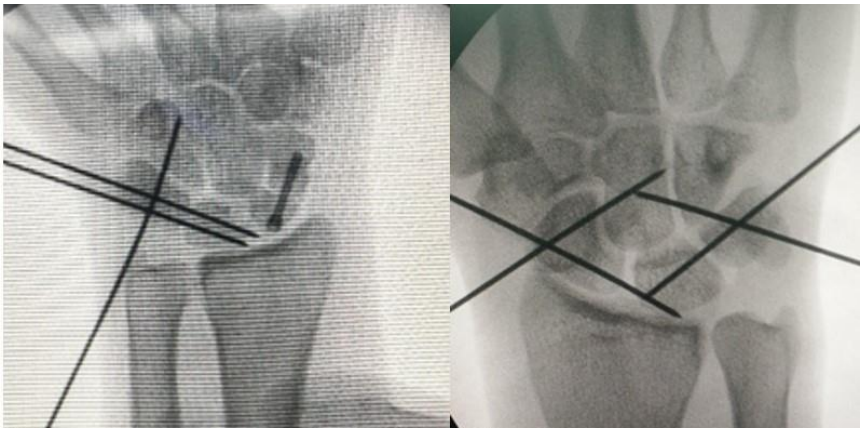
All patients who met the inclusion criteria underwent surgery under general or regional anesthesia. The surgery began with a dorsal longitudinal incision of the wrist (Figure 3A), and the extensor retinaculum between the 3rd and 4th extensor tendon compartments was opened (Figure 3B). The posterior joint capsule was exposed by retracting the extensor pollicis longus and extensor digitorum communis, including the extensor indicis proprius, laterally and medially, respectively. An arthrotomy was then performed using the ligament-splitting technique (Figure 3C) to access the injured carpal bones and ligaments.

In the non-fracture case, the patient was treated by repairing the ligaments between the lunate and scaphoid (SL ligament). Prior to suturing, the bone was aligned and fixed using a K-wire. The alignment of the bone and the K-wire was checked using a fluoroscope. A suture was then

made through the bone to the SL ligament (transosseous suture) (Figure 3D). A transosseous suture technique was employed in cases where the ligament was avulsed from a bony origin. After repairing the SL ligament, the wound was closed by suturing the ligaments around the joint, extensor retinaculum, and skin using Nylon 3-0.

The surgical sequence in the case of fracture was the same as that in the case of non-fracture. When an open reduction was performed, the scaphoid bone was reduced and fixed using a headless compression screw (Figure 4A). For other fractured bones, the fixation was performed based on the location and size of the bone, usually using K-wires. (Figure 4A, 4B) The mid-carpal joint was also stabilized using K-wires. The overall carpal alignment was checked using a fluoroscope prior to wound closure.

Postoperatively, a volar plaster slab was applied for approximately 12 weeks. By week 8, the K-wire was removed, and the volar plaster slab was retained until 12 weeks. Following splint removal, physiotherapists and occupational therapists provided advice on physical therapy. Patients were recommended to continue physical therapy at home for at least 6 months.



(A) (B)

Fig. 4 Headless screw with K-wire fixation in trans-scaphoid perilunate fracture dislocation (A) and K-wire fixation in perilunate dislocation (B).

RESULTS

Of the screened patients, from 2013 to 2021, 40 were diagnosed with PLD and perilunate fracture dislocation (PLFD). Notably, 13 patients had insufficient data, and 5 did not meet the research inclusion criteria. Therefore, 22 patients, including 20 males and 2 females, were finally enrolled in this study. The mean age of the patients was 30.5 (18–55) years. Of the total patients, 16 (72.7%), 3 (13.6%), 2 (9.1%), and 1 (4.6%) exhibited PLFD, PLD, volar lunate fracture dislocation (VLFD), and volar lunate dislocation (VLD), respectively. For the surgical methods, the patients were divided into two groups as follows: (i) 10 (45.5%) patients underwent dorsal SL ligament repair with K-wire fixation, and (ii) 12 (54.5%) patients underwent headless screw fixation of the scaphoid or K-wire fixation of other bones. The mean follow-up period was 15.3 (12–20) months, and the mean period from injury to surgery was 9.5 (3–28) days.

The mean range of motion flexion/extension (SD) was 67.2° (10.1°)/70.1° (8.8°). Ulna deviation/radial deviation (SD) was 25.4° (4.3°)/ 13.8° (4.1°). The pronation/supination (SD) was 85.6° (3.8°)/88.3° (2.9°) (Table 1). The mean grip strength of the treated side compared with that of the normal side was 80% (8.6). The mean modified Mayo wrist score was 73.6 (7.3). The final modified

Mayo wrist scores were 4, poor; 11, fair; 6, good; and 1, excellent. The mean visual analog scale during ADL was 0.59 (0.66).

Radiographic Outcomes

The mean SL angle was 50.4° (10.1°). The mean of the SL gap was 2.43 mm (0.66 mm). The mean carpal height ratio was 0.50 (0.02). Notably, 18 (81.1%) and 4 (18.2%) patients exhibited congruent and incongruent Gilula's lines, respectively. In addition, 13 patients (59.1%) did not have joint arthrosis, whereas 9 had joint arthrosis, with 8 (36.3%) in mid-carpal and 1 (4.6%) in radiocarpal and mid-carpal (Table 2).

Table 1 Summary of Primary Outcomes.

Parameter	Wrist (n=22)	
	Mean	SD
Flexion/Extension (degrees)	67.2/76.2	10.1/8.8
Radial/Ulna deviation (degrees)	25.4/13.8	4.3/4.1
Pronation/Supination (degrees)	85.6 /88.3	3.8/2.9

Table 2 Summary of Secondary Outcomes.

Parameter	Mean	SD
Grip strength (% of contralateral hand)	80	8.6
Modified Mayo wrist score (point)	73.6	22
Visual analog scale at rest/ADL (point)	0/0.59	0/0.66
SL angle (degrees)	50.40	10.1
SL gap (mm.)	2.43	0.66
Carpal height ratio	0.50	0.02
Gilula's line: Congruence/Incongruence (%)	81.8 / 18.2	
Arthrosis: none/OA (%)	50.1 / 40.9	

DISCUSSION

Injuries around the lunate bones, non-fracture (PLD or VLD) and with fracture (PLFD or VLFD), are caused by severe trauma mechanisms, resulting in injury to the bones, ligaments, and surrounding soft tissues[1,8,14] and treatment complications such as joint stiffness and bone misalignment.

Surgery is currently the standard treatment for these injuries to align the bones (fractured and non-fractured) and suture ligaments. However, discrepancies exist in the surgical methods reported in the literature. Notably, dorsal, volar, and combined dorsal and volar approaches are applied to such injuries. However, reports on treatment outcomes are ambiguous. Dean et al.[10] reported that, compared with the normal wrist, the flexion/extension range of motion of the wrist and mean grip strength were 71% and 77%, respectively, in 11 patients with PLD and PLDF who underwent the combined approach, with 1 patient with osteoarthritis. Forli et al.[7] reported treatment outcomes for 18 patients, including 11 and 7 patients with PLD and PLFD, respectively, of whom 11, 3, and 4 were treated using dorsal, volar, and combined approaches, respectively, with at least 10 years of follow-up. Notably, the mean Mayo wrist score was 76 (60–90), with five, three, seven and three patients with excellent, good, fair, and poor results, respectively. Further, 12 patients were diagnosed with osteoarthritis, and the authors

concluded that osteoarthritis could occur at long-term follow-up, but the patients tolerated such changes well. Kremer et al.[6] reported treatment outcomes in 39 patients, including 9 and 30 patients with PLD and PLFD, respectively, of whom 13, 6, and 20 were treated using dorsal, volar, and combined approaches, respectively, with a median follow-up period of 65.5 months. The mean flexion/extension arc was 77°, and the ulnar deviation/radial deviation was 42°. The mean visual analog scale at rest and during the activities were 1.8 and 4.8, respectively. Notably, 18 patients had a SL angle greater than the normal value, and 20 had osteoarthritis. Krief et al.[4] reported the treatment outcomes in 30 patients, including 14 and 16 with PLD and PLDF, respectively, of whom 2, 10, and 18 were treated using closed reduction with casting, closed reduction with percutaneous pinning, and dorsal and/or volar approaches, respectively, with at least 15 years of follow-up. Notably, the mean flexion/extension, radial–ulna abduction, and pronation–supination arcs were 68%, 67%, and 80%, respectively. The mean grip strength compared with the uninjured side was 70%. The mean Mayo wrist score was 70, and two patients with the lowest scores had osteoarthritis.

According to the severity of injury in patients with PLD and PLFD, which require surgical treatment, the combined dorsal and volar approach may cause additional soft tissue injury. Kevin et al.[11] reported flexion/extension arc and grip strength of 57% and 73% respectively, compared with the contralateral wrist, at an average follow-up period of 37 months in 22 patients (23 wrists) who underwent a combined approach. , three patients required wrist arthrodesis, four required an immediate scaphoid excision and 4-corner arthrodesis, and one required proximal row carpectomy. Consequently, a greater risk of complications exists after surgery using the combined approach than using a one-sided incision. The volar approach is used less commonly than the dorsal approach. Our study results for the primary outcomes demonstrated that the mean range of motion of flexion/extension, ulnar deviation/radial deviation, and pronation/supination were 67.2°/76.2°, 25.4°/13.8°, and 85.6°/88.3°, respectively. Notably, these values are close to those of Dean et al.[10], and they are greater than those of Kremer et al.[6] As the secondary outcomes, the mean grip strength, modified Mayo wrist score, and visual analog scale during ADL were 80%, 73.6, and 0.59, respectively. Our grip strength and modified Mayo wrist score results were comparable to those of other reports. The visual analog scale score in our study was better than that of Kremer et al.[6] However, our follow-up period was shorter, which precluded the comparison.

For radiographic outcomes, the mean SL angle, SL gap, and carpal height ratio were 50.4°, 2.43 mm, and 0.5, respectively. These values were close to normal values (SL angle 30–60°, SL gap ≤2 mm, carpal height ratio of 0.54 ± 0.03)[1]. Four (18.2%) patients had a non-parallel Gilula's line, and nine (40.9%) had osteoarthritis, which was less than that reported by Forli et al.[7] and Kremer T et al.[6]. However, the follow-up period in our study was shorter than others. Therefore, it may not be possible to definitively conclude that the dorsal approach decreases the occurrence of osteoarthritis.

Our study has a few limitations. First, this was a retrospective study, and some patients could not be included in the analysis because of insufficient data. Second, we did not separate patients with and without fractures in the data analysis, which may have influenced some of the data, such as the fixation of a headless screw for the scaphoid bone, resulting in bone shortening due to the compression effect.

CONCLUSIONS

The results of the surgical treatment for patients with PLD and PLFD using open reduction and internal fixation via the dorsal approach with a minimal 1-year follow-up were satisfactory. Although some patients develop osteoarthritis postoperatively, radiographic evidence did not correlate with the patients' clinical symptoms. Therefore, we recommend the dorsal approach as a well-accepted treatment option for patients with PLD or PLFD. However, further studies are warranted to compare the results of previous studies with respect to clinical and radiographic outcomes.

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