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Original Research

Predicting Acute Median Neuropathy in Perilunate Injuries

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Purpose: Perilunate fracture dislocation (PLFD) injuries are associated with the development of acute carpal tunnel syndrome (CTS). The purpose of our study was to identify the factors that increase the likelihood of developing CTS in patients with PLFD. Additionally, we attempted to classify patients who did not initially undergo carpal tunnel release (CTR) at the time of injury but eventually underwent CTR within the follow-up period.
Methods: Patients presenting to a level-1 trauma center with isolated PLFDs (Mayfield III–IV) were retrospectively identified by using CPT and ICD-10 codes. Polytraumatized patients, those with a history of previous wrist trauma, or those with previous carpal tunnel symptoms or surgery were excluded. Outcomes of interest included the development of acute CTS, pre- and post-reduction changes in CTS symptoms, and associated hand and wrist fractures. Chi-square tests, Kruskal–Wallis tests, and multivariate logistic regression were used to examine the predictors of developing CTS after a PLFD.
Results: In total, 43 patients were included in the final cohort, with a mean age of 44 years, of which 77% were men. The most common fracture of the carpus included scaphoid fractures (9/43, 21%). The average time from presentation to reduction was 636 minutes. Acute CTS symptoms before reduction were present in 26% of the patients and increased post-reduction to 28%. No difference exists between the time to sedation and the presence of acute carpal tunnel symptoms (P >.05). During initial surgical intervention, 79% underwent CTR (27/34). Of the seven patients who did not initially undergo a CTR, 57% (4/7) required a CTR within the follow-up period.
Conclusion: Reduction of PLFDs did not significantly improve the number of patients with acute CTS. More than 50% of the patients who did not undergo a CTR at the initial surgery required a CTR within the follow-up period.
Type of study/level of evidence: Prognostic III.

Perilunate dislocations and fracture dislocations (PLDs and PLFDs) are rare but serious injuries with devastating consequences for patients. These injuries are often the result of high energy impact on the hyperextended wrist, such as multivehicle accidents or falls from a significant height.[1,2] However, PLDs and PLFDs are infrequently encountered, representing only 7% of all carpal injuries, and as such, initial diagnosis is missed in approximately 25% of the cases.[3,4] Current standard management for PLDs and PLFDs consists of closed or open reduction and internal fixation.[2] Functional outcomes for patients with a history of PLD and PLFD are fairly dismal, with high incidences of post-traumatic arthritis and residual pain and low return to work statuses.[4,5,6,7]

A concerning complication of PLDs and PLFDs is the development of acute carpal tunnel syndrome (CTS). Compression of the median nerve can occur through one of the following two ways: (1) direct compression from the fractured or dislocated carpus or (2) post-traumatic blood and edema within the carpal tunnel.[3] The presentation of acute median neuropathy after PLDs and PLFDs is not uncommon, with reports ranging from 15.2% to 50%.[8,9,10,11] It is recommended that patients presenting with acute CTS with PLDs and PLFDs undergo immediate closed reduction to avoid permanent injury to the median nerve.[3]

Thus, this study aims to further describe the specific predictors for the development of acute CTS after PLDs and PLFDs. We hypothesize that prolonged times to reduction and a larger number of

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carpal bone fractures will be positive predictive risk factors for the development of acute CTS in patients presenting with PLDs or PLFDs. Secondarily, we also anticipate that patients who did not initially undergo carpal tunnel release (CTR) at the time of injury would be more likely to require a CTR at a later time point.

Materials and Methods

This retrospective study used Current Procedural Terminology (CPT) codes to identify subjects who presented to an urban level-1 trauma center with a PLD between January 1, 2014 and December 31, 2022. In addition, IRB approval was granted for this study, and consent was waived due to the retrospective nature of the project. We retrospectively reviewed electronic medical records for identified patients to collect the following data: patient sex, mechanism of injury, pre- versus post-reduction carpal tunnel symptoms, treatment modality used, time to surgery, timing of CTR, rate of postoperative carpal tunnel symptoms, recovery outcomes, and complications. An orthopedic surgeon manually reviewed the relevant radiographs to verify PLDs and identify associated ipsilateral carpal and wrist fractures (ulnar and, or, radial styloid fractures).

The inclusion criteria were as follows: patients with perilunate fractures either treated nonsurgically or surgically, those aged 18 years or older at the time of injury, and those who had more than 12 months of follow-up. The exclusion criteria were as follows: those with previous ipsilateral distal radius fractures, previous ipsilateral carpal bone fractures, and previous surgical intervention on the ipsilateral wrist. Radiographs were reviewed by orthopedic surgical residents, and only those with Mayfield type III or IV were included. Carpal tunnel syndrome for the purposes of this study was defined as the presence of numbness and tingling of the thumb, index, middle, and radial ring fingers.

Statistical analysis

To investigate whether any association exists among the demographic data, the rate of pre- versus post-reduction acute carpal tunnel symptoms, and surgical versus nonsurgical treatment used, we used a *t* test for parametric data and Mann-Whitney U test for nonparametric data. The chi-squared test was used for comparing nominal data. Binary logical analysis was used to determine the patient factors associated with pre- versus post-reduction acute carpal tunnel symptoms.

Results

Of the 77 fractures, 34 cases were excluded, leaving 43 patients, with a mean follow-up period of 390.8 days (range: +/− 647.9 days), eligible for inclusion in this study. In total, 12 patients were excluded for previous wrist or carpal trauma, 11 patients were excluded for previous CTR, 4 patients were excluded due to age, and 7 patients were excluded for having less than 12-month follow-up at the time of analysis. The average age of the study population was 44 ± 17.5 years with 33 patients (76.7%) being men and 31 patients (72.1%) being white. On the initial presentation, most patients presented to the emergency room (emergency room: 36 patients [83.7%], outpatient hand clinic: 6 patients [14%)], and urgent care: 1 patient [2.3%]) (Table 1).

Most of these PLDs were closed (41 patients, 95.3%). However, a number of these patients had associated wrist fractures (radial styloid: 8 [18.6%] and ulnar styloid: 7 [16.3%]) and carpal bone fractures (scaphoid: 9 [20.9%]; triquetrum: 7 [16.3%]; hamate: 1 [2.3%]; and trapezium: 1 [2.3%]). Only four patients (9.3%) had ≥2 associated carpal bone fractures (Table 2). No significant difference was noted in the number of carpal bone and wrist fractures and the development of acute CTS pre- or post-reduction (Table 3).

Before reduction, 11 patients (25.9%) were present with acute CTS with the average time from clinical presentation until reduction being 636.5 ± 449.6 minutes. After reduction, one more patient was present with acute CTS, bringing the total count to 12 patients (27.9%) (Table 2). Of note, no significant difference was observed between acute CTS after reduction and the time to reduction (time to reduction in patients with acute CTS being 481.3 ± 416.1 minutes [P =.595] and in patients without acute CTS being 705.6 ± 454.4 minutes [P =.152]) (Table 4).

Most of the patients underwent surgical intervention—34 patients (79%) within 24 hours. During patient's initial surgery, 27 patients (79.4%) had release of the carpal tunnel. Of the seven patients who did not have release of the carpal tunnel during initial surgery, four of these patients (57.2%) needed secondary surgery to release the carpal tunnel (Table 5).

Table 1
Patient Clinical and Demographics Characteristics

Patient Clinical and Demographics Characteristics	
Mean age (yrs)*	44.0 ± 17.5
Sex (N (%))	
Men	33 (76.7%)
Women	10 (23.3%)
Race (N (%))	
White	31 (72.1%)
Black	10 (23.3%)
Other	2 (4.7%)
Clinical presentation (N (%))	
Emergency room	36 (83.7%)
Outpatient hand clinic	6 (14.0%)
Urgent Care	1 (2.3%)

* Mean ± SD.

Table 2
Characteristics of Perilunate Dislocation

Characteristics of Perilunate dislocation	
Fracture type (N (%))	
Open fracture	2 (4.7%)
Closed fracture	41 (95.3%)
Associated carpal bone fractures (N (%))	
Scaphoid	9 (20.9%)
Triquetrum	7 (16.3%)
Hamate	1 (2.3%)
Trapezium	1 (2.3%)
Associated wrist fractures (N (%))	
Radial styloid	8 (18.6%)
Ulnar styloid	7 (16.3%)
Number of associated carpal bone fractures (N (%))	
0	29 (67.4%)
1	10 (23.3%)
≥2	4 (9.3%)
Number of associate carpal bone and wrist fractures (N (%))	
0	19 (44.2%)
1	16 (37.2%)
2	7 (16.3%)
≥ 3	1 (2.3%)
Acute CTS (N (%))	
Prior to reduction	11 (25.9)
Post-reduction	12 (27.9)
Acute CTS addressed by urgent surgical intervention (N (%))	16 (37.2%)
Time from clinical presentation to reduction (min)*	636.5 ± 449.6

CTS = Carpal tunnel symptoms.
* Mean ± SD.

Table 3
Relationship Between Acute Carpal Tunnel Symptoms (ACTS) and Number of Associated Carpal Bone Fractures

Relationship between Acute Carpal Tunnel Symptoms (ACTS) and Number of Associated Carpal Bone fractures			
	Pre-Reduction ACTS*		
	OR	95% CI	*P* value
Number of carpal bone & wrist fractures (N (%))			
1	2.66	0.59 − 11.9	.199
≥ 2	3.21	0.48 − 21.2	.228
	Post-Reduction ACTS*		
	OR	95% CI	*P* value
Number of carpal bone & wrist fractures (N (%))			
1	0.275	0.067 − 1.12	.072
≥ 2	0.458	0.072 - 2.89	.406

* Reference group are patients without carpal or wrist fractures

Table 4
Relationship Between Acute Carpal Tunnel Symptoms (ACTS) and Time to Reduction

Relationship between Acute Carpal Tunnel Symptoms (ACTS) and Time to Reduction				
	Pre-Reduction ACTS		OR; 95% CI	*P* value
	Yes	No		
Time to reduction (min)*	558.6 ± 384.2	663.4 ± 473.3	0.999; [0.998 − 1.00]	.595
	Post-Reduction ACTS		OR	*P* value
Time to reduction (min)*	Yes	No		
	481.3 ± 416.1	705.6 ± 454.4	0.998; [0.997 − 1.00]	.152

* Mean ± SD.

Additionally, logistic regression analysis of developing acute CTS when controlled for age, sex, race, and the number of carpal bone fractures pre- and post-reduction showed no significant differences (P >.05) (Table 6).

Discussion

Perilunate dislocations and fracture dislocations are challenging injuries presented to orthopedic trauma surgeons and hand surgeons alike, typically presenting a high energy and rare injury pattern. Despite the relatively rare occurrence, literature has demonstrated that PLDs and PLFDs can be associated with the development of acute median neuropathy as the alignment of the carpus and space within the carpal tunnel has been altered.[10,12] Our study has demonstrated that nearly half of the patients presenting with these injuries develop acute median neuropathy. We also found that of those cases not addressed surgically at the time of presentation, nearly half of them required a CTR in the future. Furthermore, the frequency with which additional carpal fractures are present increases the likelihood of acute carpal tunnel symptoms. Understanding these data may aid in the prediction of those likely to develop acute CTS and prompt surgical treatment and perhaps the prevention of CTS in future.

This is the largest sample size in literature examining the association of PLFDs with the development of acute CTS. However, we performed a post hoc analysis, and the power of this study was 0.93 ($n = 43$, $\alpha = 0.05$, effect size of 0.5 using a paired t test between the

Table 5
Perioperative Characteristics

Perioperative Characteristics	
Treatment (N (%))	
Surgical intervention	34 (79%)
Nonsurgical intervention	9 (21%)
Pre-op CT scan (N (%))	
Yes	16 (47.1%)
No	18 (52.9%)
Release of capral tunnel during initial surgery (N (%))	
Yes	27 (79.4%)
No	7 (20.6%)
Release of carpal tunnel after initial surgery (N (%))	
Yes	4 (57.2%)
No	3 (42.8%)
Estimated blood loss (mL)*	15.2 ± 24.7
Length of stay (Days)*	2.1 ± 3.1
Average follow-up time (Days)*	390.8 ± 647.9

* Mean ± SD

Table 6
Logistic Regression Analysis of ACTS and Patient Factors

Logistic Regression Analysis of ACTS and Patient factors			
	Pre-Reduction ACTS		
	OR	95% CI	P value
Age	1.00	0.97 − 1.05	.785
Gender	3.91	0.43 − 35.1	.223
Race	1.17	0.36 − 3.85	.794
Number of carpal bone fracture	2.41	0.88 − 6.58	.084
	Post-Reduction ACTS		
	OR	95% CI	*P* value
Age	0.99	0.96 − 1.03	.789
Gender	1.73	0.311 − 9.69	.528
Race	1.04	0.22 − 4.9	.953
Number of carpal bone fracture	0.432	0.125 − 1.42	.166

time of pre- versus post-closed reduction and the development of acute CTS). Therefore, we believe that the finding from this study has both statistical and clinical significance.

Our study has several notable limitations. The first of which is that it is a retrospective study of a single institution with a limited sample size. Although our data do not support Garcon and colleagues' finding of opening the carpal tunnel to be a predictor of poor functional outcomes, we do not have the statistical power to contradict their findings.[5] Another limitation of our study was that multiple providers exist with different surgical specialties that are diagnosing and treating acute CTS. Thus, the characterization of acute CTS may have been underreported in our study, and the decision to perform a CTR may more reflect provider preference rather than carpal tunnel symptom severity preoperatively. Carpal tunnel syndrome was defined as the presence of numbness and tingling of the thumb, index, middle, and radial ring fingers. Due to the retrospective nature of the project, CTS could not be more objectively diagnosed such as through ultrasound, electrodiagnostic, or a validated scoring system. This may have potentially overreported or underreported the true number of CTS patients. Additionally, the study was conducted in an urban level-1 trauma center in the north-east United States, and thus, the results of this study may not be generalizable to the entire population. Finally, the exact time of injury could not be reliably determined retrospectively, and therefore, the time of presentation to the hospital was used as proxy.

The rates of the development of acute CTS in PLDs and PLFDs have been varied in the literature and are reported to range from 15.2% to 50%.[8–9,11] We found that 21 of the 42 patients (50%) in the present study had acute median neuropathy at the time of presentation, which is in alignment with prior studies. When evaluating the rates of CTS after reduction, it was found to increase slightly to 57% (24/42). This suggests that it is unlikely to improve CTS after reduction and that manipulation of the carpus during reduction may increase the risk of acute CTS. Additionally, when evaluating the time to reduction, no statistically significant difference was noted between the time to sedation and the presence of pre- and post-acute CTS ($P > .05$) thereby suggesting that these injuries are urgent but not emergent in the setting of closed injuries without worsening symptoms.

Although it has been well established that acute CTS can develop with these injuries, the rates of CTR during initial surgical treatment and those requiring a CTR after initial injury have been ill-defined in the literature.[10] Reports of late CTR have been as low as 3% noted in a study by Eglseder and Abzug.[8] Seventy-seven percent of patients (27/35) underwent CTR at the time of initial surgical treatment, and of the remaining eight who did not undergo CTR, four required a CTR within the follow-up period. It is noted that depending on surgeon preference, some patients underwent CTR despite no clinical symptoms of acute CTS. This represents a lack of standard and variation in care across those caring for patients with these injuries. However, our data demonstrate that if CTR is not performed initially, nearly 50% of the patients may require a CTR in the future.

Studies have demonstrated discrepancies regarding patients at risk of developing acute CTS. Wickramasinghe et al[11] report no associated factors for the development of acute CTS; however, many believe that higher energy injury and trauma may increase the rate of acute CTS as the amount of soft tissue/osseous disruption increases. Our study confirms that the number of associated carpal/wrist bone fractures was independently associated with the development of acute CTS ($P = .01$). Therefore, 45% of the patients had at least one associated fracture (19/42) with the scaphoid and radial styloid representing the two most fractured bones. Only 14% (6/42) had two or more associated fractures. These data therefore support that an increased number of associated fractures, which may represent higher energy injury, is associated with the development of acute CTS.

In conclusion, the present study would support that patients with PLFDs who have an increased number of associated carpal fractures are at an increased risk of acute median neuropathy. Reduction does not appear to improve symptoms of acute CTS in the setting of PLFDs, and if CTR is not performed at the initial surgery, nearly half of the patients will require CTR in the future.

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