Review Article

Perilunate Dislocation and Perilunate Fracture-dislocation

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Abstract

Perilunate dislocations and perilunate fracture-dislocations usually result from high-energy traumatic injuries to the wrist and are associated with a characteristic spectrum of bony and ligamentous damage. Radiographic evaluation of the wrist reveals loss of normal radiocarpal and intercarpal colinearity and bony insult, which may be overlooked at the initial presentation. Prompt recognition is important to optimize outcomes. Closed reduction is performed acutely, followed by open reduction and ligamentous and bony repair with internal fixation. Complications include posttraumatic arthrosis, median nerve dysfunction, complex regional pain syndrome, tendon problems, and carpal instability. Despite appropriate treatment, loss of wrist motion and grip strength, as well as persistent pain, is common. Medium- and long-term studies demonstrate radiographic evidence of midcarpal and radiocarpal arthrosis, although this does not correlate with functional outcomes.

Perilunate dislocations and perilunate fracture-dislocations (PLD-PLFDs) are challenging, generally high-energy injuries that carry a guarded prognosis. Prompt recognition and treatment are imperative. Diagnosis is typically made by careful inspection of wrist radiographs, followed by immediate, gentle closed reduction. Historical treatment by closed methods results in unsatisfactory outcomes; the current standard is open reduction, ligamentous and bony repair, and protection of the repair with supplemental fixation.

Pathomechanics

PLD-PLFDs comprise a spectrum of injury patterns most commonly incurred as a result of a fall from a height, motor vehicle accident, or injury during sporting activities.[1] Dorsal perilunate dislocation involves dorsal dislocation of the capitate with respect to the lunate while the lunate remains in its normal position in the lunate fossa. In a volar lunate dislocation (ie, the final stage of perilunate injury), the capitate has reduced from its dorsally dislocated position to become colinear with the radius, dislocating the lunate into the carpal tunnel (Figures 1 and 2). Herzberg et al[2] classified perilunate dislocations as stage I injuries and lunate dislocations as stage II. Lunate dislocations are further classified as stage IIA when the lunate has subluxated out of its fossa but has rotated <90°; stage IIB injuries exhibit lunate rotation >90°. Volar perilunate and dorsal lunate dislocations have been reported but are not nearly as common.

Although a variety of different types of PLD-PLFDs have been re-

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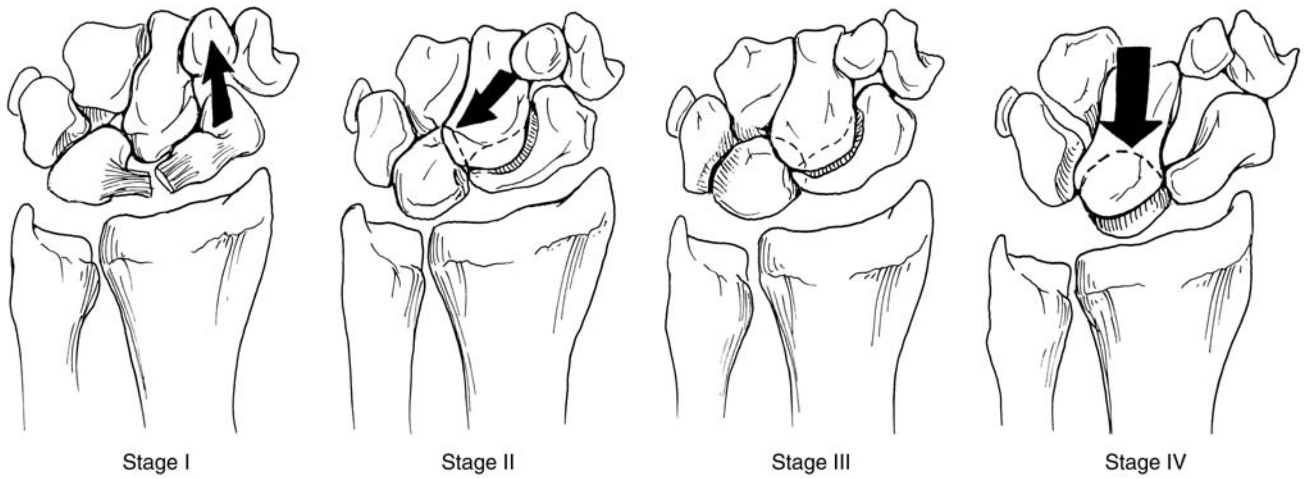
Neither of the following authors nor any immediate family member has received anything of value from or owns stock in a commercial company or institution related directly or indirectly to the subject of this article: Dr. Stanbury and Dr. Elfar.

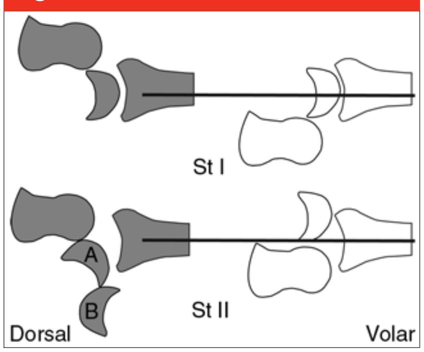
J Am Acad Orthop Surg 2011;19: 554-562

Figure 1



Stages of progressive perilunar instability. Stage I involves disruption of the scapholunate ligamentous complex (arrow). In stage II, the force propagates through the space of Poirier and interrupts the lunocapitate connection (arrow). In stage III, the lunotriquetral connection is violated, and the entire carpus separates from the lunate. In stage IV, the lunate dislocates from its fossa into the carpal tunnel, the lunate rotates into the carpal tunnel, and the capitate becomes aligned with the radius (arrow). (Reproduced from Kozin SH: Perilunate injuries: Diagnosis and treatment. *J Am Acad Orthop Surg* 1998;6[2]:114-120.)

Figure 2



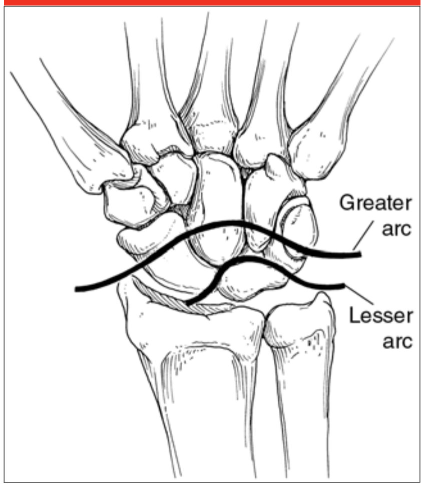
Perilunar instability. Stage I (*top*) refers to perilunate dislocations with dorsal dislocation on the left and the rarer volar perilunate dislocation on the right. Stage II (*bottom*) refers to lunate dislocations with volar lunate dislocation on the left and the rarer dorsal lunate dislocation on the right. Stage II can be broken down into stage IIA with <90° of lunate rotation and stage IIB with >90° of lunate rotation, or enucleation. (Redrawn with permission from Herzberg G: Acute dorsal trans-scaphoid perilunate dislocations: Open reduction and internal fixation. *Tech Hand Up Extrem Surg* 2000;4:2-13.)

ported, most of these injuries lie along a particular spectrum with a common etiologic force. The pathomechanical force of traditional PLD-PLFDs, as described by Mayfield,[3] is that of extension, ulnar deviation, and intercarpal supination. The resultant pattern of injury is dependent on the type of three-dimensional loading, the magnitude and duration of the forces involved, the position of the hand at the time of impact, and the biomechanical properties of the bones and ligaments. The sequence of injury propagates in an ulnar direction about the lunate, with initial disruption through the scapholunate interval. This force continues on to the space of Poirier, which is located at the volar aspect of the proximal capitate, lying between the volar radiocapitate and volar radiotriquetral ligaments, and disrupts the capitolunate articulation before disrupting the lunotriquetral articulation. Finally, the dorsal radiocarpal ligament fails, allowing the lunate to rotate about its proximal volar attachments and dislocate into the carpal tunnel.[3] The high-energy force may disrupt ligaments (ie, scapholunate, lunotriquetral, radiocarpal), bones (ie, radial styloid, scaphoid, capitate, lunate, triquetrum, hamate), or combinations of these. Injuries that cross bone are greater arc injuries; those with purely ligamentous disruption are lesser arc injuries[4] (Figure 3). The term translunate arc has been used to describe the rare, usually high-energy injury in which perilunate dislocation occurs in the setting of a lunate fracture. This injury pattern further destabilizes the carpus. Initial stabilization of the lunate should occur before further reconstruction.[5] In naming greater arc injuries, the prefix trans- is used before the name of the fractured bone.

Diagnosis and Imaging

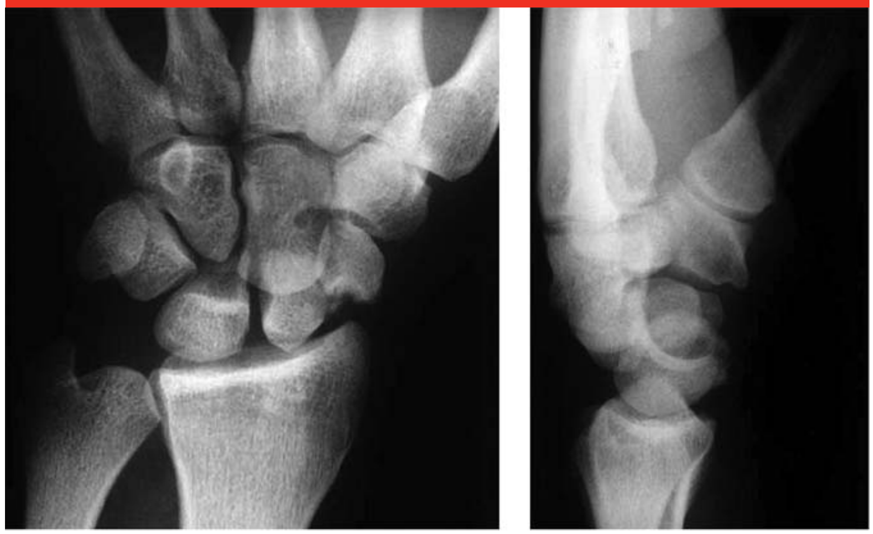
PLD-PLFDs can defy radiographic and clinical examination and are

Figure 3



The lesser and greater carpal arcs of perilunate instability. (Reproduced from Kozin SH: Perilunate injuries: Diagnosis and treatment. *J Am Acad Orthop Surg* 1998;6[2]:114-120.)

Figure 4



A B

Preoperative PA (**A**) and lateral (**B**) radiographs demonstrating transscaphoid perilunate fracture-dislocation. (Reproduced with permission from Hildebrand K, Ross D, Patterson S, Roth J, MacDermid JC, King GJW: Dorsal perilunate dislocations and fracture dislocations: Questionnaire, clinical, and radiographic evaluation. *J Hand Surg Am* 2000;25[6]:1069-1079.)

missed on clinical and radiographic examination in up to 25% of cases.[2] This has notable implications; retrospective analyses demonstrate that delayed or chronic injuries have worse outcomes.[6,7] Although deformity may be mild, the injury usually presents with swelling, pain, and limited wrist motion. Approximately 10% are open injuries, and 26% are associated with polytrauma.[8] Reported rates of acute median nerve symptoms range from 24% to 45%.[9-12] Median nerve symptoms, which present shortly after injury, are likely secondary to contusion from the trauma. Delayed onset of symptoms is likely the result of increasing pressures caused by hemorrhage and edema resulting in carpal tunnel syndrome.

Standard wrist PA and lateral radiographs are typically sufficient for diagnosis in most injuries. The PA radiograph should be scrutinized for uneven gapping in the carpal bones, and the three smooth carpal arcs of Gilula should be free of discontinuity. The arcs of Gilula refer to the curves produced by the anatomic alignment of the carpal row bones. The first arc represents the proximal convexity of the triquetrum, lunate, and scaphoid. The second arc represents the concave distal surfaces of those bones. The third arc is produced by the proximal hamate and capitate. Any disruption or gapping of these arcs should raise the suspicion of ligamentous or bony injury.

PLD-PLFD injury is often seen on PA radiographs as a loss of carpal height with overlapping of the carpal bones, particularly the capitate and lunate. On PA radiographs, evidence of scapholunate interosseous ligament (SLIL) disruption is represented by a scapholunate interval >2 mm or a scaphoid ring sign created by rotation of the scaphoid with overlapping of the distal pole and the tubercle.[1] On lateral radiographs, the hallmark of PLD-PLFDs is loss of colinearity of the radius, lunate, and capitate (Figure 4). In lunate dislocation, the spilled teacup sign seen on the lateral radiograph is created by proximal rotation of the lunate about its attached palmar ligaments[13] (Figure 5). Traction radiographs with 5 kg of weight, in conjunction with anesthesia, can be particularly helpful in further delineating the injury pattern, especially with respect to identifying fractures on the PA radiograph.[14]

MRI without contrast is sensitive and specific for intercarpal ligamentous ruptures and occult fractures or bone bruises.[15,16] Preoperative high-resolution CT is helpful in assessing the position of fracture fragments and the degree of comminution as well as in identifying occult fracture.

Management

Historically, PLD-PLFD injuries were managed with closed reduction and casting. In a review by Adkison and Chapman,[17] more than half of 32 patients with PLD-PLFD treated with closed reduction failed to maintain reduction despite immobilization. In a comparison by Apergis et al[18] of patients with PLD-PLFD, 12 of 20 wrists managed with open reduction and internal fixation had good or excellent results, whereas the 8 treated with closed reduction and casting had fair or poor outcomes. Based on these studies and others, surgical repair is now favored.[2,9-12]

Management of PLD-PLFD typically starts with immediate, gentle, closed reduction. This is followed by open reduction, ligament and bone repair, and supplemental fixation performed within 3 to 5 days as swelling subsides. Immediate closed reduction is necessary to decrease pressures on critical neurovascular structures and cartilage. Stable closed reduction is typically achieved, with reported maintenance of reduction in >90% of cases.[9,10] Significant muscle relaxation improves the chances for a successful closed reduction. At our institution, muscle relaxation is typically performed in the emergency department with the use of local anesthetic block and conscious sedation.

Although no published evidence indicates the need for immediate closed reduction of a PLD-PLFD without acute carpal tunnel symptoms, the authors prefer immediate reduction to decrease pressure that could lead to damage to both the median nerve and the cartilage of dislocated bones of the wrist. Reduction is performed with the elbow flexed to 90° and the hand placed into finger traps. Ten to 15 pounds of longitudinal traction is applied for at least 10 minutes. Dorsal perilunate dislocations are reduced by initial wrist extension, applying traction, and then flexing the wrist. The reduction usually occurs with a palpable clunk.[19]

As recommended by Herzberg,[14] we feel that closed reduction should not be attempted for stage IIB lunate dislocations (>90° rotation) because closed reduction is typically ineffective and could damage the short radiolunate ligament and its vascular contribution. Closed reduction of stage IIA lunate dislocation has been described. It begins with wrist flexion to release tension on the volar ligaments, followed with dorsally directed pressure placed on the lunate, thereby usually reducing it into the lunate fossa. After reduction of the lunate, the wrist is extended, traction is exerted, and the wrist is flexed, all while maintaining a volar buttress with a digit to the lunate. This maneuver should relocate the capitate back onto the recently reduced lunate stabilized by volar pressure.[19]

After reduction, the injured extremity is placed in neutral rotation into a sugar tong splint to allow elevation and full range of motion (ROM) of the fingers. If an acceptable, stable reduction is achieved, surgery is typically performed 3 to 4 days later when swelling has improved. For the open injury or one in which adequate reduction is not possible or is difficult to maintain, prompt surgical intervention is advised.

Figure 5

Lateral radiograph of stage IIA volar lunate dislocation. (Courtesy of Peter J. Stern, Cincinnati, OH.)

Surgical Management

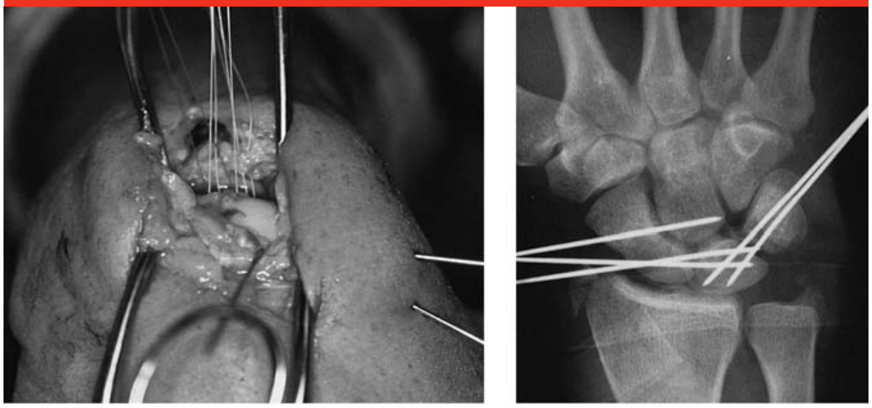
Approach

The approach used in surgical management of these injuries remains controversial. Isolated dorsal, isolated volar, and combined approaches have been described, with comparable outcomes.[8-12] The dorsal approach provides excellent exposure of the proximal carpal row and midcarpal joints. Proponents of the combined dorsal and volar approaches feel that the added volar approach provides the benefits of improved exposure, ease of reduction, access to distal scaphoid fractures, the ability to repair volar ligaments, and carpal tunnel decompression.[20] Advocates of an isolated dorsal approach (in the absence of carpal tunnel syndrome) point out that the volar ligaments and capsule become opposed upon reduction and heal during immobilization without any need for direct repair; also, the additional volar exposure may impart further swelling, wound problems, carpal devascularization, and difficulty regaining digital flexion and grip.[8]

Dorsal approaches to PFD-PFLD are typically performed through longitudinal incisions centered at or ulnar to the Lister tubercle. The long thumb extensor is usually transposed radially, and the wrist capsule is opened with either a longitudinal or dorsal capsule ligament–sparing incision (V-shaped). Volar approaches include a standard carpal tunnel release incision that usually extends proximal to the volar wrist crease for improved ligamentous exposure. The incision typically veers ulnarly at the proximal wrist crease to avoid injuring the palmar sensory branch of the median nerve while crossing the crease at an acute angle.

Unknown is the role of carpal tunnel release in patients who lack any

Figure 6



A B

A, Intraoperative photograph demonstrating open treatment of dorsal perilunate dislocation, with the digits inferior. **B,** PA radiograph obtained following open repair and pinning. (Reproduced from Kozin SH: Perilunate injuries: Diagnosis and treatment. *J Am Acad Orthop Surg* 1998;6[2]:114-120.)

Figure 7

Postoperative PA radiograph of a volar lunate dislocation managed with a combined dorsal and volar approach using a 20-gauge intraosseous cerclage wire. (Reproduced with permission from Trumble T, Verheyden J: Treatment of isolated perilunate and lunate dislocations with combined dorsal and volar approach and intraosseous cerclage wire. *J Hand Surg Am* 2004;29[3]:412-417.)

symptoms of median nerve dysfunction following PLD-PLFD. The presence of such symptoms in patients with PFD-PFLD is 24% to 45%.[10,12] Carpal tunnel release is supported by most authors when symptoms are present.[21] We perform an open carpal tunnel release whenever we suspect that median nerve trauma exists. We also recommend that patients with severe displacement of fracture fragments or fragments within the carpal tunnel (in the absence of carpal tunnel syndrome) be treated with a combined dorsal and volar approach for open reduction, ligamentous stabilization, and carpal tunnel decompression. No evidence exists to support such a strategy over an isolated dorsal exposure. Nonetheless, comparable results for the different approaches have been published, and there are no prospective randomized comparisons available to advocate a particular exposure over any other.

Technique

Surgical management of PLD-PLFDs includes open reduction, ligamentous repair, and supplemental fixation. The surgical maxim for greater arc injuries is fixation of the bony involvement before soft-tissue repair. Scaphoid fractures are typically fixed using cannulated headless screw systems. Comminuted fractures can be treated with Kirschner wire (K-wire) fixation and autologous bone grafting from the distal radius. When concomitant scaphoid fracture and SLIL injury are present, both injuries should be treated surgically. K-wire and headless screw fixation have been described for lunate and triquetral fracture fixation.[3,14] Capitate fractures or osteochondral fragments should be managed with headless screw fixation and are best visualized through a dorsal approach.[14] Fracture of the radial styloid should be managed with rigid fixation by cannulated screws, headless screws, K-wires, or radial column plates. Excision of the radial styloid is not recommended.[14,22] Any extruded carpal bone should be reduced to its anatomic position and stabilized, with ligamentous repair undertaken in the hope of achieving a stable wrist after healing.[22]

Many surgeons feel that the most critical issue in lesser arc injury is the repair of the SLIL (Figure 6). The ligament typically avulses from the scaphoid, and repair is commonly performed using suture anchors, with a horizontal mattress suture through the SLIL.[22] Unicortical K-wires can be used as joysticks for aiding reduction. Traditionally, K-wires were used to protect the SLIL repair. However, concerns over pin tract infection, soft-tissue irritation, delayed motion, inability to provide compression, and biomechanical weakness have led some to advocate more rigid fixation of the scapholunate interval.[22]

Temporary intercarpal screw fixation and intraosseous cerclage wiring (Figures 7 and 8) have been described as methods of protection of the soft-tissue repair.[9,23] Theoretic benefits include subdermal location, decreased infection risk, increased biomechanical stability, and the abil-

Figure 8

Postoperative PA radiograph in a 36-year-old man injured in a motor vehicle collision. Management consisted of open reduction, carpal tunnel release, interosseous ligament repair with suture anchors, and open reduction and internal fixation of the radial styloid with temporary screw fixation of the carpal bones. (Reproduced with permission from Souer JS, Rutgers M, Andermahr J, Jupiter J, Ring D: Perilunate fracture-dislocations of the wrist: Comparison of temporary screw versus K-wire fixation. *J Hand Surg Am* 2007;32[3]: 318-325.)

Figure 9

Postoperative AP (**A**) and lateral (**B**) radiographs of screw fixation of the scaphoid, suture anchor repair of the lunotriquetral ligament, and K-wire stabilization of the lunotriquetral joint. (Reproduced with permission from Knoll VD, Allan C, Trumble TE: Trans-scaphoid perilunate fracture dislocation: Results of screw fixation of the scaphoid and lunotriquetral repair with a dorsal approach. *J Hand Surg Am* 2005;30[6]:1145-1152.)

ity to impart compression. Potential drawbacks include the need for a secondary surgical procedure as well as difficult implant placement. Results with these methods are at least comparable to reported results of K-wire fixation, with trends toward improved outcomes possibly limited to study size and type.[9,23]

The surgical management of lunotriquetral interosseous ligament (LTIL) injury varies by surgeon; no published studies directly compare outcomes of treatment method. Some surgeons address LTIL injury with K-wire pinning of the joint; others stress the additional need for LTIL repair to protect against the development of volar intercalated segment instability[10] (Figure 9). The decision to repair the dorsal ligament or the stronger volar component is also unclear and is surgeon dependent.[14]

Ulnocarpal translation is an emerging concern as a cause of persistent radiocarpal instability. This translation may be secondary to injury to the palmar and dorsal radiocarpal ligaments. The clinical implications of this translation are yet to be elucidated; however, in the sole study published to date on this topic, pinning the lunate to the radius with removal at approximately 8 weeks led to significantly less ulnocarpal translation in PLD-PLFDs than did not pinning the lunate to the radius in wrists with similar injuries.[24]

The longitudinal arthrotomy in the dorsal capsule should be repaired anatomically whenever possible. Alternatively, use of the dorsal intercarpal or dorsal radiocarpal ligament, when it is intact, to reinforce SLIL or LTIL repairs has been described.[22] If a volar approach was incorporated, then repair of the volar capsule can be performed.[22]

Arthroscopically assisted and percutaneous fixation of less severe PLD-PLFD is an emerging management option that combines fluoroscopy and traction to obtain arthroscopic reduction and fixation. This method promises improved visualization of the carpal bones, joints, and fractures while potentially decreasing surgical insult. A drawback, however, is the inability to perform direct ligamentous repair.[4,14,25]

Treatment of Chronic PLD-PLFD

With up to 25% of PLD-PLFDs missed at initial evaluation, delayed diagnosis of PLD-PLFD is not uncommon.[5] A multicenter study found that the average clinical score of PLD-PLFDs managed between 7 and 45 days was not statistically significant compared with the scores of those treated within 1 week, whereas the group treated after 45 days was significantly worse.[5] A comparison by Komurcu et al[7] reported that surgically treated dorsal transscaphoid PFLDs managed from 10 to 40 days postinjury had an average Green and

O'Brien score of 72.5 versus an average score of 89.2 in those treated before 7 days postinjury. Sample size, however, did not allow a statistical comparison.

These studies reinforce the need for prompt diagnosis and management. Reports of acceptable results with open reduction and internal fixation have been published when treatment was delayed up to 6 months.[7,26] Proximal row carpectomy has successfully been used in cases delayed >2 months, although some authors believe that a prerequisite for proximal row carpectomy is an intact and uninjured proximal capitate.[26] Delayed cases managed with isolated (scaphoid or lunate) carpal bone excision have had poor results.[26,27] Total wrist arthrodesis is an option in the chronic, unreduced PLD-PLFD with extensive degenerative changes.[14]

Postoperative Care

Our postoperative care regimen typically begins with placement of a short arm thumb spica splint in the operating room, with transition to a short arm thumb spica cast at 10 to 14 days. Initial rehabilitation focuses on active movement of the shoulder, elbow, and fingers to prevent stiffness. At 6 to 8 weeks postoperatively, the cast is removed, and a thermoplastic static wrist and thumb splint, with free motion of the thumb interphalangeal joint, is fabricated for protective wear between exercise sessions. Active, active-assisted, and gentle passive ROM exercises are initiated at the wrist, forearm, and thumb. These exercises are performed in 10-minute sessions six to eight times daily. Lifting is limited to <1 lb.

At 8 to 10 weeks postoperatively, passive ROM exercises with unrestricted extension are initiated, with supplemental use of dynamic wrist splinting or weighted wrist stretches, as tolerated. Progressive hand, wrist, and forearm strengthening is also initiated with graduated weights. As early as 12 weeks after surgery, some patients can be returned to unrestricted use of the hand in daily activity, with progressive return to sport or work conditioning. Typically, implants are removed at 12 weeks.

Complications

Complications related to the original trauma include posttraumatic arthrosis, median nerve dysfunction, complex regional pain syndrome, hand or wrist weakness, tendon ruptures or dysfunction, residual carpal instability, and wrist or hand stiffness.[5,11,28-31] Surgical complications include pin tract infection, superficial or deep wound infection (including septic arthritis), skin irritation, implant failure, flexor tendon adhesions, loss of reduction, scaphoid nonunion or malunion, and painful implant.[9-11,23] Transient ischemia of the lunate is a known sequela of PLF-PLFD injury; its presence should not be overinterpreted because it is usually a benign, self-limiting event.[30]

Outcomes

PLD-PLFDs are severe injuries with a poor prognosis for return to full previous function. Open injuries, those with delayed treatment, those with osteochondral fractures of the head of the capitate, and the presence of persistent carpal malalignment all imply poorer outcomes.[8,19,32] Outcomes are improved by early, accurate reduction and stable internal fixation, with repair or reconstruction of the dorsal SLIL undertaken when it is compromised.[4,33] Nearly all patients experience decreased grip strength and loss of ROM (Table 1). Most published studies include short- and medium-term results; one recent publication included long-term follow-up.[9-12,28,32] In these studies, most patients maintain adequate reduction, have scaphoid union, and are employed but demonstrate radiographic evidence of midcarpal or radiocarpal arthrosis.[9-11,23,28,32] Several studies found that, despite radiographic evidence of midcarpal and radiocarpal arthrosis, the findings did not correlate with Mayo wrist scores and that pain was often mild to moderate, occasional, and activity-related.[12,28,32]

In a review of 10 professional football players with PLD treated by closed reduction and percutaneous pinning or open reduction and K-wire fixation, none of the injuries forced retirement, and 9 of the athletes returned to play by the following season.[34] Forli et al[28] recently reported on a retrospective review of 18 patients with PLD-PLFD treated surgically, with an average follow-up of 13 years. These authors reported Mayo wrist scores, grip strength measures, and flexion-extension arcs similar to those reported in studies with average follow-ups less than half as long. Radiographic evidence of carpal degenerative changes, however, were 20% to 34% higher than those of the studies with shorter follow-ups, indicating that long-term progression of degenerative changes may increase, although functional outcome may be independent of these changes.[28]

Summary

PLD-PFLDs comprise a spectrum of traumatic soft-tissue and bony insults typically incurred through high-energy mechanisms. Accurate early diagnosis is essential; delayed treatment worsens outcomes. The diagnosis is typically made on wrist radiographs, with loss of carpal height

Table 1

Outcomes in Surgically Treated Perilunate Dislocation and Perilunate Fracture-dislocation

Study	No. of Cases	Average Follow-up	Type	With Acute Carpal Tunnel Syndrome (%)	Employed (%)	Average Flexion/ Extension Arc (% of contra-lateral)	Average Grip Strength (% of contralateral)
Trumble and Verheyden[9]	22	49 mo	Dislocation only	32	100	80	77
Knoll et al[10]	25	44.3 mo	Fracture-dislocation only	24	100	83	80
Sotereanos et al[12]	11	30 mo	Both	45	45	71	77
Hildebrand et al[11]	23	37 mo	Both	35	82	57	73
Herzberg and Forisser[32]	14	8 yr	Fracture-dislocation only	29	86	N/A	79
Forli et al[28]	18	13 yr	Both	N/A	N/A	76	87

N/A = not available

and disruption of carpal arcs identified on the AP radiograph and loss of the colinearity of the radius, lunate, and capitate found on the lateral radiograph. Initial gentle, closed reduction is performed, followed by delayed open reduction, ligamentous and bony repair, and internal fixation. Despite optimum treatment, this injury carries a guarded prognosis, with permanent partial loss of wrist motion and grip strength.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 10, 23, and 33 are level III studies. References 2, 5-9, 11, 12, 18, 20, 24-28, 30, 32, and 34 are level IV studies. The remaining references are review articles and level V expert opinion.

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