Perilunate Injuries: Diagnosis and Treatment

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Abstract

Perilunate injuries are severe disruptions of the carpus, which present a formidable challenge to the treating physician. Accurate recognition of the pattern of injury is not always straightforward. The injury can propagate through ligaments and/or bone, creating multiple variations of a basic injury pattern. Posteroanterior and lateral radiographs will depict a perilunate injury, but additional views may be necessary to appreciate subtle carpal fractures. Once the diagnosis has been established, early intervention is necessary for optimal results. An initial closed reduction with sedation and traction is performed to restore overall carpal alignment. However, subsequent closed or open reduction is necessary to restore anatomic alignment of all injured structures. The outcome of perilunate injuries correlates with the adequacy of reduction. Complications such as chondrolysis, carpal instability, and traumatic arthritis can occur despite satisfactory treatment.

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Perilunate injuries are severe carpal disruptions. Unfortunately, such injuries are frequently missed. The natural history of untreated injuries is progressive traumatic arthritis with pain and dysfunction.[1] Early accurate diagnosis is necessary to initiate appropriate intervention. To achieve the optimal outcome, carpal alignment must be accurately restored. Delayed treatment has been shown in several reports to significantly compromise the result.[1,2] This article will review carpal anatomy, kinematics, and pathomechanics, as well as diagnostic techniques and treatment options.

Anatomy and Kinematics

The carpal bones are tightly linked by a combination of capsular and interosseous ligaments.[3] The capsular ligaments originate from the radius and insert on the carpus. The interosseous ligaments traverse the carpal bones. The lunate is the keystone of the carpus and acts as the intercalated segment.

The lunate is connected to the scaphoid and the triquetrum by strong interosseous ligaments, which allow the proximal row to move in synchrony. Disruption of the interosseous ligaments leads to dysynchronous motion within the proximal row, which has been termed "dissociative carpal instability."[4]

The proximal row is attached to the distal row by capsular ligaments that cross the midcarpal space on both sides of the lunocapitate articulation. This arrangement promotes a smooth interaction between the carpal rows. Disruption of the capsular ligaments causes incongruity and abnormal motion between the proximal and distal rows, which has been termed "nondissociative carpal instability."[4]

The area directly between the lunate and the capitate is deficient in terms of substantial ligamentous connections. The palmar region of inherent capsular weakness, called the space of Poirier, is torn in perilunate injuries, creating a capsular rent across the midcarpal joint.[5]

Pathomechanics

The pathomechanics of perilunate injuries has been reproduced in the laboratory by Mayfield et al.[6] Forcing cadaver wrists into wrist extension by a load applied to the thenar eminence reproduced perilunate dislocation. The sequence of perilunate disruption was recorded and defined according to the concept of progressive perilunar instability. In this sequence, there are four stages of instability of increas-

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ing severity as the carpus is disrupted around the lunate (Fig. 1). In stage I, there is disruption of the scapholunate ligamentous complex. In stage II, the force propagates through the space of Poirier and interrupts the lunocapitate connection. In stage III, the lunotriquetral connection is violated, and the entire carpus separates from the lunate. The lunate remains aligned with the radius and the remainder of the carpus dislocates, usually in a dorsal direction. In stage IV, the most severe degree of injury, the lunate dislocates from its fossa into the carpal tunnel; the lunate rotates on its intact palmar ligaments into the carpal tunnel; and the capitate becomes aligned with the radius.

Variations of perilunar instability occur when some or all of the bones around the lunate are fractured before lunate dislocation. In the nomenclature, the prefix "trans-" is applied to the fractured bone or bones. For example, the term "transscaphoid transtriquetral dorsal perilunate dislocation" denotes an injury involving fractures of the scaphoid and the triquetrum with dislocation of the carpus in a dorsal direction.

The terms "lesser-arc injury" and "greater-arc injury" have been used to describe the configuration of injury through the carpus (Fig. 2).[5] A lesser-arc injury refers to a purely ligamentous disruption, as described by Mayfield et al.[6] In the greater-arc pattern, the osseous structures around the lunate are fractured.

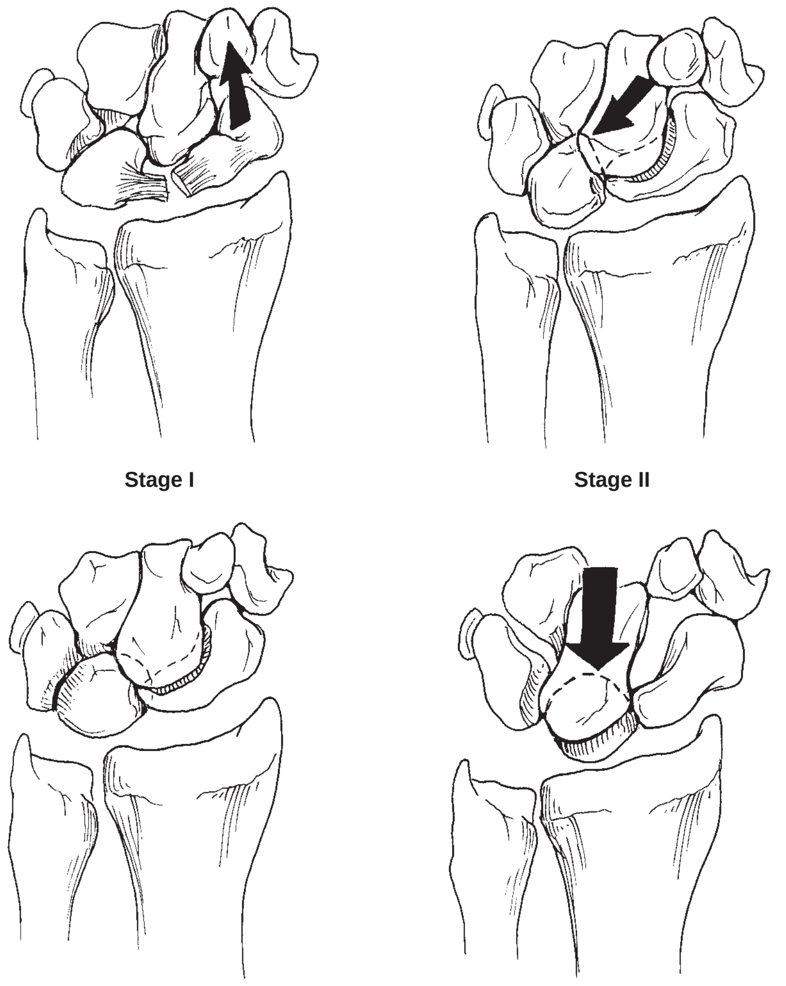


Fig. 1 Stages of progressive perilunar instability. Stage I involves disruption of the scapholunate ligamentous complex. In stage II, the force propagates through the space of Poirier and interrupts the lunocapitate connection. In stage III, the lunotriquetral connection is violated, and the entire carpus 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.

Diagnostic Techniques

Perilunate injuries are usually the result of high-energy trauma, such as a fall from a height, a sports-related injury, or a motor-vehicle accident. The findings at initial examination depend on the time from injury and the pattern of injury. The digits are often held in a semiflexed position, and passive extension causes pain. In a perilunate dislocation, the carpus is usually dorsal, and a prompt examination will discern the abnormal carpal alignment, with the prominent capitate behind the lunate. In a lunate dislocation, the lunate lies in the carpal tunnel, and median-nerve paresthesias are a common complaint. Because of the taut palmar structures of the hand, the lunate cannot be palpated. Crepitation may be felt with injuries that involve fractures. Examination after soft-tissue swelling has developed is more difficult because the osseous landmarks are obscured.

Plain radiographs are the key to diagnosis. An inadequate x-ray evaluation is a common cause of

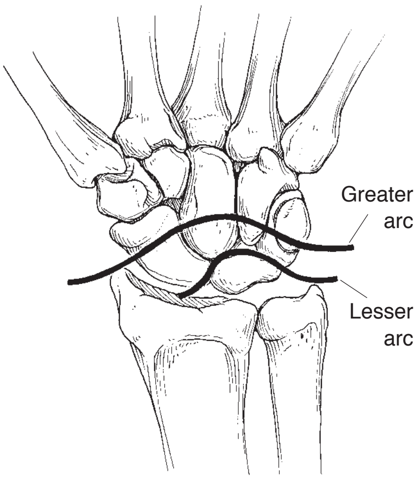


Fig. 2 The lesser and greater carpal arcs of perilunate instability.

missed diagnosis. True lateral and posteroanterior (PA) or anteroposterior (AP) radiographs are mandatory. Supplemental views can provide additional information about the particular pattern of perilunar instability. The definitive finding on a lateral radiograph is loss of colinearity between the radius, lunate, and capitate.[7] In a perilunate injury (stage III perilunar instability), the capitate is displaced from the lunate, usually in a dorsal direction (Fig. 3). In a lunate dislocation (stage IV perilunar instability), the lunate is dislodged from the radius, usually in a volar direction. The lunate rotates on its attached palmar ligaments so that the concavity faces downward, which is termed the "spilled teacup sign."[7] On the PA film, loss of the normal smooth carpal arcs of the proximal and distal articular surfaces should be apparent (Fig. 4).[8] The carpal bones of the proximal and distal rows will appear crowded and overlapping.[7,8] The lunate, which normally appears trapezoidal, will rotate and appear triangular or wedge-shaped. The PA film should also be scrutinized for fractures indicative of a greater-arc injury. Oblique radiographs are helpful for further clarification of the injury pattern. Subtle fracture lines can become visible on these films, especially in the scaphoid and triquetrum. Distraction radiographs obtained at the time of reduction can also add information about the fracture pattern and ligamentous injuries.

Computed tomography is not necessary in the acute setting, but may be valuable for clarification of injury in the case of delayed perilunate disruptions. Magnetic resonance imaging and bone scanning are not beneficial in the acute situation. Arthrography does not add anything to the evaluation, as ligament tears are universal in perilunate injuries.

Treatment

The treatment options for perilunate injuries vary according to the pattern of dislocation and/or the fracture configuration. In the vast majority of cases, the carpus dislocates in a dorsal direction. Volar perilunate and dorsal lunate dislocations are uncommon; therefore, the details of these injuries will not be discussed. The perilunate injury should also be classified according to the time from injury, as acute, delayed, or chronic. The treatment algorithm will be different in each circumstance, as will the expected outcome.

Initial Treatment

The initial treatment of a perilunate or lunate dislocation is early surgical intervention or delayed surgery preceded by a gentle closed reduction. Early surgery is preferred if swelling is not excessive. If there is excessive soft-tissue swelling, a closed reduction can be performed to reestablish overall alignment, followed by delayed surgery. Preliminary reduction of the perilunate dislocation will decrease pain, improve finger range of motion, and decrease swelling.

Closed reduction is performed by suspending the arm with 10 to 15 lb of traction. Analgesia is administered to provide relaxation. Intravenous sedation is often adequate in the acute setting before swelling

Fig. 3 Lateral radiograph depicts dorsal perilunate dislocation, with the capitate and scaphoid dorsal to the lunate.

Fig. 4 PA radiograph depicts perilunate dislocation with loss of articular alignment, overlapping carpal bones, and a triangular-appearing lunate.

and spasm occur. Longitudinal traction is applied for 5 to 10 minutes to regain length and overcome reflex muscle spasm. For dorsal perilunate dislocations, the thumb of one hand is used to manipulate the dislocated perilunate carpus while the other hand stabilizes the lunate. A volar-directed force is applied to the carpus while counterpressure is applied to the lunate. Palmar flexion of the perilunate carpus is used to reduce the capitate into the concavity of the lunate. A similar maneuver with trading pressure and counterpressure is executed for reduction of volar perilunate fracture-dislocations.

After preliminary reduction has been accomplished, radiographs obtained with traction can provide additional details of the perilunate injury pattern, including fracture configuration. Progressive signs and symptoms of median-nerve dysfunction despite adequate closed reduction require immediate surgery. Failure to achieve a closed reduction with gentle manipulation (irreducible dislocation) necessitates an open procedure with removal of the obstructing factor, usually interposed capsule.

Adequate postreduction radiographs are imperative to confirm reduction and determine further treatment requirements. A true lateral image should demonstrate restoration of the colinearity between the radius, lunate, and capitate. Both AP and lateral views should be examined for signs of persistent carpal instability. Despite closed reduction, scapholunate and lunotriquetral instability usually persists. Signs of scapholunate dissociation are widening (Terry Thomas sign) or loss of parallel alignment between the scaphoid and lunate articular surfaces, continued volar flexion of the scaphoid (the scaphoid ring sign), and an abnormal scapholunate angle on a lateral film.[7] The normal intercarpal angle between the scaphoid and the lunate is between 30 and 60 degrees.[9] When the scapholunate connection has been torn, the scaphoid tilts volarly, and the lunate tilts dorsally, creating an intercarpal angulation greater than 70 degrees. Fracture alignment must be acceptable on both the AP and lateral views, with bone displacement less than 1 mm.

Acceptable closed reduction implies restoration of carpal bone and fracture alignment. This will optimize the healing potential for the torn ligaments and the fractured carpus. Closed reduction alone rarely produces permissible alignment, as residual carpal instability or fracture malalignment usually persists.[7,10,11] Options for further treatment are closed reduction and percutaneous pinning or open reduction and pinning with possible direct ligamentous repair.

Closed Reduction and Percutaneous Pinning

Percutaneous pinning is a viable alternative when acceptable carpal alignment can be achieved by manipulation but is lost when the reduction maneuver is withdrawn.[10] The recommended technique is to stabilize the carpus by reversing the mechanism of injury. Under fluoroscopic guidance, the dorsally tilted lunate is derotated by passive wrist flexion. The lunate is then retained in a neutral lateral position by a percutaneous 0.045-inch pin placed through the radius. This restores the intercalated lunate to normal rotation and provides the foundation for the remaining carpus. The triquetrum is then pinned to the lunate to stabilize the ulnar side of the perilunar carpus.

If the radial side of the carpus has been destabilized by a scapholunate dissociation or a scaphoid fracture, it is considerably more difficult to reduce. This is because the scaphoid or scaphoid fracture fragments are profoundly malrotated and displaced in multiple planes. In a scapholunate dissociation, the volar-flexed scaphoid must be realigned to the lunate in both the AP and lateral planes. This reduction is a formidable task, especially with the lunate restrained to the radius. Wrist extension, ulnar deviation, and direct pressure applied to the scaphoid tuberosity are potential maneuvers to restore scaphoid alignment. If reduction is achieved, Kirschner wires are placed across the scapholunate and scaphocapitate articulations. If the scaphoid is fractured (transscaphoid injury), acceptable closed reduction is virtually impossible to obtain.

Open Reduction

Because of the inherent problems with closed reduction and pinning, an open procedure is usually preferred to restore anatomic alignment. Open reduction allows accurate reduction of the perilunate injury and proper pin placement. Surgical approaches that can be used are the volar, dorsal, and combined dorsal-volar techniques.[10-13] The dorsal method yields the best exposure of the carpus for restoration of alignment and interosseous ligament repair. In addition, fractures of the scaphoid and capitate can be secured with antegrade fixation devices. The volar approach allows decompression of the carpal tunnel and direct repair of the palmar capsular ligament tear. The combined dorsal-volar approach offers the advantages of both approaches, but increases surgical time and dissection.

My preferred approach for perilunate and lunate dislocations is the combined dorsal-volar approach with anatomic reduction and repair of the disrupted structures. The dorsal approach is performed first unless there is an irreducible volar lunate dislocation that is trapped within the carpal tunnel. The dorsal approach is the standard longitudinal incision across the wrist, with exposure of the capsule between the third and fourth compartments. The capsule tear is extended longitudinally with elevation of capsular flaps for exposure of the carpus. The carpus is inspected to assess chondral damage and the adequacy of closed reduction and to verify the injury pattern. Adequate closed reduction is judged at the midcarpal joint; the lunate should completely cover the capitate head. An exposed capitate head implies incomplete reduction due to a dorsiflexed lunate.

The lunotriquetral interosseous ligament is usually torn too severely for primary repair. However, the scapholunate ligament often tears from the scaphoid, and sufficient tissue is available for repair. Before scapholunate ligament repair, 0.045-inch wires are placed percutaneously across the scaphoid into the scapholunate articulation. The scapholunate wires can also be placed through the scaphoid (before reduction) from within the scapholunate articulation and into a percutaneous position (Fig. 5). The wire insertion is adjusted to just below the articular cartilage in readiness for fixation after complete reduction. Kirschner wires are placed into the triquetrum either percutaneously or in a retrograde fashion by way of the lunotriquetral joint.

To facilitate accurate scapholunate joint reduction and ligament repair, 0.045-inch Kirschner wires are placed in the scaphoid and lunate to act as joysticks. Nonabsorbable 3-0 braided polyester sutures are placed through the torn interosseous ligament for reattachment to the scaphoid (Fig. 6, A). The sutures are then passed into the remaining cuff of ligament on the scaphoid or, in the absence of sufficient cuff, through the scaphoid to the waist level with drill holes. In addition, suture anchors can be placed in the scaphoid to facilitate ligament repair. The sutures are not tied until scapholunate reduction has been accomplished and the previously positioned Kirschner wires have been passed across the joint. An additional percutaneous pin across the scaphocapitate joint is frequently added to help maintain appropriate scaphoid position. After the scapholunate repair has been completed, the lunotriquetral joint is reduced and pinned, again with the aid of joysticks (Fig. 6, B). Although the lunotriquetral joint can be pinned first, it is preferable to initially repair the more difficult scapholunate articulation to take advantage of the lunate mobility.

Attention is then directed to the volar side. An extended carpal tunnel incision is performed. The transverse carpal ligament and antebrachial fascia are incised, and the flexor tendons and median nerve are retracted. The volar wrist ligaments are visualized, and the tear across the midcarpal joint is identified. The configuration of this capsular rent is always an upside-down smile. The tear, which encompasses important pal-

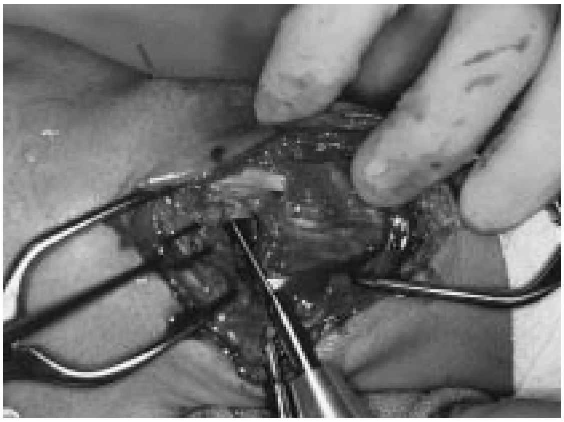
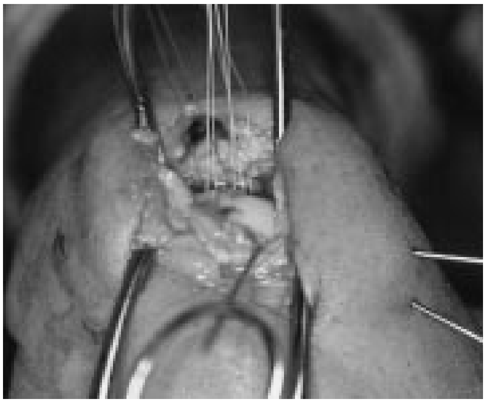


Fig. 5 If the scapholunate wire is not placed percutaneously, then before reduction a Kirschner wire is placed across the scaphoid from within the scapholunate articulation and out through the skin (as shown here). The reduction is then completed, and the ligament is repaired.



A

B

Fig. 6 **A,** Scapholunate ligament repair. **B,** PA film obtained after open repair and pin placement for perilunate injury.

mar ligaments, is repaired with nonabsorbable sutures.

After closure, the extremity is placed in a sugar-tong splint with the wrist in slight extension. Elevation and finger motion are encouraged. Sutures are removed at 2 weeks, and a long arm cast is applied for an additional 2 weeks. At 4 weeks, the cast is changed to a short arm variety, which is retained until pin removal at 10 to 12 weeks. Graduated therapy is then performed.

In a transscaphoid perilunate dislocation (Fig. 7, A), the dorsal approach for fracture fixation is used. The scaphoid fracture is then reduced, and antegrade fixation is applied. Joysticks placed into the proximal and distal fragments may be necessary to achieve reduction. For scaphoid fracture fixation, the Herbert-Whipple cannulated differential pitch screw is preferable (Fig. 7, B). The screw can be inserted over a guide wire that provides preliminary fixation and is buried within the scaphoid. Bone graft from the distal radius is used for comminuted scaphoid fractures. After scaphoid fixation, Kirschner wires are advanced across the lunotriquetral joint to stabilize the ulnar carpus. A volar approach can be added to repair the torn volar ligaments. The postoperative protocol is similar to that for perilunate dislocation without fracture. Rigid scaphoid fracture fixation allows protected motion after lunotriquetral pin removal and before scaphoid union.

Complications

Inaccurate or missed diagnosis is a common problem.[1] Inadequate x-ray examination and the bizarre appearance of the disrupted carpus contribute to errors in diagnosis. Complications related to the injury include median-nerve injury, transient ischemia of the lunate, chondrolysis, carpal instability, scaphoid nonunion or malunion, and traumatic arthritis.[10,12,14]

Acute median-nerve symptoms should be treated with urgent reduction and observation. Most median-nerve problems are secondary to the traumatic event and represent traction injuries. However, if symptoms progress, a carpal tunnel release should be performed emergently. Late carpal tunnel syndrome can result from failure to reduce a volar lunate dislocation and subsequent canal compromise. This requires release of the transverse carpal ligament and lunate excision.

Transient ischemia of the lunate can occur after perilunate injuries and should not be confused with

A

B

Fig. 7 **A,** PA radiograph of a transscaphoid perilunate dislocation with a scaphoid fracture and overlapping of the carpal bones. **B,** Antegrade Herbert-Whipple screw fixation of a transscaphoid perilunate dislocation.

complete avascular necrosis.[14] The palmar wrist ligaments usually remain attached to the dislocated lunate and provide adequate blood supply. Therefore, the ischemia is transient, and observation is the preferred treatment.

Chondrolysis can occur at the radiocarpal or midcarpal joint. Cartilage damage is often apparent at the time of open reduction, especially in the head of the capitate in perilunate dislocations. This may progress to early or delayed chondrolysis with subsequent arthritis.

Carpal instability can be secondary to unsatisfactory reduction or inadequate ligament healing. The instability pattern can occur within the proximal carpal row (scapholunate or lunotriquetral) or at the midcarpal articulation, or it may involve the entire carpus, resulting in ulnar translation. Scaphoid malunion with a humpback deformity can also be a cause of carpal instability.

Chondrolysis, scaphoid nonunion, and carpal instability usually result in posttraumatic arthritis necessitating a salvage procedure, such as partial or complete wrist arthrodesis or proximal-row carpectomy.

Outcome

The variability of injury patterns and the variety of treatment options have made it difficult to define the outcome of perilunate injuries. Because of the severity of this injury, some loss of motion is inevitable regardless of the treatment method. A 50% loss of wrist motion and 60% diminished grip strength have been reported after treatment.[12] However, a number of studies have noted that the restoration of normal carpal alignment is associated with improved outcome.[1,10,12,15] These studies underscore the importance of accurate reduction of the dislocated joints and carpal fractures. Other factors that have a deleterious effect on outcome include a delay in treatment, open injury, chondral damage, persistent instability, and fracture malunion.[1,2]

Summary

Perilunate injuries can be conceptualized as a spectrum of progressive perilunar instability with the injury propagating through ligament and/or bone. The injury must be diagnosed acutely, and accurate identification is dependent on the availability of radiographs that adequately define the injury pattern. An initial gentle closed reduction can be performed, but conclusive treatment requires accurate open reduction of the dislocated joints and fixation of the fractured carpal bones.

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