Avascular necrosis of the lunate secondary to perilunate fracture dislocation: Case report and review of the literature

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Abstract
This is a 39-year-old male, fell from a bike, left wrist with trans-styloid perilunate fracture dislocation that underwent open reduction internal fixation, 20 months after surgery the patient developed avascular necrosis of the lunate, final wrist fusion was performed secondary to the arthritic changes on the wrist. Anatomic dissection was performed and vascularity of the lunate was identified, its origin is from the volar palmar arch, when dislocated palmarly and more than 90 degrees the vessel is still intact. More than 512 patients with perilunate dislocation and perilunate fracture dislocation are included we identified in the literature transient avascular necrosis of the lunate in nine and seventeen of pure avascular necrosis of the lunate. Concluding that avascular necrosis of the lunate after perilunate dislocation or perilunate fracture dislocation is an infrequent finding especially when the volar ligaments are intact.

Keywords
Perilunate dislocation, perilunate fracture dislocation, lunate, avascular necrosis, trans-scaphoid fracture, lunate dislocation

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Introduction
Perilunate dislocations (PLDs) and perilunate fracture dislocations (PLFDs) caused by high-energy injuries. Diagnosis is challenging and prompt treatment is required in order to avoid long-term complications.1 Ligament injuries, or PLD, are referred to as lesser arc injuries, whereas dislocations with associated fractures are referred to as greater arc injuries, or PLFDs.2 After the diagnosis of PLDs or PLFDs, one should attempt provisional closed reduction and proceed to urgent open reduction and internal fixation (ORIF) through a dorsal or volar approach or both approaches are needed some times. If closed reduction is unsuccessful open repair of the ligaments are necessary.2 There is little evidence or description of avascular necrosis (AVN) of the lunate secondary to ORIF after to a PLDs or PLFDs. We present a case report and a review of the literature in order to identify the lunate AVN after these terrible injuries.

Case report
A 39-year-old male was injured in a bicycle accident and sustained a left wrist trauma. After that, the patient complained about pain and had a visual deformity of the wrist. Initial radiographs (Image 1(a)) showed a trans-styloid PLFD. The patient underwent ORIF of the trans-styloid PLFD at another institution. The wrist and distal aspect of the radius was exposed through a dorsal approach, and the distal radius was fixed with a dorsal plate. After percutaneous fixation of the lunate with scapholunate, scaphocapitate, and lunacapitate Kirschner wires (K-wire), the dorsal scapholunate ligament was repaired to the dorsal side of the lunate using a bone anchor (Image 1(b)). The K-wires were removed 1 month after surgery (Image 1(c)). Five months after surgery, wrist extension/flexion was 70/50 degrees, wrist ulnar/radial deviation was 20/50 degrees, and forearm pronosupination was 80/60 degrees. Seventeen months after the surgery, the patient consulted another hand surgeon complaining about left wrist pain and decreased grip strength. The physical examination at that moment was flexion of the
left wrist 30 degrees, extension 45 degrees, left-hand grip strength 40 pounds (lbs), and right-hand grip strength 100 lbs.

Wrist radiographs showed radio-scaphoid osteoarthritis 17 months after the initial injury, dorsal collapse of the distal radius, and AVN of the lunate secondary to fragmentation and cystic changes. Four-corner fusion was recommended, but the patient did not have surgery (Image 1(d)). Finally, 20 months after the initial surgery, the patient came to our clinic and was evaluated by the senior author (H.T.), due to the findings in the computerized tomography of the wrist, that shows arthritic changes, is important to recognize that the best way to identify AVN of any bone is the magnetic resonance imaging (MRI) (Image 1(e)). The main goal of the patient was to keep using his left hand and keep bicycling. With the findings in the computed tomography (CT), four-corner fusion was not an option due to the arthritic changes in the lunate fossa and the dorsal inclination of the radius. Total wrist fusion was proposed, and the patient accepted this procedure. Total wrist fusion was performed 29 months after the initial injury. At 5 months after the total wrist fusion, the patient had no complaints, no pain, full range of motion of the fingers, and is back to regular activities (Image 1(f)).

Discussion
To the best of our knowledge, there is scarce evidence or description of lunate AVN secondary to a PLD or PLFD.1 Throughout the literature, a total of 151 PLDs and 367 PLFDs were identified, with a follow-up of 58 months. We identified 9 cases of transient AVN of the lunate and 17 cases of pure AVN of the lunate. Only one series described a treatment for the AVN of the lunate proximal row carpectomy was performed in two cases (Table 1).

Bain et al.26 described that AVN of the lunate is caused by a compartment syndrome of the bone. The factors that contribute to this compartment syndrome are increased intraosseous pressure including the arterial supply, emboli formation, decrease in venous drainage, and destruction of the intraosseous bone marrow. White and Orner3 first described the transient AVN of the lunate after PLFDs in 3 out of 24 patients who underwent ORIF. During the immobilization, all carpal bones underwent some osteopenic changes between the first and the fourth month after initial operative treatment. Normal lunate was seen between 5 and 32 months after trauma. Reasons for this transient AVN is decreasing inflow and outflow from the bone creating a so-called compartment syndrome of the bone.3 The details can be found in Table 1.

Herzberg7 described AVN of the lunate in 5 out of 166 patients and of them underwent ORIF. In two cases, the lunate was found to be rotated over 180 degrees with respect of the radius. Four cases underwent urgent surgery in less than a week, and one case underwent delayed surgery 45 days after the initial trauma. All cases of AVN are listed in Table 1.
The vascular supply of the lunate is originally described by Gelberman et al. He described that the external vascular supply of the lunate is by direct dorsal blood supply from the dorsal plexus of vessels on the mid-dorsum of the carpus and fed by the branches of the radial artery and the dorsal branch of the anterior interosseous artery. The volar carpus is supplied by four arteries: the ulnar artery, the radial artery, the volar branch of the anterior interosseous artery, and the recurrent branch of the deep palmar arch.

In the study performed by Lamas et al. on the dorsal aspect of the lunate, vessels enter through one of the three foramina located in the proximal, central, or ulnar, non-articular space of the bone. On the volar aspect, one to five nutrients vessels enter the volar pole through various ligamentous insertions, including the ligament of Testut-Kuentz, radiolunate triquetrum ligament (now called long radiolunate ligament), and ulnar lunotriquetral ligament (Image 2). (This anatomic dissection was performed by the authors.)

In our case, AVN of the lunate could be secondary to the PLFDs itself because of disruption of the volar and dorsal vessels entering in the lunate or secondary to the hardware after the first surgery. During surgery, volar and dorsal approach may be necessary to reduce the PLFDs. K-wires may be useful to reduce the scaphoid, the lunate and also used them both as a joystick to maintain the reduction, reconstruction of the dorsal scapholunate ligament can be performed using anchors, the volar lunotriquetrum ligament.

### Table 1. Transient and avascular necrosis of the lunate after perilunate dislocation (PLD) and perilunate fracture dislocation (PLFDs).

| Series, year | PLDs | PLFDs | Type of fixation | Follow-up (months) | Transient AVN | AVN | AVN treatment |
|--------------|------|-------|------------------|-------------------|---------------|-----|---------------|
| White, 1984 | 24   |       | ORIF closed      | 96                | 3             | 0   | No info       |
| Viegas, 1987| 8    |       | ORIF            | 18                | 0             | 0   | No info       |
| Gelberman, 1988 | 1 |       | ORIF            | 52                | 1             | 0   | No info       |
| Conway, 1989 | 3    |       | ORIF            | 19                | 0             | 0   | No info       |
| Herzberg, 1993 | 56  | 104   | 64 ORIF         | 75                | 0             | 5   | No info       |
| Sotereanos, 1997 | 3 | 8     | ORIF            | 30                | 0             | 0   | No info       |
| Inoue, 1997  | 14   |       | 8 ORIF          | 29                | 0             | 1   | No info       |
| Inoue, 1997  | 29   |       | ORIF            | 24                | 0             | 0   | No info       |
| Hildebrand, 2000 | 23 |       | ORIF            | 21                | 0             | 1   | No info       |
| Herzberg, 2002 | 14 |       | ORIF            | 103               | 4             | 0   | No info       |
| Trumble, 2004 | 22  |       | ORIF            | 49                | 0             | 0   | No info       |
| Knoll, 2005  | 25   |       | ORIF            | 44                | 0             | 0   | No info       |
| Souer, 2007  | 18   |       | ORIF            | 44                | 0             | 0   | No info       |
| Martinage, 2008 | 7  | 7     | ORIF            | 25                | 0             | 0   | No info       |
| Komurcu, 2008 | 12 |       | ORIF            | 45                | 0             | 0   | No info       |
| Forli, 2010  | 11   | 7     | ORIF            | 156               | 0             | 0   | No info       |
| Kailu, 2010  | 1    | 11    | ORIF            | 90                | 0             | 0   | No info       |
| Laporte, 2012 | 6  | 11    | 13 ORIF         | 26                | 0             | 0   | No info       |
| Akane, 2014  | 1    |       | ORIF            | 6                 | 0             | 1   | No info       |
| Krief, 2015  | 14   | 16    | 18 ORIF         | 216               | 0             | 2   | Proximal row carpectomy |
| Wilke, 2015  | 1    |       | ORIF            | 14                | 0             | 1   | No info       |
| Meszaros, 2018 | 1 | 20    | ORIF            | 112               | 0             | 6   | No info       |
| Dunn, 2018   | 14   | 26    | ORIF            | 47                | 0             | 0   | No info       |

| n = 151 | n = 367 | Mean follow-up = 58.30 months | n = 9 | n = 17 |

ORIF: open reduction and internal fixation; AVN: avascular necrosis.
The learning point, in this case, is that major dissection of the volar ligaments from the radius to the lunate must be avoided to preserve the blood supply, intercarpal bone fixation with K-wires and reconstruction of the intercarpal ligaments should be performed but with less hardware to avoid AVN of the lunate in PLDs and PLFDs.

Conclusion

Despite the massive trauma to the surrounding tissues, AVN secondary to PLD or fracture dislocation is an infrequent event. This is probably due to the enormous blood supply that the lunate has from the volar and the dorsal aspect. Especially when the volar ligaments are still intact, they provide irrigation to the lunate.

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Human and animal rights

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration on 1975, as revised in 2008.

Informed consent

Written informed consent was obtained from the patient(s) for their anonymized information to be published in this article.

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