Open Perilunate Fracture Dislocation with Lunate Extrusion: A Case Report and Literature Review

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Keywords
Lunate enucleation · Lunate extrusion · Open injury · Perilunate injury · Perilunate fracture-dislocation

Abstract
Perilunate injuries with lunate extrusion are extremely rare, representing an extreme subgroup of the Mayfield type 4 spectrum, with prognosis and management remaining controversial. We present a 45-year-old man with an open type 4 perilunate fracture dislocation, with lunate extrusion through the volar skin. Despite emergent treatment with open reduction and internal fixation, lunate and scaphoid proximal pole avascular necrosis developed. However, the overall functional outcome was satisfactory for daily activities at 30 months follow-up, with substantial improvement in the range of motion after hardware removal. To our knowledge, this is the third reported case of an open perilunate injury with lunate extrusion in the literature.

Introduction
Perilunate lesions, first described by Malgaigne [1], are high-energy injuries with complex carpal instability [2], involving around 7% of all the traumatic lesions of the carpus [3]. In 1980, Mayfield described a continuum of 4 stages [4], in which progressive ligament and bone dissociation occur [2]. These may be isolated perilunate dislocations (PLDs) or perilunate fracture dislocations (PLFDs), with scaphoid fractures seen in 65% of cases [1, 2]. Herzberg
reviewed 166 cases and found that transscaphoid PLFDs were the most common pattern, though only 20% had a volarly dislocated lunate [5]. Although posttraumatic arthritis can be expected in the majority of patients, most cases are clinically well-tolerated [1, 3].

Rarely, the lunate migrates volarly with complete ligamentous detachment and impaired vascularization, greatly increasing the risk of avascular necrosis (AVN) [6]. Few reports in the literature describe well-defined lunate extrusion or enucleation [7–17], of which only 2 were open injuries [9, 14]. We present a case of an open Mayfield type 4 PLFD with lunate extrusion through the volar skin.

**Case Presentation**

A 45-year-old male electrician presented to the emergency room with a severe injury to the left wrist after a fall from height with forced hyperextension (nondominant hand, previously treated with a volar plate for a distal radius fracture 20 years ago). On examination, there was gross deformity of the left wrist and a volar wound (15 × 10 mm) proximal to the wrist crease, with evident bone exposure (Fig. 1a). No neurovascular...
Deficits were noted. Initial management included temporary splinting and intravenous antibiotic. Plain radiographs and computed tomography scan revealed an open Mayfield type 4 transradial-styloid transephaloid PLFD, with lunate extrusion through the volar wound (Fig. 1b–e) [4].

Emergent surgery was promptly performed after adequate irrigation, using a combined approach. Through a volar approach across the open wound, an extended carpal tunnel release was performed. The extruded lunate was found isolated, with complete ligamentous attachment disruption. It was then reduced onto the radius lunate fossa, followed by repair of the volar capsule rent with nonabsorbable sutures. A subsequent dorsal approach was performed, with a ligament-sparing dorsal capsulotomy [18] and neurectomy of posterior interosseous nerve. The scapholunate and lunotriquetral ligaments were irreparable, with no remnants remaining. Scaphoid fracture was anatomically reduced and fixed with a Herbert-type screw, followed by scapholunate and lunotriquetral pinning after correct scapholunate alignment was obtained. The radial styloid was reduced and fixed with a buttress plate. Postoperative radiographs revealed a malpositioned scaphoid screw (Fig. 2a, b), and surgical revision was proposed but refused by the patient. A dorsal splint was maintained for 8 weeks, with Kirschner wires removal at 6 weeks. Unrestrained wrist mobility and physical rehabilitation initiated afterward.

At 12-month follow-up, radiographic evaluation revealed a scaphoid nonunion with a scapholunate angle of 70°. Neither osteoarthritis nor collapse was evident, with a normal carpal height ratio of 1.65 [19] (Fig. 2c). On the Visual Analog Scale for pain, the patient attributed 2 of 10 and reached 32 points on the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. Wrist range of motion was evaluated with a classic goniometer: flexion 60°, extension 20°, radial deviation 10°, and ulnar deviation 10° (67%, 33%, 33%, and 38%
of contralateral side, respectively). Strength parameters were obtained with a dynamometer (Lafayette Hand-Held Dynamometer): grip strength 8.8N and pinch strength 8.2N (80 and 97% of contralateral side, respectively).

By 30 months of follow-up, the patient reported progressive loss of motion of the left wrist, despite having no increase in pain. Radiographs revealed signs of lunate and scaphoid proximal pole AVN, with mild radiocarpal osteoarthritis and collapse (Fig. 2d). Hardware removal was then performed (Fig. 2e, f). The patient reported a significant increase in wrist range of motion afterward, with minimal pain performing common daily activities and good overall satisfaction on last evaluation.

Discussion

Lunate extrusions represent an extreme subgroup of the type 4 spectrum, lacking evidence and guidelines, and have been proposed as an additional fifth type to the Mayfield classification [16]. Due to the additional volar ligamentous attachment disruption, there is a total absence of vascularization to the lunate, and the risk for AVN greatly increases [6].

To the best of our knowledge, there are twelve reports in the literature of PLD/PLFD with well-documented isolated lunate extrusion and complete ligamentous detachment, which are detailed in Table 1. All patients were male, ranging from 19 to 48 years old, who suffered a high energy trauma to the wrist. The most common injury pattern was a transscaphoid PLFD, and only 2 patients (17%) had open injuries. Regarding treatment, open reduction and internal fixation (ORIF) was performed in 8 cases (67%), while a primary proximal row carpectomy (PRC) was opted in 4 (33%). Intrinsic ligaments repair was only possible in half of the ORIF cases, reflecting soft tissue injury severity. The immobilization period was diverse, averaging 9.2 and 5.8 weeks for ORIF and PRC, respectively. As the lunate becomes avascular after such an injury, it should be expected that all ORIF attempts would lead to inevitable AVN [10]. In contrast, lunate osteonecrosis was only observed in 3 patients (38%) – with 2 of those requiring a second surgery for wrist arthrodesis. Nonetheless, among the 5 patients with a surviving lunate, 2 still developed important radiocarpal osteoarthritis over 144 and 36 months, while those with no reported complications had only 6–12 months of follow-up. We believe that such small follow-up periods are insufficient to draw optimistic conclusions from and should not make an argument for ORIF efficacy.

Though initially reserved for chronic cases or as a salvage procedure after failed ORIF, some authors have proposed PRC as a first-line treatment for acute PLFD, where AVN or severe carpal instability is expected [8, 20]. For arthritis treatment, PRC has durable results, with a low failure rate and good functional wrist motion expected at long-term follow-up [21–23]. However, worse outcomes have been observed with younger patients and those with heavy manual labor. A study comparing primary ORIF and PRC in acute PLFD observed that medium-term results were equivalent between groups, apart from moderate better extension with ORIF [20]. In the cases summarized in Table 1, 4 patients were treated with primary PRC. This group had reduced immobilization times, and all patients reported a painless wrist at the final follow-up, with no reported complications. In retrospect, PRC might have been a viable option for our patient as the probability of AVN was extremely high even if a successful ORIF had been obtained.

There are a few reports of extrusion of lunate and scaphoid as a unit, where ORIF appears to provide good results. We believe these to be different injuries, with distinct prognosis implications as the intact scapholunate ligament may allow for lunate revascularization after scaphoid healing occurs [24, 25]. Though the ability of the lunate to recover from transient vascular compromises has been well-described [25], there is still no explanation for how the vascularization is restored after a complete ligamentous detachment.
| Author                | Gender, age (years) | Injury pattern                  | Surgical technique | Ligament repair | Approach | Immobilization period (w) | FU (m) | Pain | ROM (F, E) | Grip strength | Complications                                | Revision surgery |
|-----------------------|---------------------|--------------------------------|--------------------|-----------------|----------|-----------------------------|--------|------|------------|--------------|---------------------------------------------|-----------------|
| Mamon et al. [7]      | M, 25               | Closed PLFD (TS, TH, TC)       | ORIF               | NR              | NR       | NR                          | 5      | Yes  | Limited    | NR           | Lunate and PS AVN                           | Wrist arthrodesis |
| Draaijers et al. [8]  | M, 48               | Closed PLFD (TRS)              | ORIF               | Yes             | Dorsal   | 6                           | 3      | Yes  | Severely diminished | Greatly diminished | Lunate AVN, radial arthritis                | Wrist arthrodesis |
|                       | M, 38               | Closed PLFD (TS, TT)           | PRC                | NA              | Combined | 3                           | 6      | No   | Diminished   | NR           | –                                           | –               |
| Razafimahandry et al. [9] | M, 32            | Open PLFD (TS)                 | PRC                | NA              | Palmar   | 12                          | 72     | No   | 30°, 40°    | Slightly diminished | Lunate AVN, radial arthritis                | –               |
| Emami et al. [10]     | M, 19               | Closed PLFD (TS)               | ORIF               | No              | Palmar   | 10                          | 24     | Yes  | Limited    | Diminished   | Lunate and PS AVN, mild arthritis           | –               |
| Koh et al. [11]       | M, 24               | Closed PLFD (TS)               | ORIF               | No              | Combined | 15                          | 144    | No   | 70°, 50° (88%, 63%) | 76%          | Mild arthritic changes, SL widening         | –               |
| Marzouki et al. [12]  | M, 40               | Closed PLFD (TS, TRS)          | PRC + RS ORIF      | NA              | Combined | 4                           | 36     | No   | 60°, 45°    | Slightly diminished | –                                           | –               |
| Jaiswal et al. [13]   | M, 25               | Closed PLFD (TRS)              | ORIF               | Yes             | Combined | 8                           | 6      | NR   | Diminished   | NR           | –                                           | –               |
| Arango et al. [14]    | M, 40               | Open PLD                       | ORIF               | No              | Combined | NR                          | 10     | No   | Full       | NR           | –                                           | –               |
| Phan et al. [15]      | M, 47               | Closed PLD (scaphoid divergent dislocation) | ORIF | Yes | Combined | 8 | 36 | 30°, 60° (50%, 98%) | 98% | Arthritic changes, PS partial resorption | – |
| Severo et al. [16]    | M, 28               | Closed PLFD (TS)               | PRC                | NA              | Palmar   | 4                           | 18     | No   | 86°, 70°    | NR           | –                                           | –               |
| Kastanis et al. [17]  | M, 42               | Closed PLFD (TS)               | ORIF + EF          | Yes             | Combined | 8                           | 12     | No   | 60°, 40° (92%, 91%) | 78%          | –                                           | –               |

Y, years; W, weeks; FU, follow-up time; M, months; ROM, range of motion; F, wrist palmar flexion; E, wrist dorsal extension; DASH, Disabilities of the Arm Shoulder and Hand; M, male; PLFD, perilunate fracture dislocation; TS, transscaphoid; TH, trans-hamate; TC, transcapitate; ORIF, open reduction and internal fixation; NR, not reported; PS, proximal scaphoid; AVN, avascular necrosis; TRS, transradial-styloid; TT, transtriquetum; NA, not applicable; SL, scapholunate; RS, radial styloid; PLD, perilunate dislocation; EF, external fixation; RC, range of motion.

For ROM and grip strength, percentage values refer to uninjured side.

*Radiographic evaluation appears to show an increase in lunate radiodensity, suggestive of compromised vascularization.
Open injuries amount for 8% of PLD/PLFD and have a detrimental effect on the overall outcome [5]. Besides the need for initial debridement and antibiotic coverage, treatment of open PLD/PLFD is similar to their closed equivalents, with definitive primary fixation plus ligamentous repair being advised, unless major soft tissue injury is present [1–3, 26, 27]. In the 2 previous reports of open lunate extrusions [9, 14], 1 patient underwent PRC, while the other was subjected to a successful ORIF. As in our case, infectious complications did not occur.

Due to the injury severity of the presented case, ligamentous repair was not possible, and scaphoid fixation revealed unsatisfactory. This led to lunate and scaphoid AVN, with carpal degeneration subsequently developing. Nonetheless, in a short follow-up, our outcomes were consistent with the literature, except for a slightly poorer overall mobility, which improved after hardware removal. Regarding expected outcomes in the literature, Kremer et al. [28] reported an average of 61–63% and 71% of contralateral side for mobility and grip strength, respectively. Residual pain can be expected in 20–30% of patients and reference values for DASH scores are 23–27 [20, 27, 28].

PLFD with lunate extrusion are challenging injuries with a guarded prognosis, even when promptly and adequately treated. The limited number of cases reported start to provide some insights into this unique injury pattern. Though lunate revascularization appears to be possible after an extrusion, the mechanisms for its occurrence are still not understood and its outcome remains unpredictable. Hence, treatment should be decided on an individual basis, considering the expected instability, extent of soft tissue injury, and the surgeon’s ability to restore a normal carpus.

**Statement of Ethics**

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. The study is exempt from ethical committee approval, according to institutional rules regarding retrospective case reports where patient’s anonymity is assured.

**Conflict of Interest Statement**

The authors have no conflicts of interest to declare.

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**Author Contributions**

Mário Baptista: design of the work, data acquisition and interpretation, manuscript writing, and final approval. Elisabete Ribeiro: conception of the work, data acquisition and interpretation, manuscript review, and final approval. Melanie Ribau: data acquisition, manuscript review and final approval. Nuno Vieira Ferreira: data acquisition, manuscript review, and final approval. Pedro Varanda: manuscript review, and final approval. Luís Filipe Rodrigues: conception of the work, manuscript review, and final approval.
Data Availability Statement

All data analyzed during this study are included in the article. Further inquiries can be directed to the corresponding author.

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