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Redefining radiocarpal fracture-dislocations with injury specific management and a clinical classification system: a retrospective review

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Key words
classification system, distal radius fracture, fracture types, intra-articular fracture, radiocarpal fracture-dislocation, wrist fracture.

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Abstract

Background: Unlike articular shear fractures of the distal radius, radiocarpal fracture-dislocations defined as complete dislocation of the lunate from its articular facet of the radius are relatively uncommon. The management principles of these fractures have not been defined and there is no consensus on approach to management of these injuries. The aim of this study is to review our series of radiocarpal fracture-dislocations and propose a radiographic classification to guide surgical management.

Methods: This study is reported based on STROBE guidelines. A total of 12 patients underwent open reduction and internal fixation. All the fracture-dislocations were dorsal and satisfactory objective outcomes achieved were comparable to literature. Injury morphology-specific management approach was used based on the size of dorsal lip fragment and the volar teardrop fragment attached to the short radiolunate ligament assessed by preoperative CT scans.

Results: All patients with known outcome ($n = 10$) went on to resume their prior occupation and hobbies that included high-demand activities and manual labour at mean follow-up of 27 weeks. Average wrist flexion was 43° and wrist extension was 41° while radial and ulnar deviation were 14° and 18° respectively. Average forearm pronation was 76° and supination was 64° at final follow-up.

Conclusion: We describe four injury patterns of radiocarpal fracture-dislocations based on preoperative CT scans that guide fixation. We believe that early recognition of radiocarpal fracture-dislocations and appropriate management can yield satisfactory outcomes.

Introduction

Radiocarpal fracture-dislocations are an uncommon injury pattern and often underdiagnosed or misdiagnosed with other carpal dislocations and subluxations.[1–4] These fractures are often confused with articular fractures of distal radius like volar and dorsal Barton fractures that are shear fractures with subluxation of the lunate along with the displaced articular surface of the distal radius. In radiocarpal fracture-dislocations, by contrast, a major portion of the distal radius articular surface is intact and the lunate along with the rest of the carpus dislocates out of the radiolunate fossa.[5,6] Maintenance of intercarpal relationship in radiocarpal fracture-dislocations differentiates this injury from lunate and perilunate dislocations.

The management principles of radiocarpal fracture-dislocations have not been defined and there is no consensus on approach to these injuries. Radiocarpal fracture-dislocations have variable injury patterns necessitating fragment-specific fixation utilizing a variety of surgical approaches. The aim of this study is to review our series of radiocarpal fracture-dislocations and describe a radiographic classification to guide surgical management.

Methods

We performed a retrospective review of radiocarpal fracture-dislocations from a case series of distal radius fractures managed at our institution over a 2-year period. Ethics approval was obtained from the HREC of our institution (HREC/17/QGC/162). All patients had the major portion of the distal radius articular surface intact and the lunate along with the rest of the carpus was dislocated out of the radiolunate fossa.

Patient demographics, surgical management and clinical outcomes were recorded. Clinical records and imaging studies were analysed to extract the relevant data sets. Statistical tests have not been used due to the small number of patients.

Preoperative evaluation included history, mechanism of injury and functional requirements of the patient. Every patient underwent closed reduction under intravenous sedation in the emergency department on initial presentation. CT scanning was obtained in all cases following closed reduction to identify critical fragments and plan the surgical approach and fixation technique (Fig. 1b and 2b,c).

We managed these injuries based on the injury morphology – specifically the presence or absence of avulsed volar and dorsal fragments of the distal radius articular surface as visualized on post-reduction CT scans. The critical parameters were the size of the dorsal lip fragment of the distal radius and the presence or absence of the teardrop fragment at the volar ulnar corner of the distal radius signifying bony or soft tissue avulsion of the short radiolunate ligament (SRL), respectively. We defined 'large' or 'small' fragments based on the size of fragment on CT scan and the ability to fix or buttress the fragment using conventional distal radius plating systems. We describe four injury types to help plan surgical approach and fixation (Table 1). All fracture patterns were associated with radial styloid fractures.

The following three steps were considered critical in the surgery for radiocarpal fracture-dislocations:

(1) Stabilization of radius volar teardrop fragment or SRL repair
(2) Stabilization of the radial styloid and a large dorsal lunate facet fragment if present
(3) Nerve decompression in cases with persistent neurological deficit after closed reduction.

The surgical approach was either dorsal, volar or combined and with a separate radial approach when needed to stabilize the styloid fracture. An extensile volar-ulnar approach in the interval between the flexor carpi ulnaris and the flexor digitorum profundus was utilized for exposure and fixation of the volar teardrop fragment if present or for direct repair of the volar ligaments or when median nerve decompression was required. Fixation of the teardrop fragment was achieved with 2.4 mm hook or buttress plates. In the absence of a teardrop fragment the SRL was isolated and prepared for repair using bone anchors to the volar-ulnar corner of the distal radius. The radial styloid fracture was stabilized (as described below) prior to repair of the SRL to ensure appropriate soft tissue tensioning (Figs 1, 3 and 4).

Comminuted radial styloid fractures were managed by an additional lateral approach through the floor of the first extensor compartment. The fracture was stabilized by a buttress plate applied to the lateral metaphysis of the radius. For radial styloid fractures without comminution, styloid fixation was achieved percutaneously with a cannulated headless compression screw or using variable angle styloid screws of the volar implant. In cases of radial styloid fractures that extended onto the dorsal rim of the distal radius, a

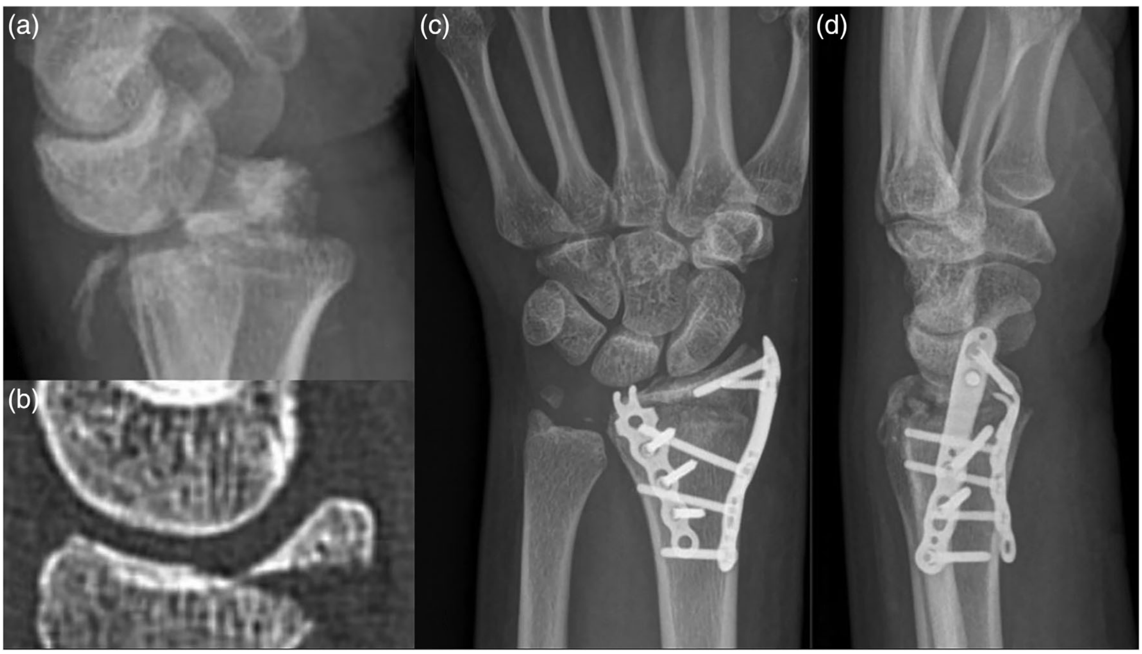

Fig. 1. Type I injury (a) lateral radiograph showing the small dorsal and large teardrop volar bony fragment with dislocated lunate. (b) sagittal CT view showing the similar findings in the reduced joint (c) posteroanterior (PA) view after fixation of the teardrop fragment with specific volar ulnar plate and styloid fixation with a plate through a separate radial approach.

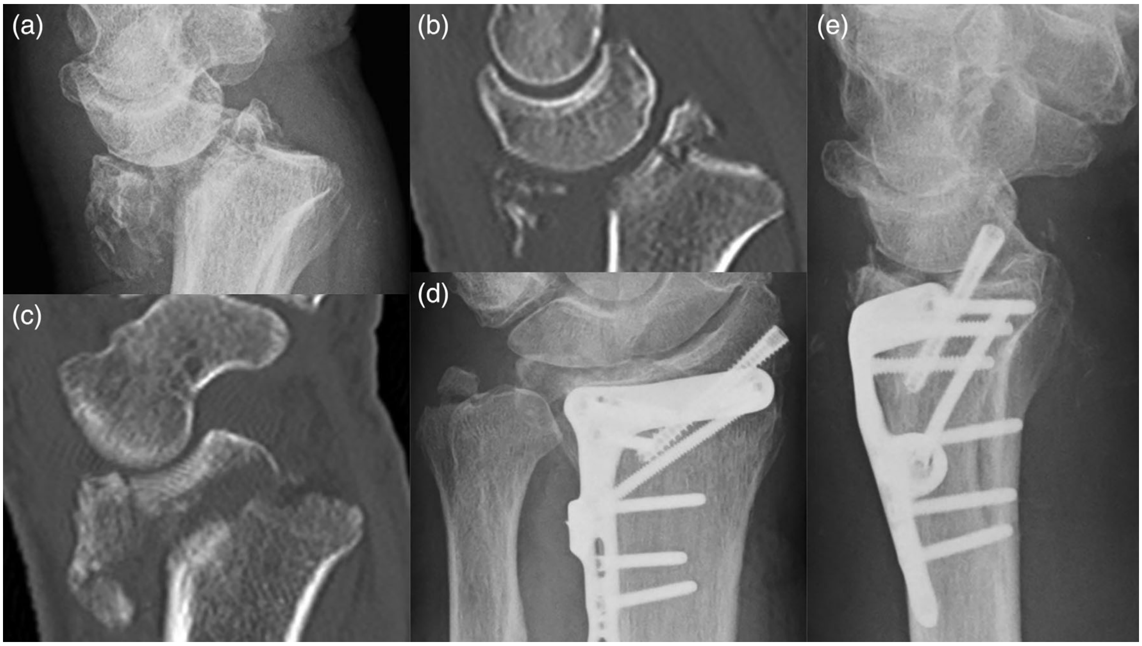

Fig. 2. Type II injury (a) lateral radiograph and (b) CT sagittal view showing large dorsal and small volar fragment with (c) a styloid fracture (d) PA and (e) lateral views post-fixation using dorsal approach to fix with dorsal rim plate and percutaneous styloid screw. Also, note styloid fixation with the screw through the proximal ulnar hole of the plate. No volar approach was taken in this case as wrist was stable post fixation and ulnar styloid fracture was also managed conservatively.

dorsal approach was performed through the floor of the third extensor compartment and the styloid and dorsal fragments were stabilized with a dorsally applied buttress plate.

In type II injuries with large dorsal and radial styloid fractures with small/absent teardrop fracture, dorsal fragment and radial styloid stabilization were performed first. Stability of the radiocarpal joint was tested intraoperatively by stressing the joint under image intensification. If the radiocarpal joint was stable and aligned in both planes, repair of the SRL was not performed. Approach to radiocarpal fracture-dislocations incorporating above-mentioned principles is summarized in the flowchart (Fig. 5).

Postoperatively, the wrist was immobilized for 8 weeks for all patients and interval imaging was performed to confirm maintenance of reduction.

Results

Twelve cases of radiocarpal fracture-dislocations were managed over the study period. Mean patient age was 36 ± 20 years, and all were male except one (Table 2). All patients presented with dorsal dislocation of the radiocarpal joint in association with fracture of the radial styloid and were managed with internal fixation based on the injury pattern as described above. (Fig. 1 to 4) Surgical approaches utilized were dorsal in five patients, volar in two patients and combined dorsal and volar in five patients. (Table 2) Six patients had an additional direct lateral or percutaneous approach for styloid stabilization in addition to a dorsal or volar approach but none of them had all three approaches together. We recorded scapholunate interosseous ligament (SLIL) pathology by direct visualization in five cases treated with dorsal approach- only two required repair as they were complete disruption of the dorsal band of the ligament (Table 3). Two cases had proximal ligament disruption and one case had chronic degenerative changes.

Median nerve decompression was performed in six cases for either persistent neurological deficit after closed reduction or if neurological examination could not be reliably performed preoperatively. Two of these cases were Type II fracture-dislocations and two were Type IV fracture-dislocations. Remaining two cases were

Table 1 Different injury patterns of radiocarpal fracture-dislocations and the corresponding surgical approach

Type	Number of patients	Injury pattern	Surgical technique
Type I	2	Small dorsal fragment with large volar teardrop fragment (Fig. 1)	Volar fixation + styloid fixation
Type II	7	Large dorsal fragment with small/absent volar teardrop fragment (Fig. 2)	Dorsal fixation + styloid fixation + SRL repair if unstable
Type III	1	Large dorsal as well as large volar teardrop fragment (Fig. 3)	Combined dorsal and volar fixation
Type IV	2	Small dorsal fragment with small/absent volar teardrop fragment (Fig. 4)	Styloid fixation with SRL repair

All types have radial styloid fracture. SRL, short radiolunate ligament.

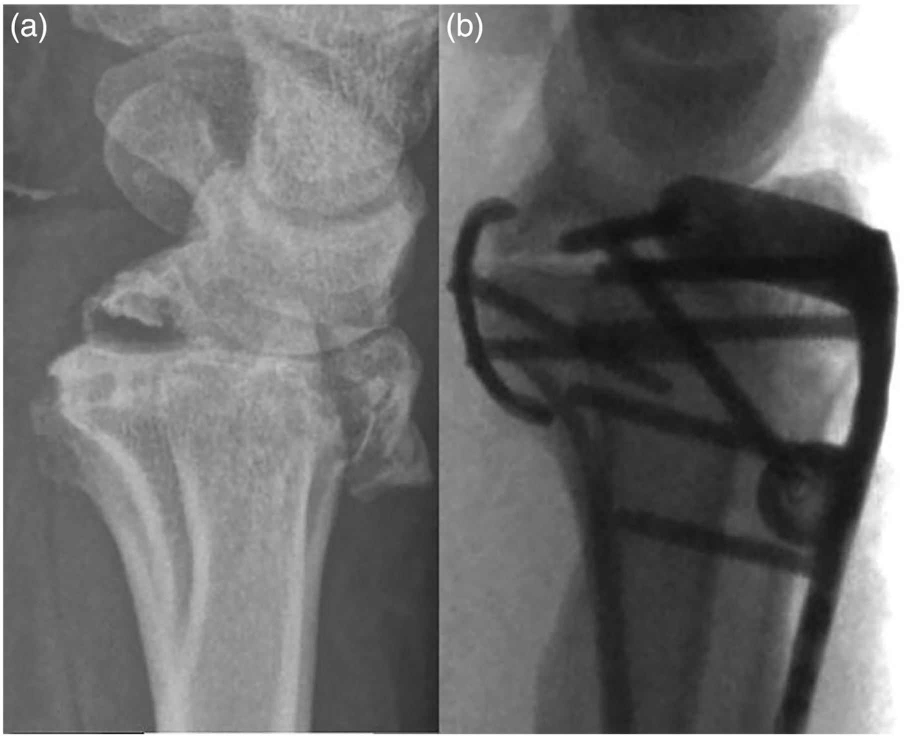

Fig. 3. Type III (a) Lateral radiograph showing the large dorsal fragment, large teardrop volar fragment and the dorsally displaced lunate out of the radiolunate fossa (b) Post fixation per-operative view where both fragments were fixed using combined volar and dorsal approaches. Also note the styloid screw from the dorsal rim plate.

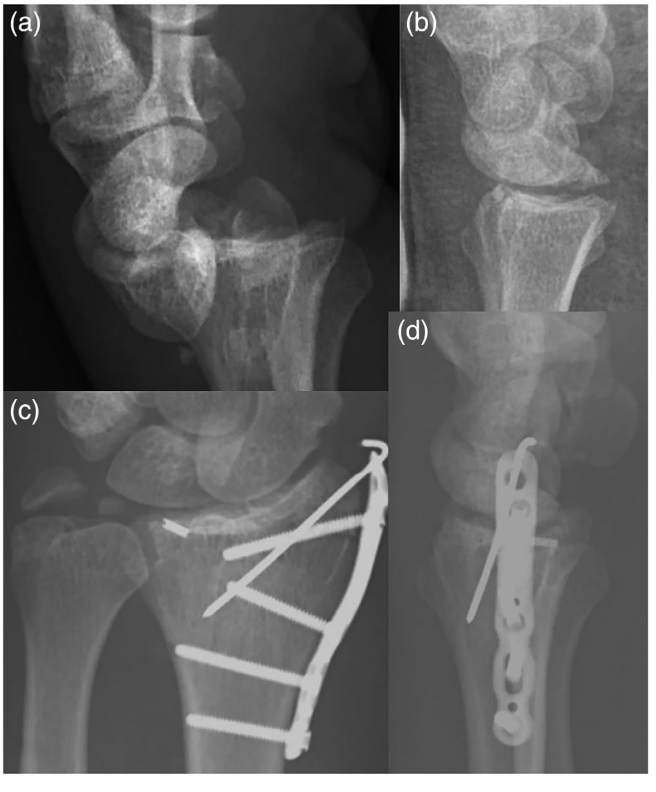

Fig. 4. Type IV (a) dislocated and (b) reduced lateral radiograph views of the wrist joint showing small dorsal and small volar fragment (c) PA view post fixation of the radial styloid fracture using a plate and buried k wire. Note the metal anchor in place ulnarly post repair of the SRL. (d) Lateral view showing the metalware and reduced joint. Approach in this case was volar with separate incision for styloid plate.

Type I and Type III fracture-dislocations where median nerve decompression was performed by extension of the volar ulnar approach into the carpal tunnel. One patient had an unstable distal radio-ulnar joint (DRUJ) after fixation and underwent TFCC (triangular fibrocartilage complex) repair at the index surgery (Table 3).

The mean follow-up was 27 weeks. Only one patient reported moderate pain and all patients under follow-up ($n = 10$) went on to resume their prior occupations and hobbies that included high-demand activities such as mountain biking, motorbike racing and working as a roofer. Range of motion outcomes are depicted in Table 2 with average wrist flexion of 43° and wrist extension of 41° while radial and ulnar deviation were 14° and 18°, respectively. Average forearm pronation was 76° and supination was 64°. The average grip strength of the injured hand was 23 kg compared with 41 kg on the contralateral side (Table 2, Fig. 6). It is not possible to draw relevant conclusions by comparing outcomes of SLIL ($n = 2$) and TFCC repair ($n = 1$) to the rest of the cohort because of small sample size.

Discussion

We propose a radiographic classification of radiocarpal fracture-dislocations in order to guide management. Dorsal radiocarpal dislocations are more common than volar dislocations and all fracture-dislocations were dorsal in nature in this series.[2,3,7,8] The few cases of volar dislocation reported in literature would fall into Type IV of our classification and the principles of management would remain the same.[3,4] (Table 1).

We believe that preoperative assessment of the fracture fragments with post-reduction CT scanning is essential to plan surgical

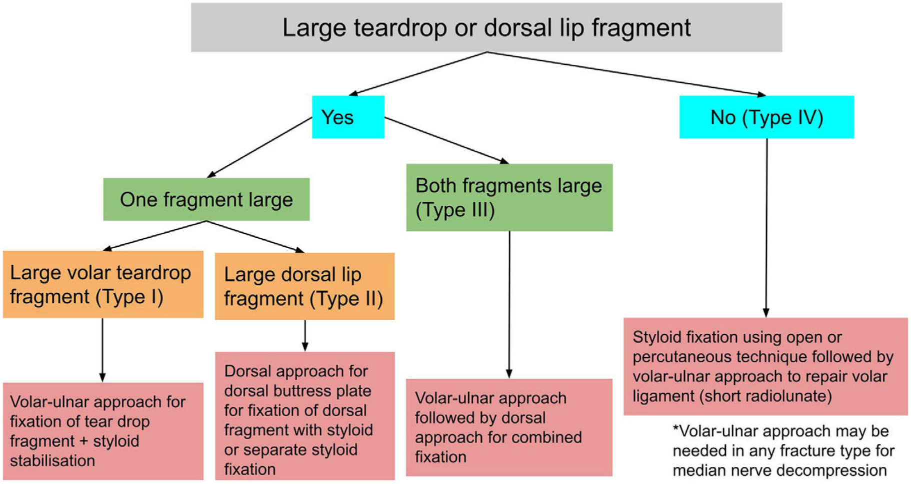

Fig. 5. The injury morphology-based approach to the management of radiocarpal fracture-dislocations.

strategy. Critical steps include fixation of the radial styloid, fixation of the large dorsal rim fragment and fixation of the volar teardrop fragment or SRL repair. Median nerve decompression must be performed in presence of neurological symptoms or if neurological assessment cannot be performed. Functional range of motion with a stable and pain-free joint can be achieved in most cases of radiocarpal fracture-dislocations. On average, a patient can expect to lose 30% to 40% of the total arc of wrist motion following radiocarpal fracture-dislocations.[2,3] Range of motion outcomes are depicted in Table 2 in comparison to reports in literature. Closed reduction alone has been suggested for management of radiocarpal fracture-dislocations without intercarpal injuries. Moneim *et al*. successfully managed one of three patients with closed reduction and casting.[4] In contrast, in our series, utilizing CT scans, anatomical radiocarpal alignment was not achieved in any case and we agree with other reports that these injuries are unstable. Even after achieving reduction in the emergency room, there should be a low threshold for stabilization by internal fixation.[6]

Radiocarpal fracture-dislocations have previously been classified based on the presence of associated intercarpal dissociations.[4] We concur with Dumontier *et al*. that isolated radiocarpal dislocations behave differently and should not be included with intercarpal

Table 2 Cohort characteristics and outcomes – comparison to literature

	This study	Mudgal *et al.*[2]	Dumontier *et al.*[3]
Cohort characteristics			
Total number of cases	12	12	27
Age	36 (24–85) years	33 (19–54) years	32.3 ± 9.8 years
Male:Female	11:1	11:1	20:7
True radiocarpal fracture dislocations	12	NK	23
Dorsal dislocation	12	11	23
Volar dislocation	0	1	4
Pure radiocarpal dislocations (without fracture of the radius)	0	NK	4
Intercarpal injuries	0	2	0
Outcomes			
Follow up	7 months (2–22)	36 months (7–96)	44.3 months (3–135)
Wrist extension	41° (15°–63°) ($n = 10$)	53° (25°–85°)	Gp 1: 54° (40°–80°) Gp 2: 56° (25°–75°)
Wrist flexion	43° (15°-74°) ($n = 10$)	59° (25°–80°)	Gp 1: 54° (40°–80°) Gp 2: 51° (5°–65°)
Pronation	76° (60°–90°) ($n = 9$)	82° (70°–85°)	Gp 1: 76° (60°–90°) Gp 2: 63° (10°–90°)
Supination	64° (30°–90°) ($n = 9$)	74° (40°–85°)	Gp 1: 66° (40°–80°) Gp 2: 76° (50°–80°)
Radial deviation	14° (5°–20°) ($n = 7$)	NK	Gp 1: 15° (10°–20°) Gp 2: 21° (0°–35°)
Ulnar deviation	18° (5°–30°) ($n = 7$)	NK	Gp 1: 18° (10°–25°) Gp 2: 39° (15°–60°)
Ulnar translocation of carpus	5	0	4
Return to work (*n*)	10	8	NK
Complications	Stiffness Radiographic arthritis	4 implant removal 1 ulnar styloid NU 1 SSG to wound	Septic arthritis 1 Arthritis Flexor tendon rupture 1 Persistent dorsal subluxation 1

n, number; NK, not known; NU, non-union, SSG, split skin graft.

Table 3 Cases with carpal tunnel release, ulnar translation of lunate and significant ligamentous injuries

	CTR	Median neuropathy	Symptoms resolved	Ulnar translation of lunate	Others
Case 1	Yes	NK	NAP	No	–
Case 2	No	Yes	Yes (on reduction)	Yes	TFCC repair
Case 3	Yes	Yes	Yes	No	SLIL repair
Case 4	Yes	NK	NAP	No	–
Case 5	Yes	Yes	Yes	Yes	SLIL unrepairable
Case 6	No	No	NAP	Yes	–
Case 7	Yes	NAS	NAP	NK	–
Case 9	Yes	NK	NAP	Yes	–
Case 12	No	No	NAP	Yes	SLIL repair

CTR, carpal tunnel release; NAP, not applicable; NAS, not assessable; NK, not known; SLIL, scapholunate interosseous ligament; TFCC, triangular fibrocartilage complex.

dislocations.[3] Dumontier divided their cases ($n = 27$) in two groups based on styloid fragment size and volar ligament disruption. Group 1 cases had pure ligamentous injuries or with less than one-third of scaphoid fossa (styloid) fracture with avulsion of the volar carpal ligaments from the radial styloid and Group 2 were cases with radial styloid fractures where the ligaments remained attached to the fractured fragment. Their series included two radiocarpal dislocations with no associated fracture and two patients with isolated ulnar styloid fractures in their Group 1. In the series of seven cases reported by Moneim *et al*., one case did not have radial styloid fracture thus qualifying it as a pure dislocation.[4] We have proposed four types of injury patterns based on preoperative CT scans to guide surgical fixation. Pure ligamentous injuries without distal radius fracture are not included in this classification as we consider them a separate entity (Table 1).

We approached our patients with a management algorithm based on injury pattern with a view to fix all fragments where possible and repair the SRL when there was no associated fracture. We did not employ additional fixation with spanning plates or external fixators as all injuries were stable after completion of fixation.[3] Supplemental fixation with a wrist spanning plate or external fixator may be given consideration in dislocations in the absence of fractures in order to protect the soft tissue repair or in the presence of associated injuries of the lower extremity where the patient may be required to bear weight on the injured arm.

In Type II fractures in our series, fixation of the dorsal fragment of the distal radius and radial styloid restored carpal stability hence repair of the SRL was not performed. However, we recommend that the operating surgeon consider repair of the SRL if there is any concern for radiocarpal instability by intraoperative assessment. In our series, all patients maintained radiocarpal alignment and did not require additional surgical procedures. Type IV cases did not have a substantial dorsal fragment that could resist dorsal radiocarpal translation, therefore, repair of the SRL was performed in addition to styloid fixation (Figs. 2 and 4).

We observed asymptomatic radiographic ulnocarpal translation in five of our patients. All five had radial styloid fixation. Two patients had direct SRL repair using bone anchors, one of which had a Type IV injury pattern and the other had a Type II injury pattern (Table 3). The other three cases had Type II injuries with a small/absent volar teardrop fracture and were treated with dorsal plates. These three cases were stable after fracture fixation and repair of SRL was not performed. Dumontier *et al*. suggested that the radioscaphocapitate ligament insufficiency is responsible for ulnar translation of the carpus and injuries with smaller bone fragments have higher chances of radioulnar

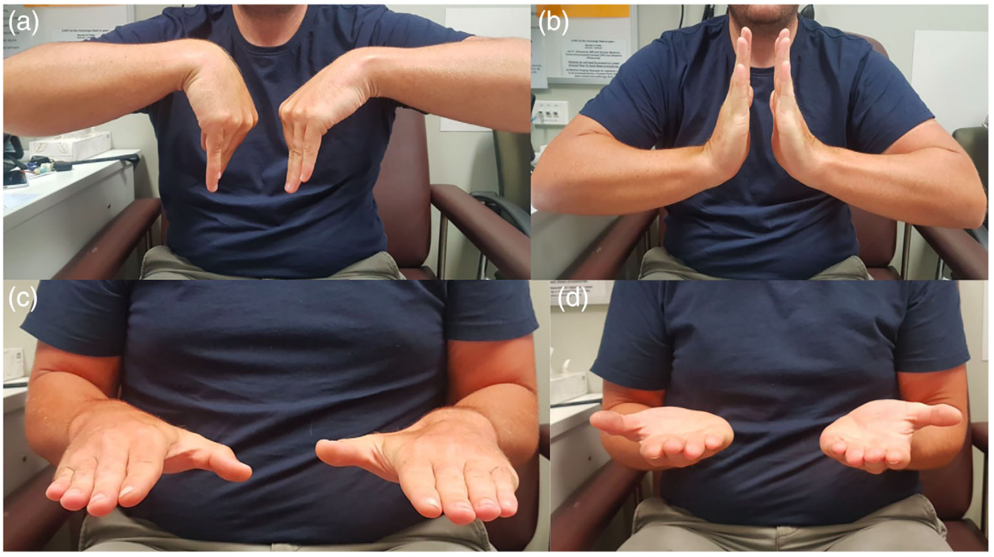

Fig. 6. Good outcome in a patient with left wrist injury (a) wrist flexion (b) wrist extension (c) pronation (d) supination.

instability or ulnar translation.[3,6] We believe that the ulnar translation may be a result of pre-failure stretch of the short and long radiolunate ligaments thereby restoration of normal tension does not occur after repair. Due to the small number of cases, we are unable to determine if there is a correlation between ulnar translation and repair of the SRL, but would recommend that SRL repair be considered in cases of persisting instability after fracture fixation.

Limitations

Limitations of the study are its retrospective nature, small sample size and relatively short follow-up. However, this is an uncommon injury and longer-term follow-up is challenging in this population.

Conclusion

Radiocarpal fracture-dislocations is a distinct and uncommon injury pattern that needs to be recognized and managed differently from radiocarpal shear fractures and carpal dislocations. Careful assessment with post-reduction CT scanning is essential to plan the operative approach. Fragment fixation to address the radial styloid and the volar teardrop fragment of the distal radius or repair of the SRL are the key steps in achieving and maintaining reduction. We propose a classification based on injury patterns that may help guide treatment. Satisfactory outcomes can be achieved with appropriate intervention.

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Author contributions

Rahul Bamal: Formal analysis; investigation; methodology; project administration; resources; validation; visualization; writing – original draft; writing – review and editing. **Randy Bindra:** Conceptualization; data curation; investigation; methodology; project administration; resources; supervision; visualization; writing – review and editing.

Conflict of interest

None declared.

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