Carpometacarpal 4/5 Fracture Dislocations: Fracture Morphology and Surgical Treatment

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Abstract

We conducted a retrospective review of six patients with carpometacarpal (CMC) 4/5 fracture-dislocations managed with ORIF by a single surgeon between October 2006 and August 2017. An open, dorsal approach to the hamate was used with a combination of interfragmentary screw fixation and Kirschner wire reduction in the CMC joints. At a mean of 96 days follow-up (range: 31–265), all patients had recovered wrist motion, excellent grip strength, and complete resolution of pain. There were no complications or reoperations during the postoperative period. Radiographic review showed restoration of anatomy and well-maintained congruity of the CMC joints. Our study has shown favorable outcomes after open reduction and internal fixation of the hamate body fracture with interfragmentary screws, when combined with stabilization of the CMC dislocation with percutaneous Kirschner wires. Fracture morphology does not appear to guide choice for specific hardware (size screw, headed/headless) or use of a washer. This is a level IV, therapeutic study.

Keywords

- carpometacarpal fracture-dislocation
- fracture morphology
- hamate fracture
- surgical technique

Introduction

Hamate fractures represent only 2 to 4% of all carpal fractures, with injuries to the hamate body being the most rare variant.^{1–3} Coexistence with carpometacarpal (CMC) dislocation accounts for less than 1% of all hand trauma.^{1,2,4–6}

A high clinical suspicion and adequate use of radiological tests are required for diagnosing the injury.^{1,7} An early diagnosis is essential to avoid or minimize the risk for fracture malunion, nonunion, posttraumatic arthritis, and chronic pain.^{3,7} Plain radiography is not optimal to evaluate this area of the carpal anatomy, due to the irregular topography, small fracture fragments, and complex articulations. Computed tomography (CT) can be more useful for the diagnosis and for an accurate definition of the fracture pattern.^{1,3,7,8}

The original classification system of CMC 4/5 fracture-dislocations was developed by Cain et al and was based on the orientation of the hamate fracture line.⁹ Advances in diagnostic imaging have allowed for more accurate assessment of injury morphology to the hamatometacarpal complex, which

has resulted in the development of novel classification systems. These new classification systems have focused on more specific features, such as the presence of metacarpal base fractures and the size of the intra-articular hamate fracture fragment.^{2,6,7,10}

Treatment options for fractures of the hamate range from nonoperative immobilization to operative internal fixation with Kirschner wires (K-wires) and/or interfragmentary screws. Displaced hamate fractures, or those with an associated metacarpal fracture and dislocation, are probably better treated with open reduction and internal fixation (ORIF).^{1–6,8,9,11–14}

To date, treatment guidelines have largely been based on individual case reports or small case series without consistent outcome measures.^{1–6,8,10,14,15} We therefore aim to present a series of patients who underwent surgical treatment for this injury by a single surgeon at our institution, to assess the fracture morphology and to describe the surgical technique that was used. Furthermore, we aim to report complications and outcomes after surgical treatment.

Methods

This study was approved by the hospital's institutional review board (# 2017P000694). We conducted a retrospective review of patients at a single institution who underwent surgical treatment for CMC 4/5 fracture-dislocations between October 2006 and August 2017, by a single surgeon. We excluded patients younger than 18 years and those who previously underwent other surgical treatment for their injury. All patients were operated on and followed by the senior author (C.S.M.).

The electronic medical records were reviewed for demographic data including age and sex, as well as clinical information such as date of injury, laterality and dominance of injured hand, mechanism of injury, and additional imaging that was obtained.

CT scans were reviewed on a picture archiving and communication system (AGFA IMPAX version 6.6, Mortsel, Belgium) to assess the fracture morphology. We performed the following measurements using TeraRecon version 4.4 (Foster City, California, United States): length of the distal bone surface of the dorsal hamate fragment (in millimeter), length of the distal bone surface of the palmar hamate fragment to include the hook of the hamate (in millimeter), length of the gap between the fragments at the midpoint in the sagittal plane (in the radioulnar direction) (in millimeter), distance between the fragments in the axial plane (in the dorsal-palmar direction) on the fourth metacarpal side (in millimeter), distance between the fragments in the axial plane (in the dorsal-palmar direction) on the fifth metacarpal side (in millimeter), volume of the dorsal fragment (in square centimeter), and volume of the volar fragment (in square centimeter).

Medical records were reviewed for the surgical technique that was used for fixation. The postoperative course was determined by collecting data on complications, need for subsequent procedures, clinical union, and outcomes in terms of range of motion and pain resolution.

Surgical technique involved exposure of the injury from a dorsal approach. If the hook of hamate was widely displaced, a volar and dorsal approach was used. A dorsal longitudinal incision is made between the bases of the fourth and fifth metacarpals to expose the CMC joint between the extensor tendons. The CMC joint is exposed, and the capsule is entered longitudinally to expose the fracture segments. Fracture-site hematoma is removed, and the hamate is reduced under fluoroscopy. A guidewire for a cannulated screw is placed into the hamate fracture, aiming for the hook of hamate. It is vital that this guidewire is placed incrementally with periodic imaging to avoid cortical penetration volarly, thereby reducing the possibility of endangering the ulnar neurovascular bundle. The screw length is then determined, and a cannulated screw is placed over the guidewire to fix the fracture. In most circumstances, the screw used was a 2.4- or 3-mm headed/headless cannulated screw (Synthes, Paoli, Pennsylvania, United States). An additional interfragmentary screw would be placed into the body of the hamate, if needed for additional stability.

The fourth and fifth metacarpal bases are then reduced to restore the CMC joint under fluoroscopy. Depending on the stability of the affected metacarpals, one or two 0.062-in

Kirschner wires are placed transversely from ulnar to radial along the fifth to fourth metacarpals or alternatively transarticularly into the hamate, if there is concern about hardware purchase in the fourth metacarpal in the presence of its concomitant fracture. The wound is then closed and placed into a forearm-based bivalved splint, with the wrist in 20 degrees of extension and the metacarpophalangeal joints in an intrinsic plus position.

The patient is immobilized in a cast for 4 weeks. Metacarpophalangeal and interphalangeal range of motion (ROM) is initiated at the first postoperative visit, on the fifth postoperative day. The cast and pins are removed at around 4 weeks. The patient is then placed in a volar forearm-based orthoplast resting splint, with the ring and small fingers buddy taped and the splint is weaned over the next 2 to 3 weeks, as strengthening is commenced. Unrestricted use of the hand and contact sports are allowed after 12 weeks.

Results

A total of six patients were identified as having undergone surgical treatment of CMC 4/5 fracture-dislocations using the aforementioned inclusion criteria. All patients were male, with a mean age of 35 years (range: 23–51 years). The dominant hand was most commonly affected ($n = 4$, 67%). Mechanism of injury was either punching ($n = 3$), fall from standing position ($n = 2$), or fall from a height ($n = 1$). Two patients had a prior injury to the affected hand or wrist: one patient had a fracture of the ulnar styloid process and the other had a fracture through the midshaft of the fifth metacarpal bone. None of the patients had any previous surgeries performed on their injured hand or wrist. The average time from injury to presentation at our clinic was 12 days (range: 3–30 days).

Recognition of the true nature of the injury and immediate diagnosis by the radiologist based on initial plain radiographs occurred in only one case (►Fig. 1). CT scans were obtained for further evaluation and preoperative planning in all but one patient ($n = 5$). Five patients had an associated fracture of the fourth metacarpal base, and one patient had a fracture of the capitate. There was dislocation of the fifth CMC joint in four patients, dislocation of the fourth CMC joint in one other patient, and dislocation of both fourth and fifth CMC joints in the remaining patients (►Table 1).

CT scans were reviewed to further assess the hamate fracture morphology (►Table 2; ►Figs. 2 and 3). The average length of the distal bone surface of the dorsal hamate fragment was 5.3 mm, the average length of the distal bone surface of the palmar hamate fragment was 13.7 mm, the average length of the gap between the fragments at the midpoint (in the radioulnar direction) was 8.3 mm, the average distance between the fragments on the fourth metacarpal side was 9.5 mm, the average distance between the fragments on the fifth metacarpal side was 5.3 mm, the average volume of the dorsal fragment was 0.88 cm³, and the average volume of the volar fragment was 1.66 cm³.

Surgery was performed in all six patients, at an average of 18 days after injury (range: 7–33 days; ►Table 1). All patients were immobilized with either a cast or a splint before surgical intervention. Operative treatment consisted

Fig. 1 Initial radiographs. (A) Posteroanterior view. (B) Lateral view of patient 1 (diagnosis of fracture-dislocation underdiagnosed by radiologist). (C) Posteroanterior view. (D) Lateral view of patient 3 (diagnosis of fracture-dislocation made by radiologist).

of ORIF of the hamate fracture with interfragmentary screws and reduction in CMC dislocation with K-wires under fluoroscopy. A dorsal approach was used in five cases; in one case a combined dorsal and volar approach was used. One screw was sufficient for fixation of the hamate in four cases, and two screws were required in the two other cases. Two K-wires were used for stabilization of the CMC joints in three cases, and one wire was used for the same purpose in one case. One patient had articular depression of the hamate, which was elevated, bone-grafted, and fixed with a threaded K-wire cut flush and buried in an intraosseous manner. A washer was placed in two cases. In one case, a concomitant ulnar nerve release in Guyon's canal was performed because this patient had developed a posttraumatic ulnar neuropathy of the hand in the setting of a delayed presentation. Intra-operative assessment showed stable CMC joints and stable reduction in the hamate fracture in all cases. Patients were placed in a short-arm splint after final radiographic confirmation (► Fig. 4). The K-wires were removed after an average of 33 days (range: 24–39 days).

Mean follow-up was 96 days (range: 31–265 days). There were no complications or reoperations during the postoperative period. At the time of last follow-up, all six patients had good functional outcomes with full wrist flexion and extension, no distal deficit, no malrotation, excellent grip strength, and complete resolution of pain. Review of final radiographic images showed restoration of anatomy and well-maintained congruity of the CMC joints (► Fig. 5).

Table 1 Injury and surgical characteristics

Patient	MC fracture	CMC dislocation	Time injury to surgery (in days)	Approach	Articular depression hamate	Number of screws	Type screws	No. of K-wires	No. of washers	Concomitant procedure
1	4th MC base	CMC 5	14	Dorsal	No	1	Headless, cannulated screw (3 mm)	1 (base 5th MC across hamate into capitate)	0	None
2	4th MC base	CMC 5	33	Dorsal + volar	No	2	Headed screw, short threaded × 2 (3 and 2.4 mm)	2 (5th MC to 4th MC)	1	Ulnar nerve release at Guyon's canal
3	4th MC base	CMC 4	7	Dorsal	Yes	1	Headed, cannulated screw (3 mm)	1 (threaded K-wire to treat articular depression hamate)	1	None
4	None	CMC 4 + 5	12	Dorsal	No	1	Headed screw, fully threaded (2.4 mm)	2 (base 5th MC across hamate into capitate)	0	None
5	4th MC base	CMC 5	20	Dorsal	No	2	Headed, cannulated screw × 2 (3 mm)	1 (5th MC to 4th MC)	1	None
6	4th MC base	CMC 5	24	Dorsal	No	1	Headless, cannulated screw (3 mm)	2 (5th MC to 4th MC and base 5th MC into hamate)	0	None

Abbreviations: CMC, carpometacarpal; K-wires, Kirschner wires; MC, metacarpal.

Table 2 Fracture morphology

Patient	Length of distal bone surface of dorsal hamate fragment (in mm)	Length of distal bone surface of palmar hamate fragment (in mm)	Length of gap between fragments at midpoint (in mm)	Distance between fragments on 4th metacarpal side (in mm)	Distance between fragments on 5th metacarpal side (in mm)	Volume of dorsal fragment (in cm ³)	Volume of volar fragment (in cm ²)
1	5.1	13.8	6.6	7.5	4.6	0.55	2.42
2	7.5	11.7	9.4	11.1	5.5	1.73	0.91
3	3.4	14.0	8.1	8.9	5.9	0.28	2.07
4 ^a	–	–	–	–	–	–	–
5	4.2	14.7	6.8	7.8	4.6	0.82	1.20
6	6.1	14.4	10.4	12.0	5.9	1.01	1.69

^aNo CT available.

Fig. 2 Fracture morphology of patient 5. (A) Length of distal bone surface of dorsal hamate fragment (solid arrow) and length of the distal bone surface of the palmar hamate fragment including the hook (open arrow). (B) Length of gap between fragments at the midpoint (in the radioulnar direction). (C) Distance between fragments on fourth metacarpal side (solid arrow) and distance between fragments on fifth metacarpal side (open arrow).

Fig. 3 Fracture morphology of patient 5. (A) Volume of the dorsal fragment. (B) Volume of the volar fragment.

Fig. 4 Immediate postoperative radiographs. (A) Posteroanterior view. (B) Lateral view. Radiographs of patient 1 show K-wire fixation of the base of the fifth metacarpal across the hamate into the capitate, in addition to headless screw fixation of the hamate fracture. (C) Posteroanterior view. (D) Lateral view. Radiographs of patient 3 show K-wire fixation after elevating the articular depression of the hamate, in addition to headed screw fixation of the hamate fracture.

Discussion

The rarity of hamate body fractures with CMC dislocations as well as the difficulty in diagnosing them on plain radiographs supports that they are likely underdiagnosed.⁷ Inadequately treated hamate body fractures with CMC dislocations can result in nonunion and resultant disability.^{16,17} Similar to most displaced articular fractures in other locations, appropriate

Fig. 5 Radiographs at last follow-up. (A) Posteroanterior view. (B) Lateral view. Radiographs of patient 1 show restoration of anatomy and well-maintained congruity of the carpometacarpal (CMC) joints at 52 days postoperatively. Kirschner wire was removed on day 24 postoperatively. (C) Posteroanterior view. (D) Lateral view. Radiographs of patient 3 show restoration of anatomy and well-maintained congruity of the CMC joints at 265 days postoperatively.

diagnosis and ORIF of the hamate body fractures involving the CMC articular surface are important to achieve optimal outcomes from this injury. In our series, we present our experience with this injury pattern, including the clinical presentation, radiographic analysis, surgical technique, and clinical outcomes in six patients. With our technique, good results have been achieved as has been noted by other authors.^{5,18–20}

A high index of suspicion is necessary when assessing patients on initial presentation. In our series, five of the six patients were underdiagnosed on initial plain imaging read by an attending radiologist. CT imaging ultimately confirmed the diagnosis in the remaining patients. In a review of imaging of cadaver hands with hamate fractures, radiographs were noted to be 72.2% sensitive and 88.8% specific and CT scans were 100% sensitive and 94.4% specific.²¹ Other authors have reviewed this injury and noted improved sensitivity and specificity on plain films by measuring an increased index to small metacarpal angle of the CMC joint on lateral radiographs.²² With displacement of a hamate body fracture, associated posterior dislocation of the ulnar-sided CMC joints has been noted in a previous report on radiographs.²³

The mechanism of injury is thought to occur from axial loading of the ulnar-sided metacarpals transmitting force across the carpus through the hamate.^{7,9,24}

In an effort to better understand the morphology of this fracture pattern, we have reviewed the available CT scans in our series and measured the fracture segments in multiple

planes. In our series, the fracture preferentially occurred ulnar to the hook of the hamate. Van Schil et al have also reported a fracture ulnar to the hook of the hamate in their case report.²⁵ This suggests that the fifth metacarpal impaction may provide a more central dislocating force than the fourth metacarpal. Most commonly, the palmar segment was considerably larger than the dorsal segment as well. Knowledge of the fracture morphology may have implications in the technique of internal fixation. On the basis of our study, we feel that obtaining fixation into the hook of the hamate may not be critical to stable fixation or ultimate outcome. While headless screws were used in the two oldest cases, more recently our practice has changed toward the use of headed screws as the amount of bone that can be covered by headed screws is greater. Although the use of a headless screw appears to be independent of fragment size, we speculate that headless screws are best utilized when the dorsal fragment is thick enough to accommodate all the trailing threads of the headless screw. Furthermore, a washer was placed in three cases. Fragment size did not dictate the use of a washer either. The use of a washer appears to be more arbitrary and based on surgeon preference after intraoperative assessment of dorsal fragment thickness as well as size. In the presence of a thinner dorsal fragment, the use of a washer may seem prudent to help dissipate the compressive forces over a larger area of the fragment, thereby reducing the possibility of fragment comminution and loss of fixation. Threaded K-wires can be used for extremely small fragments or articular fragments. These can be cut flush with the surface of the bone and appear to provide adequate stability, without the concern for migration. Multiple classification schemes have been reported in the literature. Milch initially differentiated fractures of the hamate into those affecting the hook and body.²⁶ Additional classification schemes have further subdivided hamate body fractures. Cain's review of 17 patients differentiated a progressive pattern of worsening hamate/CMC joint injuries from isolated CMC dislocations (type IA) to type III with a coronal plane fracture splitting the hamate and CMC dislocation.⁹ Ebraheim et al further categorized coronal-plane fractures into a central (type A), oblique (type B), and dorsal (type C) pattern along with CMC dislocation.²⁷ The relative incidence of these types of patterns is currently unknown.

For operative technique, we used an open, dorsal approach to the hamate with a combination of interfragmentary screw fixation and K-wire reduction in the CMC joints. Multiple reports in the literature exist including closed reduction and percutaneous pinning^{13,18} to ORIF with K-wires,^{5,9,11,19,28,29} screws,^{2,5,24,30} and plates.^{11,31} The heterogeneity between different studies highlights the variation seen clinically, and it remains unclear whether different injury patterns are best treated differently.^{12,15}

At mean follow-up of 96 days, all patients achieved clinical and radiographic healing of the injury. At final clinic follow-up, all patients were noted to have no pain, full wrist motion, composite digital flexion, and normal rotation of the digits. We experienced no complications or reoperations in our series. Our findings are similar to others. Hirano and

Inoue reported on five cases, and all achieved bony union. Three out of five of their patients reached full range of motion of the wrist and fingers and full grip strength. Two patients had ulnar nerve palsies and reduced grip strength.¹⁸ More recently, Wharton et al reviewed their experience with the operative management of nine patients treated with a variety of approaches.⁵ At an average follow-up of 14.8 months, six out of eight patients had excellent Disabilities of Arm, Shoulder, and Hand (DASH) scores. Delays in diagnosis have been associated with worse outcomes in other studies.^{16,17}

Hamate body fractures represent a spectrum of morphologies that can involve the fourth and fifth CMC joints. Terminology in the literature aims to be descriptive but can vary widely between reports. A review of the literature reflects multiple names for a similar pattern of injury: coronal hamate fracture,^{5,28,32} hamate body fracture,^{7,19,25,29} divergent fracture-dislocation of the hamatometacarpal joint,^{9,24} hamate fracture,^{30,33} intraosseous fifth CMC dislocation,² CMC fracture-dislocation,²² and dorsal hamate fracture.²³ We believe that a coronal hamate fracture with CMC dislocation is a specific injury pattern and would benefit from a uniform terminology.

This study has several weaknesses, including the retrospective data collection, observer bias, small patient number, and short duration of follow-up. However, we feel that our mean follow-up time of 96 days was sufficient to assess radiographic union and clinical range of motion. Because all the surgical procedures were performed by a single surgeon, there is a consistency of surgical technique, implant usage as well as surgical decision making and postoperative rehabilitation. This could be considered strength of our study. Inclusion of standard outcome measurements and longer-term follow up would improve reporting in the future.

In summary, our study has shown favorable outcomes after ORIF of the hamate body fracture with interfragmentary screws, when combined with stabilization of the CMC dislocation with percutaneous K-wires. Fracture morphology does not appear to guide choice for specific hardware (size screw, headed/headless) or use of a washer. However, CT scans should be routinely considered and also possibly routinely acquired for surgical approach planning, to rule out other injuries and to assess for articular depression of the hamate. Further studies should be considered if fracture fixation of the hamate near the fifth metacarpal and ulnar to the hook of hamate is sufficient for clinical union and stability.

Ethical Approval

The institutional review board of our institution approved this study under protocol #2017P000694.

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None.

Conflict of Interest

None declared.

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