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REVIEW

Fractures of hamate: a clinical overview

G. Mouzopoulos[1] · C. Vlachos[1] · L. Karantzalis[1] · K. Vlachos[1]

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Abstract
Hamate fractures are exceedingly rare clinical entities. However, the diagnosis and treatment of these injuries are often delayed and can severely handicap the performance of affected laborers or athletes. This review focuses on fractures of the hamate and provides an update on the current consensus as to mechanism, diagnosis, management, and complications after such injuries.

Keywords Hamate · Hook · Fracture

Epidemiology

Fractures of the hamate usually occur through the hook or body of the bone [1]. Type I fractures involve the hook of the hamate and further are subdivided into three subtypes involving: base, waist, and avulsion (tip). Fractures located at the base and proximal third (76%) of the hook are presented more frequently than fractures located at the mid-third (13%) or the distal third (11%). Type II fractures involve the body of the hamate [2]. Fractures in the sagittal plane of the body can be subdivided into those occurring on the radial and those occurring on the ulnar side of the hook [3, 4]. Fractures occurring in the coronal plane have also been reported [5].

Mechanisms of injury

Apparently, no severe trauma is necessary to fracture the hamate bone [4]. Direct blow to the palm due to a single hit or repeated impact of the end of the sport devices, particularly baseball bats, rackets, and golf clubs with the hypothenar volar prominence of the hamate bone on the ulnar side of the wrist, usually as a result of inappropriate positioning of the sports equipment [6]. Tennis and racquetball players grasp the handle so that the butt of the racquet rests against the hook of the hamate [2]. If the grip is relaxed or control is lost, the fracture occurs at the end of a poor swing, as centrifugal force is transmitted through the handle of the racquet against the hook [7]. In golfers or baseball players, a dubbed shot or a checked swing will fracture the hamulus because the butt of the club or bat will strike the hook. It has also been described in polo and ice hockey [8].

Fall on an outstretched hand causing sudden forcible dorsiflexion of the wrist, which is associated with severe muscular contraction of the hypothenar intrinsic muscles or the extrinsic flexor tendons of the ring and little fingers, anchored to the hook or by stress upon the pisohamate ligament [4]. The former usually fractures the base of the hook; the latter produces an avulsion of the tip of the hook [3].

Besides, a direct blow to the pisiform bone may produce sudden tension on the pisohamate ligament and avulse the hook from the hamate [7]. Avulsion fractures of the hamate may be associated with pisiform fractures [8].

Fractures of the body occur mostly in young and active individuals following punch injuries [6]. Medial tuberosity fracture is postulated to be the result of a direct blow over the ulnar border of the wrist [1]. Most commonly, these fractures occur with a punch-press injury or dorsopalmar compression of the wrist between heavy weights [9]. Body fractures can also result from severe wrist fracture dislocation, direct blow to the ulnar hand, anteroposterior crush injury, or transcarpal carpal metacarpal dislocations, resulting in dorsal coronal fracture with posterior subluxation of the fourth and fifth metacarpal bones [10].

✉ G. Mouzopoulos
gmouzopoulos@yahoo.gr

[1] Orthopaedic Department of Sparti General Hospital, 23100 Sparti Lakonia, Greece

Clinical signs

The index of suspicion for hook of the hamate injuries should be high in any patient who sustains an injury to the ulnar side of the wrist while using a racquet, bat, or club [4]. Patients usually do not seek medical attention when the acute injury occurs [9]. Clinical diagnosis is often delayed. In a review of a recent large series of hook of the hamate fractures, there was an average 23-week interval from injury to diagnosis [11]. The first visit to the orthopedic surgeon is generally after persistent pain on the ulnar side of the wrist which results in chronic pain, associated with weakness of grasp, or after a second minor injury, which aggravates the initial complaints in case of stress fracture [4].

In the case of a hamate body fracture, patients may present immediately. Fractures involving the body of the hamate are typically associated with high-energy, direct-force trauma, or crushing injuries [6]. External evidence of these forces is obvious in these individuals.

Clinical signs suspicious for a hamate hook or hamate body fracture are listed at Table 1. In the presence of a fracture of the hamate hook, firm pressure is required to elicit pain through the thick soft tissue coverings on the volar ulnar aspect of the wrist, approximately 1.5–2 cm distally and radially to pisiform, along a line extending from the pisiform to the third metacarpal head [12]. However, direct pressure on the thinly covered dorsolateral aspect of the wrist is more painful, especially if the fracture is at the base of the hook [13]. But it is not uncommon for tenderness to be absent in a long-standing injury [14]. Tenderness over the pisiform is secondary to traction forces transmitted through the pisohamate ligament [12].

Some patients with a silent fracture are presented with pain elicited by resisted small and ring finger flexion, positioning the wrist in ulnar deviation (pull test), secondary to tenosynovitis or motion at the fracture site [15]. Rarely, the first symptoms of hook fractures include dysesthesias or dysfunction of the median or ulnar nerve and rupture of tendon flexors [16].

Usually, nonunions of the hook of the hamate manifest as unresolved pain in the hypothenar eminence, aggravated by gripping and contraresisted flexion of the fourth/fifth finger or inability to flex the ulnar two fingers due to tendon rupture [17]. Also abduction or adduction of the little finger against resistance is uncomfortable [13]. Voluntary wrist and finger motions are usually painless [14]. Pressure usually over the dorsoulnar aspect of the wrist causes tenderness [12].

Radiographic findings

Radiographic evaluation of hamate fractures includes the conventional or special wrist views and CT scan [4].

On the posterior–anterior view, the hook of hamate is seen en face super-imposed over the body of hamate and demonstrates a cortical ring shadow known as the "eye sign" or ring sign (Fig. 1). In the posterior–anterior projection, a disruption of the so-called ring sign is a common finding in hamate hook fractures [5]. Besides, Norman et al. [18] described three diagnostic features that were seen on routine posterior–anterior views of the wrist. In order of importance and frequency, these findings are: absence of the hook of the hamate, sclerosis of the hook of the hamate, and loss of cortical density at the base of the hook.

The absence of the hook signifies a fracture at the base of the uncinate process generally with a 5–10° tilt of the fragment, often toward the ulnar side [19]. The displacement of the hook explains the disappearance or the disruption of the ring sign on the posterior–anterior view [8]. A dense hook is secondary to sclerosis at the nonunion site [18]. The lack of a clear outline is a result of minimal displacement of the fragment when the fracture is away from the base of the hook [20]. The short proximal segment remains attached to the body of the hamate, and a faint ring-like density is recognized on the posterior–anterior film [5].

Table 1 Clinical signs of hamate fractures

Fractures of hook of hamate	Fractures of body of hamate
Volar ulnar wrist pain aggravated or elicited by grasp (most common symptom), ulnar deviation and dorsal flexion of the wrist, flexion and abduction or adduction of the little and ring finger against resistance	Dorsal ulnar wrist pain aggravated or elicited by grasp, ulnar deviation and dorsal flexion of the wrist
Weakened grip strength	Weakened grip strength
Swelling of the soft tissue and bruising over the hypothenar area	Marked tenderness and swelling on the dorsal ulnar side of the carpus
Point tenderness over the ulnar aspect of the palm, the dorsal aspect of the fourth and fifth carpometacarpal joints, the pisiform or over the canal of Guyon is present	Limited active motion of ring and little finger
	Fracture or dislocation of the fourth/fifth metacarpal bone with prominence of the base of the metacarpal bone

Fig. 1 The ring sign seen normally on posterior–anterior X-ray

The fracture line is rarely seen on a routine frontal view of the wrist [5]. As a rule, these radiographs are reported to be normal [3]. Scheufler reported that the posterior–anterior projection was false negative in 42.8% and the lateral projection in 92.9% of the patients sustained hamate hook fractures [19]. Also in the same study, the ring sign was evidenced only in eight of 14 patients (57.1%) and the other two criteria were absent in 42.8% of cases [19]. In other cases, projection of the anterior margin of the capitate on the base of the hook may be misdiagnosed as a fracture [8]. A considerable number of clinicians have found routine wrist radiographs to be unreliable in diagnosing an acute fracture of the hamate [3]. As a matter of fact, conventional radiographs are 72% sensitive and 88% specific in detecting hamate fractures [21].

Under these circumstances, in order to confirm or improve visualization of the hook fracture, the carpal tunnel view is commonly used [20]. This view requires that the flexor surface of the patient's forearm be placed on the film cassette [22]. The fingers and wrist are maximally dorsiflexed [14]. The patient may use his other hand or some other appropriate device to hold his wrist in this extended position (Fig. 2). The X-ray tube should be parallel and slightly anterior to the third metacarpal [20]. The exact angle varies from patient to patient, ranged between 20 and 30° [14]. This view demonstrates the hook of hamate [23]. Ulnar deviation is avoided because it may cause the hook and pisiform bone to overlap [20]. However, optimal images may not demonstrate fractures at the base of the hamate hook [14].The carpal tunnel

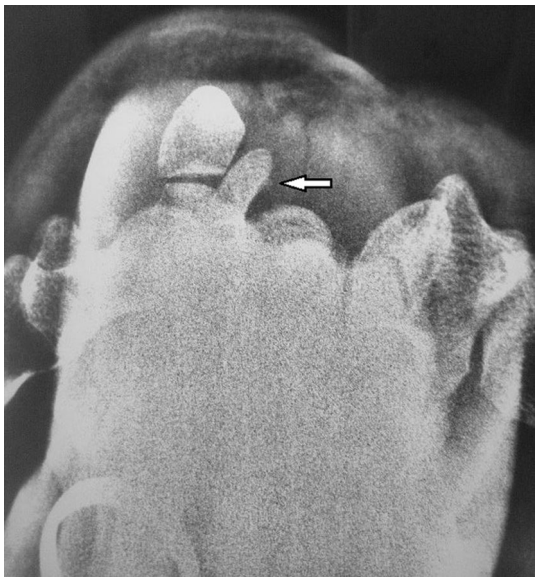

Fig. 2 The carpal tunnel view demonstrates the hook of hamate

view cannot always be obtained in the acute phase of injury because it requires hyperextension of the wrist, which can be limited by pain and swelling [23]. So image quality may be suboptimal, and in certain instances images may even be impossible to obtain [24]. In these cases, the semisupine oblique radially deviated view can be beneficial because it is performed without pain [20].

This last view is obtained with the wrist maximally radially deviated [18].The patient is instructed to maximally extend and abduct his thumb, to maximally widen the web space between the index finger and thumb (Fig. 3). The beam is centered on the web space between the thumb and the index finger [21].By positioning the hand in this way, the hook of the hamate is made to lie in the center of the

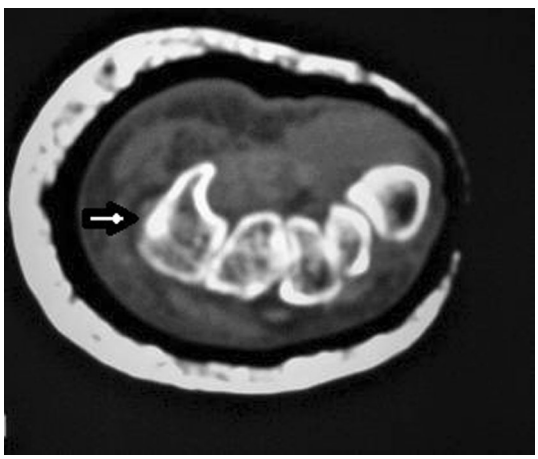

Fig. 3 The oblique radially deviated wrist and thumb abducted view showing the hamate

beam and away from the base of the metacarpal of the thumb [18].This view provides optimal visualization of the hook of the hamate, but accurate positioning of the wrist is crucial because rotation of the wrist by a few degrees can project the hamate behind the carpal arch [25].Repeated views are therefore recommended before the final films are taken to ensure a perfect position [20].

CT scan is the radiographic technique of choice in the diagnosis of hook of the hamate fractures (Fig. 4). Axial 2 mm cuts through the wrist are obtained with the hands in the prayer position [3]. This axis is parallel to the long axis of the hook of the hamate and demonstrates the fracture and its displacement clearly [21]. The use of the prayer position allows comparison between the two wrists [4]. Simultaneous imaging of the contralateral wrist for comparison may help exclude congenital variations of the hamate, which tend to be bilateral, such as the os hamuli propnium, a secondary center of ossification for the hook that unites with the hamate during childhood [25].

MRI scans have high sensitivity in showing avascular necrosis of the hamate hook. An altered signal caused by marrow edema is seen in the presence of a fracture [4]. This study can be performed instead of CT scanning if the patient lacks neurologic and/or vascular competency in order to better view soft tissue structures [22].

On the other hand, fractures of the hamate body are more easily demonstrated on plain routine radiographs, than the fractures of the hook [5]. Particular meaning deserves the dorsal fractures of the hamate body to be mentioned [1]. The main radiological characteristics of the dorsal fracture of the hamate include a 5- to 10-mm oblong fragment of bone, the bone fragment projects immediately over the dorsal surface of the hamate, the fragment is most visible on the pronation oblique and/or lateral projections and is not seen on the posteroanterior projections, the source of the bone fragment is not clearly seen on the radiographs in most instances. However, it is too proximal to be a fracture of a metacarpal, and too distal and too large to be an avulsion of the triquetrum [19].

Finally, the most specific exploration of hamate body fractures is CT scan which provides the most information on the position of the fragment, and its possible displacement and the amount of articular surface were involved [3].

Fig. 4 CT scan demonstrates clearly the hamate

Differential diagnosis

Patients sustained hamate fractures are often misdiagnosed [1]. Usually, TFCC tear and ulnar flexor carpi tendinitis consist of the initial wrong diagnosis instead of the hamate fracture [2].

Disappearance of the hook of the hamate, on the PA projection, due to congenital absence, hypoplasia, surgical resection of the hook, or erosion by amyloid tumor of the carpal tunnel, can mimic a fracture of the hook of hamate [18].

Bipartite hamate (os hamuli proprium) which is thought to be the result of fibrocartilaginous union between the body and hook of the hamate typically causes symptoms on the ulnar side of the wrist and may be difficult to differentiate from avulsion fractures of the hamate hook [25].

As a matter of fact, the hook arises from a separate center of ossification that should unite with the body during the second half of childhood (more than 15 years old) [18]. If it fails to unite, the hook is not seen on the PA view [20]. Features of hamate bipartite according to Pierre-Jerome and Roug include: bilaterally similar bipartite hamulus, no sign or history of traumatic wrist injury or edema or soft tissue changes suggestive of un-united fracture, equal size and uniform signal intensity on MRI evaluation of each part, absence of progressive degenerative changes between the two components of the hamate or elsewhere in the wrist smooth, well corticated and rounded margins of the hamate and un-united hook [26]. Besides, acute fracture margins lack cortication [21].

Occasionally, longitudinal sprain between trapezoid and capitate or capitate and hamate gives rise to ill-defined pain in ulnar aspect of the wrist [4].

Therapy

Whalen et al. [27] supported that acute nondisplaced fractures of the hook of the hamate treated within 7 days of the injury usually respond to 6 weeks of support in a short arm plaster cast or splint, involving the fourth and fifth fingers, with restricted use of these fingers. They reported six patients with acute and two patients with subacute nondisplaced fractures of the hamate hook who were treated with immobilization. The patients with acute fractures were treated within 7 days of the injury, and those with subacute fractures were treated after 7 days. Seven of the eight patients showed documented healing of their fractures.

Similarly, Carroll and Lakin [28] determined that if hook fractures are identified acutely within 2 weeks of occurrence, plaster immobilization for 4–6 weeks can result in painless union. Since 76% of the hook fractures are located at the base and proximal third of the hook, a region which is evaluated with difficulty even though after carpal tunnel view, representing a fracture which is usually associated with impaired blood supply, only 19.4% of all hook fractures are diagnosed early and the 30–32% of them are displaced; therefore, many clinicians believe that nonunion is the rule after fracture of the hamate hook. However, movement of the fingers or thumb during lower arm cast immobilization may impair bony union because of shearing forces of the flexor tendons [29]. Retrospective analyses have demonstrated nonunion rates greater than 50% and as high as 80–90% with conservative treatment [27, 28]. So surgical treatment is an alternative therapy option which is advocated as the treatment of choice for all types of hamate hook fractures, especially because offers pain relief and complete recovery. Sports players are usually able to return to sports activities within 3 months of the surgery [30].

Two types of surgery are commonly performed for hamate hook fractures [17]. One involves excision of the hook itself. The other is an open reduction and internal fixation (ORIF) procedure. The indications of surgical treatment are listed at Table 2.

Stark et al. [31] proposed that a fractured hook of the hamate, whether it is acute, chronic, or even considered partially united, should be removed and they reported that this treatment reliably eliminates the symptoms and lessens the likelihood of subsequent rupture of nearby flexor tendons. In their study, three acute fractures failed to heal after conservative treatment and the fragment was excised. Scheufler et al. [32] performed conservative therapy in six patients with acute fracture, and finally, a delayed consolidation of the fracture with persisting clinical symptoms was found in five of them. Similarly, Egawa and Asai [33] reported six cases with acute hamate hook fracture.

Table 2 Indications of surgical treatment of hamate hook fracture

Displaced fracture
Delayed diagnosis
Painful or painless nonunion
Painful partial nonunion
Ulnar or median nerve or ulnar artery compression
Tendon rupture
Metacarpal subluxation
Patients who are unable to keep the affected wrist immobilized
Late or recurrent cases

Immobilization in plaster cast was beneficial in one patient, and the other five patients required removal of the fractured fragment. But none of the above authors mentioned if these fractures were displaced or not. Besides, the definition of a displaced hook fracture is not available in the literature. Probably, the high failure rates of the conservative treatment could be attributed to the absence of significant criteria of displacement seen in radiographic evaluation of these fractures in the previous studies [27, 28, 32, 33].

Although fragment excision is mentioned as a treatment of choice by most surgeons, but it impairs flexor tendon function and power grip [34]. On the other hand, open reduction and internal fixation is associated with perfect anatomical reduction, giving the opportunity to the hook to serve as a pulley of the flexor tendons of the small and ring fingers [19]. But open reduction and internal fixation of the hook is associated with documented bony union only in 2/3 of patients, whereas the rest of 1/3 of cases is resulted to nonunion [24].

However, the clinical results after open reduction, particularly concerning pain relief, are comparable to the results after hook excision [31]. Generally, open reduction and internal fixation is advocated for acute displaced fractures in patients who can tolerate a possible reduction in grip strength and hook excision is the treatment of choice for delayed fracture or nonunion [30].

Excision of the hook is performed through a curvilinear, volar incision [34]. Care is taken to prevent damage to the motor branch of the ulnar nerve. The flexor tendons are inspected for damage. The hook is excised with a sharp osteotome. After the fragment is excised, the ligament attachments to the tip of the hook are repaired. Then, the hand is immobilized in a short arm cast for 3 weeks.

In nonunion of the fracture, bone grafting using a corticocancellous peg inserted through the hook is a choice of treatment. Management of the painless nonunion remains controversial [31]. Some authors advocate removing the united fragment [17, 31]. It is mentioned that excision

should be reserved for the development of pain, neurologic deficit, or fraying tendinitis of the flexor tendons [5, 34].

With median or ulnar nerve symptoms exploration is indicated to relieve any possible compression in carpal tunnel or Guyon canal [19]. Fractures of the body of the hamate bone without any displacement can be treated by casting for 6 weeks, and usually good healing occurs [27]. With any displacement however, open reduction and internal fixation is usually necessary [34]. In cases of associated metacarpal subluxation, the treatment is consisted of closed reduction, cutaneous Kirschner wire fixation is performed from the fifth to the fourth metacarpal, and a dorsal plaster slab is applied [35]. Pathologic fractures due to cyst formation in the hamate may also occur [4]. These types of fractures are treated best with bone packing, using tissue from the iliac crest, and external fixation. In addition, there has been one case report that described avascular necrosis occurring in the hamate hook [36].

Physical therapy

Conservative treatment requires immobilization with casting for 6 weeks, followed by an additional 4–6 weeks of physical therapy [27]. If the injury is treated with hook excision, the patient can start physical therapy immediately, without limitations, and can return to full activity within 6–8 weeks [30]. If the injury is treated surgically with open reduction, the patient requires casting for 2–3 weeks, followed by an additional 4 weeks of physical therapy without placing strain on the affected wrist, before progressing to full activity in 6–8 weeks [33, 34].

Complications

The common complications encountered after hamate fracture are listed at Table 3.

Table 3 Complications of hamate fractures

Rupture of the flexor tendons of the little and ring fingers
Sensory or motor deficit of the ulnar nerve
Ulnar artery compression
Mild carpal tunnel syndrome
Fracture nonunion
Fracture partial nonunion
Osteonecrosis of the distal hook or distal pole of body fragment
Arthritis/instability of fourth/fifth metacarpals
Tear of palmar carpal ligament, flexor retinaculum, pisohamate ligament,
Palmar carpometacarpal ligament, dorsal carpometacarpal ligament
Chronic hypothenar pain
New bone formation after subperiosteal hook excision

Return to play

Return to full activity is dependent on the initial fracture treatment. Typically, if treated conservatively, simple fractures of the hamate are healed within 6–8 weeks of injury [28]. Patient participation in full-contact sports, such as football, usually requires bracing or protection for the wrist until full musculature and flexibility have returned [30]. This improvement should be achieved within 12 weeks with a diligent physical therapy program [17].

In contrast, if the injury is treated surgically with either ORIF or excision, return to play occurs much sooner [17, 32]. Although no evidence-based guidelines have been developed, the general consensus is that return to play takes 6–8 weeks after either surgery, but this is very individualized and often depends on the level of the athlete [17].

Prevention

Having good strength and flexibility of both the wrist flexors and extensors can aid in the prevention of some wrist injuries [2]. If participating in sports activities in which diving or falling is not an uncommon occurrence (e.g., rollerblading, skiing, ice skating), a protective wrist guard may be recommended to prevent injury to the wrist and hand [7]. Athletes who golf may have increased risk for fracturing the hook of the hamate secondary to repetitive wrist extension [10]. One good method of prevention in this population is to ensure that a proper length of club is always used [8].

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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