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Hook of the Hamate: The Spectrum of Often Missed Pathologic Findings

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Abstract

OBJECTIVE—The purposes of this article are to review hook of the hamate anatomy, describe the imaging features of the spectrum of pathologic conditions, and discuss the pearls and pitfalls of imaging for clinical decision making for pathologic entities affecting the hook of the hamate.

CONCLUSION—Knowledge of the anatomy, imaging appearance, and clinical management of hook of the hamate abnormalities is important for radiologists in guiding the care of patients with ulnar-sided wrist symptoms.

Keywords

bipartite; coalition; delay in diagnosis; fracture; hamate; hook of the hamate; wrist

Pathologic conditions affecting the hook of the hamate are uncommon. Fractures are the most common abnormality but account for less than 4% of carpal fractures [1, 2]. Despite its continued importance as a key anatomic landmark in modern medicine, the hook of the hamate remains a source of diagnostic errors in current clinical practice [3, 4]. Delay in diagnosis or missed diagnosis of abnormalities of the hook of the hamate is common [4–6]. Imaging plays a central role in identifying pathologic conditions affecting the hook of the hamate and in guiding clinical decision making. This article reviews the diagnostic imaging, clinical presentation, and treatment of hook of the hamate fracture, developmental anomalies, infection, avascular necrosis, and tumors.

Anatomy

The hamate is situated in the distal carpal row at the ulnar aspect of the wrist. The hook (also known as the hamulus) is a curved bony process that extends from the palmar surface of the body (Fig. 1). The hook of the hamate contributes to the medial border of the carpal tunnel and the lateral border of the Guyon canal. The pisiform-hamate ligament, flexor retinaculum (also known as the transverse carpal ligament), flexor carpi ulnaris tendon, opponens digiti minimi tendon, and flexor digiti minimi tendon all attach to the hook. The biomechanical

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function of the hook is to act as a pulley for the flexor tendons of the ring and small fingers [7, 8].

Imaging

Radiography

The typical set of radiographs obtained for acute or chronic ulnar-sided wrist symptoms includes conventional posteroanterior, oblique, and lateral views. However, images in these standard views poorly show the hook of the hamate. Additional special projections for the hook of the hamate include the semi-supinated oblique view, carpal tunnel view, and lateral view with thumb abduction and radial deviation of the hand [9]. Despite best efforts, some patients are unable to tolerate the positions required for these special views because of pain [5].

CT

CT is the reference standard for diagnosis of hook of the hamate fracture. CT is highly sensitive and specific for detection of fracture, with an accuracy of 97.2% compared with 80.5% for radiography [10]. CT is the go-to option for imaging of the hook of the hamate in patients with suspected acute or chronic bony abnormalities.

MRI

MRI is an alternative to CT for the detection of radiographically occult pathologic conditions involving the hamate. Although less accurate than CT for visualization of hook cortical fractures, MRI is superior for characterization of associated bone marrow edema, ulnar nerve injury, tendon abnormalities, and carpal tunnel abnormalities [2, 11]. MRI is also a useful adjunct examination after initial CT to determine the extent of soft-tissue abnormality related to hook of the hamate lesions.

Hook of the Hamate Fractures

Hamate fractures are uncommon and represent 2–4% of all carpal fractures [1]. Fractures involving the hook are the most common type of hamate fracture [2]. The incidence of hook of the hamate fractures among professional and recreational athletes is much higher than in the general population and is posited to be on the rise owing to the increasing popularity of golf and racket sports [9, 12]. Several mechanisms cause hook of the hamate fractures, including blunt trauma, repetitive microtrauma, and avulsion injury. Fall on an outstretched hand, motor vehicle collision, and direct strike from a projectile such as a baseball are common causes of acute traumatic fracture [7, 13, 14]. Gripping-related acute trauma to the hook when holding a bat, racket, golf club, or bicycle handle is an additional common mechanism [7, 9, 15] (Fig. 2A). Stress fractures occur as a result of ongoing repetitive microtrauma from gripping a bat, racket, or golf club [2, 7, 11] (Fig. 2B). Avulsion fractures occur as the result of ligamentous or tendinous forces tugging on the hook [9].

Hamate fractures are categorized as either hook or body fractures [8, 13]. Combined fractures involving the body and hook of the hamate are rare [13] (Fig. 3). Hook of the

hamate fracture has been classified into three types according to anatomic location: type 1, distal tip; type 2, middle part; and type 3, base of the hook (Figs. 4 and 5). Type 3 fractures account for over 75% of hook of the hamate fractures [4, 12]. Acute traumatic fractures of the hook often present with other fractures of the distal upper extremity, especially distal radial fractures [14] (Fig. 6). Distal ulnar fractures, other carpal bone fractures, hamate dislocations, and medial carpometacarpal joint disruptions are additional bone- and joint-related injuries [13, 16, 17]. Soft-tissue abnormalities most commonly associated with hook of the hamate fractures include ulnar nerve palsy and tear of the small finger flexor tendons [2, 7].

The clinical presentation of hook of the hamate fracture is often nonspecific and requires a high degree of clinical suspicion to establish the diagnosis. Patients have reported sudden-onset generalized pain and swelling at the hypothenar region of the hand and wrist after acute trauma [13, 16]. Hook of the hamate stress fractures present with a gradual onset of pain, over weeks to months, without report of a traumatic event [4, 8, 11]. Ring- and small-finger paresthesias have been reported with acute and chronic fractures [11, 13]. The site of maximal pain may be misleading at physical examination, and localizing signs directly attributable to the hook of the hamate are often difficult to detect [9, 11]. Presence of the Tinel sign at the hypothenar region should raise clinical suspicion of the presence of a hook fracture [7]. An increase in hypothenar pain or weakness with hand gripping is another associated sign of hook fractures [5, 8, 11].

On posteroanterior radiographs the hook of the hamate overlaps with the midportion of the distal hamate body and projects as an ovoid bony density. Radiographic signs of hook of the hamate fracture on posteroanterior images include an absent or indistinct hook or sclerosis of the hook [18]. Evaluation of the hook is often limited on standard lateral images owing to overlap with other carpal bones [8]. Carpal tunnel, supinated oblique, and lateral radiographs with thumb abduction and hand radial deviation radiographs are special views that improve visibility of the hook of the hamate. Overall, radiography has a sensitivity of 53–90% for detection of hook of the hamate fractures [10, 19]. However, standard posteroanterior and lateral wrist images are often obtained without special views, and false-negative radiographic findings often occur for hook of the hamate fractures, even when special views are used [19]. Hook of the hamate fractures at the midpoint or distal tip are more readily detected in special views, whereas fractures at the base of the hook are more commonly obscured [18].

The typical natural history patterns of missed hook of the hamate fractures include uncomplicated fracture healing, asymptomatic nonunion, and symptomatic nonunion or partial union [5]. Advanced imaging with CT or MRI usually establishes the diagnosis in the acute or chronic phase [2, 10]. CT is considered the reference standard for detection of hook of the hamate fractures and has sensitivity of nearly 100% [10]. CT has better sensitivity than radiography for the diagnosis of fractures occurring at the base of the hook [18]. CT also has the added value of quantifying the degree of displacement, which has implications for clinical decision making [8]. Acute displaced fractures of the hook typically have sharply defined margins on CT images, whereas chronic cases of nonunion present with sclerotic or corticated margins [13, 20]. On CT images, nondisplaced hook of the hamate fracture

appears as a sharply defined, thin, lucent line with cortical disruption. Healing of nondisplaced hook fracture is less distinct and exhibits associated sclerosis [5, 11, 21]. CT is also an excellent modality for evaluating hook fracture healing after treatment [22, 23]. MRI is useful for detection of hook fractures and concomitant associated ulnar nerve and flexor tendon injury [2, 18]. Hook fractures present as low-signal-intensity lines and typically are associated with bone marrow edema in the acute phase [11, 15, 18]. MRI also may provide information on the degree of displacement of hook of the hamate fractures [1].

Treatment of hook of the hamate fracture depends on the acuity of diagnosis, degree of displacement, and location of fracture. Nondisplaced fractures within 3 months of injury initially receive conservative treatment with cast immobilization [13, 14, 21, 24]. Treatment of symptomatic displaced fractures, nonunion, and nondisplaced hook fractures older than 3 months is controversial [21]. Surgical excision of the hook of the hamate is a common treatment [5, 7, 17, 21]. The importance of preserving the hook of the hamate as a pulley for the medial flexor tendons continues to be debated [21]. Surgical fixation has been advocated for restoring normal biomechanics of the wrist. Operative techniques include open palmar screw or K-wire fixation, hook plate fixation, and dorsal percutaneous screw fixation [7, 20, 21, 25]. Low-intensity pulsed ultrasound has been advanced as a noninvasive alternative to surgical intervention in nondisplaced fractures [22, 23].

Type 1 fractures involving the distal third of the hook are most likely to receive conservative treatment regardless of other factors. Type 2 fractures at the middle part are theorized to be the most at risk of nonunion [12].

Developmental Anomalies

Bipartite Hook of the Hamate

Secondary hamate ossification centers typically fuse with the primary ossification center during adolescence. An accessory ossicle, the os hamuli proprium, forms when there is failure of fusion between the hook and body ossification centers [2, 26]. The accessory ossicle is bound to the hamate by a fibrous pseudoarthrosis instead of an osseous union [26].

Bipartite hamate is rare and found in less than 1% of the general population [3]. Most cases of os hamuli proprium are discovered incidentally and are often in the differential diagnosis of hamate fractures (Fig. 7A). Differentiating an accessory ossicle from a chronic nonunion of the hook may have no clinical relevance in patients without ulnar-sided wrist symptoms. Suggested criteria favoring os hamuli proprium over fracture include round well-corticated margins of the ossicle and hamate, absence of a history of trauma, and bilateral presentation of the ossicle [26]. Fracture of the os hamuli proprium is rare (Figs. 7B and 7C).

Recognition of a bipartite hamate is critical for preoperative planning before open or endoscopic carpel tunnel release to avoid iatrogenic injury to the ulnar neurovascular bundle [3]. In rare cases, resection of the os hamuli proprium is performed for treatment when the abnormality presents in association with carpal tunnel syndrome or ulnar tunnel syndrome [4, 26].

Pisiform-Hamate Coalition

The carpal bones arise from a single cartilaginous anlage before the 10th week of fetal life. Most carpal coalitions occur across the same carpal row; lunotriquetral coalition accounts for 90% of cases [27–29]. Carpal coalition typically results from failure of routine programmed cell death, leading to the absence of normal joint space between carpal bones [30, 31]. However, pisiform-hamate coalition does not develop in this way. The pisiform is a sesamoid bone related to the flexor carpi ulnaris tendon and arises from its own endochondral ossification center [27, 32, 33]. The mechanism of pisiform-hamate coalition has been posited to result from metaplasia of the pisohamate ligament or ossification of the distal flexor carpi ulnaris [32].

Pisiform-hamate coalition is exceedingly rare, there being only a handful of case reports in the literature. Pisiform-hamate coalition occurs in isolation or in association with a congenital syndrome [27] (Fig. 8). Classification of pisiform-hamate coalition is based on the amount of osseous bridging between the pisiform and the hamate, as adopted from the Minaar classification system for lunotriquetral coalition: type I, no osseous bridging, resembling pseudoarthrosis; type II, partial osseous bridging; type III, complete osseous bridging; type IV, complete bridging with associated carpal anomalies [34].

Several cases of asymptomatic pisiform-hamate coalition have been described [27, 33, 35]. Symptomatic pisiform-hamate coalition has been reported to occur with or without associated trauma. Associated pathologic features include small-finger flexor tendon rupture, ulnar and median nerve neuropathy, and degenerative arthropathy [27, 34, 36, 37]. Surgical resection of the pisiform and hook of the hamate is the typical definitive treatment for relief of symptomatic coalition, although screw arthrodesis has been described as an alternative for fibrous type I coalitions [32, 34, 37].

Infection

Osteomyelitis of the carpus typically is the sequela of an open fracture, penetrating trauma, septic arthropathy, or infectious tenosynovitis in skeletally mature patients [38]. The most common organism associated with bone infection is *Staphylococcus aureus*, although numerous pathogens are known to cause osteomyelitis [38, 39]. The clinical presentation typically involves fever, wrist pain, edema, and erythema. The contiguous spread of infection from elsewhere in the wrist is the typical cause of hamate osteomyelitis (Fig. 9), and isolated infection of the hamate is rare [38, 39].

CT findings of acute bone infection are lytic bone destruction, erosion, osteopenia, intraosseous gas, and aggressive periostitis. Chronic sequelae may result in a sequestrum and involucrum [38]. MRI findings associated with osteomyelitis include bone marrow signal intensity that is decreased on T1-weighted and increased on fluid-sensitive T2-weighted images and enhancement on contrast-enhanced images [40]. Abnormal bone marrow signal intensity in a patient with suspected infection may represent either reactive edema or osteomyelitis, two entities that can be challenging to differentiate on the basis of MRI findings alone [40]. Treatment of osteomyelitis suspected on clinical grounds or based on a

positive result of biopsy or aspiration culture requires IV antibiotics and on occasion surgical débridement [38–40].

Avascular Necrosis

The hamate receives blood supply from the ulnar artery, dorsal intercarpal arch, and recurrent ulnar artery. Avascular necrosis of the hook of the hamate is rare. The clinical presentation is often nonspecific; patients present with nonlocalizing ulnar-sided wrist pain. Range of motion and grip strength are often variable [41]. Avascular necrosis is difficult to appreciate on radiographs and CT scans. MRI reveals decreased T1 signal intensity with variable T2 signal intensity. The diagnosis is confirmed at surgical pathologic analysis after surgical resection for a symptomatic hook of the hamate [41].

Tumor

Tumors of the body and hook of the hamate are rare. The clinical presentation of hamate tumors is variable. Reported cases in the literature include osteoid osteoma, giant cell tumor, intraosseous ganglion, osteoblastoma, chondroblastoma, aneurysmal bone cyst, osteochondroma, unicameral bone cyst, intraosseous schwannoma, and lung metastasis [6, 42–52]. Radiographs are often noncontributory in evaluation of hook of the hamate tumors. The multiplanar capabilities of CT and MRI are more sensitive for detecting and characterizing bony masses in the hook (Fig. 10). The definitive diagnosis of hamate tumors is most often established at surgical pathologic analysis after surgical resection [43, 45, 50].

Conclusion

Knowledge of the anatomy, imaging appearance, and clinical management of the spectrum of pathologic conditions affecting the hook of the hamate is important for the radiologist so that they may guide the care of patients who present with ulnar-sided wrist symptoms.

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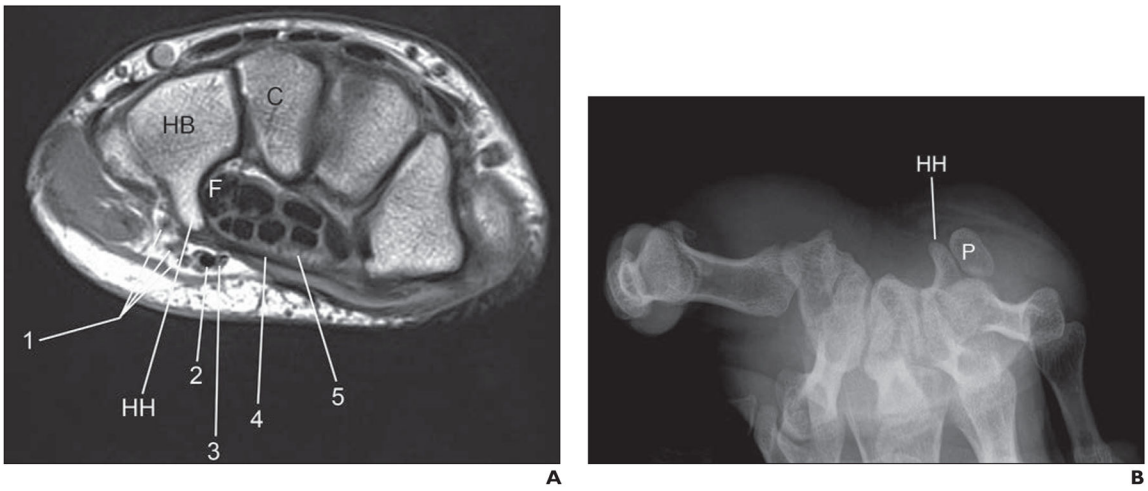

Fig. 1. 31-year-old man with normal wrist

A, Axial proton density–weighted MR image shows body of hamate (HB), capitate (C), small-finger flexor tendons (F), hook of hamate (HH), ulnar nerve and branches (1), ulnar artery (2), ulnar vein (3), flexor retinaculum (4), and median nerve (5).

B, Carpal tunnel view radiograph shows hook of hamate (HH) and pisiform (P).

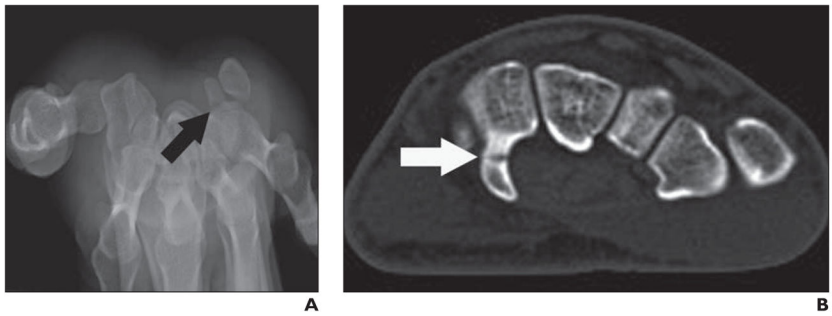

Fig. 2. Two patients with sports-related hook of hamate fractures

A, 21-year-old male baseball player with acute medial wrist pain while batting in game. Carpal tunnel radiograph shows acute nondisplaced transverse fracture (*arrow*) at base of hook.

B, 21-year-old male lacrosse player with gradual onset of wrist discomfort over several weeks without blunt trauma. Axial CT image shows nondisplaced transverse stress fracture (*arrow*) near base of hook.

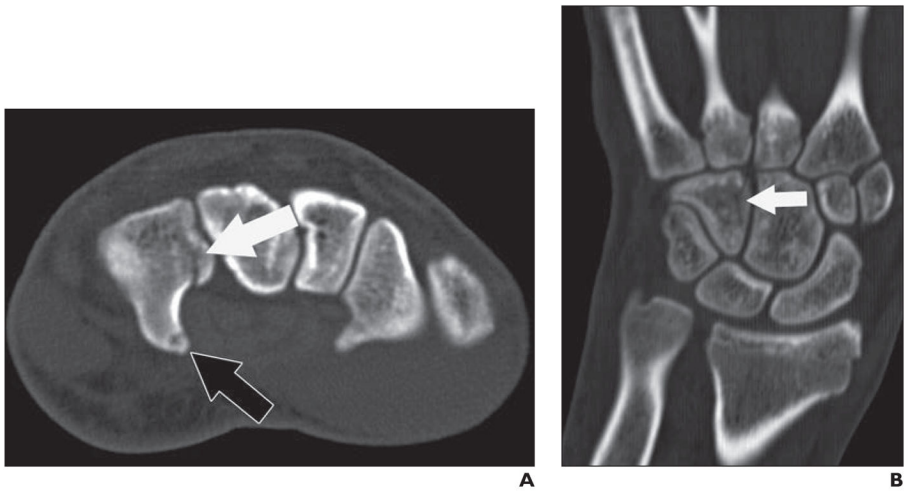

Fig. 3. 22-year-old man injured in dirt bike accident

A, Axial CT image shows acute nondisplaced transverse fracture at tip of hook (*black arrow*) and nondisplaced vertical fracture of hamate body (*white arrow*).

B, Coronal CT image shows extent of acute hamate body fracture (*arrow*).

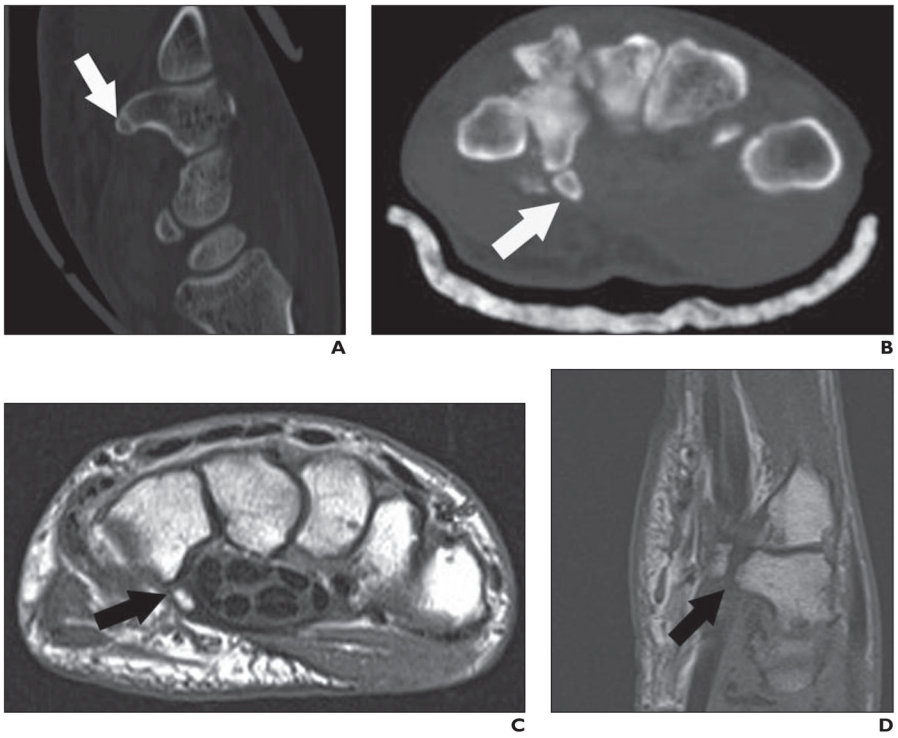

Fig. 4. Type 1 and type 2 hook of hamate fractures

A, 63-year-old man after fall 6 weeks earlier. Sagittal CT image shows partially healed type 1 transverse fracture at tip of hook (*arrow*).

B, 53-year-old man after acute blunt trauma. Axial CT image shows chronic nonunion of type 2 transverse fracture at middle portion of hook (*arrow*), which was incidental finding in evaluation of acute displaced comminuted fractures at bases of fourth and fifth metacarpals.

C and **D**, 61-year-old woman with chronic wrist pain. Axial proton density–weighted (**C**) and sagittal T1-weighted (**D**) MR images show chronic nonunion of type 2 transverse fracture (*arrow*).

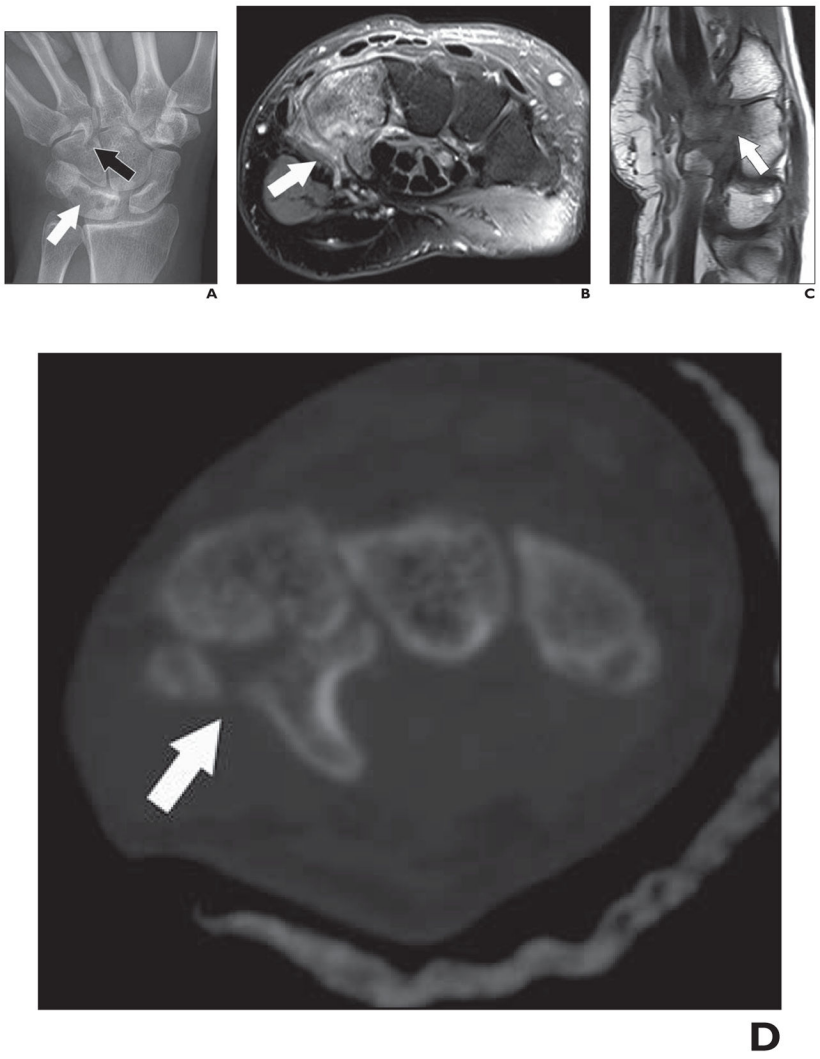

Fig. 5. Type 3 hook of hamate fractures

A–C, 45-year-old man after falling down steps 5 weeks earlier. Posteroanterior radiograph (**A**) shows focal lucency (*black arrow*) at hamate and subtle overlap of hook with fourth carpometacarpal joint. Incidental lunotriquetral coalition is also present (*white arrow*). Axial T2-weighted fat-saturated (**B**) and sagittal T1-weighted (**C**) MR images show displaced type 3 transverse fracture at base of hook (*arrow*) with associated bone marrow edema and adjacent soft-tissue edema.

Type 3 hook of hamate fractures. **D**, 56-year-old man after recent motor vehicle collision. Axial CT image shows acute displaced comminuted type 3 fracture of hook (*arrow*).

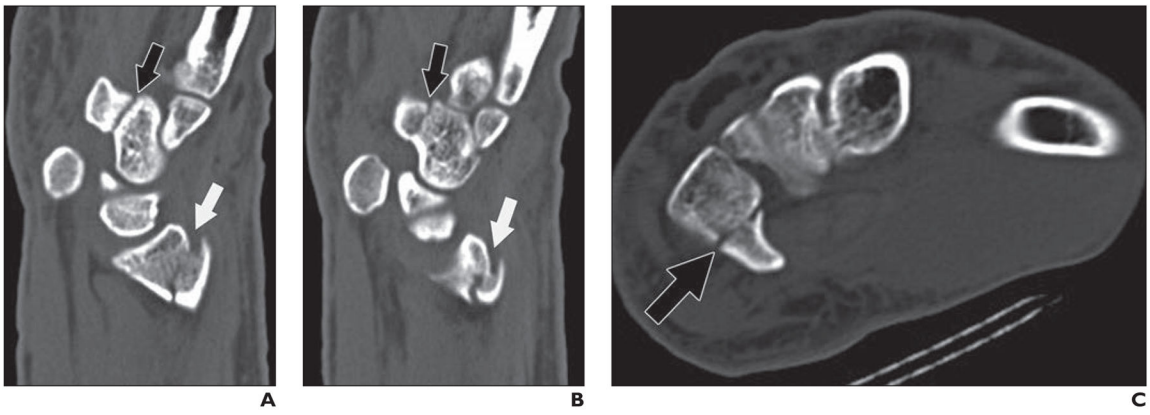

Fig. 6. 27-year-old man after fall from bicycle

A–C, Two contiguous sagittal CT images (**A** and **B**) and axial CT image (**C**) show acutely displaced hook of hamate transverse fracture (*black arrow*) in association with acute displaced oblique fracture of distal radius (*white arrow*, **A** and **B**).

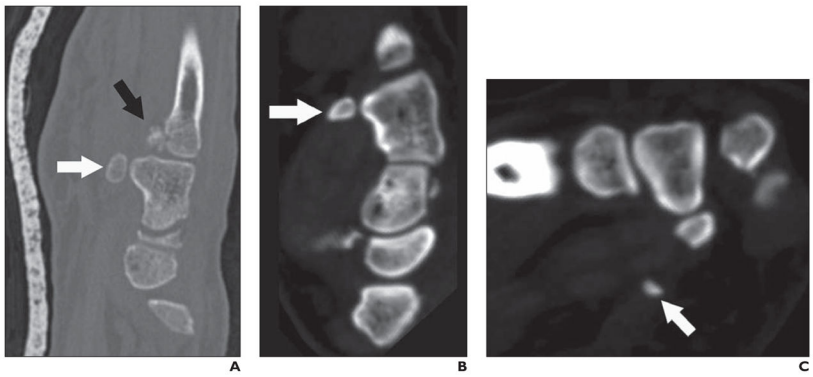

Fig. 7. Bipartite hook of hamate

A, 67-year-old man with acute wrist pain after fall from standing. Sagittal CT image shows displaced comminuted fracture (*black arrow*) at base of fourth metacarpal. Os hamuli proprium (*white arrow*) is incidental finding. Ossicle and adjacent hamate have rounded well-defined margins.

B and **C**, 41-year-old man after motorcycle collision. Sagittal CT image (**B**) shows bipartite hook of hamate (*arrow*). Axial CT image (**C**) shows acute displaced avulsion fracture of os hamuli proprium (*arrow*).

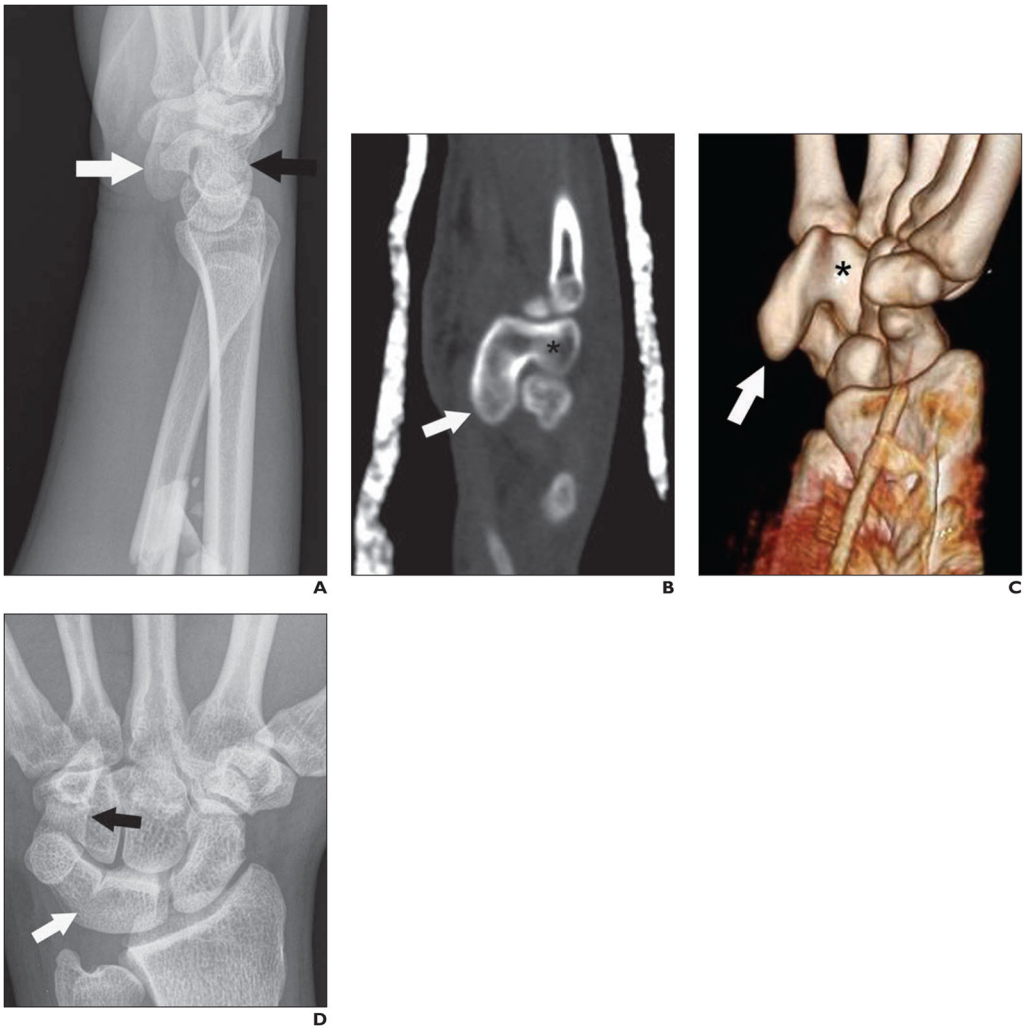

Fig. 8. Two patients with pisiform-hamate coalition

A–C, 21-year-old man after motor vehicle collision. Lateral radiograph of wrist (**A**) shows acute displaced comminuted distal ulnar shaft fracture. Osseous body (*white arrow*) was initially thought to represent anterior capitate dislocation. However, capitate was soon thereafter properly identified in its normal anatomic position (*black arrow*). Sagittal conventional (**B**) and sagittal volume-rendered (**C**) CT images show complete osseous fusion of hamate (*asterisk*) and pisiform (*arrow*). (**A** and **C** adapted from presentation at Radiological Society of North America 2013 annual meeting, Chicago, IL)

D, 25-year-old woman 2 days after fall. Posteroanterior radiograph shows pisiform-hamate coalition (*black arrow*) and lunotriquetral coalition (*white arrow*). (Adapted from presentation at Radiological Society of North America 2013 annual meeting, Chicago, IL)

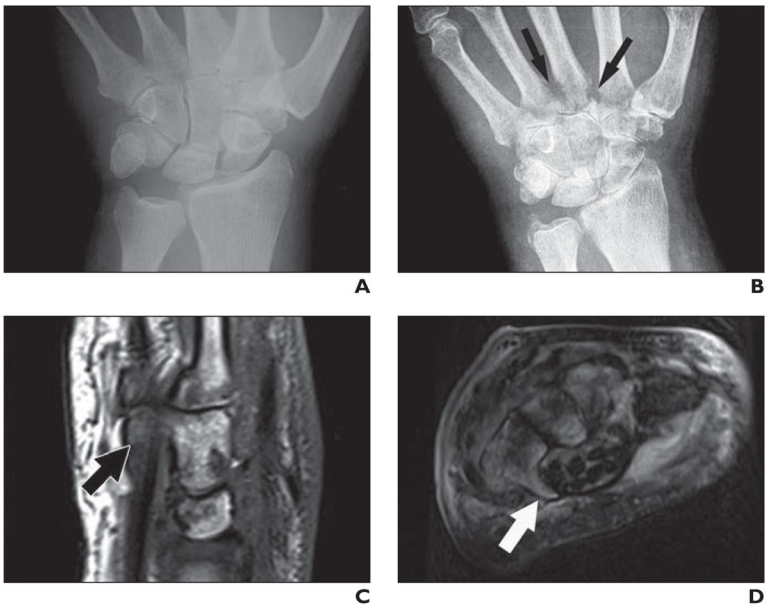

Fig. 9. 75-year-old man with wrist sepsis that developed during long-term IV antibiotic treatment of blood culture–positive methicillin-sensitive *Staphylococcus aureus* and mitral valve endocarditis

A, Posteroanterior radiograph obtained at hospital admission shows no signs of infection.

B, Posteroanterior radiograph 5 weeks after hospital admission shows interval development of erosions (*arrows*), global joint space loss, and diffuse osteopenia at carpus.

C and **D**, Sagittal T1-weighted (**C**) and axial T2-weighted fat-saturated (**D**) MR images 5 weeks after hospital admission show abnormal marrow signal intensity, compatible with reactive bone marrow edema or osteomyelitis, involving hook of hamate (*arrow*), body of hamate, capitate, and trapezoid bones. Synovitis of carpus and carpal tunnel flexor tendon compartment is also present.

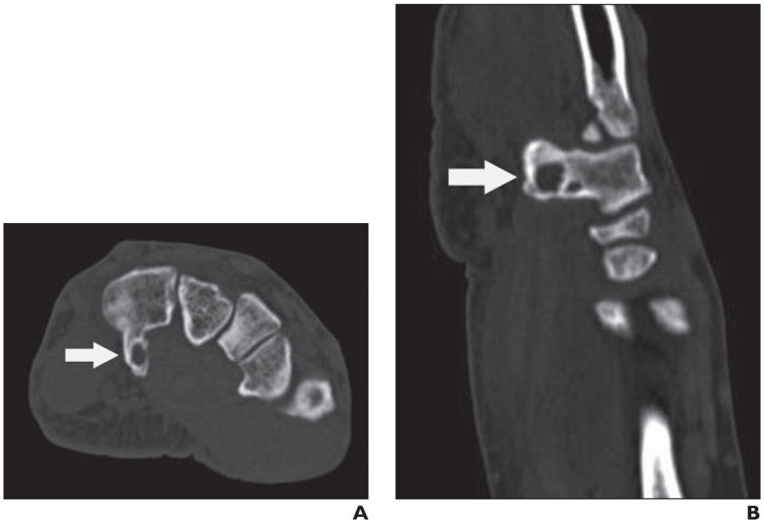

Fig. 10. 63-year-old man with chronic wrist pain and inability to flex small finger

A and **B,** Axial (**A**) and sagittal (**B**) CT images show ovoid lytic lesion with adjacent sclerosis centered in hook of hamate (*arrow*) with thin cortical defect along radial aspect of hook. Surgical exploration 1 month later revealed small-finger flexor tendon tear. After surgical resection of hook, pathologic analysis showed lytic mass to be posttraumatic inflammatory cyst in setting of hook of hamate fracture nonunion.