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Isolated hook of hamate fracture in sports that require a strong grip comprehensive literature review

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Abstract

Background: The aim of the study was to report characteristics of isolated hook of hamate fractures related to sports that require a strong grip and to identify factors affecting early diagnosis and recovery period.

Methods: A comprehensive literature search was conducted using MEDLINE, EMBASE, SCOPUS, Web of Science, the Cochrane Central Register of Controlled Trials, the World Health Organization International Clinical Trials Registry Platform, and the clinical trials registry and database of the US National Institutes of Health (ClinicalTrials.gov). There were no limits on the language or year of publication.

This article included case reports and literature reviews for patients with isolated hook of hamate fractures related to sports that require a strong grip from 1977 to 2016.

Two experienced reviewers extracted data from each study. The following data were extracted: sample size, patient's characteristics, cause of injury, injury side, time to diagnosis and symptoms, physical examination results, diagnostic work-up, treatment, complications, and recovery period.

Results: A total of 21 case reports and literature reviews with 120 patients satisfied our inclusion criteria. There was no significant difference in the time to diagnosis between the group before computed tomography (CT) was widely used and the group after CT was widely used. Recovery period showed a positive relationship with age (coefficient = 0.418, $P<.01$), time from injury to diagnosis or surgery (coefficient = 0.206, $P<.05$), and type of athlete (coefficient = 0.270, $P<.01$). On multiple stepwise regression analysis, recovery period was significantly associated with age ($\beta=0.418$, $P=.00$), but not with time from injury to diagnosis or surgery.

Conclusions: Advance in diagnostic techniques does not guarantee early diagnosis of hook of hamate fractures. Strong suspicion of the disease with physical examination and carefully hearing patient's history are important for early diagnosis and management for patients with hook of hamate fractures.

Abbreviations: ADM = abductor digiti minimi, APB = abductor pollicis brevis, DIP = distal interphalangeal, EMG = electromyography, FDI = first dorsal interosseous, NPRS = Numeric Pain Rating Scale, ORIF = open reduction and internal fixation, PA = postero-anterior, TFCC = triangular fibrocartilage complex.

Keywords: baseball, fractures, golf, hamate bone, racquet sports, tennis

1. Introduction

Fractures of the hamate are relatively rare. Their exact frequency is unknown due to the lack of clear data.[1] Urch et al have reported that, among total carpal bone cases, the hamate accounts for only 2% of fractures, in contrast with the scaphoid which accounts for 70%.[2,3] The hook of hamate is raised from the body of the hamate bone. It has a curved process that protrudes palmary into the hypothenar area.[4,5] It provides attachment points for the flexor carpi ulnaris, flexor digiti minimi, and opponens digiti minimi. It also constitutes the border of Guyon's canal carpal tunnel.[6] In the canal, the ulnar nerve splits into a motor and sensory branch. The superficial sensory branch of the ulnar nerve supplies sensation to the surface of the fifth digit and the medial region of the fourth digit and travels close to the tip of the hook. The deep motor branch of the ulnar nerve travels deep along the base of the hamate bone and innervates hypothenar muscles.[7,8] The hook of hamate is palpable in the hypothenar area. It is located 2 cm distal along the imaginary line from the pisiform to the second metacarpal head.[9]

The most frequent causes of fractures of the hamate hook are sports that require a strong grip such as golf, baseball, and tennis.[10] Repeated micro-trauma of the hypothenar eminence induced by the end of the racquet, club, or bat has been thought to be the cause of these fractures.[1,10]

Relative rarity of injury pattern, nonspecific symptoms, and complex carpal anatomy can make it common to miss this fracture.[11] As a result, diagnosis and proper treatment are

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Figure 1. Wrist PA/oblique view.

often delayed, resulting in sequelae such as tendon rupture, nonunion, carpal instability, and neurovascular compression.[10,12] For these reasons, early diagnosis is considered the most important factor in avoiding complications. We present a case of hook of hamate fracture combined with ulnar nerve injury with a comprehensive review of articles that have been published up to date about hook of hamate fractures in sports that required strong grip.

Here we report a case of hook of hamate fracture combined with ulnar nerve injury due to delayed diagnosis to aid readers in understanding the challenge associated with diagnosis. A 41-year-old, right-handed man presented with a 3-month history of pain on the ulnar side of his left hand after hitting the ground heavily behind the ball with his golf club. We found mild atrophy in the hypothenar and first interosseous muscle in his left hand. He had weak grasp and pinch grip. However, his sensation was normal. He reported moderate pain between the ulno-carpal joint and the fifth metacarpal base on palpation that was exacerbated when he gripped a golf club. When swinging the club, he rated his pain 8 out of 10 on a Numeric Pain Rating Scale (NPRS). Wrist x-ray (posterior-anterior, lateral view) showed no gross abnormality (Fig. 1). Based on these findings, we suspected ulnar neuropathy and triangular fibrocartilage complex (TFCC) injury. Thus, we conducted an electrodiagnostic evaluation to confirm ulnar nerve injury and localize a lesion.

In a motor nerve conduction study, the left ulnar nerve measured at the first dorsal interosseous (FDI) muscle showed decreased amplitude for more than half of the right side. Its conduction velocity was also slow. In needle electromyography (EMG) for left hand and forearm muscles, reduced motor unit recruitment in the left FDI muscle was found.

As a result of these findings, we could diagnose type II ulnar neuropathy at the wrist which typically reflects compression of a deep branch of the ulnar nerve at or near the piso-hamate hiatus.[11,13] We then needed to check bone scans and wrist magnetic resonance imaging (MRI) to attempt to locate a concealed fracture or a space-occupying lesion. Bone scan revealed increased uptake on the left ulnar aspect of the distal carpus (Fig. 2). Wrist MRI (Fig. 3) showed hook of hamate fracture in the left hand without evidence of TFCC injury. Since then, the patient received excision of hook of hamate. Two weeks after the surgery, he had resumed his regular work. He reported only 3 out of 10 on the NPRS. His grip power had also gradually increased and he had full motion in all digits. Nine weeks after his surgery, the patient had experienced no pain while playing golf. His left grip strength had recovered to its previous level.

2. Methods

2.1. Literature search

We performed a search of all clinical studies on hook of hamate fractures published up to date by searching MEDLINE, EMBASE, SCOPUS, Web of Science, the Cochrane Central Register of Controlled Trials, the World Health

Figure 2. Bone scan. Left ulnar aspect of the distal carpus show increased uptake.

Organization International Clinical Trials Registry Platform, and the clinical trials registry and database of the US National Institutes of Health on December 17, 2016. We had no restrictions for language or year of publication in our search. We used the following keywords hamate bone, hook of hamate, fracture, nonunion, racquet sports, golf, baseball, and tennis.

2.2. Inclusion and exclusion criteria

Two reviewers screened searched articles for eligibility criteria. Studies were included if the following inclusion criteria were met: patients who had been diagnosed with isolated hook of hamate fractures, time to diagnose was specified, cause of injury was racquet, bat, club, or stick sports, tools used for diagnosis were specified, and recovery period after treatment was specified. We excluded a number of studies that did not reveal the cause of the injury or the time from injury to diagnosis and/or surgery, cases related to falls, motor accidents, racquet, bat, club, or stick-free

Figure 3. Wrist MRI showing hamate hook fracture in the left hand without evidence of TFCC injury. A, Sagittal T1-weighted image. B, Sagittal T2-weighted image. C, Axial T2-weighted image.

exercise, or studies that included patients with comorbid fractures.

2.3. Data extraction, synthesis, and statistical analysis

Two independent reviewers extracted data from individual studies. All articles were case reports or case reports with literature reviews. Data retained included patients characteristics, cause of injury, injury side, time to diagnosis, and symptoms and physical examination results, diagnostic work-up, treatment, complications, and recovery period.

To compare 2 groups according to the use of computed tomography (CT) for early diagnosis, a Mann–Whitney test was conducted. Pearson and Spearman correlation analyses were used to evaluate the correlation between recovery period and variables. Multiple regression analysis was used to identify independent factors predicting recovery period after surgery with possible confounders such as time from injury to diagnosis or surgery, age, sex, type of athlete (professional or amateur player), and type of sport (baseball, golf, or tennis). Possible multicolinearity between covariates was assessed using correlation analysis and colinearity statistical tests. All statistical analyses were performed with SPSS version 20.0 (IBM, Armonk, NY). Statistical significance was considered at $P < .05$. As this is a case and literature review, ethical approval was not required, which is in compliance with the institutional and national policies concerning research approvals. The patient provided informed consent to collect data and images for publication

3. Results

3.1. Epidemiology

We found 21 case reports and analyzed them comprehensively. The earliest report was from 1972 and the most recent one was published in 2016. There were a total of 120 patients with hook of hamate fractures related to sports that required a strong grip, including 115 men and five women. According to reasons of injury, 52 (43%) patients had been injured from playing golf while 47 (39%) had been injured from playing baseball (Table 1).[1,4,12,14–31] The mean age of patients at the time of injury was 33.04 ± 13.64 years (range: 17–67 years).

3.2. Injury side

A total of 13 studies on 85 patients reported whether the injury had been on the patient's dominant or nondominant side. Twenty-one patients had injuries on the dominant side while the remainder had injuries on the nondominant side. For dominant-side injuries, 13 had been injured from playing tennis and 7 had been injured from playing baseball. Among the patients with baseball injuries, 2 had been switch hitters and 1 patient had been right-handed but batted left. In comparison, 37 of injuries on patients' nondominant sides had been from playing baseball while 27 had been from playing golf (Fig. 4).

3.3. Time to diagnosis

Time from injury to diagnosis or surgery was 5.91 ± 7.60 months on average (range: day of injury to 48 months). Our case took 3 months to diagnose, which was less than the average time to diagnosis in 120 patients in 21 case reports. However, it is difficult to compare these studies simply because they varied so broadly by time (from 1972 to 2016). During this period, CT and MRI were developed which improved the accuracy of diagnosis of hook of hamate fracture.

Thus, we divided these studies into those before CT was widely used and those after CT became popular (that is, before and after 1983). We then compared the time from injury to diagnosis or treatment. We assigned studies of Foucher et al,[15] Parker et al,[16] and 4 cases from the 1970 s into the former group and the remainder into the latter group (6 case reports with 38 patients compared with 15 case reports with 82 patients). Our results revealed that there were no statistically significant differences in the time from injury to diagnosis or treatment between the 2 groups (Table 2).

3.4. Subjective symptoms and physical examination results

The most frequent initial symptom (patients were allowed multiple responses) was pain at the injury site including the ulno-palmar area. It occurred in 76 (38%) patients (Fig. 5).

The most common finding on doctors' physical examinations was tenderness over the hook of hamate or ulno-palmar side (57 patients, 56%). Eight (9%) patients showed positive results for the hook of the hamate pull test known to be a simple and highly sensitive test for diagnosing both non-unions and fresh fractures. In this test, the wrist is placed in full ulnar deviation with the ring and little distal interphalangeal (DIP) joints flexed. The examiner then pulls the DIP joints of 2 fingers against the patient's resistance, eliciting pain around the patient's wrist, and volar area[32,33] (Fig. 6).

3.5. Diagnostic work-up

A total of 19 reports on 113 cases described the diagnostic tool used to detect the hook of hamate fracture. Duplicated results were included. Only 2 (1.8%) cases had plain x-ray including antero-posterior (AP), postero-anterior (PA), and lateral views while 46 (40.7%) cases presented carpal tunnel view. CT revealed fractures in 31 cases while MRI revealed fractures in 8 cases. Another 8 cases were diagnosed with CT or MRI (total for both: 41.6%) (Fig. 7).

3.6. Treatment and complications

Patients were treated with surgery and/or conservative treatments such as cast immobilization. For cases that we identified, 111 patients had hook fragments excised while 7 patients were immobilized. In 3 patients who initially underwent cast immobilization, there was no symptom improvement or recurrence of pain. Eventually they underwent excision of the hook of hamate.

3.7. Recovery period

The average time from surgery to return to exercise or daily life was 12.66 ± 11.58 weeks (15 case reports and 93 patients, range: 3 weeks to 1 year). Recovery period showed a positive relationship with age (coefficient = 0.418, $P < .01$), time from injury to diagnosis or surgery (coefficient = 0.206, $P < .05$), and type of athlete (coefficient = 0.270, $P < .01$) (see Table, Supplemental Digital Content 1, http://links.lww.com/MD/C642, which demonstrates the correlation between recovery period and multiple variables). On multiple stepwise regression analysis, only age ($\beta = 0.418$, $P = .00$) was a significant independent factor affecting recovery period (see Table, Supplemental Digital Content 2, http://links.lww.com/MD/C642, which demonstrates the multiple linear regression analysis for period of recovery).

Table 1

List of case reports of hook of hamate fractures due to racquet sports injuries.

Author, Year (Years of diagnosis)	Case /Sex	Mean age (range), y	Cause	Injury hand side	Diagnostic tool /Detected cases	Treatment/Cases	Mean time to diagnosis (range)	Recovery period§ or Treatment outcome
Stark et al, 1977 (1969–1976)*[18]	20 /M	32.3 (17–64)	B:9 G:7 T:4	D:7 N:13	P-XR/ND CTV/20	Ex/18	10.3 Mos (1/3–48 Mos)	Mean 8.8 Wks (range 6–17 Wks)
Torisu,1972[44]	1 / M	54	G	UC	P-XR/ND O-XR/1	Im/1 (Cast for 6 Wks)	10 d	Seven Mos after injury, slight tenderness at the hamate and weakness in the fourth and fifth fingers remained.
Nisenfield et al, 1974[45]	3 (2)† / M	38.5 (46–31)	G:2	UC	P-XR/ND CTV/2	Im/1 (short arm cast) Another patient refused surgery.	2.5 Mos (Day-5 Mos)	Eight Mos after injury, residual tenderness at the hamate with some weakness was noted. He couldn't hit a ball with maximum force due to pain.
Carter et al, 1977[46]	9 (6)† / M	31.3 (27–45)	G:2 B:2 T:1 S:1	UC	CTV/4 O-XR/2 Lat. tomogram/1	Ex/6	5 Mos (5 Wks–10 Mos)	Mean 7.2 Wks (range 6–8 Wks). All had no pain or tenderness, full range of motion, and strong grips.
Foucher et al, 1985 (1982–1983)*[14]	6 (5)† /M	33 (24–40)	T:5	D:5	CTV/5	Ex/4 Another patient refused surgery	4.5 Mos (1 Wks–1 y)	Mean 4 Mos (range 3–5 Mos). One patient's grip strength remained lower than before.
Parker et al, 1986 (1983)*[15]	6 (4)† /M	23.5 (22–24)	B:4	N:4	CTV/1 with O-XR/1 with bone scan/2	Ex/4 1 patient (Short arm cast for 5 Wks→Ex)	3.6 Wks (2 d—8 Wks)	Mean 5 Wks (range 4–6 Wks). Two patients returned following the season.
Polivy et al, 1985 (1983)*[47]	2 (1)† / M	30	G:1	N:1	Bone scan with CTV/ND Lat. tomogram/ND CT/1	Ex/1	7 Mos	Five Mos after surgery, patient had no more pain and returned to playing golf but not to full activity.
Schlosser et al, 1984[22]	6 (5)† /M	28.8 (22–41)	G:2 H:1 T:1 B:1	N:1 (The rest are UC)	P-XR & CTV/ND Lat. tomogram/3 (The others are UC)	Ex/14 Conservative/1	12.6 Mos (6–24 Mos)	From 6 to 8 Wks after surgery, patients could resume full activities. One patient received conservative therapy and was completely free of pain 22 Mos after the injury.
David et al,2003 (1991–1998)*[12]	8 /M	34 (20–55)	G:5 B:3	N:8	P-XR with CTV/1 CT/8	Ex/8 1 patient (Cast for 6 Wks →Ex)	22 Wks (11.3–35.7 Wks)	Mean 8 Wks (range 4–12 Wks). One patient with FDI weakness and claw deformity in the ring and little fingers showed complete resolution by 4 Mos
Futami et al,1993 [36]	8 (7)† /4M, 3W	41.1 (30–67)	T:4 G:3	UC	CTV/2 Lat. tomogram/5	Ex/7	7.25 Mos (1–18 Mos)	Four patients without tendon rupture had fully recovered within 2 Mos after surgery. Three patients with free tendon grafting had fully recovered within 4 Mos after surgery.
Bachoura et al, 2013 (2000–2012)*[35]	8 /M	21.7 (18–26)	B:8	D:3 N:5	P-XR/ND CT or MRI/8	Ex/7	33 d‡ (3–270 d)	Mean 5.7 Wks (range 4.3–10.4 Wks). One patient had scar hypersensitivity.
Guha et al, 2002[4]	1 /M	33	T:1	D:1	P-XR & USG/ND CTV/ND Bone scan/1 CT & MRI/1	Brace & plaster cast for 6Wks	7 Wks	After 6 Wks of treatment, he was completely free from pain and had regained full function. After 1 year from the onset of symptoms, he had returned to playing tennis at his previous level.
Kang et al, 2008 (2002–2005)*[24]	9 (8)† /7M 1W	44.4 (32–57)	G:6 T:1 F:1	D:2 N:6	P-XR/1 CTV/6 CT/8	Ex/8	9.25 Mos (2–36 Mos)	One year after their injuries, 8 patients had recovered without complications. In one patient with transient fourth and fifth finger paresthesia, symptoms had resolved 2 Mos after surgery.
Aldridge et al, 2003[34]	7 /6M, 1W	30 (20–38)	G:7	N:7	AP X-ray/ND Lat. X-ray/ 1 CTV/1 CT/2 MRI/5	Ex/7	9Wks (4–24Wks)	All patients could resume full golf activities at 3 Mos after surgery. All recovered previous level of play within 3 to 6 Mos after surgery.
Koh et al,2004 (2003)*[48]	1 /M	64	G:1	UC	P-XR/ND EMG/ND CTV/1 Bone scan/1 MRI/1	Ex/1	7 Mos	Not reported
Deverse et al, 2013 (2005–2011)*[1]	12 (11)† /M	19.5 (19–21)	B:10 G:1	D:2 N:9	Not reported	Ex/11 1 patient (Cast for 7 Wks →Ex after 6 Mos)	1.43 Mos‡ (0.5–17 Wks)	Mean 6.2 Wks (range 3–8Wks). In 1 patient with ulnar area paresthesia, the symptom resolved within 5 Wks after surgery.
Lee et al,2016 (2008–2013)*[41]	10 /M	19.6 (17–25)	B:10	N:10	CT/10	Ex/10	7.2 Mos (4–12 Mos)	Mean 11.8 Wks (range 8–16 Wks). In 1 patient with ulnar neuropathy after surgery, the symptoms resolved after 12 Wks.
Kim et al, 2016 (2008–2014)*[25]	16 (12)† /M	51.1 (42–62)	G:12	UC	P-XR/UC CTV/UC CT/UC	Ex/12	4.16 Mo‡ (1–7 Mos)	ASSH grading ¶ Excellent 1, Good 2, Fair 2, Re-rupture 1
Gill et al, 2010[49]	1 /M	44	G	UC	P-XR/ND CTV/1	Ex/1	6 Mos	Twelve Wks after surgery, he returned to full activities without complications.
O'Grady et al, 2012[20]	1 /M	66	G	UC	P-XR/ND MRI/1	Ex/1	10–12Wks	More than 6 Mos after surgery, he could play 1 or 2 rounds of golf.
Josipovic et al, 2016[50]	1 /M	17	T	D:1	P-XR/ND CTV/ND EMG/ND Bone scan/1 MRI/ND CT/1	Ex/1	1 y	He was pain free and gradually returned to tennis at 2 Mos after surgery. He had no pain and had recovered normal muscle power at 6 Mos.

M, men, W, women, B, baseball, T, tennis, G, golf, S, squash, H, hockey, F, fencing, D, dominant side, N, nondominant side, UC, unclear, P-XR, plain X-ray, O-XR, oblique X-ray, CTV, carpal tunnel view, AP, anteroposterior, Lat., lateral, CT, computed tomography, EMG, electromyography, ND, not detected, Ex, excision of hook, Im, immobilization, FDI, first dorsal interosseous.

¶: American Society for Surgery of the Hand grading for flexor tendon assessment, sum of the degree of active metatarsophalangeal, proximal interphalangeal, distal interphalangeal joint flexion: Excellent, 257° (100%), Good, 195°-257° (75–99%), Fair, 130°-194° (50–74%), Poor, < 129°(50%), (% of corresponding contralateral digit).

*: Recruitment time of patients, †: Number of patients who met the criteria, ‡: Time between injury and surgery, §: Recovery period from surgery to return to play or daily life.

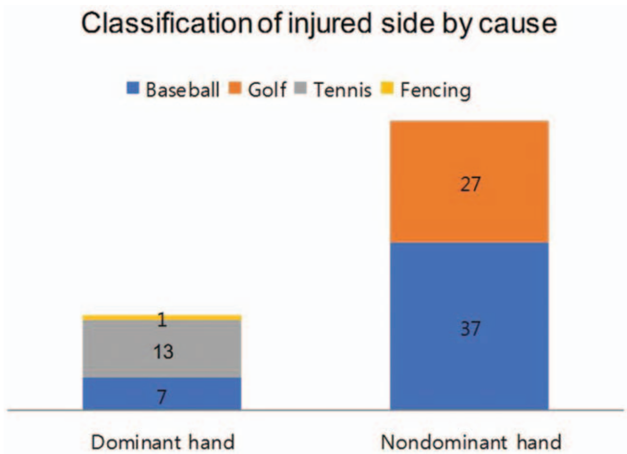

Figure 4. Classification of injured side of hands by causal sport (N=85).

Table 2

Comparison between before and after 1983.

	Before using CT (n=38)	After using CT (n=82)	*P*
Mean time from injury to diagnosis or surgery	7.02±10.91	5.39±5.46	.411

(The pre-1983 group consisted of Parker et al[15], Foucher et al[14], and 4 cases from the 1970 s). CT=computed tomography.

4. Discussion

Fractures of the hook of the hamate are rare, although the incidence of these fractures is increasing with increasing participation in racquet, bat, or club sports. However, these can often be misdiagnosed because it is difficult to make an accurate diagnosis early.

Many patients have been misdiagnosed initially in several literatures. Stark et al[14] have reported that 19 of 20 patients have been examined at other clinics and only 2 have been correctly diagnosed with fractures of the hook of the hamate. Eleven patients had been treated for wrist sprain or tendinitis while 7 had been injected with steroids on one or more occasions. Bishop et al[34] have reported that 17 patients have sought medical attention soon after their injuries but only 2 cases with this fracture have been diagnosed by the original physician.

4.1. Pathophysiology

These injuries are associated with repetitive grasping and loading of the hypothenar eminence in sports that require a strong grip such as baseball and golf.[30] The hook of hamate fracture is usually caused by inappropriate positioning of the instrument where the end of a club or butt of a racquet exerts force on the hamate directly or when there is a shearing force applied by the extrinsic flexor tendons of the ring and little fingers on the hook of hamate.[7,14,35] Especially in golf swings, at the moment of impact (ie, the wrist extension and radial deviation), the force transfer to the hook can reach its maximum.[14] This fracture can also occur during checked swings in baseball.[21]

Injury side is specifically related to the type of sport. Damage to a nondominant hand usually occurs during swinging while grasping the implement with both hands such as in baseball and golf. In contrast, dominant-side hand damage often occurs during racquet sports that use one hand such as tennis.[1,36]

4.2. Symptoms & physical examination

The most common symptoms in physical examinations are tenderness over the hook of hamate or ulno-palmar side or the dorso-ulnar side. Before examination, physicians should know the exact anatomical structure and test techniques of musculo-skeletal system. Foucher et al[15] have reported firm pressure over the hook of hamate area because the volar aspect of the hook is

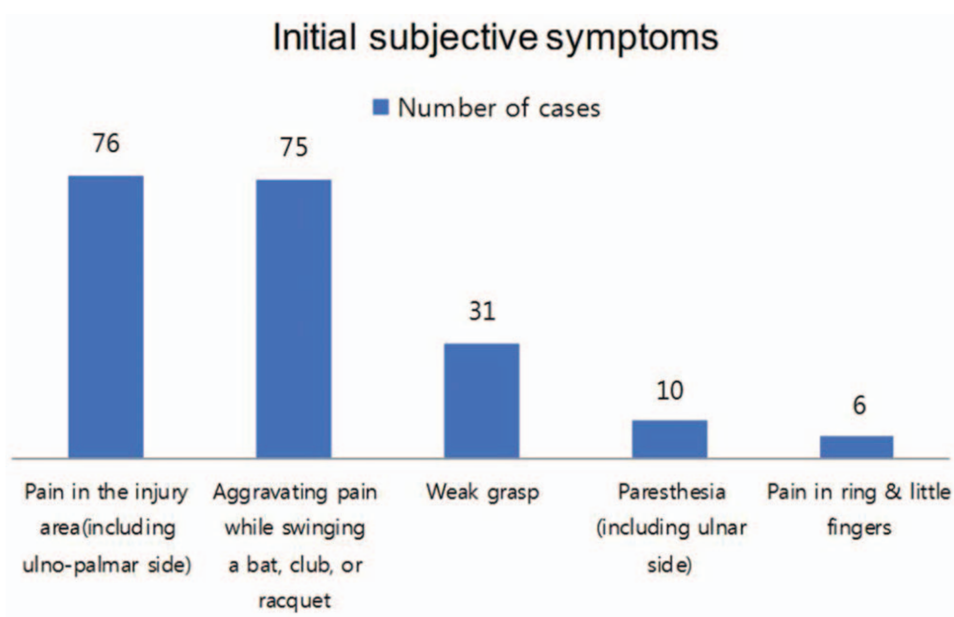

Figure 5. Initial subjective symptoms of patients with hook fractures (multiple answers were allowed, N=120).

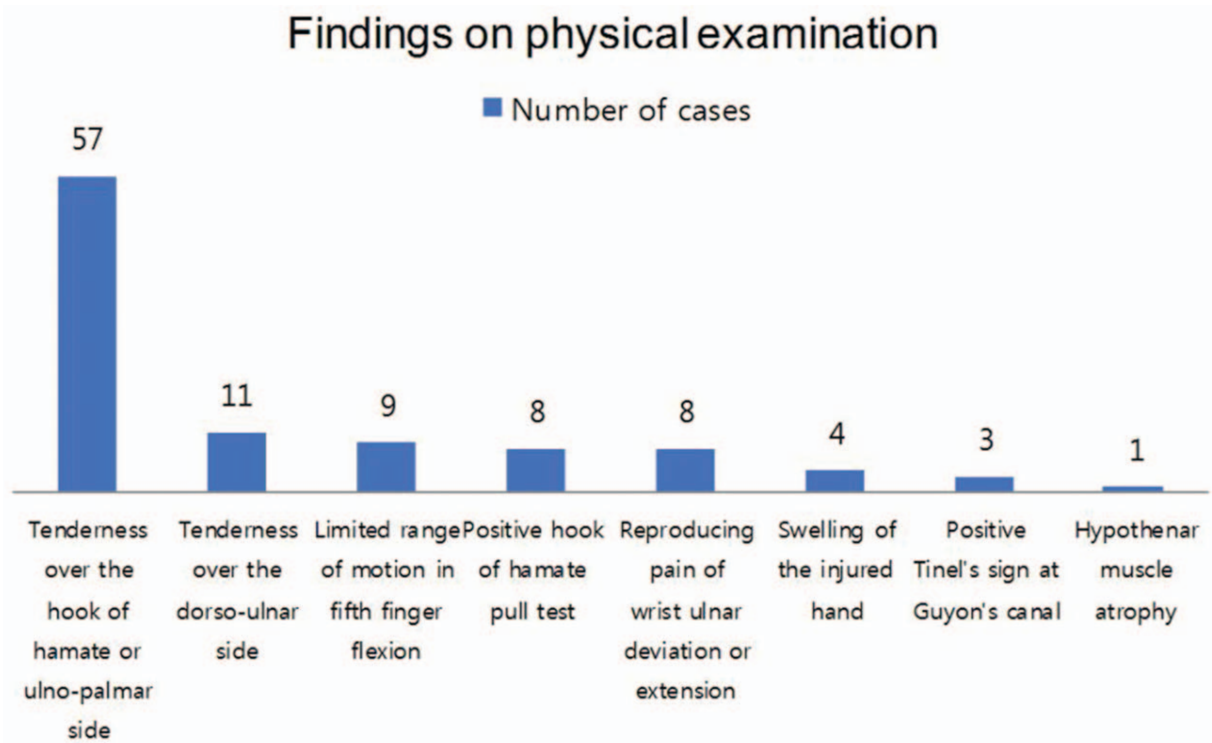

Figure 6. Physical examination findings (multiple answers were allowed, N=120).

covered with thick skin, subcutaneous tissue, a fibro-fatty pad, and parts of the palmaris brevis muscle. If a physician does not apply sufficient pressure onto this area, the patient may not feel discomfort. Because the fracture occurs at or near the base of the hook, tenderness can elicit pain in the dorso-ulnar area of the wrist.

Both pain and limited motion in the ring and/or little fingers are associated with fraying tendinitis of the flexor tendon. This is because hook of hamate fractures can create a rough surface that irritates the flexor tendon, causing pain and even rupture when fracture worsens.[15,24] Flexor tendon rupture in the hand is known to be very rare in patients without rheumatoid

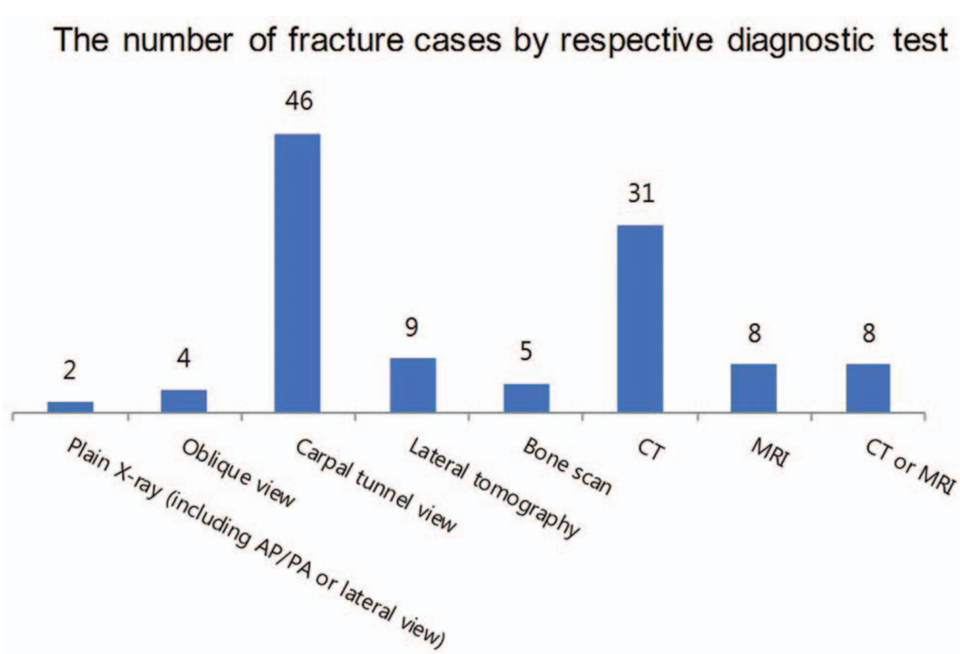

Figure 7. Number of cases detected by each diagnostic test (multiple tests were possible, N=113).

arthritis.[36] However, it has been reported in approximately 17% of hamate fractures.[28] Therefore, it is important to suspect that there is no hidden fracture such as hamate hook fracture when flexor tendon rupture occurs.

4.3. Time to diagnosis

Previously, plain x-ray and carpal tunnel view were primary diagnostic tools. However, Kato et al[37] reported that routine PA view could only identify 31% of fractures. Papp et al[38],have shown that the carpal tunnel view has an overall sensitivity of only 40% to 50% for diagnosing hook of hamate fractures.[39] In contrast, other studies have reported that CT has sensitivity of 100%, specificity of 98.4%, and accuracy of 97.2%.[4] CT scans are regarded as one of the best ways to detect hook of hamate fractures in difficult diagnostic cases.[40] Therefore, we compared the period before popular use of CT and after popular use of CT. We also determined how the development of diagnostic technique influenced early diagnosis of hook of hamate fractures. CT scans were first used clinically in 1971. Since then, their use has been extended rapidly, from fewer than 3 million per year in 1980 to more than 80 million now in the United States.[41]

It was impossible to determine exactly when this test was widely used for hamate fractures, although in 1983, Egawa et al[42] introduced CT as a new method for diagnosing these fractures. Referring to that original study, many subsequent studies have described the usefulness and application of CT in diagnosing hamate fractures.

As mentioned earlier, we divided studies into 2 groups (before- and after-1983) and compared the time from injury to diagnosis or treatment using a Mann–Whitney test. The purpose of this research was to investigate whether the development of diagnostic techniques affected the early diagnosis of hook of hamate fractures by comparing before- and after-1983 studies to determine whether there were significant differences in diagnosis or treatment time. Our results showed no statistically significant differences in diagnosis or treatment time between the 2 groups, indicating that the development of diagnostic techniques did not guarantee early detection of hook of hamate fractures. Although the development of imaging techniques has improved the sensitivity, specificity, and accuracy of the diagnosis, it is a tool that can aid the diagnostic process. Clinicians should have a strong suspicion for the disease first based on physical examinations and patient's history. With such suspicion, appropriate imaging tests can then be selected and used for diagnosis.

4.4. Diagnosis

It is difficult to identify such fractures because the base of the hamate is not well visualized on plain x-ray.[30] The carpal tunnel view may be helpful. However, full wrist dorsiflexion is necessary.[43] Pain of patients when hyperextending the wrist during test makes it difficult to perform the test during the acute phase of a fracture. Even if the examination is successfully carried out, it may not detect the fracture if it is extremely close to the base of the hamate.[15,44] Bishop and Beckenbaugh[34] have concluded that these x-ray tests are unreliable. They have recommended CT when there is doubt. CT can be done without pain. It shows the complete hamate bone which can help us diagnose the hook of hamate fracture. It is also useful for excluding other bone injuries or congenital anomalies. It is the radiographic technique of choice in the diagnosis of hook of hamate fractures.[4,15,16] MRI may provide information regarding injury to the surrounding soft tissue and vascularity of the hamulus. Separately, Aldridge et al[25] have suggested that MRI shows structures near the hamate bone such as the ganglia and neurovascular bundle in the Guyon's canal well with advantage of providing important information to differentiate TFCC. Bone scans are also helpful for localizing injuries. If hot uptake is detected, additional examinations such as CT, MRI, or carpal tunnel view x-ray are needed.[16] Hamate fractures suggest a high probability of ulnar nerve damage due to the anatomical position of hamate.[22,23,] These fractures can lead to motor, sensory, or mixed deficits. If patients present with obscure wrist pain and suspect ulnar nerve injury, it is worth performing electrodiagnostic study to diagnose the disease.

This diagnostic process is the same as in other fractures of carpal bone such as scaphoid, triquetrum, and trapezoid.[5–47] Because they might be radiographically occult initially, many investigators recommend that if there is still clinical suspicion with negative radiologic findings, a CT or MRI should be taken to confirm a fracture.[45] For early and proper diagnosis, it is important to be able to suspect a carpal bone fracture based on the mechanism of injury, local tenderness, and physical examination in order to choose appropriate diagnostic methods.

4.5. Treatment

Cast immobilization has shown high recurrence of symptoms and failure of union. Parker et al[16] have explained that the distracting force by the hypothenar musculature and the piso-hamate ligament applied to the hook of the hamate during cast immobilization can hinder bone union. In addition, limited finger movement and impaired vascularity of the hook through cast immobilization are factors that can affect recovery. Poor blood supply can cause nonunion and osteonecrosis.[48] Excising the hook fragment is regarded as the gold standard treatment. The procedure is desirable for athletes and laborers because it requires only short rehabilitation duration after surgery while allowing for early return to sports and work.[16,48] However, this surgery disconnects some important structures in the carpus. Thus, only some symptoms may improve.[48] As a result, functional impairment such as residual pain and reduced grip strength may remain.[34] Lee et al[27] have reported one patient with ulnar neuropathy after surgery, although the patient has a full recovery at 12 weeks after the surgery. The authors explained that neuropathy was caused by excessive traction of the deep branch of the ulnar nerve during surgery.

Open reduction and internal fixation (ORIF) using Kirschner wires or screws can be an alternative to excising the hook.[34] Its aim is to prevent functional impairment by maintaining anatomic connection of the carpus.[48] However, studies that establish standard surgical guidelines are limited. There is no clear evidence that ORIF is more beneficial than excision either.[1,48] In addition, it is technically difficult, requiring a long period before the patient can return to work or sports activities.[27,49]

4.6. Predictive factors of recovery period

In multiple regression analysis, only age had a significant effect on recovery period. This result may be explained by the fact that older patients tend to have better compliance with pain medication than younger patient. Therefore, pain scores tend to decrease with age when fracture occurs.[50] These patients may continue sports activity, leading to progression of fractures or complications such as nerve and tendon injury that eventually require more time for treatment and rehabilitation. We hypothesized a positive relationship between recovery period and time from injury to diagnosis or surgery. However, the result did not support such hypothesis. This might be due to multiple factors that affect injury recovery. We expect that the degree and extent of initial injury, type of fractures, accompanying nerve injury, initial pain scores, surrounding tissue damage, methods of treatment, and duration of postoperative rehabilitation can affect recovery periods. As a few papers have described this information, effects of each variable on the recovery period are currently unknown. The correlation between independent variables could not be assessed either. In addition, most studies were case reports with small sample sizes. They mainly focused on treatment such as the surgical technique. Very little information is available about the diagnosis process. Thus, additional researches with larger sample sizes are needed to investigate factors that influence the recovery period.

In chronic hook of hamate fractures, ulnar nerve and flexor tendon injuries have been reported in as many as 38% of cases.[12] These complications may also affect treatment outcomes and period to return to daily life and activity of sports. Thus, early diagnosis is an essential precedent factor for rapid recovery.

5. Conclusions

Despite advances in diagnostic techniques, the diagnosis period for hook of hamate fractures did not decrease. Delayed diagnosis can lead to nonunion or late complications such as flexor tendon rupture, ulnar nerve injury, carpal tunnel syndrome, and avascular necrosis. Early diagnosis requires knowing the nature of the injury such as the type of sport that caused it, the side of the hand pain, any major symptoms and physical examination results, and appropriate diagnostic work-ups. All these suggest clinical suspicion of this disease. In conclusion, strong clinical suspicions with careful history taking and physical examination enable early diagnosis to prevent delayed complications.

Author contributions

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