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Computerized tomographic prediction of flexor tendon injuries complicating hamate hook fractures

Shinsuke Takeda[1,2], Masahiro Tatebe[1], Hisao Ishii[1], Akimasa Morita[3], Kenji Wakai[4] and Hitoshi Hirata[1]

Abstract

We reviewed computerized axial tomography of 28 patients with hamate hook fractures who had surgical resection of the hook. We analysed the relationship between the fragment height ratio, fragment gap, and intraoperative findings of the tendons. We determined whether parameters in the images can predict complication of tear or disruption of the flexor tendons to the ring or little fingers. Of 28 patients, 16 had fragment height ratios between 50–74; ten among them had worn (eight patients) or ruptured (two patients) flexor tendons. Nine of the ten patients had fragment gaps greater than 2 mm. The remaining 12 patients had fragment height ratios between 75–100 and had intact tendons. We conclude that a fragment height ratio greater than 75 and fragment gap less than 2 mm in computer tomography may rule out tear or disruption of the flexor tendons of the ring and little fingers after hamate hook fractures, and a fragment height ratio between 50–74 with fragment gap greater than 2 mm indicates a high risk of flexor tendon tear or disruption.

Level of evidence: IV

Keywords

Computerized axial tomography, tendon injury, hamate hook fracture, hamate, fragment height ratio

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Introduction

Hamate hook fractures often occur during sports activities. Hamate hook fractures are treated conservatively or surgically (Scheufler et al., 2006). Neglected hamate hook fractures increase the risk of flexor tendon ruptures (Hartford and Murphy, 1996; Milek and Boulas, 1990; Minami et al., 1985; Stark et al., 1989; Yamazaki et al., 2006). The hamate hook acts as a pulley for the flexors of the ring finger and little finger. Flexor tendons are prone to irritation by the rough fracture surface, causing rupture (Scheufler et al., 2013; Xiong et al., 2010). A careful physical examination resulting in early diagnosis is important for preventing tendon rupture. Traditionally, fractures and dislocation of the hamate are identified with plain X-ray films (Borse et al., 2010; Rockwood and Green, 1996). High-resolution computerized tomography (CT) has been used for diagnosis of these fractures (Andreson et al., 1999). CT can be considered part of the initial diagnostic investigation when a hamate fracture is suspected.

A united hamate hook fracture fragment sometimes shows peripheral sclerosis or a round surface due to tendon irritation (Hartford and Murphy, 1996; Yamazaki et al., 2006). However, not all hamate hook fractures cause flexor tendon rupture (Scheufler et al., 2013; Stark et al., 1989; Xiong et al., 2010).

[1]Department of Hand Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan
[2]Hand and Microsurgery Center, Anjo Kosei Hospital, Anjo, Aichi, Japan
[3]Department of Orthopaedic Surgery, Suzuka Kaisei Hospital, Suzuka, Mie, Japan
[4]Department of Preventive Medicine, Nagoya University Graduate School of Medicine, Nagoya, Japan

Corresponding Author:
Shinsuke Takeda, Department of Hand Surgery, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan.
Email: s7.takeda.jpn@gmail.com

Xiong et al. (2010) suggested a relationship between tendon injury and the three fracture types: type I (avulsion fracture at the tip of the hamate hook), type II (fracture in the middle part of the hamate hook), and type III (fracture at the base of the hamate hook). According to their report, type II fractures were associated with a higher tendon rupture risk and nonunion incidence than type I and type III because flexors are directly in contact with the fracture sites (Xiong et al., 2010). However, these classifications have no clear radiological parameters; therefore, we cannot detect the risk of flexor tendon rupture distinctively by the fracture patterns.

In this study, we reviewed CT images of hamate hook fractures and the intraoperative findings of flexor tendons of 36 patients. We hypothesized that the radiological parameters of CT may be useful for predicting flexor tendon complications.

Methods

We retrospectively assessed 36 patients who had hamate hook fractures and who were treated between January 2008 to December 2015 at two institutions specializing in hand surgery from. The inclusion criteria for this study were acute or chronic hamate hook fractures with exposure of the fracture site and diagnosis with CT. We eliminated eight patients: seven who were treated conservatively and one who underwent percutaneous osteosynthesis.

The remaining 28 patients (27 male and one female; mean age 32 years; range 15 to 57 years) were included in this study. Ten injured the right hamate and 18 injured the left hamate. The time from the first symptom of fracture to surgical treatment ranged from 10 days to 24 months.

Almost all patients had tenderness in the proximal ulnar part of the palm. One patient fractured the scaphoid and capitate as well as the hamate hook. Two patients could not flex their little finger when they presented to our hospital. No patient had difficulty flexing the ring finger, and none had ulnar or median nerve palsy.

CT assessment

We obtained CT images from the distal radioulnar joint to the proximal one-third of the metacarpals at an average of 3.3 months after the first symptom of fracture (range 1 day to 23 months) using a Brilliance CT scanner (64-row Aquilion multislice CT system; Toshiba, Tokyo, Japan). These images were obtained in the standard prone position with 90° of forearm pronation and a hand neutral position. We used a high-resolution sequence with a slice thickness of 0.5 mm.

We assessed the morphology of the fractures, such as transverse fractures and oblique fractures (from ulno–dorsal to radio–palmar or from ulno–palmar to radio–dorsal), using CT images (Figure 1). We drew five parallel lines: on the dorsal border of the hamate (point A) (Figure 2), base of the hamate hook (point B), dorsal point of the fracture site (point C), palmar point of the fracture site (point D), and palmar tip of the hamate hook (point E). Points C and D were through each radial edge. The fracture gap was measured between points C and D.

We defined the fragment height ratio (FHR) as the distance between points D and E divided by points A and C (Figure 2). To measure interobserver and intraobserver reliability, three orthopaedic surgeons (including the first author) were provided with a series of plain CT films from the 28 patients. They were asked to estimate both the FHR and fragment gap on the plain film using the standard computerized measurement calliper (Figure 2) without instructions. After a 2-week washout period, the same three repeated estimates were performed for the provided films.

Intraoperative findings

All hook excision surgeries were performed through a volar approach, and we examined both the flexor digitorum superficialis and flexor digitorum profundus tendons of the ring and small fingers. The whole flexor tendon surface status was classified as intact, worn, or ruptured, according to intraoperative observations by the surgeon. Intact was defined as a smooth surface, worn was defined as a rough surface, and ruptured was defined as a torn flexor. Figure 3 shows representative examples of ruptured and worn tendons.

Intraobserver and interobserver reliabilities

Intraobserver and interobserver reliabilities were calculated using the intraclass correlation coefficient (Shrout and Fleiss, 1979). Agreement was interpreted as poor if the intraclass correlation coefficient was < 0.20, fair if it was 0.21–0.40, moderate if it was 0.41–0.60, good if it was 0.61–0.80, and very good if it was > 0.80 (Landis and Koch,1977).

Results

Patients with tendon complications

During surgery, ten patients had torn (eight patients) or ruptured (two patients) flexor tendons. All ten

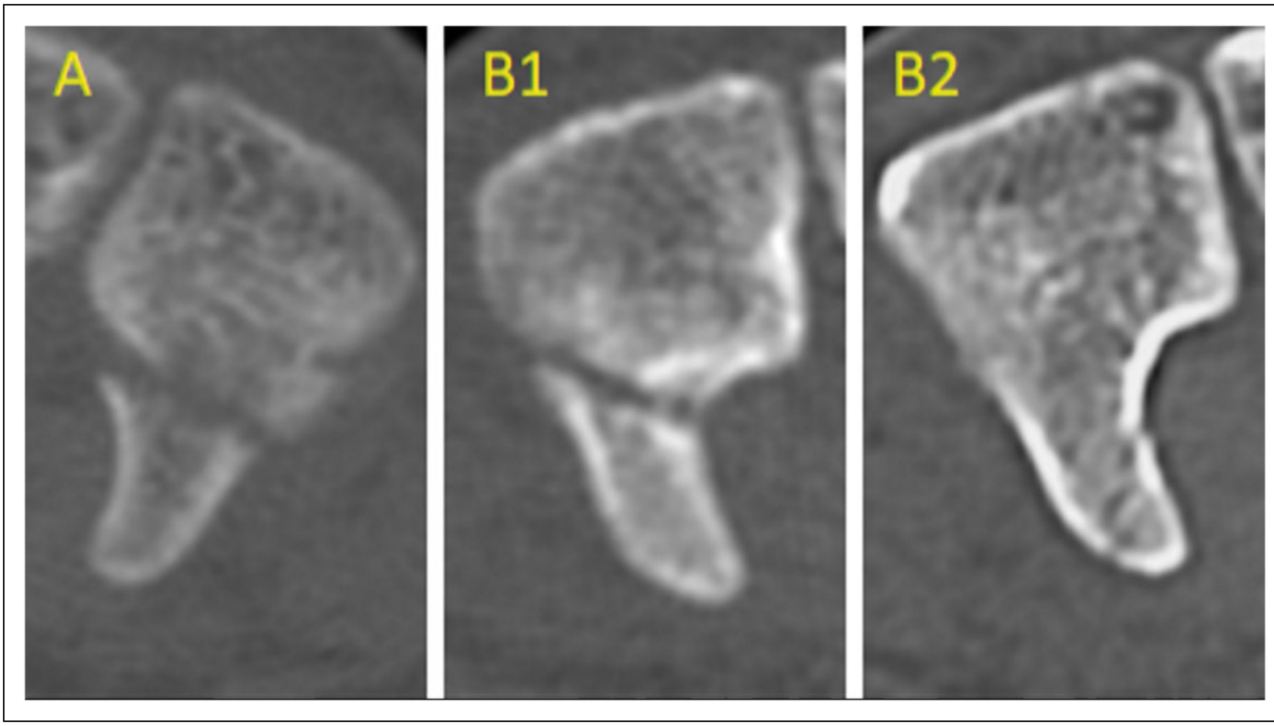

Figure 1. Fracture types: transverse type (A) and oblique type. Ulno–dorsal to radio–palmar type (B1) and ulno–palmar to radio–dorsal type (B2).

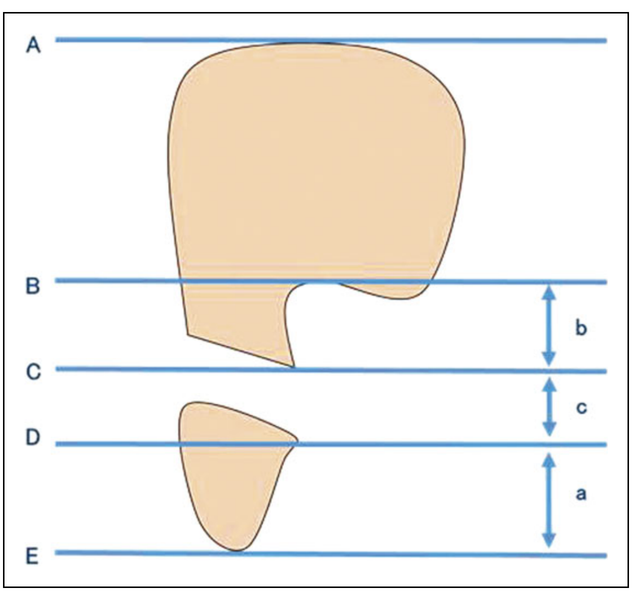

Figure 2. Radiological parameters. Fragment height: a. Fragment height ratio (FHR): a/(a+b) × 100. Fragment gap: c.

were men. The interval between primary clinical symptom with injury and surgery ranged from 18 days to 12 months (Table 1). The operation was conducted 40 and 60 days after primary clinical symptoms of fracture for the two cases of ruptured flexor tendons. The remainning18 patients had intact flexor tendons.

Relation of tendon complications with the FHR and fragment gap size

Of 28 patients, 16 had FHR of 50–74; ten among them had worn or ruptured flexor tendons. Nine of the ten patients had fragment gaps greater than 2 mm. The remaining 12 patients had FHR of 75–100 and had intact tendons. The fragment gap size of these 28 patients ranged from 0 to 5.2 mm. Nine out of ten patients having had tendon complications had the gap size greater than 2 mm.

We found that patients with FHRs between 50–74 were at risk for tendon injuries. Furthermore, ten patients with FHRs between 50–74 had type II fractures, and all patients with rupture of the flexor tendons had type B1 hamate fractures (Xiong et al., 2010).

Intraobserver reliability and interobserver reliability

Because of its unique hook shape and the small size of the hamate hook, we usually chose the same axial view to confirm the whole hamate by measuring 0.5-mm slice thicknesses. The three observers chose the same axial view for 24 of 28 patients.

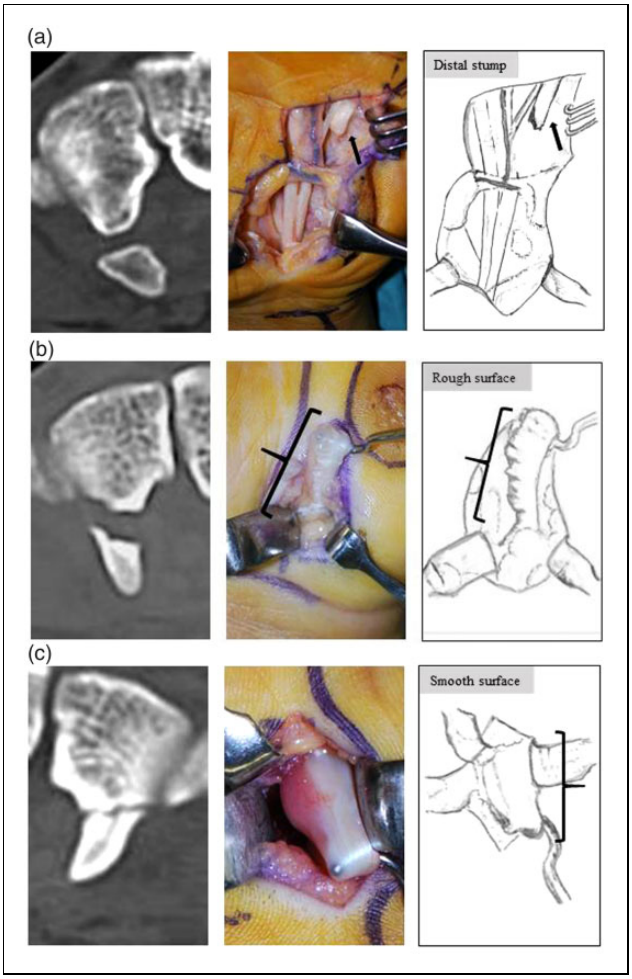

Figure 3. Computerized axial tomography images and findings of tendon injuries. (a) Ruptured tendon. The arrow indicates the distal stump of the flexor digitorum profundus of the left small finger. (b) Worn tendon. The bracket indicates the rough surface of the flexor digitorum profundus of the left small finger. (c) Intact tendon. The bracket indicates the smooth surface of the flexor digitorum profundus of the left small finger.

Fragment gap measurements had excellent or good intraobserver reliability for the three observers (intraclass correlation coefficients = 0.900, 0.921, and 0.764). FHR had excellent intraobserver reliability (intraclass correlation coefficients = 0.914, 0.879, and 0.841). The fragment gap and FHR measurements showed good interobserver reliability for primary and secondary observations (fragment gap intraclass correlation coefficients = 0.701 and 0.821; FHR intraclass correlation coefficients = 0.686 and 0.754).

Discussion

In our series, eight out of ten patients with tendon complications had tears and two had complete disruption of the flexor tendons. Our data indicate that patients with FHRs between 50–74 and fragment gaps $\geq$ 2.0 mm are at high risk for injury of the flexor tendons to the ring or little fingers. The CT assessment for FHR had excellent or good interobserver and intraobserver reliabilities. A FHR between 50–74 indicates that the fracture is in the middle part of the hamate hook. Tendon ruptures typically occur with the fracture in the middle part of the hamate. A FHR between 0–49 indicates a tip fracture. None of our patients had FHRs in this range. A flexor tendon rupture can occur with tip fractures (Pajares-López et al., 2011; Yamazaki et al., 2006). Our patients with FHRs between 75–100 did not have tendon complications.

Although our study aim was not about treatment of this fracture, we consider the decision on how to treat hamate hook fractures should be based on the demands of the patient and if the fragment gap is $\geq$2.0 mm and the FHR is between 50 and 74. We strongly recommend open reduction and internal fixation or hook resection for these patients. The actual incidence of complete rupture of the flexor tendons in these patients is still low, but such complications cannot be ruled out. Clinical examination of the power and active motion of the ring and little fingers should also aid in the decision regarding the need for surgical exploration. If weakness, pain, or loss of active flexion of the ring and little fingers are found, we strongly recommend surgical exploration.

This study had some limitations. First, it was retrospective, and the study contains surgical cases from two institutes over a 7-year period. The hook fracture is not common and those needing surgery is even less. Thus, it is quite difficult to have a large number of patients with hamate fractures who undergo surgical exploration. Second, there may be bias in decision on operation timing; earlier explorations may mean that there has not been enough time for the tendon injury to develop, because the tendon injuries are caused by the fractured hamate after occurrence of the fracture. The longer the delay, the greater risk of traumatizing the flexor tendon during finger motion. Third, we could not investigate the association between three-dimensional morphology of the fracture and tendon injury. Fourth, we could not analyse plain radiographic data or assess the tendon location using CT images.

Table 1. Ten patients with complications of injuries to the flexor tendons.

Patient no.	Age (years)	Hand	Tendon finding	FHR (%)	Gap (mm)	Interval between primary symptom and surgery (days)	Cause of injury
1	46	Right	Ruptured	59	4.2	40	Golf (swinging)
2	30	Left	Worn	75	4.8	300	Baseball (batting)
3	23	Left	Worn	68	4.3	20	Baseball (batting)
4	24	Left	Worn	63	4.2	18	Baseball (batting)
5	56	Left	Ruptured	61	2.8	60	Lawn mowing
6	44	Right	Worn	70	2.8	210	Carrying heavy baggage
7	38	Left	Worn	72	4.1	120	Softball (batting)
8	36	Right	Worn	65	2.1	360	Fall down
9	40	Left	Worn	71	5.2	150	Softball (batting)
10	26	Right	Worn	68	1.0	22	Baseball (batting)

FHR: fragment height ratio.

Declaration of conflicting interests The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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