Clinical Imaging 58 (2019) 66–69

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: www.elsevier.com/locate/clinimag

Musculoskeletal and Emergency Imaging

Closed rupture of the flexor tendon pulleys of the thumb☆

Michael S. Brown*, John O'Donnell, Daniel Walz

Department of Radiology, Northwell Health, 300 Community Drive, Manhasset, NY 11030, United States of America

ABSTRACT

Closed rupture of the thumb flexor tendon pulleys is rare and, to our knowledge, the MRI findings associated with this injury have not been described in the radiology literature. The injury can result in nonspecific clinical and physical exam findings and advanced imaging may be crucial to diagnosis. A familiarity with the normal anatomy of the flexor mechanism of the thumb and the imaging appearance of pathology is therefore necessary. We report a case of a 31-year-old female nurse with ruptures of several of the thumb flexor pulleys and the corresponding findings on MRI.

1. Introduction

Pulleys of the digits are fibrous bands that overlie the synovial sheaths of the flexor tendons and are present in the thumb and fingers. The anatomy of the pulley system of the thumb is different from that of the fingers. (Fig. 1). There are three constant pulleys of the thumb: the first annular pulley (A1), the oblique pulley (Ao), and the second annular pulley (A2). The first annular pulley (A1) is located at the level of the metacarpophalangeal (MCP) joint and the second annular pulley is located at the level of the interphalangeal (IP) joint. As it courses distally, the oblique pulley runs from the ulnar aspect of the proximal phalanx to the radial aspect of the proximal phalanx in between the A1 and A2 pulleys [1]. A variable annular pulley (Av), located between the A1 and oblique pulleys, has also been found in over 90% of cadaver specimens with three possible orientations: transverse, oblique, or continuous with the A1 pulley [2]. By preventing bowstringing of the flexor tendons, flexion of the thumb is mainly supported through the first annular and variable annular pulleys [3].

Only a small number of studies in the orthopedic literature have dealt with flexor tendon pulley injuries of the thumb [4–6]. Damage to part or all of the flexor pulleys can have a substantial effect on the performance of the digit, so diagnosis is important [7]. The excellent soft tissue contrast and resolution of MRI allows for visualization of the entire pulley system in the thumb and fingers [8,9]. Findings on MRI have been reported in the fingers when the pulleys are torn [9]. MRI findings of rupture of the thumb flexor pulleys have not been reported.

2. Case report

The patient is a 31-year-old Asian right hand dominant female nurse. She reported pain in her thumb after riding an ATV nearly a year prior to presenting to her orthopedist. She reported forcefully squeezing the accelerator of the ATV for over 2 h followed by thumb pain. The symptoms persisted for 11 months and were described as intermittent, dull and aching and were made worse with activity and relieved with rest. There was also limited passive range of motion at the metacarpophalangeal joint. Physical exam revealed no swelling, ecchymosis or deformity with mild tenderness over the expected region of the A1 pulley.

PA, lateral and oblique X-rays performed in the orthopedist's office demonstrated no fracture or dislocation with preserved joint spaces. The flexor tendon sheath was injected with 6 mg of Celestone and 1 ml of lidocaine (0.5%). She reported good initial response to the injection but returned to the orthopedist two months later for persistent symptoms which she stated never completely resolved. MRI of the thumb was performed utilizing a 1.5 T GE Optima MR430 Extremity Scanner with sagittal T1 weighted, sagittal proton density, coronal proton density, coronal fat saturated proton density, axial proton density, axial T1 weighted and axial fat saturated T2 weighted sequences. The thumb was fully extended for imaging and coronal and sagittal images were

☆ The authors have no conflicts of interest.

* Corresponding author.
E-mail addresses: Mbrown26@northwell.edu (M.S. Brown), jodonnell@northwell.edu (J. O'Donnell), dwalz@northwell.edu (D. Walz).

https://doi.org/10.1016/j.clinimag.2019.06.004
Received 2 April 2019; Received in revised form 21 May 2019; Accepted 11 June 2019

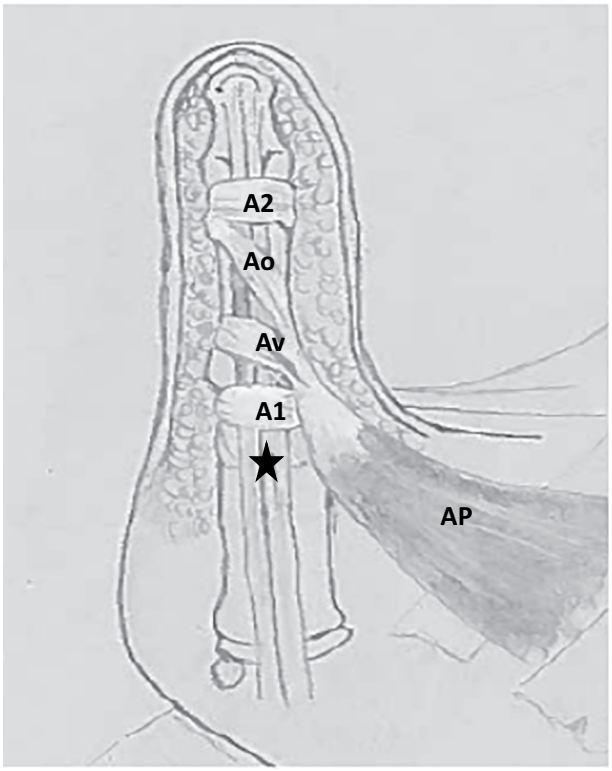

Fig. 1. Anatomy of the thumb pulley system. AP – Abductor Pollicis Muscle. Star – Flexor Pollicis Longus Tendon.

tilted 90 degrees to the sesamoids at the level of the metacarpophalangeal joints. The MRI demonstrated tears of the A1 and oblique pulleys of the thumb with associated thickening and scar remodeling of the torn pulley stumps (Figs. 2 and 3). The flexor pollicis longus tendon was intact but there was scarring of the tendon sheath and tenosynovitis from the level of the metacarpophalangeal to the level of the interphalangeal joint. There was slight volar displacement of the tendon from its expected location at the level of the metacarpophalangeal joint and proximal phalanx, consistent with bowstringing (Fig. 4). Unfortunately, after completion of the MRI, the patient was lost to follow-up.

3. Discussion

Closed rupture of the flexor tendon pulleys is an uncommon injury, occurring mainly in rock climbers and usually described in fingers, especially the ring finger and middle finger. The ruptures can be partial or complete and can occur in isolation or in combination with multiple pulley tears. Patients frequently complain of an audible pop or tearing sensation with pain over the injured pulley. Physical exam demonstrates swelling and pain over the affected pulley with possible ecchymosis and hematoma formation. Significant bowstringing is not appreciated until sequential pulleys are ruptured [10]. Repeated corticosteroid injections have also been described as a cause of pulley rupture [11].

Damage to the pulley system can have a significant effect on the performance of the digit. The oblique pulley is the most important pulley in the thumb and facilitates the full range of motion of the flexor pollicis longus [1]. Some surgeons support that two of the three pulleys have to be torn before the functional consequence of a loss of thumb flexion can be clinically observed [12]. In a cadaver model, Zissimos et al. found that isolated sectioning of either the A1 pulley or the oblique pulley did not significantly alter thumb flexor biomechanics, however, when both the A1 and oblique pulleys were disrupted, significant bowstringing occurred in association with decreased flexion of the interphalageal joint. They found no difference with bowstringing with respect to intact versus sectioned A2 pulley. Their conclusion was that either the A1 or oblique pulley must be kept intact or reconstructed to maintain normal thumb mechanics [13].

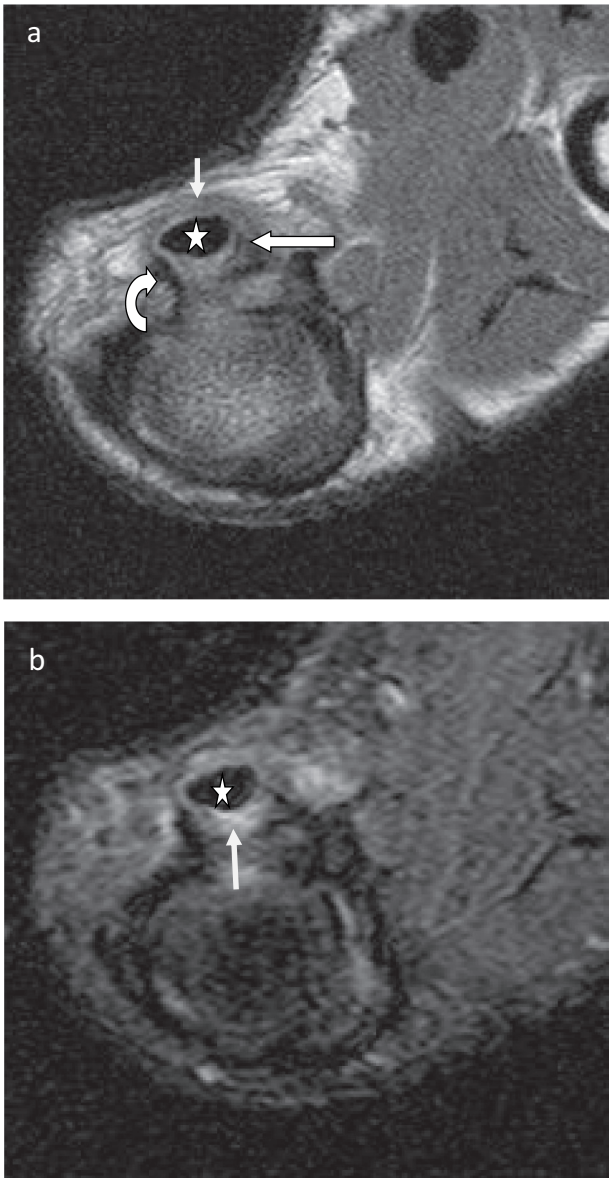

Fig. 2. A 31 year old female nurse with thumb pain. (a) Axial proton density MR image demonstrates a tear of the first annular pulley (A1) (short arrow) at the level of the metacarpophalangeal joint with retracted radial (curved arrow) and ulnar (long arrow) limbs of the pulley. The flexor pollicis longus (FPL) tendon (star) is intact, but volarly displaced from its expected location. (b) Axial fat-saturated proton density sequence at the same level demonstrates fluid (arrow) in the FPL tendon sheath (star), consistent with tenosynovitis.

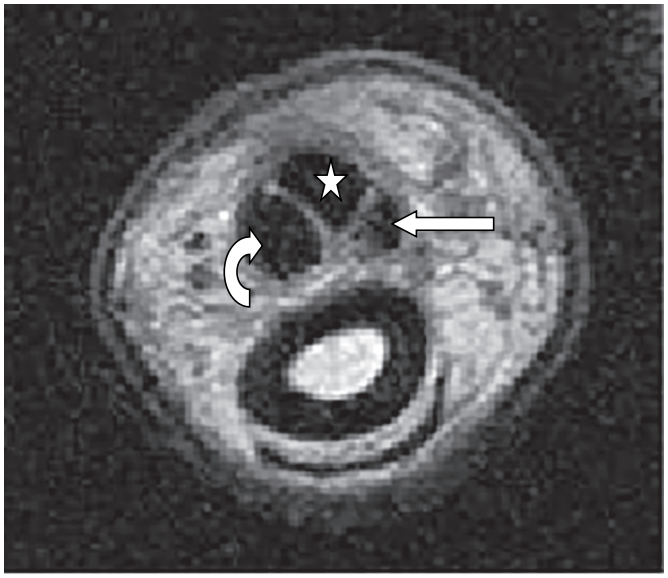

Fig. 3. Same patient. Axial proton density MR image demonstrates a tear of the oblique pulley (Ao) at the level of the proximal phalanx with thickened/scarred and retracted radial (curved arrow) and ulnar (arrow) limbs of the pulley. The flexor pollicis longus (FPL) tendon (star) is intact, but volarly displaced from its expected location.

Imaging may be obtained in patients with flexor pulley ruptures when clinical exam findings are nonspecific. Radiographs are typically normal but may rule out other injuries. MRI allows for visualization of the entire pulley system and, in the longer fingers, abnormalities have been shown to be directly diagnosed with either direct visualization of the torn pulley in the axial plane or nonvisualization of the pulley in the sagittal plane. There may be edema along the course of the involved pulleys and increased tendon to bone distance secondary to anterior subluxation of the flexor tendons ("bowstringing") in more severe injuries [9].

On MRI, Hirschmann et al. found that the signal intensity of the four pulleys of the thumb to be variable on T1 weighted images in asymptomatic volunteers. The oblique annular (Ao), first annular (A1), and second annular pulleys were found to have intermediate signal intensity in the majority of volunteers while the variable annular pulley was primarily of low signal intensity. The thickness of the first annular pulley was reported at 0.5 mm [8].

In our case, ruptures of the A1 and oblique pulleys of the thumb were demonstrated on MRI in a 31 year old female after a remote traumatic episode. The findings were similar to that noted in pulley ruptures of the fingers with clearly visualized fiber disruption of the affected pulleys, retraction of the ulnar and radial limbs of the pulleys, and volar displacement of the flexor pollicis longus tendon. Thickening of the limbs was consistent with scar remodeling and the chronic nature of the injury. There was also associated tenosynovitis which may have contributed to patient discomfort. Given that the oblique and A1 pulleys were torn, restricted flexion of the interphalangeal joint may have been expected.

Treatment of flexor pulley injuries is mostly conservative with rest, ice and anti-inflammatory medications. External tape or rings have been shown to reduce tendon bowstringing [14]. Various pulley reconstruction techniques have been described including several for thumb pulley reconstruction and may include a palmaris longus autograft [4–6].

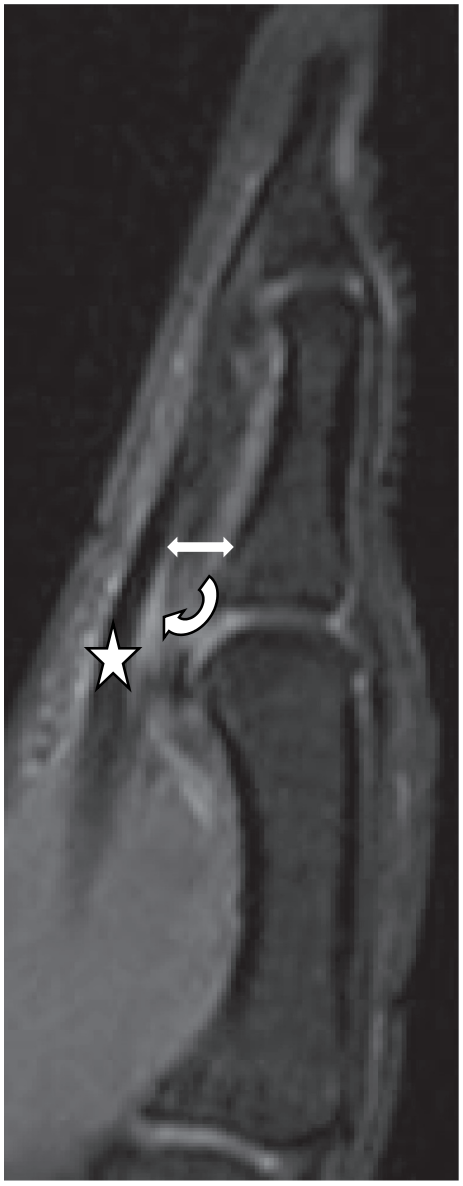

Fig. 4. Same patient. Sagittal fat saturated proton density MRI demonstrates volar displacement ("bowstringing") (double arrow) of the flexor pollicis longus tendon (star) with associated tenosynovitis (curved arrow).

References

[1] Doyle JR, Blythe WF. Anatomy of the flexor tendon sheath and pulleys of the thumb. J Hand Surg Am 1977;2(2):149–51.

[2] Schubert MF, Shah VS, Craig CL, Zeller JL. Varied anatomy of the thumb pulley system: implications for successful trigger thumb release. J Hand Surg Am 2012;37(11):2278–85.

[3] Bayat A, Shaaban H, Giakas G, Lees VC. The pulley system of the thumb: anatomic and biomechanical study. J Hand Surg Am 2002;27(4):628–35.

[4] Wilson SM, Roulot E, Le Viet D. Closed rupture of the thumb flexor tendon pulleys. J Hand Surg Br 2005;30(6):621–3.

[5] Kosiyatrakul A, Jitprapaikulsarn S, Durand S, Oberlin C. Closed flexor pulley rupture of the thumb: case report and review of literature. Hand Surg 2009;14(2–3):139–42.

[6] Fazilleau F, Cheval D, Richou J, Le Nen D. Reconstruction of closed rupture of thumb flexor tendon pulleys with a single free palmaris longus tendon graft: a case report and review of literature. Chir Main 2014;33(1):51–4.

[7] Low CK, Pereira BP, Ng RT, Low YP, Wong HP. The effect of the extent of A1 pulley

release on the force required to flex the digits. A cadaver study on the thumb, middle and ring fingers. J Hand Surg Br 1998;23(1):46–9.
[8] Hirschmann A, Sutter R, Schweizer A, Pfirrmann CW. MRI of the thumb: anatomy and spectrum of findings in asymptomatic volunteers. AJR Am J Roentgenol 2014;202(4):819–27.
[9] Hauger O, Chung CB, Lektrakul N, Botte MJ, Trudell D, Boutin RD, et al. Pulley system in the fingers: normal anatomy and simulated lesions in cadavers at MR imaging, CT, and US with and without contrast material distention of the tendon sheath. Radiology 2000;217(1):201–12.
[10] Zafonte B, Rendulic D, Szabo RM. Flexor pulley system: anatomy, injury, and management. J Hand Surg Am 2014;39(12):2525–32. [quiz 33].
[11] Hamano H, Motomiya M, Iwasaki N. Adverse effect of repeated corticosteroid injections for trigger finger on flexor pulley system. J Hand Surg Eur Vol 2013;38(3):326–7.
[12] Esplin VS, Tencer AF, Hanel DP, Cosio MQ. Restoration of function of the thumb flexor apparatus requires repair of the oblique and one adjacent flexor tendon pulley. J Orthop Res 1996;14(1):152–6.
[13] Zissimos AG, Szabo RM, Yinger KE, Sharkey NA. Biomechanics of the thumb flexor pulley system. J Hand Surg Am 1994;19(3):475–9.
[14] Schoffl I, Einwag F, Strecker W, Hennig F, Schoffl V. Impact of taping after finger flexor tendon pulley ruptures in rock climbers. J Appl Biomech 2007;23(1):52–62.