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CASE REPORTS

Spontaneous rupture of a flexor digitorum profundus tendon at two levels in zones II and III in a child

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Introduction

Closed flexor tendon ruptures in the mid-substance rarely occur in healthy adults [25] and usually are subject to an underlying pathologic condition. Extrinsic causes for rupture are due to abnormalities of the carpus as fracture, tumor, or deforming arthritis, leading to fraying of the tendon against rough cortex or bone spikes and attritional tendon rupture [8, 12, 19, 30]. Intrinsic causes for rupture are intratendinous steroid injections or diminished tendon vascularity and nutrition, leading to intratendinous weakening of the tendon [1, 9, 18]. Most spontaneous flexor tendon ruptures without underlying pathology occur in zone III [4, 25]. We present a case of a traumatic closed flexor digitorum profundus (FDP) rupture at two levels in zones II and III of the ring finger in a 12-year-old boy. To date, traumatic closed mid-substance flexor tendon ruptures have not been reported in the pediatric population nor has a simultaneous rupture of a flexor tendon at two levels been described.

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Case Report

A healthy 12-year-old boy sustained an axial trauma to his extended right ring finger playing basketball. He presented to our clinic 5 weeks after the injury. He showed minor swelling of the ring finger at the middle phalanx with inability to actively flex his distal interphalangeal (DIP) joint. The range of motion of the other joints of the finger was normal and there were no neurovascular deficits. Plain radiographs did not show any fracture or underlying osseous pathology. On MRI, a complete rupture of the FDP tendon was appreciated in zone II and a second rupture was described in the palm, corresponding to zone III (Fig. 1a–c). Surgery was performed 40 days after the injury in arm plexus anesthesia; a 250-mm Hg arm tourniquet was applied after exsanguination. Loupes (3.5×) were used. A Bruner-type incision was carried out from the DIP joint to the flexor crease of the metacarpophalangeal joint of the ring finger. A transverse incision of the ecchymotic flexor tendon sheath was performed distal to the A3 pulley. A complete rupture of the deep flexor tendon was evident with minor adhesions of the tendon stumps to the pulley system. The proximal stump was retracted to the level of the A3 pulley, and the distal stump measured 1.5 cm. Both tendon ends showed fibrotic scar formation that was resected and adhesions to the surrounding gliding sheet were liberated. By pulling at the proximal stump to approximate the stumps for the tendon suture, an 8-cm free segment of the FDP tendon was delivered out of the synovial sheath. A second skin incision was done proximally to the distal palmar crease. Resection of the fibrous degenerative tissue at the stumps was performed meticulously to preserve maximum length of the free intercalated tendon segment that was to act as a "graft." The pulley system was intact. On inspection, a possible underlying pathology for the tendon rupture was not found. Macroscopically, the tendon presented normal without signs for an intratendinous malformation (Fig. 2a). The free

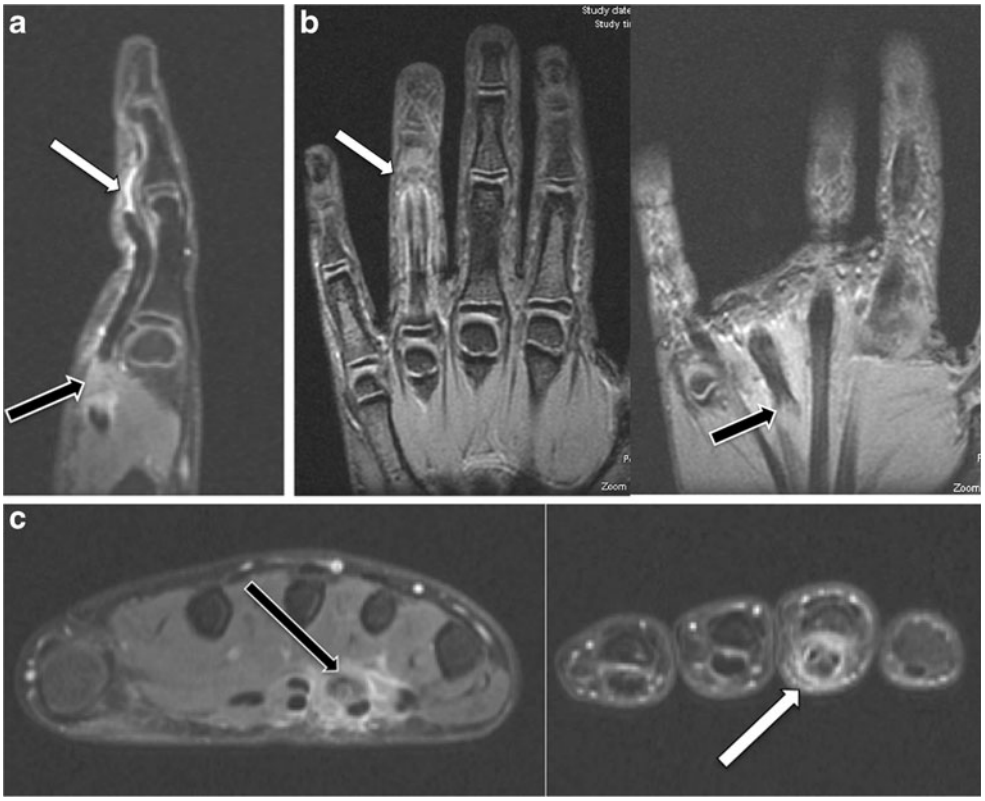

Fig. 1 **a**–**c** MRI findings. Proximal rupture site in zone III (*black arrow*) and distal rupture site in zone II (*white arrow*). **a** Sagittal plane. **b** Frontal plane. **c** Transversal plane

tendon fragment was repositioned anatomically into the tendon sheath and pulley system. First, the distal tenorraphy was performed with a four strand core suture according to Savage [31] with 4.0 Prolene® suture distal to the A4 pulley followed by an epitendinous partial interlocking cross stitch with 6–0 Prolene® suture (Fig. 2b). The repair was reinforced by a transosseous pullout suture with 4–0 Prolene®, placed through the distal phalanx distal to the physis and secured dorsally with a button for 8 weeks. Second, the direct suture at the proximal tendon rupture site was performed as described above (Fig. 2c). Free gliding of the tendon under the pulleys was evident on passive traction. Skin suture was accomplished with 6–0 Ethilon® suture. On completion of the intervention, the finger showed more flexion than the other fingers but it could be passively fully extended with the wrist in neutral position. Immobilization was carried out in a plaster of Paris back slap with the wrist in 30° and the metacarpophalangeal joints in 60° of flexion. The postoperative rehabilitation consisted of "place and hold" exercises with flexion of the PIP joint starting at the first postoperative day and achieving complete extension of all finger joints was emphasized. This was done for 4 weeks

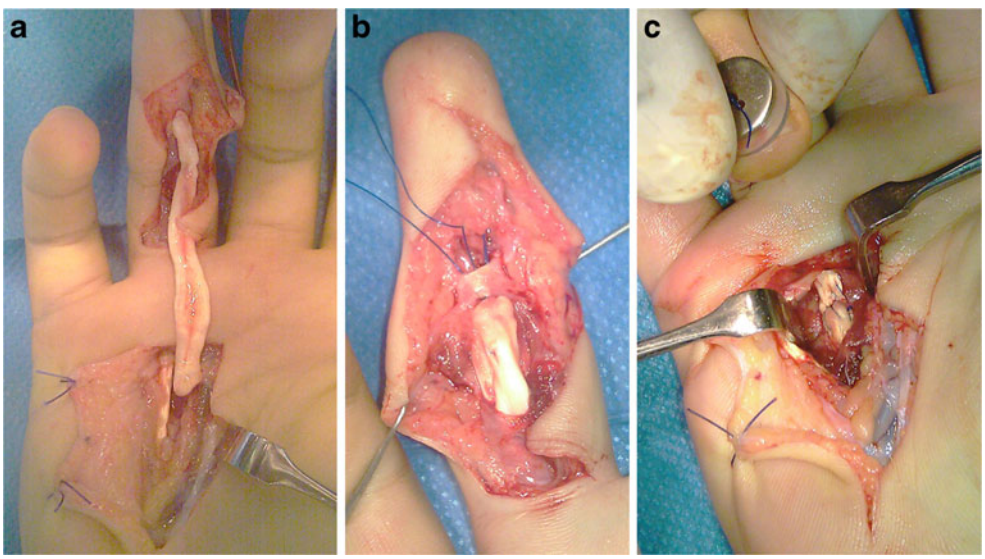

Fig. 2 **a**–**c** Intraoperative situs. **a** Luxated intercalated ruptured FDP tendon with proximal rupture in zone III and distal rupture in zone II. Right ring finger. **b** Distal rupture site, zone II. Tendon placed into the pulley system. A2 and A4 pulleys are intact. Armation of the proximal tendon for end-to-end suture. **c** Direct end-to-end repair at the proximal rupture site, zone III

followed by gentle early active and passive motion for further 4 weeks according to a modified Kleinert's protocol [7]. Applied force was increased gradually from week 8 to 12. Four months after the surgery, the patient had free passive range of motion in all finger joints and the active range of flexion/extension was 90°/0°/0° at the metacarpophalangeal joint, 80°/0°/0° at the PIP joint, and 30°/20°/0° at the DIP joint (Fig. 3a–c). With isolated flexion of the DIP joint against palpating resistance, the pulling FDP tendon was strong. Active flexion of the DIP joints of the adjacent digits is reduced. The patient continues with scar massage, stretching exercises to improve the extension at the DIP joint, and trains the flexion alone and with the parents.

Discussion

Flexor tendon injuries are classified into lacerations, avulsions, ruptures, and defects [17]. While lacerations with or without tendon substance defect are one of the most common traumatic injuries found by hand surgeons, ruptures of the musculotendinous unit are uncommon but not rare. Those injuries occur when the musculotendinous unit is subjected to forced axial loading and generally present at the musculotendinous junction, within the muscle substance, at its origin or insertion to bone [23]. Avulsion of the FDP tendons at its insertion is frequently found in athletes and occurs with flexion against resistance. In children, this pathology is exceptionally rare. A resulting inability to actively flex the DIP joint called Jersey finger has been classified by Leddy and Packer [14] into three categories depending on the level to which the tendon retracts. Avulsions of the flexor digitorum superficialis (FDS) tendon have also been reported [32] but are less frequent and can affect a single slip [27]. The ringer finger is involved in 75 % regarding both FDP and FDS avulsions, followed by the little finger [14, 32].

Flexor tendons are considered the strongest component of the musculotendinous system and mid-substance ruptures of finger flexor tendons and therefore do usually not occur unless weakened by a disease process. Boyes et al. [5] presented three cases of flexor tendon ruptures without underlying pathologic condition among a series of 80 closed flexor tendon ruptures and referred to them as "spontaneous rupture." In the literature, only three case series of spontaneous mid-substance flexor tendon rupture of 13 patients [25], 10 patients [11], and 5 patients [4] are reported. In five publications, a closed simultaneous, spontaneous rupture of both FDP and FDS tendons in one finger is reported [10, 16, 21, 22, 26]. Bergland and Newport [3] reported a case of simultaneous closed rupture of the FDP tendon in two adjacent fingers due to a grand mal seizure. Ostric et al. [28] described a rupture of the FDP tendons of three adjacent fingers in a healthy bowler. O'Sullivan et al. [29] presented a case of bilateral, but not simultaneous FDP tendon rupture in the index fingers at the junction of zones II and III. Isolated spontaneous ruptures of the FDS tendons have been reported less frequently as isolated case histories [2, 20, 24, 33]. They tend to present late and may be underdiagnosed, possibly because there is little functional limitation. Martinache et al. [20] described the so-called pen sign as an altered finger posture when using a pen if the FDS tendon is not functioning in the index finger.

Reviewing all reported cases, most spontaneous ruptures involved the FDP tendon and occurred in zone III at the level of the lumbricals origin [4, 25] but also in zone II, distal to the A2 pulley. The small finger was affected most frequently [4, 11], and 70 % of all spontaneous ruptures occurred in men over 40 years of age. Repetitive heavy lifting or power grip [25], repetitive minor trauma [11], hyperextension force and forced flexion against resistance [5] as well as direct contusion with unintentional load [26] were suggested as a possible cause. An anatomic tendon variant was encountered in a few cases [4, 6, 21]. Impairment of the vascular supply to the

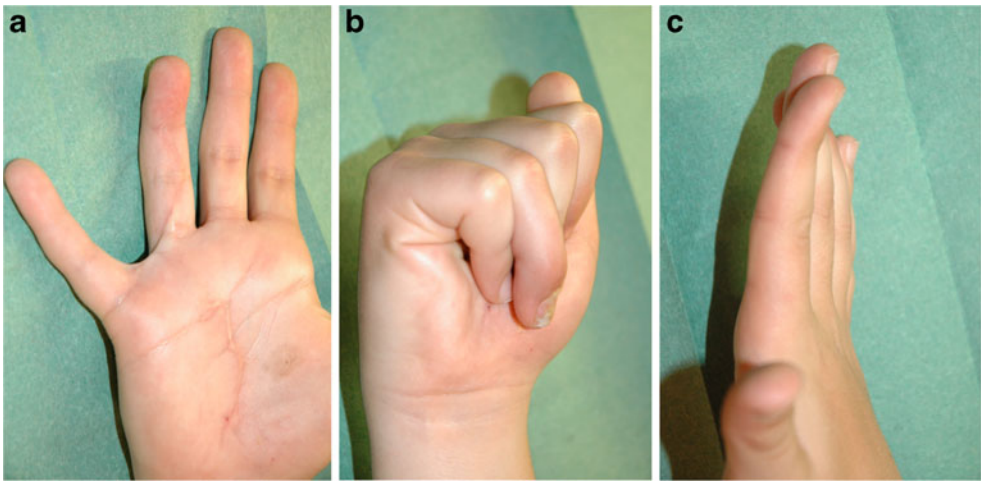

Fig. 3 **a**–**c** Postoperative clinical presentation at 3 months. **a** Discrete indurated scar in the palm. **b** Active flexion with reduction at the proximal and the distal interphalangeal joint. **c** Active extension with 20° extension lag

tendon is also implicated as a possible cause for spontaneous tendon rupture [1, 18].

The little finger FDP tendon as well as FDS tendon appears to be more susceptible to intratendinous rupture, which could be due to superior weakness or higher anatomic variations [6, 11]. In our case, a hyperextension with unintentional axial load from the basketball was the most likely cause of the FDP tendon rupture.

Treatment of tendon repair generally depends on the intraoperative findings and condition of the tendon and surrounding tissue, time from injury to surgery, and the zone of tendon injury. The options include direct repair, one-stage or two-stage grafting, tendon transfer, or tenodesis. In zone II, a direct repair is often not possible if surgical treatment is delayed.

A careful clinical examination is the most important diagnostic tool in detecting a closed flexor tendon injury in a finger. In late presentations and clinical uncertainty, an ultrasound and magnetic resonance imaging are usually helpful in localizing the rupture site [13, 15].

In our case, the patient presented late with minor swelling and pain and did not recall a snapping sensation at the time of the axial loaded trauma while playing basketball. The MRI showed a rupture of the FDP tendon at the level of the A3 pulley of the ring finger and a second rupture of the same tendon in the palm. A simultaneous closed flexor tendon rupture at two levels seemed highly unlikely, and we simply could not trust the MRI. We therefore started the incision at the PIP joint level where we clinically suspected the rupture. However, a two-level lesion became evident intraoperatively. A delayed repair with direct end-to-end sutures at both rupture sites was feasible even after 6 weeks as the tendon had ruptured at two different levels leaving the FDP tendon with an intercalated free segment that maintained the space of the synovial sheath and prevented obliteration and excessive scarring. We found minor adhesions of the tendon to the gliding ground of the flexor tendon sheath that could be released easily. There was no fraying at the tendon stumps, and after debridement and resection of the scar tissue that had developed at each tendon stump, the shortening of the free segment was minimal allowing near normal tension. No further anatomical variations or underlying pathologic condition was found that could explain the rupture. Four months after the intervention, a minor flexion deficit remained at the PIP joint and the active range of motion at the DIP joint was 15°. The reduced active flexion of the adjacent DIP joints due to a quadrigia effect will improve as the initial tension of the repaired tendon will ease and the child grows. Passive range of motion, however, was free in all finger joints and the FDP tendon is pulling strong.

Results of treatment in children below 8–10 years of age are not excellent because of poor cooperation. As the boy in our report is already 12 years old, we are confident that he will regain close to normal active finger motion with exercises and growing process.

Spontaneous closed finger flexor tendon ruptures in the midsubstance of the tendon are rare, and to our knowledge, this is the first reported case in a child. The pathogenesis remains incompletely understood, it is likely multifactorial, and repetitive strain and diminished tendon nutrition by microscopic damage to the vascular supply or diffusion may play a role.

Conflict of interest The authors declare that they have no conflicts of interest, commercial associations, or intent of financial gain regarding this research.

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