Pyogenic Flexor Tenosynovitis: Evaluation and Treatment Strategies

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Pyogenic flexor tenosynovitis (PFT)is a potentially devastating closed-space infection of the flexor tendon sheath of the hand that can result in considerable morbidity. Management of PFT, regardless of the pathogen, includes prompt administration of empirical intravenous antibiotics and often surgical treatment. However, currently, there is no standardized treatment algorithm for PFT in regards to the need for, timing, or type of surgical treatment. Many utilize a combination of surgical decompression and sheath irrigation. However, despite prompt treatment, and regardless of the protocol used, complication rates can be high, leading to impaired function and even amputation of the affected digit. Further research is needed to elucidate the role of local antibiotics and corticosteroids in treating this condition and potentially preventing the morbid outcomes that are currently seen. This paper reviews the background, microbiology, and treatment options and controversies surrounding PFT. *(J Hand Surg Am. 2019;44(11):981–985. Copyright © 2019 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Closed-space infection, flexor tenosynovitis, treatment strategies.

Pyogenic flexor tenosynovitis (PFT), also known as septic or suppurative flexor tenosynovitis, is a closed-space infection of the flexor tendon sheath of the hand. Pyogenic flexor tenosynovitis is a common problem and has been shown to make up 2.5% to 9.4% of all hand infections.[1,2]

Pyogenic flexor tenosynovitis can be caused by hematogeneous spread; however, local inoculation via lacerations, puncture wounds, and bites are more common causes.[3–5] Sheath interconnections in the palm and with Parona space in the forearm may allow for rapid spread proximally. In addition, the closed nature of the sheath limits the host's ability to fight the infection.[3]

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Despite timely treatment, patients may develop substantial morbidity from this infection including pain, swelling, stiffness, loss of motion, and ultimately, compromised function of the hand. Moreover, in severe cases with delayed or inadequate treatment, PFT can result in tendon rupture, soft tissue necrosis, and possibly amputation (Fig. 1).[3,4] Comorbidities such as diabetes, peripheral vascular disease, and renal failure are associated with a greater risk of amputations in patients with PFT.[6]

HISTORICAL PERSPECTIVE

Kanavel[7] initially described 4 cardinal signs that characterize infection of the flexor tendon sheath. These signs include symmetrical swelling of the entire digit, exquisite tenderness along the course of the tendon sheath, a digit with a semiflexed posture, and pain with attempted passive extension of the digit. During Kanavel's time,[7] antibiotic treatment was not established; therefore, the natural history of PFT was more severe and included systemic infection and even death.[8]

In 1974, Michon[9] developed a 3-tiered staging system for PFT based on intraoperative findings. In

FIGURE 1: A case of advanced PFT. Despite multiple operative debridements and prolonged antibiotics, this ultimately required ray amputation.

the first stage, there is increased serous, exudative fluid in the tendon sheath. In the second stage, purulent fluid causes progressive distension of the tendon sheath; however, the tendon is still viable. In the third stage, there is septic necrosis of the tendon and the pulleys. Michon[9] proposed that stages 1 and 2 could be treated with limited incision with drainage and irrigation of the sheath, whereas stage 3 should be treated with open debridement.

With the advent of antibiotic treatment, the incidence of catastrophic sequela associated with PFT has decreased dramatically. Now, antibiotics are a mainstay of treatment in combination with surgical intervention. There is, however, no consensus regarding need for, timing, or type of surgical treatment in PFT.

MICROBIOLOGY OF PFT

Because PFT is most commonly caused by penetrating trauma to the digit, the most common organism causing PFT is skin flora. In numerous studies, *Staphylococcus aureus* was found in up to 75% of positive cultures.[1,5,10,11] Methicillin-resistant *S. aureus* (MRSA) is another common cause and has been found in up to 29% of cases and the incidence continues to grow.[12,13] Other prevalent but less common causative organisms include *S. epidermidis*, β-hemolytic *Streptococcus* species, and *Pseudomonas aeruginosa*.[5,14] Polymicrobial infection is also moderately prevalent. In 1 study with 62 patients, only 38% had infections with a single organism whereas 62% grew 2 or more microorganisms with 26% of cultures growing mixed anaerobic and aerobic organisms.[10]

Rarely, PFT can be caused by *Eikenella corrodens* from a human bite or *Pasteurella multocida* from an animal bite.[15] Other less common causes of PFT that have been reported include *Listeria monocytogenes*, *Clostridium difficile*, *Neisseria gonorrhea*, and *Mycobacterium* species.[16] Conversely, culture-negative PFT can also occur and studies have shown that, 20% to 68% of the time, no bacteria are isolated.[4,17]

Regardless of the pathogen, management of PFT includes prompt administration of empirical intravenous antibiotics. Prior to obtaining culture results, antibiotic selection should include coverage against gram-positive organisms, including *Staphylococcus* (especially MRSA) and *Streptococcus* species. Empirical antibiotics should also cover gram-negative rods and anaerobes especially in immunocompromised patients.[3] Once the precise organism is isolated, the antibiotic regimen should be narrowed to target the specific bacteria identified.

TREATMENT

Nonsurgical treatment may be appropriate for PFT patients who present early, typically within 48 hours after penetrating trauma to the hand. In a small case series, Neviaser and Gunther[18] reported successful nonsurgical management of PFT with intravenous antibiotics, orthosis wear, and elevation in 4 patients. During nonsurgical treatment, the affected hand should be frequently examined. If this treatment is going to be successful, clinical symptoms should improve within 24 hours. If symptoms do not improve, surgical irrigation and debridement should be performed.

Several surgical methods have been developed to decompress and irrigate the flexor tendon sheath. However, there is currently no consensus regarding optimal timing of the surgical intervention, whether open surgery or closed-catheter irrigation alone can be performed, and the optimal type of irrigation fluid.

Open irrigation and debridement

Open irrigation and debridement procedures were originally described for surgical management of PFT.[7] Midaxial or volar Brunner-type incisions can be utilized to expose and open the entire flexor tendon sheath for thorough debridement. Open irrigation and debridement may be utilized for more advanced cases of infection and in cases of atypical or chronic tenosynovial infections.[4,19]

Closed tendon sheath irrigation

Dickson-Wright first described a method of catheter irrigation of tendon sheath infections in 1944[20]; however, Neviaser[4] expanded on the technique in a series of 20 patients in 1978. Zigzag incisions are made over the metacarpal neck and at the level of the distal interphalangeal joint. The tendon sheath is cut transversely at the proximal edge of the A1 pulley. A 16-gauge angiocatheter is inserted into the flexor tendon sheath proximally. The distal edge of the flexor sheath is exposed and resected distal to the distal-most pulley. A small drain can be threaded into the tendon sheath beneath the A4 pulley to keep the wound open and allow for drainage of the fluid. The sheath is then flushed gently in the operating room.[4] Nevaiser[4] reported excellent initial results with this technique: 18 out of 20 patients regained complete active and passive motion by 1 week after the operation.

More recent studies have reported good outcomes using this technique. One group conducted a retrospective review of 27 patients (28 fingers) with PFT, who were treated by a limited, open-tendon-sheath, intermittent-irrigation method that utilized a small pediatric feeding catheter. The cases were subcategorized into 3 stages, based on the intraoperative appearance of the wound. They found 100% excellent results in stage I; and 88.4% excellent, 5.8% good, and 5.8% fair in stage II.[17]

Several studies have also compared closed irrigation with open irrigation techniques. Gutowski et al[19] reviewed 47 cases of PFT to determine whether a difference in outcomes exists between PFT treated with open irrigation and debridement and closed-catheter irrigation. They found no significant differences between the groups in terms of early postoperative outcomes, including resolution of infection, need for additional surgery, and length of hospital stay.[19]

A meta-analysis reviewed 28 retrospective case series of PFT and showed that catheter irrigation resulted in superior outcomes compared with an open technique. They found that 57 of 218 cases (26%) resulted in excellent range of motion when an open technique was used compared with 245 of 343 cases (74%) excellent results when a closed irrigation technique was used.[6]

Continuous closed irrigation and postoperative irrigation

A continuous closed irrigation system with inlet and outlet tubes has also been described with positive results.[11] The continuous irrigation system consists of 2 fenestrated tubes placed within the infected sheath. The tip of the smaller-caliber inlet tube is positioned just inside the larger outlet tube. Theoretical advantages of these systems include the patient's ability to participate in hand therapy with the system in place and avoidance of pain caused by high pressures associated with intermittent closed irrigation. However, it is unclear whether timing of the initiation of hand therapy during the irrigation period or during the early postoperative period has an important impact on outcomes.[6]

Postoperative irrigation is a controversial practice because leaving a foreign body within the tendon sheath may result in additional complications including stiffness, decreasing the patient's ability to participate in therapy, or additional injury and irritation to the sheath. One study compared intraoperative closed tendon sheath irrigation alone with intraoperative and postoperative closed tendon sheath irrigation.[10] They found no significant differences in terms of mean length of hospital stay, follow-up complication rates, or postoperative range of motion, suggesting that postoperative intermittent or continuous irrigation is not necessary.

In addition, there are many differing opinions regarding the best solution to use for irrigation. Most assert that normal saline is sufficient.[4,5,19] A systematic review reported that the use of antibiotics in the irrigation fluid had no clear benefit.[6] Another group reported promising results with local injection of antibiotics into the tendon sheath and the addition of locally administered corticosteroids in the treatment of PFT in an animal model.[21,22] They found that corticosteroids decreased digit stiffness associated with PFT. However, more research is needed to elucidate the role of corticosteroids in PFT.

FUTURE TREATMENT DIRECTIONS

Recently, there has been work trying to elucidate the role of local antibiotics and corticosteroids in the treatment of PFT.[22] In a cadaveric model of PFT, the authors used confocal laser scanning microscopy and scanning electron microscopy to evaluate biofilm formation on the flexor tendon. In addition, they found that bacterial load by direct colony counting decreased by 18.5% with saline irrigation alone, 42.6% with irrigation and local steroids, 54.4% with irrigation and local antibiotics, and 77.3% with irrigation and both local antibiotics and steroids. The authors, therefore, suggest rethinking the current treatment of PFT and recommend considering a strategy more analogous to periprosthetic joint infection management with the adjunctive use of local antibiotics and corticosteroids to limit bacterial count and biofilm formation to better eradicate the infection.

AUTHORS' PREFERRED TECHNIQUE

Nonsurgical treatment with antibiotics alone is reserved for patients presenting early and without fluctuance and/or fewer than 3 Kanavel signs. However, the patient is still admitted and observed with the potential for imminent surgical decompression if symptoms do not improve. Empirical antibiotics are tailored to cover skin flora and community-acquired MRSA, which is endemic in most urban settings.[13] In cases of advanced or delayed presentation, 3 or more Kanavel signs, and/or failure to respond to antibiotics after 24 to 48 hours, surgery is indicated.

We prefer a volar approach to the finger that begins with outlining a Bruner zigzag incision along the entire finger; alternatively a midlateral incision can also be considered. Initially, only the distal-most and proximal-most incision lines are opened, thereby exposing the A5 and A1 pulleys, respectively

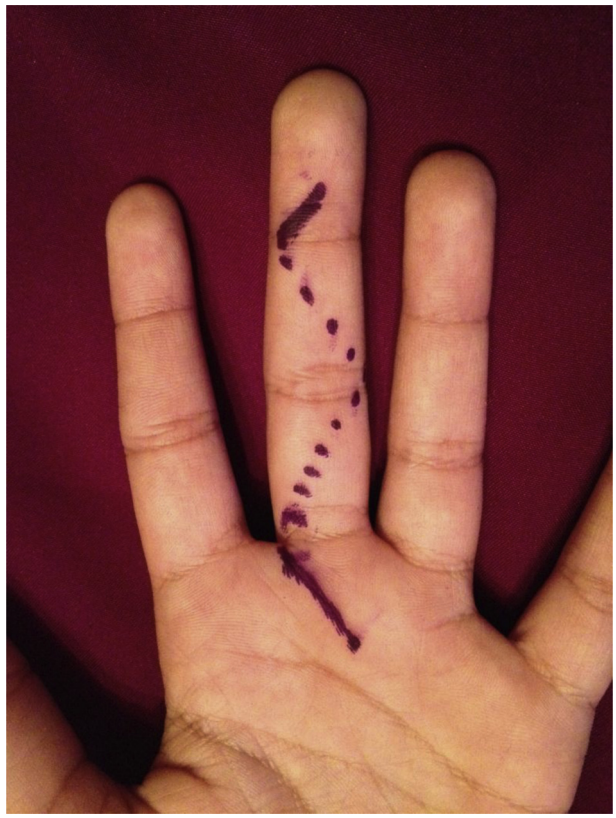

FIGURE 2: Authors' preferred surgical incision for PFT.

(Fig. 2). The A1 pulley is released longitudinally, exposing the flexor tendons. A blush of seropurulent fluid is typical. Similarly, the A5 pulley is released in a limited fashion. A 16-gauge angiocatheter needle is inserted antegrade at the level of the A1 pulley. The flexor sheath is then repeatedly irrigated with antibiotic-impregnated irrigation, until the purulent fluid has been cleared away. The finger is passively flexed and extended throughout the irrigation to maximize tendon irrigation. Any enveloping tenosynovitis or biofilm of the flexor tendons is debrided. If the exposure or the extent of irrigation is too limited to adequately clear the infection, the entire marked incision can be opened to connect the initial 2 incisions. However, care should be taken to avoid taking down all the pulleys, particularly A2 and A4. After the irrigation, the tendons are bathed in vancomycin 20 mcg/mL and the incisions are loosely closed.[21] Postoperative irrigation is not performed. Repeat surgical irrigation can be performed 2 days later, if necessary. Immediately after the infection is under control, the patient should start supervised therapy to minimize stiffness and adhesion formation. Oral antibiotics should ultimately be tailored to the intraoperative cultures with the help of an infectious

disease specialist and are typically continued for 2 to 6 weeks after surgery, or until symptoms resolve.

DISCUSSION

Ultimately, PFT is a difficult problem and can cause substantial morbidity in the population despite adequate treatment. Prompt diagnosis of PFT can be challenging, but early recognition and initiation of treatment are essential to avoid complications and preserve hand function. Early treatment is crucial with broad-spectrum intravenous antibiotics and surgical irrigation and debridement. However, despite timely and thorough treatment, severe infection can nevertheless lead to impaired function or even amputation of the affected digit. Further research is needed to improve preoperative diagnosis of PFT, clarify the role of systemic antibiotics alone without surgical intervention in cases of early infection, and investigate the role for local antibiotics and corticosteroids with surgical intervention.

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