

Original Research Article

Factors associated to amputation in pyogenic flexor tenosynovitis in a tertiary referral center in Mexico

Carlos Altamirano-Arcos, Enrique Chávez-Serna*, Ricardo Romero-Caballero,
Carlos E. Rodriguez-Rodriguez, Rogelio Martínez-Wagner

Department of Plastic, Aesthetic and Reconstructive Surgery, Dr. Manuel Gea González General Hospital, National Autonomous University of Mexico, México City, México

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*Correspondence:

Dr. Enrique Chávez-Serna,
E-mail: enrique.chavez.serna@gmail.com

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ABSTRACT

Background: Pyogenic flexor tenosynovitis is an aggressive closed-space infection, which affects the flexor tendon sheath of the hand with disabling sequelae. The purpose of this study is to describe the patient demographic characteristics and identify factors associated with amputation in pyogenic flexor tenosynovitis.

Methods: In this retrospective single-center study, included all adult patients who presented to the emergency department from 2015 to 2021 with PFT of the hand. Descriptive summary statistics were reported on patient demographics, presenting symptoms and clinical examination features, culture results, treatment strategies, and early complications. The factors influencing amputation were identified and analyzed.

Results: A total of 59 patients with PFT diagnosis were included. Most of the population was found to be immunosuppressed (34 patients). Moreover, the most common comorbidities were the combination of diabetes mellitus and systemic arterial hypertension. The third right finger was the most frequently affected region. Almost all patients were hospitalized, intravenous antibiotics, and at least one additional surgical intervention was required in 16 cases. Amputation of the infected finger occurred in 6 patients, associated with different factors: reintervention, age over forty, presence of diabetes mellitus and chronic arterial hypertension, penetrating trauma, and presence of *Enterococcus faecalis* in culture.

Conclusions: Rapid and aggressive treatment is required to prevent devastating complications such as amputation. Adequate identification of the disease and risk factors is critical for a successful result. *E. faecalis* represents the most common pathogen in this study, unlike the reported literature. Thus, broad-spectrum antibiotics and surgical intervention are required.

Keywords: Tenosynovitis, Hand infection, Tendon infection, Hand surgery

INTRODUCTION

Pyogenic Flexor Tenosynovitis (PFT) is an aggressive, closed-space infection that affects the synovial sheath of the hand's flexor tendons with substantial morbidity. Incidence rates from 2.5 to 10% of PFT have been described among all hand infections.^{1,2} The flexor tendon sheath is a closed anatomical space between the visceral

epitenon and the outer parietal layer. When bacterial invasion takes place, the pressure in the synovial area between these two layers increases, leading to disruption of the anatomical barriers. This may cause the infection to spread through the Parona space to nearby flexor sheaths and bursae, and into the forearm.³ The tendon's essential nutrition becomes impaired by the purulent fluid in the synovial area around the tendon, and increased

pressure in the infected sheath may obstruct blood flow to the tendon, causing necrosis.⁴

Etiology

Different sources have been identified as etiology of PFT, such as hematogenous seeding. Still, penetrating or puncture wounds remain the main one.⁵ Skin flora is recognized as the most prevalent reason causing PFT due to the frequency of penetrating trauma. According to several studies, one of the most common microorganisms found in cultures is *Staphylococcus Aureus* in a rate up to 75%, followed by *Methicillin-resistant S. Aureus (MRSA)* with a frequency up to 29%. Other causative organisms such as *Staphylococcus Epidermidis*, β -hemolytic *Streptococcus* species, and *Pseudomonas aeruginosa* are prevalent but less common.⁴ Culture negative PFT has been reported in a rate ranging from 20 % to 68%.³

Diagnosis

Early diagnosis allows prompt initiation of the optimal treatment in order to minimize complications. In 1912, and later in 1939, Allen B. Kanavel established four diagnostic criteria for PFT, which considers the surgical drainage as a treatment option.⁶ This criteria listed in descending frequency, include fusiform digital swelling (usually associated with erythema), pain with passive digital extension, semi-flexed digital posture, and tenderness along the flexor tendon sheath with frequent extension into the palm.⁷ These four signs are considered as the primary clinical tool for diagnosing PFT. Its sensitivity range among 91.4% and 97.1% and a specificity between 51.3% and 69.2%.⁸ Diabetic patients may have no pain due to peripheral neuropathy.⁹ In 1974, Michon classified PFT progression by establishing three different stages according to the severity and intraoperative findings: Stage I: Increased fluid in the sheath, primarily serous exudate. Stage II: Purulent exudate, granulomatous synovium. Stage III: Necrosis of tendons, pulleys, and/or tendon sheath. Michon proposed that stages I and II could be treated with limited incision with drainage and irrigation of the sheath, whereas stage III should be treated with open debridement.¹⁰

The diagnosis of PFT is mainly clinical, and the physical examination should not delay the treatment when the diagnosis is definitive; however, when the diagnosis is equivocal, complementary tests should be performed. Clinical diagnosis may underestimate mild cases with ultrasound changes without Kanavel signs presence. In a prospective study conducted in 2017, Yardin, E et. al. showed that ultrasound (US) had a sensitivity of 94.4%, specificity of 74.4%, positive predictive value of 63%, and negative predictive value of 96.7%, based on ultrasonographic findings to determine direct signs of early PFT such as hypoechogenic peritendinous effusion with signal on color Doppler and thickened synovial sheath showed as hypoechogenic and hyperemic on color Doppler in acute inflammatory phase. Therefore, a

properly performed and complete clinical evaluation and US combined, result in almost 100% sensitivity and specificity.¹¹ Soft tissue ultrasound has been demonstrated to be the imaging diagnostic tool of choice for the diagnosis of PFT, in which liquid can be observed inside the digital synovial sheath. However, some studies have mentioned first-instance radiography to differentiate non-PFT from PFT infections. Yi, A et al. refer in a retrospective study that acute PFT swelling is characterized by the contrast between volar and dorsal radiographic soft tissue thickness at the level of the proximal phalanx.¹²

Treatment

Several surgical procedures have been described for drainage of the infected digital synovial sheath, from open surgery where the digital canal is exposed to small incisions that allow adequate drainage and tube placement for continuous irrigation. Along with surgical treatment, PFT patients should be treated emphatically with intravenous antibiotics, the elevation of the affected member, and splinting.¹³

Complications

When delayed diagnosis or treatment takes place, significant morbidity can occur. The main complications include spread of the infection, soft tissue necrosis, tendon necrosis, tendon rupture, permanent impairment of the hand, and even amputation.^{14,3} The purpose of this study is to describe the patient demographic characteristics and identify factors associated with amputation in pyogenic flexor tenosynovitis in a tertiary referral center in Mexico.

METHODS

An analytic, retrospective single-center review in General Hospital Dr. Manuel Gea Gonzalez, of all patients who presented with PFT at a tertiary-care hospital plastic surgery emergency department, between January 2015 and December 2021 was performed. The study was approved by the institutional review board (IRB) and informed consent was obtained from each patient.

Patient population

Cases were identified by a review based on medical records in the Plastic and Reconstructive Surgery department. The diagnosis of PFT was made clinically on the basis of the presence of one or more Kanavel signs. A standard anterior-posterior (AP) and oblique x-ray image of the affected hand was obtained in all patients and ultrasound was performed if the surrounding soft tissue was compromised. Patients were classified according to intraoperative findings with the Michon classification. The inclusion criteria were all patients diagnosed with PFT with at least 3 kanavel signs and a positive culture result, with a minimum follow-up of 8 months. The

exclusion criteria were those patients without clinical data of PFT, who did not have a culture at the time of diagnosis and who had lost follow-up. The sample size for this study was determined by including all patients with a diagnosis of PFT who received treatment at our hospital. In this approach, the entire population of patients with PFT at the specified hospital was considered, eliminating the need for a specific sample size calculation.

Surgical Treatment and patient management

Surgical drainage was performed by Plastic and Reconstructive Surgery residents, under local anesthesia with the use of tourniquet. When the infection was limited to the tendon sheath, limited incision drainage and irrigation was used through two small incisions, with the proximal incision at the level of A1 pulley and the distal one at the level of A5 pulley and further placement of a closed continuous irrigation system which consisted in a 18G pediatric feeding tube.¹⁵ In cases where there was evident subcutaneous purulence, we used midaxial incision along with the previous described procedure for better exposure and drainage of the tendon sheath.¹⁶ Culture was obtained in all cases (Figure 1). Postoperatively, the hand was elevated, and daily normal saline irrigations with an inflow of 100 ml/4 hours were performed. Irrigation system was inspected every 4 hours and was removed after 24 to 48 hours. On the third postoperative day, a decision was made for either further débridement or secondary closure. After intravenous antibiotic administration for a minimum of 2 days postoperatively, and according to the clinical response and culture results, antibiotics were then administered orally up to 4 weeks. All patients were evaluated clinically one week after discharge. In the follow-up, the total active and passive ranges of motion were measured.

Statistical analysis

Descriptive summary statistics were reported on patient demographics, presenting symptoms and clinical examination features, culture results, treatment strategies, and early complications. The clinical factors influencing outcomes were identified and analyzed. Therefore, we specifically studied the amputation rate and total active motion as measures of outcome related to the severity of the disease process at the time of presentation. Statistical analysis was performed with SPSS statistical analysis software 25.0 (SPSS, Inc., an IBM Company, Chicago, Illinois). Univariate analysis was performed with the use of the Chi-square or Fisher exact test for comparison of proportions between two categorical data.

RESULTS

Patient population

Fifty-nine patients with PFT were identified through a 6-year period. Of the 59 patients, 41 (69.5%) were men and

18 (30.5%) women, with an average age of 45.2 ± 18.7 years (range 14-88).

Table 1: Demographic characteristics (n=59).

Characteristic	Mean±SD	Range
Age (years)	45.2±18.7	14-88
Gender, N (%)		
Male	41 (69.5)	
Female	18 (30.5)	
Place of residence, N (%)		
Urban	20 (33.9)	
Rural	39 (66.1)	
Total	59 (100)	
Educational Level, N (%)		
No education	0	
Primary	21 (35.5)	
Secondary	25 (42.3)	
Technical career with secondary school	0	
High school	13 (22)	
Bachelor's or professional	0	
Postgraduate	0	
Total	59 (100)	

Table 2: Key clinical characteristics (n=59).

Characteristic	Mean±SD	Range
WBC count (/mm3)	11.874±2973.6	6900-18000
Comorbidities, N (%)		
Chronic hypertension	7 (11.9)	
Diabetes mellitus	10 (16.9)	
Chronic hypertension + diabetes mellitus	14 (23.7)	
Arthritis	1 (1.7)	
Smoking	1 (1.7)	
None	25 (42.4)	
Total	59 (100)	
Kanavel signs present, N (%)		
4	31 (52.5)	
3	28 (47.5)	
Total	59 (100)	
Michon Classification, N (%)		
Stage I	18 (30.5.4)	
Stage II	36 (61)	
Stage III	5 (8.4)	
Total	59 (100)	

When analyzing the place of residence, 39 (66.1%) came from rural area and 20 (33.9%) urban area. Regarding the educational level, 21 (35.5%) patients had primary level, 25 (42.3%) secondary level and 13 (22%) high school (Table 1). Thirty-four (57.6%) patients were immunosuppressed. The most common comorbidity was the combination of systemic arterial hypertension and diabetes mellitus in 14 (23.7 %) patients, followed by diabetes mellitus alone in 10 (16.9%) patients.

Only one affected digit was identified in all the patients, being the most frequently affected one the third right finger in 17 (28.8%) cases followed by the second left finger in 9 (15.3%) cases, second right finger in 8 (13.6%) cases, and fourth left finger in 8 (13.6%) cases (Figure 2). At least 3 Kanavel signs were present on admission in 47.5% of the patients, with all four signs identified in 52.5% of the cases. According to the Michon classification, 18 (29.4%) patients corresponded to stage I, 36 (64.7%) patients to stage II and 5 (5.8%) patients to stage III. The average white cell blood (WBC) count at admission was 11.874/mm³ (Table 2). Signs of systemic infection were not present in any of the patients. The initial triggering cause of PFT was identified in 40 (67.7%) patients. Being penetrating trauma the most common antecedent in 32.2% of cases, followed by blunt trauma in 8.5% of cases (Figure 3). The most frequently cultured organisms were *E. Faecalis* (18.6%), followed by *methicillin-resistant Staphylococcus aureus (MRSA)* (16.9%), *E. Coli* (5.1%) and *S. Epidermidis* (5.1%). Culture was negative in 47.5 % of cases (Table 3).

Table 3: Microbiological findings associated with Pyogenic Flexor Tenosynovitis (n=51).

Microbiological findings	N (%)
Negative	28 (47.5)
<i>Streptococcus galactiae</i>	1 (1.7)
<i>Staphylococcus aureus</i>	10 (16.9)
<i>Staphylococcus epidermidis</i>	3 (5.1)
<i>Klebsiella aerogenes</i>	1 (1.7)
<i>Streptococcus constellatus</i>	1 (1.7)
<i>Enterococcus faecalis</i>	11 (18.6)
<i>Escherichia coli</i>	3 (5.1)
<i>Enterobacter cloacae</i>	1 (1.7)
Total	59

Table 4: Surgical outcomes and complications.

Characteristic	Mean±SD	Range
Hospitalization time (days)	4.6±3.9	0-27
Symptoms duration (days)	3.9±3.2	1-21
Procedure, N (%)		
Surgical reintervention	16 (21.7)	
Outcome, N (%)		
Amputation	6 (10.2)	

Surgical treatment and patient management

Almost all patients were hospitalized, with the exception of three patients who refused to receive medical care. The average length of hospitalization time was 4.6±3.9 days (range, 0-27). Intravenous antibiotics and at least one surgical debridement were administered and performed in all hospitalized cases. The most common antibiotic regimen was ceftriaxone+metronidazole (69.5 %). At least one additional surgical intervention was required in 16 (27.1%) cases. Amputation of the infected finger

occurred in 6 (10.2%) cases, and skin necrosis requiring skin graft occurred in 10 cases (Table 4).



Figure 1: Clinical Case, PFT surgical treatment. 68 year-old patient with third left finger PFT. A, B) Preoperative view. C, D) Postoperative view after double-incision and midaxial drainage and irrigation system placement.

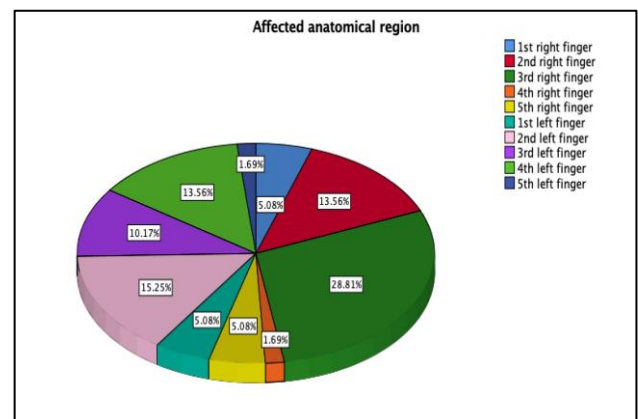


Figure 2: Affected anatomical region.

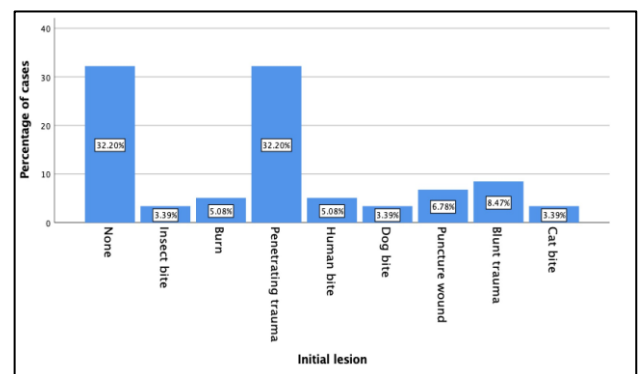


Figure 3: Initial lesion before PFT.

The factors associated with amputation were: reintervention ($p=0.000053$), age of more than forty-four years ($p=0.039$), the presence of diabetes mellitus and chronic arterial hypertension ($p=0.003$), penetrating trauma ($p=0.002$), and Presence of *Enterococcus Faecalis* in culture ($p=0.004$) (Table 5).

Table 5: Risk factors affecting rate of amputation (n=51).

Factors	P value*
Surgical reintervention	0.000053
Presence of diabetes mellitus and chronic hypertension	0.003
Age more than forty-four years	0.039
Presence of <i>Enterococcus faecalis</i> in culture	0.004
Penetrating trauma	0.002

* $p<0.05$ indicates that the factor contributed to an increased rate of amputation according to univariate analysis.

DISCUSSION

Hand infections remain as one of the most common conditions encountered in plastic surgery emergency departments. PFT constitutes an infectious disease with a significant risk of morbidity if it's not diagnosed and treated adequately and often requires surgical treatment. The study's findings demonstrate both consistencies and discrepancies with data reported in other samples. To the best of our knowledge, none of the previous studies has examined the socioeconomic and educational characteristics of the patient population. We found that most patients came from a rural area and have a low level of education. PFT is a frequent pathology in our department, since 59 patients presented in a period of 6 years, corresponding to 18% of total hand infections. Previous studies have reported an incidence up to 10%.^{17,18} Previous studies have identified *Staphylococcus aureus* as the predominant organism in PFT, with rates ranging from 28% to 80%.^{6,19,20} In our study, the main microorganisms identified were *E. Faecalis* (17.6%) followed by methicillin-resistant *Staphylococcus aureus* (MRSA) (15.7%). We recommend antibiotic coverage through broad-spectrum treatment that includes management against *E. faecalis* and *methicillin-resistant Staphylococcus aureus*.² Culture-negative cases of PFT have been reported in 20% to 63% of cases in several studies.^{4,21,22} In our study 47.5% of cases reported a negative culture, probably because of prompt antibiotic treatment or a vigorous immune response.

Nikkhah et al mentioned the importance of surgical drainage and irrigation in all cases of PFT to diminish tendon vascular compromise and other complications such as stiffness or necrosis.²³ All of the patients included in this study which accept treatment were subjected to surgical treatment. Re-intervention was necessary in 27.1% of all patients, a rate higher than those reported by Dailana et al and Pang et al.^{6,19} This can be explained by

the fact that most of the patients have previously consulted other medical services, and come to our service as an ultimate treatment option. Amputation is a devastating complication found among adult patients with PFT, with rates reported between 5% and 17%. In our study the amputation rate was 10.2%, especially in immunocompromised patients. Pang et al described that the factors that increase the likelihood of amputation include: age greater than 43 years, presence of comorbidities, including diabetes, peripheral vascular disease and renal failure, presence of subcutaneous purulence, ischemic changes at presentation delayed treatment, and involvement of more than one bacterial type.¹⁹ The main factors associated in our study with amputation are age greater than 44 years, presence of comorbidities including diabetes and chronic arterial hypertension, presence of *E. faecalis* in culture, and patients that require re-intervention. Prompt treatment of PFT, as patients from our study received, does not eliminate the potential for complications. Thus, an adequate control and metabolic management in patients which are at risk is advisable. Patients who present with fulminant PFT usually appear 28-72 hours after the initial trauma, which is often penetrating. It should be stated that patients do not always present with the four signs of Kanavel. The flexor tendon sheath has a direct connection with the radial and ulnar bursa, which are continued with the Parona space, located in the forearm, between the pronator quadratus tendon and the deep digital flexor. Infection of the tendon sheaths can spread through these spaces creating a horseshoe abscess.

Limitations

Limitations of current study were; it has been designed as a retrospective, uncontrolled study, and the sample size is relatively small. The non-systematic use of ultrasound in the diagnosis may have under diagnose mild symptomatic patients A larger patient population is needed to improve the power of our data. Patients' socioeconomic conditions pose a challenge to follow-up evaluation and long-term outcome data. 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 of local antibiotics and corticosteroids with surgical intervention.

CONCLUSION

PFT can cause significant morbidity despite adequate diagnosis and treatment. In this study we showed that immunosuppression along with the age of presentation and the microorganism causing the disease, appears to be crucial factors associated with amputation Rapid and aggressive treatment is required to prevent devastating complications. Adequate identification of the disease and risk factors are key for a successful result. *E. faecalis* represents the most common pathogen in this study, unlike the reported literature, which demonstrates *Staphylococcus aureus* as the principal pathogen. Thus,

broad-spectrum antibiotics and surgical intervention are required.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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