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Systematic review: Use of imaging exams to help diagnose infectious tenosynovitis

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ABSTRACT
Infeccious Tenosynovitis is a disease that affects tendon sheath, normal hand tendons . The origin can be hematogenous, trauma dito inoculation of pathogens ir local spread. This study aims to evaluate the use of ultrasound examination in the diagnostic approach and therapeutic follow-up in patients with tenosynovitis. This is a systematic review study, which had the PUBMED and SCIENCE DIRECT databases as a research source, selecting studies between the years 2018 and 2023. 15 articles that responded to the proposed objective and suited the criteria were analyzed. of inclusion. It was possible to verify that patients affected by infectious tenosynovitis are generally male (53.3%). They are usually over 30 years old (80.0%), and may also affect children (20.0%). Most individuals were diagnosed with pyogenic flexor tenosynovitis (53.3%). All studies used ultrasound as one of the diagnostic methods (100.0%). Among the treatments used, there was a higher prevalence of antibiotic therapy (86.6%) and surgical debridement (40.0%). According to the analysis carried out, it was possible to verify that ultrasound at the bedside is an important imaging modality, and its use should be considered in patients with suspected pyogenic tenosynovitis, due to its speed and greater sensitivity, as it makes it possible to treat the patient without surgical intervention and helps in choosing the best treatment.

Keywords: Tenosynovitis, Hand, Pyogenic.

1 INTRODUCTION

The human hand, due to its multiple functionality and constant exposure, can be injured more easily during daily activities, being the target of infections. Such acute hand infections can be superficial, when they affect the skin and subcutaneous tissue, or deep, when there is involvement of tendons, extensor and/or flexor compartments, bursae or even bone [1]. The loss of skin integrity allows contact with microorganisms in deep layers, with *Staphylococcus aureus,* Streptococcus β-haemolytic*, and* gram-negative *bacteria being more prevalent* [2]. However, immunocompromised patients may be affected by rare pathogens. In the case of tenosynovitis, which is triggered by microorganisms that reach tendons through the bloodstream, ultrasound examination becomes a rapid option for diagnosis and therapeutic definition [3].

Ultrasonography (US) is a valuable first-choice tool for visualizing traumatic, inflammatory, and degenerative conditions of the extensor and flexor tendons, particularly with the advantage of a possible dynamic examination [4]. The additional use of duplex Doppler ultrasound and power Doppler

is recommended for detection of tenosynovitis in overuse injury, inflammatory disease, infection, and after traumatic conditions [5].

US is the most convenient imaging test for hand infection. It is readily available, real-time, and easily obtainable, harmless, and inexpensive, with no need for sedation in children [6]. In addition, it can help differentiate a deep pyogenic flexor tenosynovitis-type infection or hematogenous disseminated infection from a distant site [7]. It can also detect the presence of a foreign body in soft tissue, the presence and edges of an abscess, and the integrity of deep anatomical structures [7,8].

Although surgical treatment is relatively well standardized [8], there is no consensus on the role of antibiotic therapy and its parameters in this condition [9,10]. With the exception of the rare incipient forms that present very early, antibiotic therapy alone is not recommended for the treatment of pyogenic flexor tenosynovitis (PFT). Urgent surgical care is required to flush the tendon sheath [8,10]. Several surgical techniques have been shown to be effective, such as continuous irrigation or, more recently, ultrasound-guided lavage [11]. However, the most commonly used flexor sheath washing techniques are conventional open or minimally invasive ones. Postoperative antibiotic therapy is initiated after specimens are collected for microbiology [8].

From this perspective, the general objective of the present study was to evaluate the use of ultrasound in the diagnostic approach and therapeutic follow-up in patients with tenosynovitis. And specifically, to analyze the profile of patients with infectious tenosynovitis; identify the usefulness of ultrasound in the definitive diagnostic aid, differential diagnosis and use for therapeutic follow-up; and to verify the risk factors and groups associated with infectious tenosynovitis.

2 MATERIALS AND METHODS

2.1 NATURE OF THE STUDY

This is a systematic review of the literature, and followed the methodological criteria established by Donato & Donato [12]. It was carried out in accordance with the Prefer Reporting Items for Systematic Reviews and Meta-Analyses Guidelines (PRISMA), described by Galvão et al. [13].

The research was based on the following guiding question: "What is the importance of using ultrasound in the diagnosis of tenosynovitis?", elaborated according to the PICO strategy (Population: individuals with tenosynovitis; Intervention: use of ultrasound in diagnosis; Comparison: other types of exams and Outcomes (outcome: result or contribution of the exam).

The electronic search was conducted between June and July 2023 using the following databases: Pubmed/Medline and Science Direct. The terms used in the search were: "ultrasound, hand, tenosynovits" OR "ultrasound, pyogenic, tenosynovits, flexor". These terms were obtained from the DeCS (Descriptors in Health Sciences) and from the articles studied. A comprehensive examination of the reference sections of all identified articles was conducted to identify other relevant manuscripts.

2.2 INCLUSION CRITERIA

Patients with tenosynovitis; use of ultrasound in diagnosis and/or follow-up; Articles published in full in English or Portuguese by the year 2023.

2.3 EXCLUSION CRITERIA

Articles published more than five years old; studies not available in English or Portuguese; articles that do not have open access; studies that addressed tenosynovitis triggered by rheumatologic diseases.

2.4 METHOD OF DATA COLLECTION

Two reviewers read the titles and abstracts of the retrieved articles using the predefined search strategy and applied the inclusion criteria independently in order to reduce the risk of interobserver bias. Then, the pre-selected articles and also the articles that did not contain abstracts were obtained in full and read again, applying the same eligibility criteria. Subsequently, two other reviewers independently analyzed the texts in full, using the same pre-established criteria. Cases of disagreement were resolved by discussion, and agreement was reached in all cases to establish the studies included in the systematic review.

Included studies were selected from the title, abstract, or full text when available. It was decided to include all types of articles, especially case reports, rather than randomized controlled trials, due to the small amount of scientific evidence in the literature.

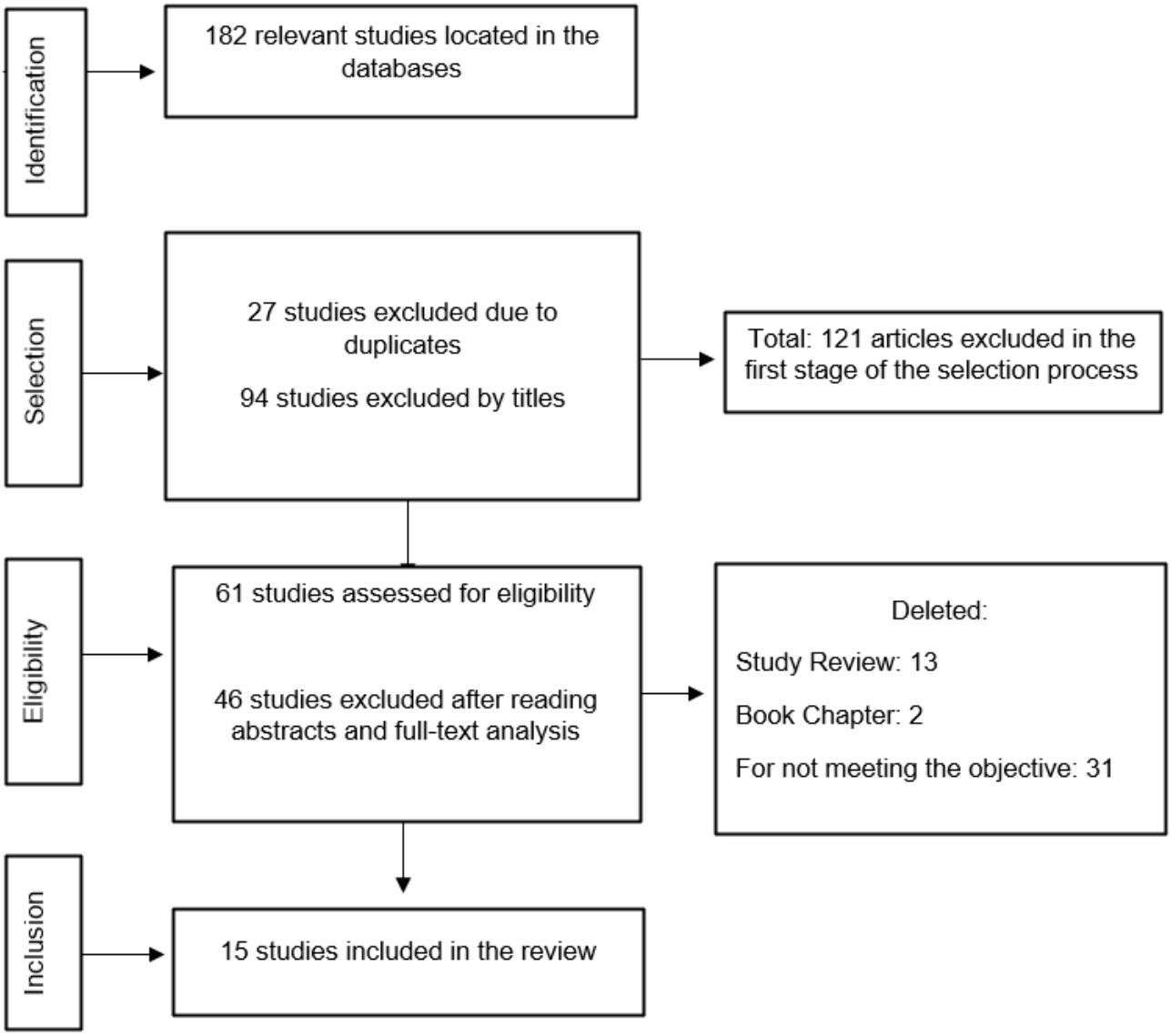
2.5 DATA ANALYSIS METHOD

Data were extracted from the selected studies, including information on the author, year of publication, study design, number and characteristics of participants, age, definitions of diagnostic methods and treatments used.

This systematic review was carried out according to the set of PRISMA recommendations (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), described by Galvão et al. [13], shown in Figure 1.

A total of 182 full papers were screened and evaluated. Figure 1 shows a flowchart that summarizes the article selection process. After evaluating the titles and abstracts, 167 articles were excluded because they did not meet the eligibility criteria. In the end, only 15 studies met all the criteria and were included in this review.

Figure 1. Research Flowchart



Source: Author (2023).

The analysis of the results was performed in a descriptive manner, including a synthesis of each study present in the review and a synoptic table, which contains the following items: identification of the article, database in which the articles were found, journal of publication, and year of study.

3 RESULTS

Table 1 shows that 2022 had the highest number of publications selected for this research, with five articles (333.3%). The most frequent journals were Clin Pract Cases Emerg Med and Hand Surgery and Rehabilitation with two publications each, used in this study (13.3%, respectively). Most of the selected articles were found in PUBMED (73.3%). And there was a higher prevalence of case report studies (80.0%).

Table 1: Indexing characteristics of the studies used

Author/ Year	Type of Study	Newspaper	Database
Mohn et al. 2022	Retrospective Descriptive Study	Biology (Basel)	PUBMED
Boudon et al. 2022	Case Report	J Med Case Rep	PUBMED
Osipchuk et al. 2023	Case Report	Clin Pract Cases Emerg Med	PUBMED
Nakamuara et al. 2023	Case Report	BMC Pediatr	PUBMED
Fortney et al. 2022	Case Report	J Ultrasound	PUBMED
Tenazinha et al. 2022	Case Report	ARP Rheumatol	PUBMED
Nimjareansuk; Rosselli, 2020	Case Report	Clin Pract Cases Emerg Med	PUBMED
Prunières et al. 2018	Prospective Study	Hand Surgery and Rehabilitation	PUBMED
Jardin et al. 2018	Prospective Study	Hand Surgery and Rehabilitation	SCIENCE DIRECT
Schroeder et al. 2020	Case Report	Current Sports Medicine Reports	PUBMED
Bhagat; Scheels, 2023	Case Report	Visual Journal of Emergency Medicine	SCIENCE DIRECT
Sexton et al. 2019	Case Report	The Journal of Emergency Medicine	SCIENCE DIRECT
Yates et al. 2020	Case Report	Oxford Medical Case Reports	PUBMED
Neill et al. 2022	Case Report	Emergency Medicine Journal	PUBMED
Suwannaphisit; Ranong, 2020	Case Report	Annals of Medicine and Surgery	SCIENCE DIRECT

Source: Author (2023)

Chart 1 shows the authorship, year of publication, characterization of the sample, methods used in the diagnosis, and treatments recommended in the included studies.

Table 1. Clinical characteristics of studies eligible for this review. (n = 16)

Author/ Year	Sample	Diagnostic Method	Treatment Used
Mohn et al. 2022	▪ N: 65 ▪ Sex: Both sexes ▪ Age: 28 to 37 years old ▪ Diagnosis: Tenosynovitis of the finger flexors	▪ Clinical evaluation ▪ Ultrasound examination of pulleys, tendon sheaths, and tendons	Standard treatment: use of modeling clay and a compression finger stretcher made of silicone
Boudon et al. 2022	▪ N: 1 ▪ Gender: female ▪ Age: 65 years ▪ Diagnosis: Persistent tenosynovitis of the flexor tendons of the fingers of the right hand	▪ Clinical history ▪ Ultrasound ▪ Mri ▪ Biopsy	Combination of antimicrobial and immunosuppressive treatment
Osipchuk et al. 2023	▪ N: 1 ▪ Gender: female ▪ Age: 52 years ▪ Diagnosis: Tenosynovitis of the extensor	▪ Laboratory tests ▪ Radiographs ▪ Ultrasound ▪ Computed tomography	Surgical Debridement and Antibiotic Therapy
Nakamuara et al. 2023	▪ N: 1 ▪ Gender: Male ▪ Age: 7 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical anamnesis ▪ Laboratory tests ▪ Ultrasound	Antibiotic therapy

Fortney et al. 2022	▪ N: 1 ▪ Gender: Male ▪ Age: 9 months ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical anamnesis ▪ Laboratory tests ▪ Ultrasound	Surgical debridement and antibiotic therapy
Tenazinha et al. 2022	▪ N: 1 ▪ Gender: female ▪ Age: 72 years ▪ Diagnosis: Bilateral Candida tenosynovitis	▪ Clinical anamnesis ▪ Laboratory tests ▪ Ultrasound	Antifungal treatment
Nimjareansu; Rosselli, 2020	▪ N: 1 ▪ Gender: Male ▪ Age: 23 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound	Antibiotic therapy, incision and drainage treatment
Prunières et al. 2018	▪ N: 20 ▪ Sex: Both sexes ▪ Age: 27 - 62 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound	Debridement and antibiotic therapy
Jardin et al. 2018	▪ N: 57 ▪ Sex: Both sexes ▪ Age: 16 – 87 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound ▪ Radiographs	Antibiotic therapy and surgical debridement
Schroeder et al. 2020	▪ N: 1 ▪ Gender: Male ▪ Age: 32 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound ▪ Radiographs	Antibiotic therapy
Bhagat; Scheels, 2023	▪ N: 1 ▪ Gender: Male ▪ Age: 38 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound ▪ Radiographs	Antibiotic therapy
Sexton et al. 2019	▪ N: 1 ▪ Gender: Male ▪ Age: 59 years ▪ Diagnosis: Tenosynovitis of the flexors	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound	Antibiotic therapy
Yates et al. 2020	▪ N: 1 ▪ Gender: Male ▪ Age: 66 years ▪ Diagnosis: Pyogenic flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound ▪ Radiographs	Drainage and Debridement and Antibiotic Therapy
Neill et al. 2022	▪ N: 1 ▪ Gender: Male ▪ Age: 49 years ▪ Diagnosis: Purulent flexor tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound ▪ Radiography	Debridation and Antibiotic Therapy
Suwannaphisit; Ranong, 2020	▪ N: 1 ▪ Gender: female ▪ Age: 83 years ▪ Diagnosis: Tuberculous tenosynovitis	▪ Clinical examination ▪ Laboratory tests ▪ Ultrasound ▪ Radiography ▪ Biopsy	Debridation and Antibiotic Therapy

Source: Author (2023)

According to the data in Chart 1, it is possible to verify that patients affected by infectious tenosynovitis are usually male (53.3%), since there was a higher prevalence of males. They are usually over 30 years old (80.0%), and may also affect children (20.0%).

Chart 1 also shows that most individuals were diagnosed with pyogenic flexor tenosynovitis (53.3%). All studies used ultrasound as one of the diagnostic methods (100.0%). In addition, among the treatments used, there was a higher prevalence of antibiotic therapy (86.6%) and surgical debridement (40.0%).

4 DISCUSSION

According to Fortney et al. [15]) pyogenic flexor tenosynovitis (PFT) is a clinical diagnosis, imaging can be an informative complement, and ultrasonography (US) can be used in the early diagnosis of pyogenic flexor tenosynovitis because of its high sensitivity and negative predictive value.

From this perspective, the present systematic review sought to analyze the literature on the use of ultrasound in the diagnostic approach and therapeutic follow-up in patients with infectious tenosynovitis of the hand.

In this sense, Boudon et al. [16] found that ultrasound images were useful for identifying the inflammatory process of the metacarpophalangeal joints of the right hand. Similarly, in the report by Fortney et al. [15], ultrasound evaluation of the index finger was performed which demonstrated a collection of fluid within the flexor tendon sheath extending from the metacarpophalangeal joint to the distal phalanx with an additional fluid collection around the extensor tendon over the proximal phalanx, and no foreign bodies were identified. Fortney et al. [15] also emphasize that US was very useful in the diagnosis of PFT, while at the same time it excluded the presence of a retained radiolucent foreign body.

Corroborating these findings, Prunières et al.[3] found in their study that the mean diameter of the digital sheath measured in transverse and longitudinal ultrasound sections near the A2 pulley was 5.01 mm in symptomatic tenosynovitis fingers and 4.17 mm in healthy contralateral fingers. This difference of 17.8% was significant (p= 0.0005). Therefore, this unilateral increase of at least 20% in the diameter of the flexor sheath measured in transverse or longitudinal ultrasound sections on the A2 pulley contributed to the surgical indication of pyogenic flexor tenosynovitis.

In the report by Nakamuara et al. [17] US showed that the left PLF tendon had ruptured. In the research by Mohn et al. [6] An ultrasonographic examination of the pulleys, tendon sheaths, and tendons was performed in a transverse plane, which identified that the lesion occurred exclusively in the middle or ring finger (58.5% and 55.4%, respectively), except in one case in which the fifth finger was affected.

On the other hand, in the report by Suwannaphisit and Ranong [18], ultrasonography indicated chronic tenosynovitis of the flexor tendons of the fingers, with fluid more localized in the distal portion of the forearm and little finger. In addition, Tenazinha et al. Stuart et al.[19] reported that, on the initial evaluation, the presence of flexor tenosynovitis of the 3rd finger of the right hand and the 1st to 4th finger of the left hand and the left common flexor tendon leaf caused by Candida *albicans infection was observed*. According to the authors, *Candida albicans* is a rare cause of infectious tenosynovitis.

And according to Nakamuara et al. [17] In addition to blood culture, ultrasound evaluation should be performed in neonates with erythematous and swollen joints in order to identify the focus of infection as soon as possible. In addition, regular repeated US examination is important in the follow-up of bone and soft tissue infections.

In the study by Nimjareansuk and Rosselli [20], the use of point-of-care *ultrasound* (POCUS) was performed to aid in the diagnosis of pyogenic flexor tenosynovitis. And according to the authors, point-of-care ultrasound (POCUS) may be an effective adjunct in revealing pyogenic flexor tenosynovitis, rather than relying solely on the classic signs of Kanavel, leading to early treatment.

In this sense, Osipchuk et al. [21]) emphasize that point-of-care ultrasonography (POCUS) can be used to aid in the diagnosis of extensor tenosynovitis. And in his case report, the patient's physical examination findings were nonspecific, and the laboratory findings, along with the POCUS results, were instrumental in making the diagnosis.

In the study by Yates et al. [22], a POCUS was performed using a high-frequency linear array transducer in a Zonare ultrasound system, which demonstrated a large collection of complex fluid around the flexor tendons of the middle of the left forearm, extending to the volar aspect of the left hand. In this case, POCUS played an important role in the diagnosis of PFT in a patient with minimal physical examination findings, speeding up the initiation of appropriate therapy and surgical intervention.

In the research by Neill et al. [23] Ultrasound performed at the emergency room showed edema around the flexor pollicis longus tendon, demonstrated by a collection of hypoechoic fluid around the tendon sheath, referring to PFT. Based on this ultrasound, intravenous antibiotics were administered and the hand surgery service was consulted for surgical management and hospitalization. For this reason, Nimjareansuk and Rosselli [20] emphasize that performing a POCUS in the emergency department is an effective and timely adjuvant to support the diagnosis of pyogenic flexor tenosynovitis, leading to early treatment with antibiotics and/or surgical intervention.

Similarly, Schroeder et al. [24] also reported that POCUS performed on the patient's finger was indicative of soft tissue edema, peritendinous fluid, and calcification consistent with cellulitis. The patient was subsequently diagnosed with pyogenic flexor tenosynovitis because of his hot and painful edematous finger and the ultrasound findings were consistent with a soft tissue infection.

The ultrasonographic findings of the patient by Schroeder et al. [24] were consistent with the findings of the study by Jardin et al.[14] This study confirmed pyogenic flexor tenosynovitis. In the study by Jardin et al. [14] The results of US were compared to the intraoperative findings or to the clinical outcome in non-operated patients. In the 57 US examinations performed, significant peritendinous effusion was found in 27 patients (47.4%) and thickening of the synovial sheath with Doppler hyperemia in 23 patients (40.4%).

According to Prunières et al. [3] In the diagnosis of pyogenic tenosynovitis, ultrasonography has been shown to be more sensitive than clinical examination alone for detecting tenosynovitis. Ultrasound is easily accessible and does not delay patient care. The sensitivity of ultrasound has been shown to be superior to that of the clinical presentation in the diagnosis of flexor tenosynovitis during rheumatoid arthritis. Additionally, ultrasound can be helpful in monitoring progression after surgery and ensuring that the joint is not infected.

Jardin et al.Stuart et al.[14] reported in 57 patients that ultrasonography has a sensitivity of 94.4%, a specificity of 74.4%, a positive predictive value of 63%, and a negative predictive value of 96.7%, using surgical exploration as a reference. Therefore, the greatest utility of ultrasonography is to rule out PFT. Similarly, Nakamuara et al. [18] emphasize that US is an essential test for the diagnosis of pyogenic tenosynovitis, with a sensitivity of 94% and a negative predictive value of 97%.

Therefore, according to Jardin et al.[14] Ultrasonography is useful as a diagnostic tool for the management of early PFT, because of its excellent negative predictive value and specificity. This objective examination complements the surgeon's subjective clinical examination.

Corroborating this finding, Bhagat and Scheels [25] point out that without their report, on-site ultrasonography with the finger in a water bath revealed soft tissue edema, fluid around the tendon and no foreign body. The authors point out that in this case, the use of ultrasonography helped in the decision-making process and in the management of the disease.

Furthermore, according to Sexton et al. [26], as demonstrated in her case, ultrasonography can aid in the early identification of soft tissues and tendon alterations in the flexor tendon mechanism, leading to the early initiation of antimicrobial therapy and surgical consultation.

It is noteworthy that the case report by Schroeder et al.[24] differs from all other studies in which ultrasonography was used only as a diagnostic device. The authors used US as the object of treatment monitoring, therefore, the use of ultrasound aided in the early diagnosis of PFT and allowed the nonoperative treatment of the patient, as well as serial monitoring over time. Follow-up ultrasound showed continued improvement with mild soft tissue edema and confirmed that the flexor tendons were moving freely.

Therefore, it is evident that the ability of ultrasonography to interpret the efficacy of antibiotic monotherapy makes it possible to treat the patient without surgical intervention or to obtain invasive

tissue culture for diagnosis. It is believed that serial monitoring with ultrasonography should be systematically studied. The use of ultrasound has its limitations, including access and ability to interpret findings. This can be overcome with resources, education, and training. It is believed that the usefulness of POCUS ultrasonography is just beginning to be perceived and further studies and guidance on its proper implementation are needed[24].

5 CONCLUSION

Through the analysis of the researches, it was possible to identify that the ultrasound exam is widely used in the diagnostic approach of patients with tenosynovitis, however, its use in therapeutic follow-up is still not frequent, although its importance has been evidenced.

In addition, it was found that patients affected by infectious tenosynovitis are usually male, over 30 years of age, and may also affect children. Most individuals were diagnosed with pyogenic flexor tenosynovitis. All studies used ultrasound as one of the diagnostic methods. Among the treatments used, there was a higher prevalence of antibiotic therapy and surgical debridement.

According to the analysis performed, we found that bedside ultrasonography is an important imaging modality and should be considered for use in patients with suspected pyogenic tenosynovitis, due to its speed and greater sensitivity, as it allows the patient to be treated without surgical intervention and helps in the choice of the best treatment.

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