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**Faculty of Veterinary Medicine
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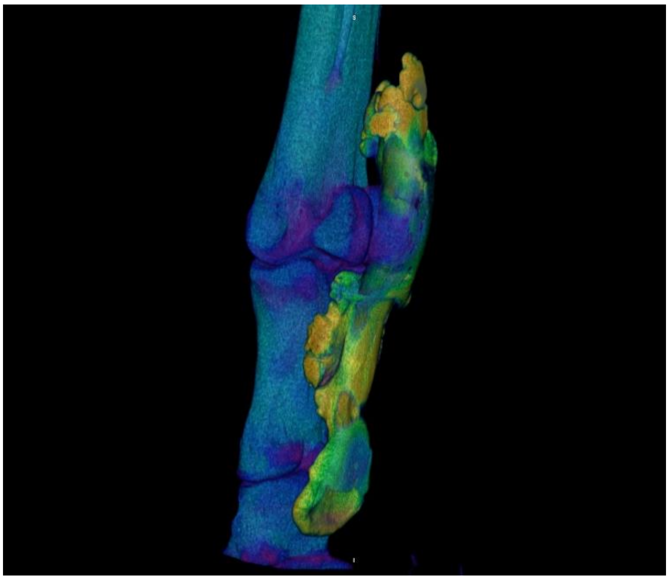
An investigation of factors associated with outcome of treatment



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SUMMARY

Contamination or infection of the digital flexor tendon sheath (DFTS) is a common problem in horses and the prognosis has traditionally been considered as poor. The purpose of this study was to increase the knowledge regarding the prognosis for horses with contamination or infection of the DFTS and to investigate whether specific factors are influencing the outcome in terms of survival. The hypothesis was that damage to tendons within the DFTS would negatively influence the survival rate and that horses treated early after injury or onset of clinical signs would have a better chance of survival. It was also hypothesized that tenoscopic surgical treatment would result in a better prognosis than through-and-through lavage.

Medical records from 111 horses diagnosed with infection of the DFTS or with a wound penetrating the DFTS, treated at three equine hospitals in Sweden between 2004 and 2019, were reviewed retrospectively. Information regarding the time from injury or the onset of clinical signs to admission, the time from admission to surgery, the aetiology, the presence of any tendon injuries, the presence of foreign material in the DFTS, the surgical method, the number of surgeries, the involvement of any additional synovial structures and the use of post-operative drainage was recorded. Outcome in terms of survival to discharge was also noted.

The aetiology was a perforating wound 101 cases, iatrogenic infection in 3 cases and unknown in 7 cases. All horses had some kind of surgical lavage performed, consisting of tenoscopy in 96 cases, through-and-through lavage in 6 cases and tenosynoviotomy in 5 cases. Four horses had both through-and-through lavage and tenoscopy performed. The overall short-term survival rate was 82% in terms of discharge from the hospital. This result is comparable with those of previous similar investigations.

Only one of the investigated factors was shown to influence the outcome significantly. A lower survival-rate was noted in horses treated by tenosynoviotomy compared to other surgical techniques (tenoscopy or through-and-through lavage or a combination of the two). The fact that a lower proportion of horses treated with tenosynovoitomy survived was suspected to reflect the severity of the injury in those horses.

The three hypotheses stated above could not be confirmed for this population. To evaluate whether the advantages of tenoscopy are generating better outcomes compared to through-and through lavage, controlled studies of a prospective design are required.

CONTENT

ABBREVIATIONS

DDFT	Deep digital flexor tendon
DFTS	Digital flexor tendon sheath
MF	*Manica flexoria*
PAL	Palmar/plantar annular ligament
SDFT	Superficial digital flexor tendon
TNCC	Total nucleated cell count
TP	Total protein

INTRODUCTION

Contamination or infection of the digital flexor tendon sheath (DFTS) are potentially fatal conditions in horses that may require extensive and costly veterinary actions. Despite these actions, complications can lead to chronic lameness and thus reduced ability of the horse to perform. The most common cause for contamination or infection of synovial structures are wounds and the DFTS is highly exposed to traumatic injuries due to its location in the distal limb with parts of it lying exposed directly under the skin (Schneider *et al.,* 1992a*)*.

Traditionally, the prognosis following treatment of DFTS infection has been regarded as poor, but in the last decades, with new treatment options and improved management, it seems like that the prognosis has improved (van Weeren, 2016). A few relatively recent publications have described the prognosis following contamination or infection of tendon sheaths. Short-term survival rates between 78 and 90% have been reported (Frees *et al.,* 2002; Fraser & Bladon, 2004; Smith *et al.,* 2006; Wereszka *et al.,* 2007) but in the long term only 41 to 54% of the treated horses returned to their previous levels of performance (Smith *et al.,* 2006; Wereszka *et al.,* 2007).

The purpose of this study was to describe the outcome of treatment of 111 horses diagnosed with contamination or infection of the DTFS. Further investigations were done to identify specific factors influencing the outcome in terms of survival. The hypothesis was that damage to tendons within the DFTS would negatively influence the survival rate and that horses treated early after injury or onset of clinical signs would have a better chance of survival. It was also hypothesized that tenoscopic surgical treatment would result in a better prognosis than through-and-through lavage.

LITERATURE REVIEW

Anatomy and physiology of the digital flexor tendon sheath

The digital tendon sheath is a synovial structure located on the palmar/plantar aspect of the distal limb. It surrounds the digital flexor tendons from 4-7 cm proximal to the fetlock to mid P2 level, and facilitates movement of the tendons by providing lubrication (Denoix, 1994; Dyce *et al.*, 2009,).

Proximal to the proximal sesamoid bones and within the DFTS the borders of the superficial digital flexor tendon (SDFT) extends into a fibrous ring that is called the *manica flexoria* (MF), which embraces the deep digital flexor tendon (DDFT) (Denoix, 1994). Further distal, the flexor tendons run through a canal formed by the palmar or plantar annular ligament (PAL). The ligament holds the flexor tendons in place by inserting abaxially on the proximal sesamoid bones. In this area the palmar/plantar sheath wall is composed of the PAL and distal to that by the proximal digital annular ligament. The proximal digital annular ligament is thin, x-shaped and adherent to the SDFT. Its proximal attachments are located proximopalmar/-plantar on either side of the proximal phalanx. Its distal insertions are situated medially and laterally together with the SDFT on the distal end of the proximal phalanx (Denoix, 1994).

Where the DFTS is not covered by annular ligaments it has a number of recesses. The proximal recess is located proximal to the MF and is palpable between the flexor tendons and the suspensory branches. There are four collateral recesses, of which two are situated on either side of the pastern just below the proximal sesamoid bones and two are situated medial and lateral between the proximal and distal attachments of the proximal digital annular ligament. In addition, there is a distal recess which can be palpated between the proximal digital annular ligament and the distal digital annular ligaments when the sheath is distended (Denoix, 1994). The anatomy of the DFTS and the nearby located structures in a hindlimb are showed in Figure 1 and 2.

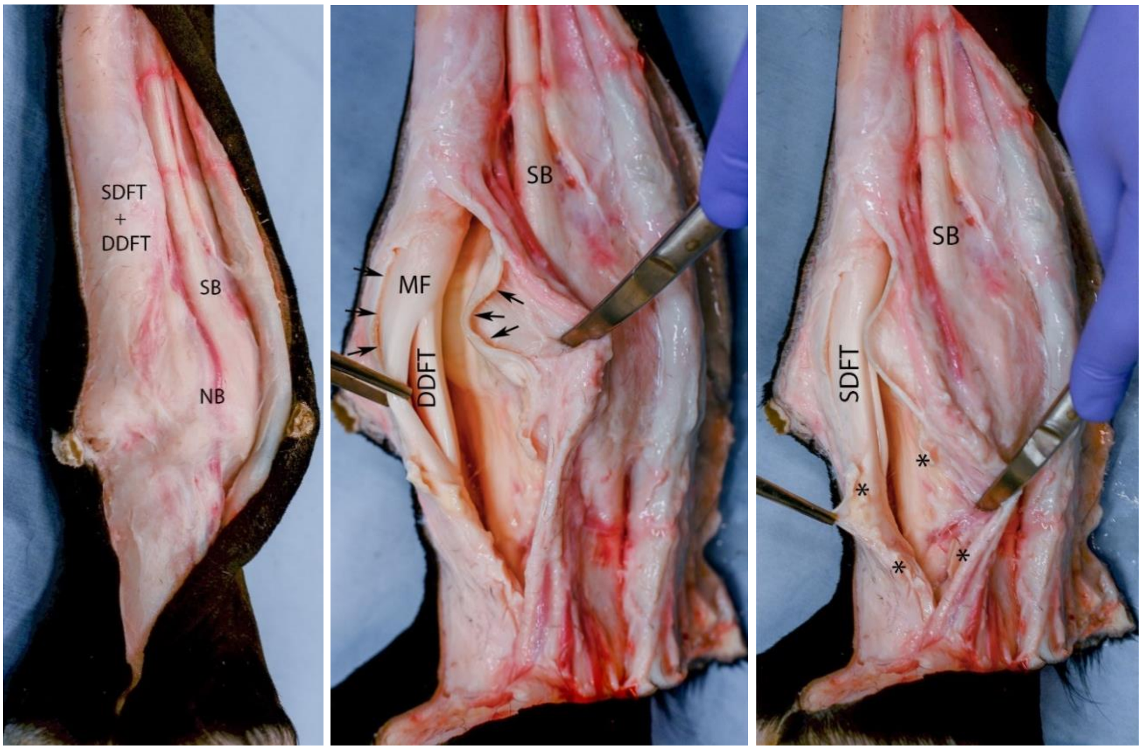

Figure 1. *From left to right:* A, B *and* C. A: *The skin has been removed in the area of the DFTS.* SB: *branch of suspensory ligament*, NB*: neurovascular bundle.* B: *The PAL has been cut and the DFTS opened. Forceps are holding the SDFT. Arrows are pointing at the transected PAL.* C: *Asterisks (*) are marking the proximal and distal attachments of the proximal digital annular ligament. Photos: Agnes Hammarlund.*

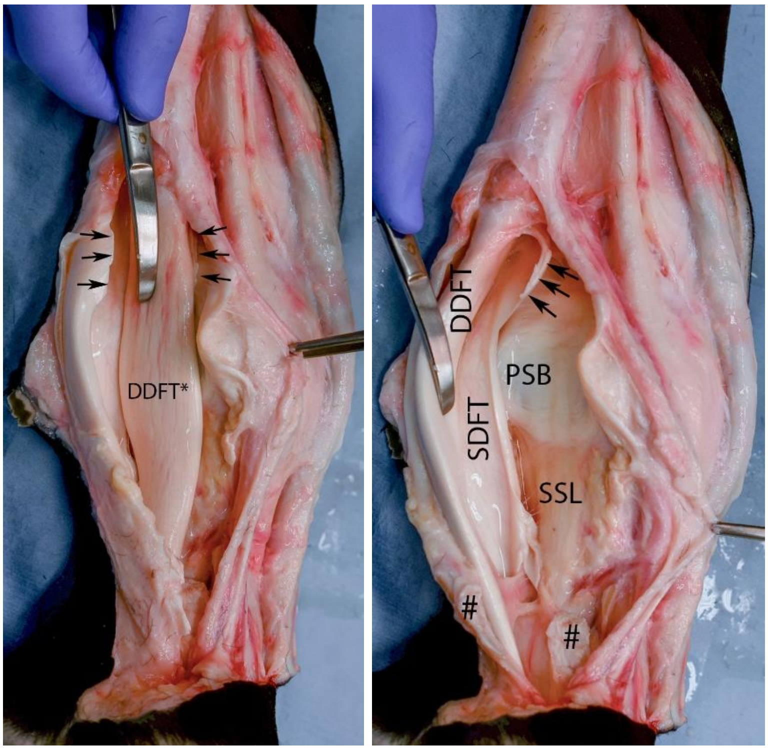

Fig 2. *From left to right:* C and D. C: *The* MF *has been cut. Arrows are pointing at the cut edges of the MF.* DDFT*: *plantar surface of the DDFT.* D: *One of the attachments of the SDFT has been cut and is marked with #. Arrows are pointing at the MF.* PSB: *proximal sesamoid bone*, SSL: *straight sesamoidean ligament. Photos: Agnes Hammarlund.*

Like in other synovial structures the inside of the tendon sheath has a lining composed of synovial cells. The most important functions of the synovium are protein secretion and phagocytosis, through which it regulates the contents of the synovial fluids. Proteins secreted into the synovial fluid are important components of synovial metabolism in healthy conditions as well as in pathologic disorders like inflammation and infection (Frisbie & Johnson, 2018). The environment inside a tendon sheath is similar to that of a synovial joint or bursa, and therefore it responds correspondingly to bacterial contamination (McIlwraith *et al.,* 2015).

The synovial fluid should be transparent to pale yellow in colour, non-flocculent, viscous and it should not clot (Steel, 2008). Total nucleated cell counts (TNCC) of synovia of up to 500 cells/μl and total protein (TP) levels of around 5 g/L are considered as normal (Frisbie & Johnson, 2018). These reference values are validated for synovial joints and not for tendon sheaths. Malark *et al.* (1991) did not observe values of TNCC and TP concentrations that differed significantly from these reference values, when synovial fluid from the DFTS specifically was evaluated in 13 horses. However, they did observe some differences, which was a lower concentration of hyaluronic acid and a lower mucin precipitation, which is a measure of hyaluronan quality.

Contamination or infection of the DFTS

Aetiology

The most common cause of contamination or infection of synovial structures is wounds. The contamination can either enter the structure by direct penetration or indirect from infected neighbouring structures. In penetrating injuries foreign material can sometimes be introduced into the tendon sheath (van Weeren, 2016).

The other two pathways of microorganisms entering the synovial structure are iatrogenic through injections or surgical procedures or by a haematogenous route. The latter is common in foals but uncommon in horses older than six months (van Weeren, 2016).

In 114 bacterial isolates from horses that were treated in the UK for synovial infection, *Staphylococcus* spp. were the most frequent cultured bacteria. Of all isolates, 75% were gram-positive bacteria and the remaining 25% were gram-negatives. Of the gram-negative bacteria, *Enterobacteriacae* were most frequently cultured (Robinson *et al.,* 2016).

Pathophysiology

The pathophysiology of infection in a tendon sheath is very similar to that of a synovial joint (Schneider *et al.,* 1992a; McIlwraith *et al.,* 2015). Microbial contamination of synovial structures can rapidly result in colonization of the synovial membranes and develop into an established infection. Wright *et al.* (2003) suggested that potentiating factors for establishment of synovial infection are the presence of foreign material, tissue damage and the characteristics and dose of the contaminating microorganism. These factors together with the immune response of the host may influence the duration of the subclinical phase and the degree of clinical signs that the horse develops (van Weeren, 2016). The tendon sheath responds to micro-organisms with an inflammatory cascade, comparable to the reaction that occurs when other parts of the body are invaded. Permeability of the blood supplying vessels increases, and the synovial membranes becomes hyperaemic. The early inflammatory reaction also consists of recruitment of neutrophils and monocytes, which releases inflammatory mediators, such as cytokines, collagenases and tumour necrosis factor. These factors are secreted into the synovial fluid directly from synovial cells as well (Joyce, 2007) and results in alterations of the synovial fluid which includes degradation of hyaluronan, reduced production of proteoglycans and fibrin deposition (Hardy *et al.*, 1998). With the inflammatory reaction follows increased intrasynovial pressure, that is a contributing cause of pain. Chronic changes that develop from a prolonged inflammation include pannus formation, hypertrophy of synovial membranes and adhesion formation within the DFTS (Joyce, 2007).

Clinical signs and diagnosis

Clinical signs associated with infection of tendon sheaths are severe lameness, painful effusion of the tendon sheath, cellulitis and fever in most cases (Frees *et al.*, 2002). In cases where the tendon sheath has been penetrated by a wound, synovial fluid may sometimes initially drain through the wound which, in turn, leads to less dramatic increase in synovial pressure and less pronounced lameness, compared with a sealed lesion (van Weeren, 2016). Similarly, horses with wounds involving the DTFS of short duration are not necessarily lame because infection is not yet established (Joyce, 2007).

Diagnosis is made based on clinical signs in conjunction with various diagnostic tests. Upon occurrence of any wound in the area of the DFTS, this should be thoroughly explored after clipping and aseptic preparation of the wound area to determine which structures that are involved or at risk of involvement. Sampling of synovia is an important diagnostic modality. Synoviocentesis should be performed at an injection site as distant from any wound as possible. Following collection of the synovial sample, a pressure test can be performed by injection of saline solution into the tendon sheath through the same needle. The test can confirm synovial communication if fluid is leaking out of the wound or indicate that this is less likely if the structure holds the pressure when distended (Joyce, 2007).

Gross examination of the synovial fluid includes assessment of viscosity, turbidity and colour. Infected synovial fluid is frequently cloudy, sometimes flocculent, and commonly has a reduced viscosity and various discolorations (Steel, 2008).

Total nucleated cell counts exceeding 20 000 cells/µl are indicative of infection (Richardsson & Stewart, 2018). Total protein levels normally increase as well but are not as reliable as they vary to a high degree depending on duration and severity. In infected synovial cavities TP levels often exceed 40 g/l (Steel, 2008).

Cytology is very helpful for diagnosis of synovial infection. A neutrophil percentage of 90 or more together with degenerative changes of neutrophils are convincing findings, especially if extracellular or intracellular bacteria are present (Steel, 2008).

A positive bacterial culture is considered as the gold standard for diagnosis of synovial sepsis. However, false negative cultures are common, despite culturing in blood culture media under aerobic and anaerobic conditions. Therefore, a negative culture does not exclude infection. Any bacterial growth should be submitted to sensitivity testing so that antimicrobial treatment can be adapted in cases not responding to treatment (Richardsson & Stewart, 2018).

Ultrasonography can be helpful in establishing the diagnosis of infection of the tendon sheath. Typical sonographic findings are effusion, thickening of synovial membranes, increased echogenicity of the synovial fluid, hyperecogenic spots and fibrinous loculations. Presence of air and foreign material due to lacerations can challenge the examination but also support the diagnosis when there is suspicion of involvement of the DFTS. One should keep in mind that findings can be highly variable, and that the absence of characteristic findings should not exclude infection. This is particularly true in acute cases when changes detectable with ultra-sonography are often less prominent (Beccati *et al.*, 2015).

Radiography may not be diagnostic for tendon sheath infections but can be valuable to diagnose concurrent pathologies, like fissures, fractures and osteomyelitis. Radiopaque foreign material can be identified and if a wound is communicating with the DFTS the appearance of gas along tendons can sometimes be seen. As a further diagnostic modality contrast radiography can be used to establish communication between a wound and the tendon sheath (Bertone, 1995).

Treatment and rehabilitation

Where the facilities exist, lavage and inspection through tenoscopy is currently the most common choice of surgical technique for contaminated and infected tendon sheaths. Tenoscopy allows direct inspection of the tendons, removal of debris, adhesions or foreign material, and the ability of flushing all areas of the tendon sheath with large volumes of fluid in a short time (Fraser & Bladon, 2004). Some reports have declared benefits of lavage through tenoscopy as compared to through-and-through lavage in the treatment of septic tenosynovitis (Frees *et al.*, 2002; Fraser & Bladon, 2004). However, in a retrospective study of 51 cases by (Wereszka *et al.*, 2007), outcome was not significantly associated with the method for lavage chosen. Regard-less of the surgical procedure chosen, extensive lavage is essential in the treatment of septic tendon sheaths. The principles of surgical treatment in addition to lavage are debridement of devitalized tissue, removal of any foreign material and elimination of microorganisms. Any presenting wounds are debrided and most often primary closed if possible (Wright *et al.*, 2003). In chronic cases, where aggressive debridement and elimination of adhesions are sometimes necessary, open tenosynoviotomy has been suggested as a good alternative (Chan *et al.*, 2000; Mc Nally *et al.*, 2013).

According to (Schneider *et al.*, 1992b) it can sometimes be indicated to create post-operative drainage in cases with established synovial infection that does not respond to single or repeated lavages. Chronic drainage can be achieved through intra-synovial drains or through incisions that are left open until they heal by second intention or are closed primarily when they are no longer needed.

Apart from surgical interventions, medical treatment should be initiated immediately when diagnosis is made. Medical treatment includes systemic broad-spectrum antimicrobials and possibly local antimicrobials (Richardsson & Stewart, 2018). Non-steroidal anti-inflammatory treatment is used to reduce inflammation and pain. When Owens *et al.* (1996) induced synovitis experimentally, horses that were pre-treated with phenylbutazone intravenously showed reduced lameness, joint temperature and synovial fluid volume compared to control horses that received saline solution. Non-steroidal anti-inflammatory treatment has also been showed to reduce the concentration of intrasynovial inflammatory mediators in acute synovitis (Owens *et al.,* 1996; Morton *et al.,* 2005; Grauw *et al.,* 2009).

According to guidelines for use of antibiotics published by the Swedish Veterinary Association (2013), systemic penicillin in combination with gentamicin are the drugs of first choice for treatment of synovial infections. Gentamicin as a first-line treatment of synovial infections is in agreement with the results of a large survey of susceptibility tests published by (Robinson *et al.,* 2016). Of the gram-negative isolates analysed 70% were susceptible to gentamicin. Gram-positive bacteria were only susceptible to penicillin in <20% of the cases and to gentamicin in >50% of the cases. Nevertheless, 100% of the *Streptococcus spp.* isolates were susceptible to penicillin. As a combined therapy, gentamicin and penicillin cover a large proportion of causative bacteria. In the referred study, enrofloxacin and ceftiofur were the antibiotics tested that had the highest susceptibility frequencies. However, as fluoroquinolones and third generation cephalosporins are considered as protected antimicrobials they should not be used routinely but be saved for life-threatening conditions in cases where other antimicrobials are ineffective. Any use should be motivated by culturing and susceptibility testing (Robinson *et al.,* 2016).

Honnas *et al.* (1991) have reported that some horses with infectious tenosynovitis can be treated without surgical interventions, recover and return to their previous use. The horses in this report received broad-spectrum antimicrobials, non-steroidal anti-inflammatory drugs and had their wounds debrided. Still, this is currently not a recommended treatment (Richardsson & Stewart, 2018).

The most commonly discussed complication following tendon sheath infections is adhesion formation within the tendon sheath (Honnas *et al.,* 1991; Frees *et al.,* 2002; Wright *et al.,* 2003; Wereszka *et al.,* 2007). To avoid adhesions, it has been suggested that walking exercise and/or passive motion should be introduced as early as possible post-operatively (Honnas *et al.,* 1991; Bertone, 1995; Frees *et al.,* 2002). The theory that this complication can be prevented by physiotherapy is supported by an experimental study performed on dogs (Gelberman *et al.,* 1983). The dogs went through tenotomy followed by surgical repair of their deep flexor tendons within the tendon sheath. Half of the dogs were completely immobilized, and the rest of the dogs were subjected to a passive motion physiotherapy program post-operatively. The dogs were euthanized at different stages of the healing process and the flexor tendons were evaluated microscopically and by gross examination. When groups were compared there was a distinct difference in quality of the flexor tendon surface between the two groups. Adhesions between the tendon sheath and the tendon was not noted at any stage of healing in the passive motion group (Gelberman *et al.,* 1983).

Other complications described are osteomyelitis of the proximal sesamoid bones and infectious tendinitis that can lead to tendon ruptures (Honnas *et al.,* 1991). The risk of contralateral limb laminitis due to unloading of the affected limb should also be taken into account (Wright *et al.,* 2003).

Prognosis

In a retrospective study of 51 horses with septic tendon sheaths 78% of the included horses survived to discharge from the hospital (Wereszka *et al.,* 2007). Both affected DFTS and other tendon sheaths were represented, and the inclusion was based on bacterial cultures or synovial fluid alterations. Long-term follow-up showed that 73% of discharged horses were alive at least one year after surgery. Of the surviving horses 57% (41% of all included horses) went back to training at their previous or a higher level. Early treatment, within 24 hours after the onset of clinical signs, was found to be favourable for a good outcome. Infection of more than one synovial structure, tendon rupture and severe pannus formation were negative prognostic factors (Wereszka *et al.,* 2007).

Frees *et al.* (2002) reported that of 20 horses that were tenoscopically treated for open DFTS injuries 90% survived. At long-term follow-up, 70% of them were sound or mildly lame. A similar investigation was made by Fraser & Bladon (2004), who included 39 horses with lacerations of the DFTS. According to the report 84.6% of them were recovered from anaesthesia and 76.9% were alive at follow-up ≥seven months post-operatively. Sixty-nine percent were back to being used for their original or intended purpose at that time. Factors that had significant correlation with survival and return to use were treatment within 36 hours post injury. The authors concluded that if treatment was initiated that early, tendon damage was the limiting factor for long-term recovery (Fraser & Bladon, 2004).

The largest retrospective study to of septic digital tenosynovitis to this date covered 90 horses (Smith *et al.,* 2006). Inclusion was made based on clinical findings, bacterial cultures or synovial fluid alterations. Of the 90 horses, 87.7% survived to discharge from the hospital and of the 72 horses that were followed up long-term 54.2% had returned to their previous level of performance. None of the evaluated variables had a significant impact on survival (Smith *et al.,* 2006).

MATERIAL AND METHODS

Medical records of horses treated at three different equine hospitals in Sweden, which will from now on be referred to as Hospital 1, Hospital 2, and Hospital 3 were reviewed. Seventy-five horses were treated at Hospital 1 between 2006 and 2019. Twenty-three horses were treated at Hospital 2 between 2004 and 2018. The remaining 22 horses were treated at Hospital 3 between 2016 and 2019. The time spans differed between the hospitals because of technical reasons related to the search for cases in the records. The cases treated in Hospital 1 and Hospital 3 were found by going through the surgery log, searching for the Swedish words for "tenoscopy" or "lavage" and "tendon sheath". The cases recorded at Hospital 2 were found through a search in the medical records for "digital tendon sheath" and "lavage". The method for finding cases resulted in that all included horses have had some kind of surgical interventions performed, although in some cases this was limited to through-and-through lavage. Cases that were euthanized prior to any surgical lavage have therefore not been included. In the case that any horses have been treated medically for contamination or infection of the SDFT at the three hospitals during the studied periods, they have not been detected. However, the latter is highly unlikely based on perceived opinions regarding acceptable standards of care at the involved hospitals.

Inclusion was made in cases where communication between the DFTS and any wound could be confirmed. Cases that were recorded without a wound were included if bacterial culturing of synovial fluid was positive or if synovial changes met specific criteria (a TNCC exceeding 20 000 cells/μl or a neutrophil percentage of 90 or more). Foals were only included if their cases were recorded with a wound or sepsis of only the DFTS and not if they showed signs of systemic sepsis. According to data obtained from the medical records 120 horses met these inclusion criteria. Eight horses were euthanized on the table and one horse was euthanized due to colic the day after surgery. These 9 horses were not included in the statistical analyses as treatment was not attempted and therefore the study population consisted of the remaining 111 horses.

Medical records were reviewed with regards to sex, age and breed, time from injury to admission, time from admission to surgery, aetiology, presence of any tendon injuries, presence of foreign bodies in the DFTS, surgical method, number of surgeries, involvement of any additional synovial structures, post-operative drainage and outcome in terms of survival to discharge. If synovial samples were taken, results from bacterial cultures and additional analyses were registered.

Statistical analyses were performed with JMP 14.0. Logistic regression analysis was performed to analyse the effects of time to treatment, time to surgery, method of treatment and effects of involvement of the flexor tendons on the short-term outcome as measured by discharge from the hospital. For time to treatment, one surviving outlier treated 16 days after injury was removed from the dataset and time to surgery was dichotomized into same day or later. For involvement of tendons; superficial abrasions were grouped with no involvement and all tearing of fibres or transections were grouped together. Furthermore, for method of treatment only tenoscopy versus through and through lavage was analysed in regression analysis. Fischer's exact test was used to test the levels of each variable independently. The level of significance was set at $p<0.05$.

RESULTS

Descriptive data

The study population of 111 horses consisted of 64 mares, 35 geldings and 12 stallions aged from 0 to 19 years with an average age of 6.3 years. Ninety-one horses (82%) survived to discharge from the hospital.

In 101 cases the reason for contamination of the tendon sheath was an identified wound, of which 84 were lacerations and 17 were puncture wounds. Three horses developed septic tenosynovitis following injection or surgery. In the remaining seven horses the aetiology could not be established. The distribution of different aetiologies and the number of surviving horses in each category are presented in Table 1. In eight horses more than one synovial structure was confirmed to be contaminated or infected. The additional structure consisted of the metacarpo- or metatarsophalangeal joint in six horses and the remaining two horses had involvement of the proximal interphalangeal joint and the navicular bursa, respectively. Survival rates of horses with and without involvement of an additional synovial structure are presented in Table 1.

Information regarding the time to admission from onset of clinical signs or from the traumatic event was available in 97 cases. This time varied from less than one hour to 7 days. The majority of horses were treated within one day (75.3%) but there was one outlier that was treated after 16 days. Data regarding the time from admission to surgery was available in all cases but one. According to the medical records 50 horses were operated the same day as they arrived and 60 horses the day after or later. In six horses surgery was not performed until between two and four days due to a delayed diagnosis or the horse not being stable enough for general anaesthesia. Three of them survived and three were euthanized. The outcome relative to time to admission and related to time to surgery is summarised in Table 1.

All horses underwent surgical lavage under general anaesthesia at least once. The vast majority of the horses (86.5%) underwent tenoscopic lavage. The six horses treated with through and through lavage as the only method of lavage were all treated between 2004 and 2006. The open method was chosen in five cases due to extensive tissue trauma or a longer duration of clinical signs, or combinations thereof. The four horses that were categorized into the “combination of therapies” group underwent through and through lavage as the initial therapy. Three of them had tenoscopy performed as the second surgery and survived. One horse had tenoscopy performed as the fourth surgery and did not survive. The outcome of different surgical methods is presented in Table 1.

In 11 cases drainage incisions were made specifically to create post-operative drainage or the tenoscopy portals were left open for the same purpose. Two of them had intrasynovial drains placed that exited through one or two of the open portals. The survival rate with or without post-operative drainage is shown in Table 1.

Five horses had an infusion pump for continuous administration of antibiotics into the tendon sheath instilled postoperatively. Two of them received the pump after the second surgery and one after the third surgery. The two horses that had the pump instilled after the first surgery had a duration of clinical signs of at least four days at the time of surgery.

Table 1. *Number of horses and the surviving proportion of them related to evaluated factors*

Evaluated factor	No. of horses	No. of horses surviving to discharge (%)
Surgical method		
Tenoscopy	96	82 (85.4)
Through-and-through lavage	6	4 (66.7)
Tenosynoviotomy	5	2 (40.0)
Combination of therapies	4	3 (75.0)
Aetiology		
Laceration	84	72 (85.7)
Puncture wound	17	13 (76.5)
Iatrogenic	3	3 (100)
Idiopathic	7	3 (42.9)
Time from onset of clinical signs or the traumatic event to admission		
<24 h	73	64 (87.7)
>24 h	24	17 (70,8)
Time for surgery relative to admission		
The same day	50	40 (80.0)
The day after or later	60	50 (83.3)
Presence of foreign material		
Foreign material detected	9	7 (77.8)
No foreign material detected	101	84 (83.2)
Presence of tendon injuries		
Tearing of fibres or transections	42	36 (85.7)
No detected injuries or superficial abrasions	66	53 (80.3)
Additional synovial structures involved		
DFTS + additional structure	8	6 (75.0)
Only DFTS involved	103	85 (82.5)
Post-operative drainage		
Portals left open	11	7 (63.6)
Primary closure of portals	100	84 (84.0)

Synovial samples were taken in 76 cases. Synovial fluid was submitted for culturing from 53 horses and 19 isolates were positive. Results of bacterial culturing are shown in Table 2. TNCC was analysed in 50 cases, TP was analysed in 36 cases and a neutrophil percentage was recorded in 46 cases. Results of synovial analyses are shown in Table 3.

Table 2. *Results of bacterial culturing*

Bacterial culturing	No. of horses (% of the total 53 isolates)	No. of horses surviving to discharge (%)
Bacterial growth	19 (35.8)	12 (63.2)
Staph. aureus penicillinase+/penicillinase-	2/2	
Other Staphylococci	2	
Streptococcus spp.	4	
Actinobacillus equuli	2	
Enterococcus spp.	2	
Citrobacter spp.	2	
E. coli	1	
Clostridium spp.	1	
Other bacteria (typing information missing)	1	
No growth	34 (64.2)	28 (82.4)

Table 3. *Results of synovial analyses*

Synovial analysis	Performed in no. of horses	Range of values	Mean value
TNCC (cells/μ)	50	300-930 000	91200
TP (g/l)	36	6-82	47
Neutrophil percentage (%)	46	10-100	91

Statistical analyses

There were no significant effects of any of the variables examined. There were no statistical differences between treatment initiated the day of injury versus later, no differences between performing surgery the same day versus later, no differences between tenoscopy and through-and-through lavage nor were there any effects of light or no tendinous injury versus partially severed or ruptured tendons on the short term outcome. However, when open technique was compared to other techniques the former was less likely to result in a successful short-term outcome, 40% for open technique versus 84%. This was significant when analysed separately, but not in the overall model.

DISCUSSION

Synovial infections or wounds contaminating synovial structures are, and will continue to be, conditions that challenge equine clinicians on a regular basis. As they require costly and extensive treatment that is followed by an uncertain future for the horse it is of great importance that this field continues to be investigated. A large number of studies of septic arthritis or both septic arthritis and septic tenosynovitis have been published, but only a few of them have investigated conditions of the DFTS specifically (Frees *et al.*, 2002; Fraser & Bladon, 2004; Smith *et al.*, 2006). In the present study, cases of different aetiology were included and there was no standard treatment protocol other than that all horses underwent surgical lavage under general anaesthesia at least once. Furthermore, only horses in which treatment was attempted, such that they were allowed to recover form general anaesthesia, were included. The reason for this is that there are no generally accepted guidelines to indicate when treatment is meaningful or not, thus horses subjected to more or less arbitrary euthanasia were excluded. This may skew the results to some extent, but that cannot be known.

The present study has determined a short-term survival rate of 82% in 111 horses treated for contamination or infection of the DFTS. This result is comparable with those previously reported, i.e. a short-term survival rate between 78 and 90% (Frees *et al.*, 2002; Fraser & Bladon, 2004; Smith *et al.*, 2006; Wereszka *et al.*, 2007). Inclusion criteria varied slightly among these studies, with Frees *et al.*, (2002) and Fraser & Bladon (2004) only including horses treated tenoscopically for lacerations of the DFTS. Few authors have compared the outcome of different lavage techniques, but Wereszka *et al.* (2007) included horses that were treated both tenoscopically, by through-and-through lavage and with tenosynoviotomy and did not find a significant variation in survival rates among the different techniques. In the present study, the survival rate for the six horses treated by through-and-through lavage was 66.7%. When compared with the corresponding proportion (85.4%) of surviving horses among the ones treated tenoscopically, the difference was not significant. The low number of horses treated with through-and-through lavage compared to the ones treated by tenoscopy is a weakness in this comparison. Furthermore, all horses that were treated by through-and-through lavage as the only method of lavage were treated between 2004 and 2006. Such changes may have increased the importance of the time-span as a confounding factor as other changes in management may also have occurred over time. However, such potential changes have not been identified in the present investigation.

However, when the open surgery technique was compared with other techniques the former was significantly less likely to result in a successful short-term outcome (p=0.04). One can speculate in that this is a reflection of the severity of the injury in these horses as the technique is usually chosen when large defects of the tendon sheath wall are present, often in combination with a long duration of clinical signs. To be able to evaluate the result of different treatment options and draw reliable conclusions regarding their efficiency another study design than the retrospective is required.

Despite the relatively high number of horses included in this study and the exclusion of one surviving outlier that was treated after 16 days, no significant difference in survival between horses that had treatment initiated within 24 hours and horses that had treatment initiated later could be shown. The results reported by (Frees *et al.*, 2002) supports that it is worth attempting to treat horses with septic tenosynovitis despite long duration of clinical signs. In Frees *et al.* (2002) the mean time from injury to surgery was 14.6 days and the short-term survival rate was still high (90%). On the other hand, Fraser & Bladon (2004) reported that the time to surgery had a significant impact on the outcome. When long-term follow-up was made, 89% of the horses operated within 36 hours and 40% of the horses operated after 36 hours returned to their intended use. Perhaps a significant relationship between time to treatment and outcome could have been shown in the present study if long-term follow-up would have been performed. Regardless of the correlation with outcome, an attempt to make a diagnosis and initiate treatment should be made as soon as possible, not least to achieve pain-relief for the suffering horse.

Fraser & Bladon (2004) found a significant difference in the proportion of horses returning to work between horses with or without tendon damage. In the present study it was hypothesized that the presence of tendon damage would influence the outcome. So was not the case. How long-term outcome was affected by tendon injuries was not investigated, and this is a subject for a separate study.

To summarize, the short-term survival rate in this particular population of horses with contamination or infection of the DFTS was good. The three hypotheses that horses treated early after injury or onset of clinical signs would have a better chance of survival, that damage to tendons within the DFTS would negatively influence the survival rate and that tenoscopic treatment would result in a better prognosis than through-and-through lavage could not confirmed for this population. Nevertheless, the survival rate of horses that underwent tenosyoviotomy was significantly lower than that of horses treated with other techniques. Controlled studies of a prospective design are required for assessment of whether the advantages of tenoscopy are generating better outcomes. However, given the current opinion that minimally invasive surgery is advantageous, it can be considered unethical to perform such a study. Long-term follow-up was not performed in this study and would perhaps have generated more conclusive results.

POPULÄRVETENSKAPLIG SAMMANFATTNING

I detta examensarbete gjordes en uppföljande studie av 111 hästar som behandlats för kontaminerade eller infekterade kotsenskidor vid tre olika svenska hästsjukhus mellan 2004 och 2019. En infektion i en kotsenskida är ett allvarligt tillstånd som kan äventyra både hästens liv och dess framtida atletiska funktion. Det är därför av stor vikt att undersöka vilka faktorer som kan påverka prognosen för tillfrisknande för att kliniskt verksamma veterinärer ska kunna optimera behandlingen av tillståndet.

Kotsenskidan är en struktur som omsluter hästens böjsenor på baksidan av frambenets eller bakbenets nedre del. Senskidor är mycket lika leder med avseende på uppbyggnad och fysiologi. Till exempel innehåller de synovial vätska, allmänt uttryckt som ledvätska, vars huvudsakliga funktion är att minska friktionen inne i senskidan. Bakterier kan kontaminera en senskida eller en led på tre olika sätt; via ett sår, via blodbanan om hästen har en infektion som är systemiskt spridd i kroppen eller genom en behandling, exempelvis i samband med en operation eller injektion. Penetrerande sårskador är den vanligaste orsaken och kotsenskidan är en struktur som relativt ofta drabbas, på grund av dess ytliga och oskyddade placering på hästens ben. När bakterier har kontaminerat en led eller senskida får de lätt fäste där, förökar sig och skapar en infektion. Ledens eller senskidans svar på detta är en kraftig inflammatorisk reaktion som orsakar stor smärta för hästen och leder till hälta och svullnad. Komplikationer som kan uppstå och påverka hästens långtidsprognos är till exempel sammanväxningar mellan senorna i senskidan eller mellan senorna och senskidans vägg.

Vid en sårskada som involverar en senskida är behandlingen densamma som vid en manifest infektion även om sårskadan är färsk och infektionen inte hunnit etablera sig ännu. Behandlingen består av omfattande kirurgisk spolning som kan genomföras antingen via titthålskirurgi, eller genom att ett antal kanyler placeras i strukturen så att de utgör in- och utfarter för spolvätskan. Om titthålskirurgi tillämpas kan senskidan genomsökas för att identifiera främmande material och eventuella skador på senor eller andra strukturer kan upptäckas. I vissa fall, framförallt om skadorna är omfattande eller infektionen kronisk, kan det vara aktuellt med öppen kirurgi, vilket innebär att man får åtkomst för undersökning och spolning av senskidan via ett längre snitt än vad som görs vid titthålskirurgi. Flera nyligen publicerade studier betonar titthålskirurgins fördelar jämfört med de övriga metoderna, men få har jämfört resultatet av de olika teknikerna. Utöver spolningen av senskidan rengörs eventuella sår, sårkanter skärs rena och i största möjliga mån sutureras skadan för att sårets läkningstid ska förkortas. Dessutom behandlas hästen med antibiotika, antiinflammatorisk och smärtlindrande medicin allmänt. Antibiotika tillförs i vissa fall även lokalt i senskidan eller regionalt i benet.

I den här studien undersöktes huruvida ett antal specifika faktorer hade betydelse för behandlingsresultatet i form av överlevnad till utskrivning från djursjukhuset eller avlivning innan dess. De faktorer som utvärderades var behandling inom ett dygn eller senare, operation på dagen för ankomst till kliniken eller senare, vilken operationsmetod som användes samt förekomst av senskador eller ej. Baserat på den statistiska metod som tillämpades vid utvärderingen visade det sig dock att ingen av de undersökta faktorerna hade någon signifikant inverkan på överlevnaden bortsett från operation med öppen metod. Då överlevnaden hos hästar som opererat med öppen metod (40 %) jämfördes med överlevnaden hos hästar som opererats med övriga metoder (84 %) visade sig skillnaden vara statistiskt säkerställd. Man kan dock spekulera i att då öppen operationsmetod valdes hos hästar som hade omfattande traumatiska skador eller kom till sjukhuset först flera dagar efter att skadan hade inträffat är det möjligt att dessa hästar hade haft dåliga förutsättningar oavsett vilken operationsmetod som hade valts. Generellt kan man endast dra begränsade slutsatser gällande resultatet av en behandlingsmetod i den här typen av studie, bland annat eftersom den inte styrs av ett specifikt standardiserat behandlingsprotokoll och på grund av att den utvärderar olika faktorers påverkan i efterhand. För att kunna dra tillförlitliga slutsatser avseende vilken operationsmetod som genererar bäst resultat skulle det behöva genomföras ytterligare forskning, i form av studier med en annan design.

Bland resultaten sågs även några ytterligare tendenser. Bland annat var procentsatsen av överlevande hästar högre bland dem som behandlades med titthålskirurgi jämfört med andra metoder och bland dem som fick vård inom ett dygn jämfört med övriga men ingen av dessa tendenser var så tydliga att slumpmässiga fördelningar inom den undersökta gruppen av fall kunde uteslutas. Då flera tidigare publikationer har framhävt tiden som en viktig faktor bör man inte förringa vikten av att så snabbt som möjligt ställa en diagnos och inleda behandling i de fall man misstänker en kontamination av eller infektion i en kotsenskida, om inte annat så för att hästen ska behöva ha ont så kort tid som möjligt.

Av samtliga inkluderade 111 hästar var det 91 stycken som överlevde fram tills att de skrevs ut från sjukhuset. Detta får anses som ett gott resultat och det stämmer överens med de resultat som publicerats i liknande studier relativt nyligen.

Det är möjligt att de utvärderade faktorer som inte hade någon statistiskt säkerställd effekt på överlevnaden fram till utskrivning från sjukhuset hade haft större påverkan på längre sikt. Långtidsuppföljningar gjordes inte i den här studien men hur prognosen för långtidsöverlevnad och utsikterna för återgång till arbete på tidigare nivå ser ut skulle vara en intressant frågeställning för en uppföljande studie.

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