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ORIGINAL ARTICLE

Injuries to the superficial digital flexor tendon branches: Clinical presentation, diagnostic features and outcome

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Summary

Background: Injury of the superficial digital flexor tendon (SDFT) branch is uncommon and the response to different treatments has not been reported.

Objectives: The aim of this study was to describe the clinical presentation, diagnostic features, treatment methods, and outcome of horses diagnosed with SDFT branch injuries. We hypothesised that the application of ancillary treatments would improve outcome and reduce re-injury rate. We further hypothesised that SDFT branch injuries associated with avulsion fractures would have a decreased probability of return to racing.

Study Design: Retrospective case series.

Methods: Data from medical records of horses diagnosed with SDFT branch injuries over a 10-year period (2014–2024) were reviewed. The inclusion criterion was the diagnosis of non-septic overstrain tendonitis of the SDFT branch based on ultrasonographic evaluation. Outcomes (return to racing, re-injury, and earnings) were compared with diagnostic features and treatment modalities for Thoroughbred racehorses.

Results: Twenty-one Thoroughbreds and nine other breeds were included in the descriptive data. Lesions in the forelimb were overrepresented ($n=25$, hindlimb $n=7$). There was an even split between the laterality of the affected branches (medial and lateral). Of the Thoroughbred racehorses that had raced prior to injury, 7/13 (53.8%) returned to racing. Overall, 9/20 (45%) surviving horses raced post-injury. No treatment group was significantly associated with a higher probability of return to racing compared to conservative management alone. The presence of avulsion fractures did not adversely affect the return to racing statistically ($p=0.84$). The re-injury rate was 19%.

Main Limitations: Small size of treatment groups with heterogeneous treatment regimens and lack of a standardised rehabilitation programme.

Conclusions: Of the Thoroughbred racehorses with SDFT branch injuries, 45% returned to racing. The presence of avulsion fractures did not decrease the likelihood of return to racing. Ancillary treatments did not influence the overall outcome, although the statistical power was limited.

KEYWORDS

horse, avulsion, stem cells, superficial digital flexor tendon branch, tendon injury

INTRODUCTION

The superficial digital flexor tendon (SDFT) branches are the distal continuation of the SDFT in the pastern region and extend distally abaxial to the deep digital flexor tendon (DDFT) to insert between the palmar/plantar axial and abaxial (proximal interphalangeal) ligaments onto the proximal extremity of the middle phalanx with fibres blending into the scutum medium (Denoix, 2019; Seiferle et al., 2004).

Tendonitis of the SDFT is frequently reported as one of the most common musculoskeletal injuries in performance horses, in which it most commonly affects the metacarpal region of the tendon (Avella et al., 2009; Dowling et al., 2000; Kasashima et al., 2004; Mitchell et al., 2021; Murray et al., 2006; Smith et al., 2002; Smith & McIlwraith, 2012). In contrast, injury to the SDFT branches in the pastern region is much less common and thought to be often associated with previous injury to the metacarpal region of the tendon (Carstens & Smith, 2022).

There are several small case series of injuries to SDFT branches for horses in a variety of disciplines. These support a fair to good prognosis for return to racing (57%–93%) with a controlled exercise rehabilitation alone, but have not evaluated newer diagnostic and treatment methodologies (Gibson et al., 1997; Reimer, 1997; Tricaud et al., 2017).

The aim of this study was to describe the clinical presentation, diagnostic findings, and treatments in a mixed-breed population as well as to report outcomes in a sub-population of Thoroughbred racehorses for which there were established outcome measures.

We hypothesised that the application of ancillary treatments would improve the outcome and reduce re-injury rate compared with conservative management. We further hypothesised that SDFT branch injuries associated with avulsion fractures would have a decreased likelihood to return to racing compared with the absence of avulsion fractures.

MATERIALS AND METHODS

Study population and data collection

The essential criterion for inclusion in the study was the diagnosis of non-septic overstrain injury to the SDFT branch(es) confirmed by ultrasonographic evaluation with or without additional diagnostic imaging. Ultrasonographic features considered consistent with the diagnosis were enlargement, hypoechogenicity, loss of physiologic longitudinal or transverse fibre pattern, and/or avulsion of the bone at the site of insertion. Horses were excluded if no ultrasonographic images or diagnostic imaging report were available, or if the SDFT branch injury could be linked to external trauma or infection. Computerised medical records from the Rood and Riddle Equine Hospital (Lexington, Kentucky, USA) for the years 2014 to 2024 were reviewed. Search terms used to search the medical records of equine patients were 'superficial digital flexor', 'SDFT', 'branch', 'SDFT branch', 'SDFT insertion', and 'tendonitis'. All included horses underwent orthopaedic examinations. Data retrieved from the clinical records included signalment, history, presenting clinical signs, response to diagnostic anaesthesia, diagnostic imaging findings, and treatment. Diagnostic modalities included ultrasonographic examination in all cases, complemented with digital radiography, magnetic resonance imaging (MRI), nuclear scintigraphy, and/or positron emission tomography (PET), based on the owners'/trainers' requests for advanced imaging and exclusion of other causes of lameness. Follow-up information was obtained through use of clinical records and race records, which were collected from a commercial database (Equibase, Lexington, Kentucky, USA).

Diagnostic workup

Horses presented for evaluation of lameness or poor performance underwent physical and orthopaedic examination by one of 3 American College of Veterinary Surgeons board-certified veterinary surgeons (LRB, SH, AR). The lame limb, lameness grade (American Association of Equine Practitioners, 2022), presence of swelling, response to manipulations and flexion tests, and response to diagnostic anaesthesia were retrieved from the clinical records if recorded. Information with regard to the duration of lameness prior to presentation was not available. Ultrasonography of the lame and contralateral limb was performed in all cases using a 10–15 MHz linear probe (Logiq E10, GE HealthCare or Philips CX50, Philips Healthcare) on the weightbearing limb in transverse and longitudinal orientations. A standoff pad was used when images of diagnostic quality could not be obtained without it. All soft tissue structures and the bone surface of the palmar/plantar aspect of the pastern, as well as the metacarpal/metatarsal regions were evaluated. No colour Doppler or non-weightbearing scans were performed. Ultrasonographic findings were grouped in binary terms for presence or absence of enlargement (compared to the contra-axial or contralateral side), hypoechogenicity, disruption of longitudinal fibre pattern, and avulsion fragments from the insertion site. Standard radiographic views (Butler et al., 2017) of the metacarpo−/tarsophalangeal joints or phalanges were obtained in 19 horses using digital radiography. Horses that underwent MRI examination were anaesthetised and scans were performed on the recumbent horse using a 1.5 Tesla MRI unit (Siemens Symphony). STIR, T2W, and PDW images were obtained in the sagittal plane and transverse plane perpendicular to the long axis of the pastern. PDW images were obtained in the dorsal plane parallel to the axis of the collateral ligaments of the distal interphalangeal joint.

PET scans (LONGMILE Veterinary Imaging) were performed in the standing, sedated horse as described previously (Spriet et al., 2022) with the scanner centred over the pastern region. Horses that underwent nuclear scintigraphy were administered 200 millicuries of technetium-99m (medronate) through an intravenous catheter. Dorsal and lateral plane images were obtained in the standing, sedated horse. All diagnostic images were evaluated by an American College of Veterinary Surgeons board-certified veterinary surgeon (KSG).

Treatment

Treatment regimens were chosen as per the discretion of the attending veterinary surgeon, under consideration of the severity of the lesions, concurrent findings, degree of lameness, and training schedule of the respective horse. All horses underwent variable periods of rest and controlled exercise, including box rest and hand walking for 1–4 weeks, light jogging exercise for 2–4 weeks, or paddock turnout for 30 days, each followed by re-examination at the hospital or by the referring veterinarian prior to return to full exercise. Ancillary treatments consisted of extracorporeal shockwave therapy (high-energy focused sound wave, trode R05, 800 pulses over the affected branch, energy level E6, at a frequency of 240 pulses/min, 3 treatments 14 days apart, PulseVet Shockwave, Zomedica), stem cell therapy, perilesional injections or combinations of these, as per the attending clinician's discretion.

Perilesional injections included treatment with stem cells or a combination of isoflupredone acetate (Predef, Zoetis, 4 mg per treatment), betamethasone sodium phosphate and betamethasone acetate (BetaVet, American Regent, 6 mg per treatment), and polysulfated glycosaminoglycans (Adequan, American Regent, 500 mg per treatment). Stem cell therapy (20 million cells per treatment) consisted of allogenic stem cells and/or autologous stem cells, culture expanded from sternal bone marrow aspirates and delivered via perilesional injection or intravenous or intra-arterial regional limb perfusions. Nine horses underwent more than one adjunctive treatment.

Racing performance

Information on performance was obtained for Thoroughbred racehorses only. Race records for each Thoroughbred included in the study were obtained from a commercial database (Equibase). Information recorded from the records of each horse included individual race results (date, race type, finish, E-speed figure, distance, amount of money earned). Using commercial software (Excel version 2208; Microsoft Corp.), these data were used to calculate parameters including number of race starts per year, number of starts pre- and post-injury, time from initial injury diagnosis to first start, amount of money earned per start pre- and post-injury and total amount of money earned pre- and post-injury.

Data analysis

Data were documented using commercial software (Excel version 2208; Microsoft Corp.). Descriptive statistics were calculated for all continuous variables. To summarise the distribution of non-normally distributed data, the interquartile range (IQR) was used. Specifically, the median and IQR (Q1, Q3) were reported to provide a measure of central tendency and variability. Inferential statistical analysis was performed for the Thoroughbred group only, given the heterogeneity and inconsistency of medical records and follow-up information available for non-Thoroughbred breeds. Statistical analysis was conducted in R, version 4.3.3. Distribution was assessed with the Shapiro–Wilk test, and statistical significance was determined using Chi-squared, Fisher's Exact, Kruskal–Wallis, ANOVA, exact binomial, and Wilcoxon Rank Sum tests, as appropriate. Horses were split into treatment groups according to which treatment they received. Seven horses received more than one treatment and were included in multiple analyses.

RESULTS

Signalment

Forty-nine horses were identified with SDFT branch injury, with 30 horses meeting the inclusion criteria. Represented breeds included 21 Thoroughbreds (70%), 3 Warmbloods (10%), 3 Quarter Horses (10%), 1 Standardbred (3.3%), and 2 other breeds (6.7%). Males (76.7%) were overrepresented, with 11 geldings and 12 entire males. There were six females (20%), and one horse (3.3%) had no sex recorded. Age at first admission ranged from 6 months to 29 years of age (median [IQR] 4.3 [3.3, 6.3] years). The median age of the Thoroughbred horses surviving to discharge from the hospital ($n = 20$) was 3.8 years [IQR 2.4, 4.5 years]. One Thoroughbred, a 29-year-old gelding, was euthanised upon diagnosis and not included in the analysis. A total of 32 limbs in 30 horses were affected. Forelimbs were overrepresented (25 forelimbs; 15 left fore, 10 right fore) when compared to hindlimbs (7 hindlimbs; 3 left hind, 4 right hind, Figure 1). In the Thoroughbred group, the difference between injuries in forelimbs and hindlimbs was significant ($p = 0.007$). Two horses had both

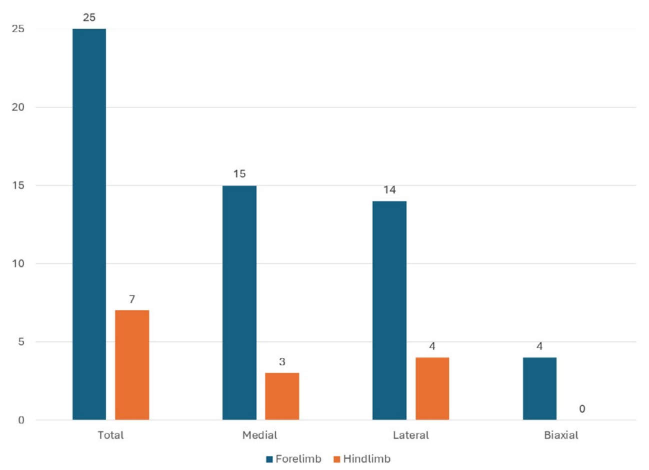

FIGURE 1 Bar chart showing the distribution of SDFT branch lesions in all breeds as number of branches (*y* axis).

forelimbs (bilaterally) affected. A total of 36 SDFT branches were injured, of which 18 medial branches and 18 lateral branches were affected (Figure 1). Four horses had both branches in the same forelimb (biaxially) affected. When considering Thoroughbreds only, the medial branch was significantly more often affected than the lateral branch (52% medial branch, 28% lateral branch, 14% biaxially, $p=0.01$), but no association between limb and laterality of the affected branch was seen. Thoroughbreds with avulsion fragments ($n=7$, median age 898 days [IQR 136, 407 days]) were significantly younger ($p=0.02$) than horses without avulsion fractures ($n=14$, median age 1600 days [IQR 271, 735 days]).

Clinical presentation

Lameness ranged from sound ($n=4$) to grade 4/5 lameness on the AAEP lameness Scale (median lameness grade 2 [IQR 1, 2]). Information with regard to swelling was available for 21/30 horses. Of these, 14 horses (66.7%) had regional swelling over the injured branch. Assessment of pain on palpation was recorded for 19 horses, of which 7 (36.8%) showed a painful response to palpation of the affected branch, or branches in cases of multiple lesion locations. The degree of filling of the digital flexor tendon sheath was recorded in 20 horses, and six horses (30%) had effusion.

Diagnostic anaesthesia

Diagnostic anaesthesia was performed in 14 horses. Of these, the lameness was only eliminated following a low palmar/plantar ('low-4-point') nerve block in 35.7% of cases, a palmar/plantar digital nerve block in 21.4% and 1 each (7.1%) to an abaxial sesamoid nerve block, plantar metatarsal nerve block, high palmar ('high-4-point') nerve block and uniaxial palmar digital nerve block (Moyer et al., 2011). In two limbs with effusion of the digital flexor tendon sheath, intrathecal anaesthesia abolished the lameness.

Ultrasonography

Enlargement was seen in 22/36 branches (61%) (Figure 2). Hypoechogenicity was appreciated in 29/36 branches (81%), and loss of fibre pattern was detected in 18 branches (50%). No branch was completely ruptured. Effusion of the digital flexor

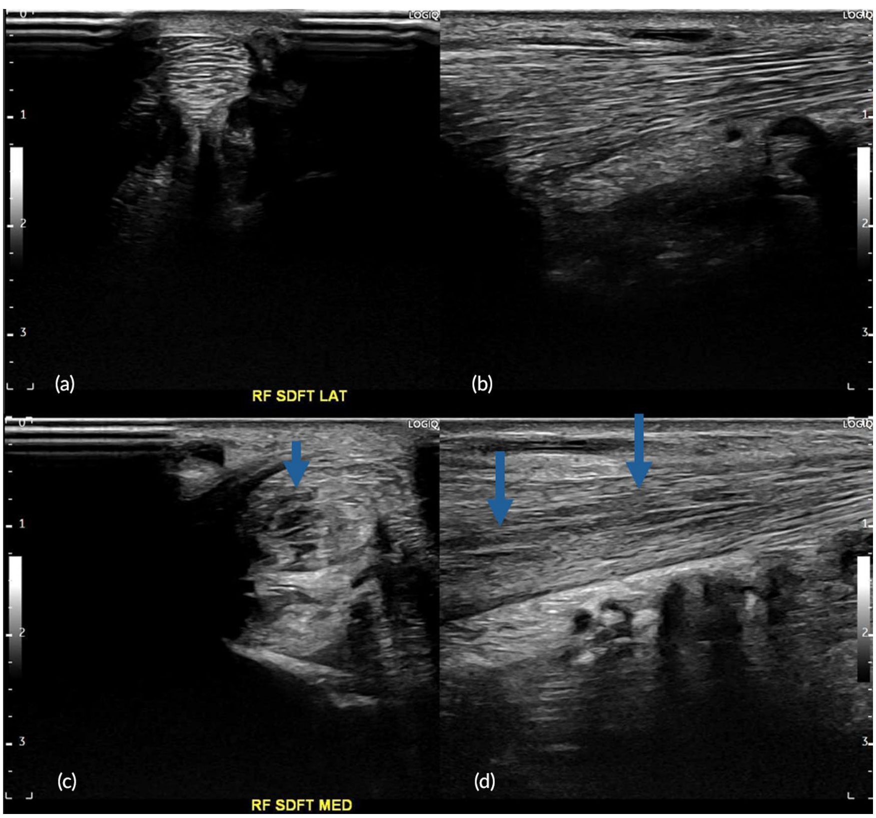

FIGURE 2 Ultrasonographic images of a right fore lateral (a, b) and medial (c, d) SDFT branch of the same horse. In transverse images (a, c, lateral to the right) enlargement of the medial SDFT branch can be appreciated as well as hypoechogenicity (arrow). Longitudinal scans (b, d, proximal to the right) show an irregular fibre pattern and hypoechogenicity of the medial SDFT branch (arrows).

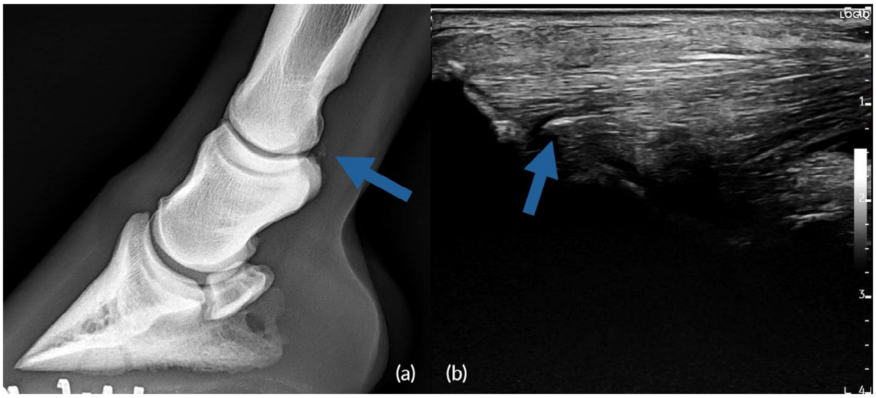

FIGURE 3 Lateromedial radiograph of the left fore proximal interphalangeal joint (a) and longitudinal ultrasonographic image of the left fore lateral SDFT branch (b) demonstrating SDFT insertion avulsions (arrows). Dorsal (a) and distal (b) are to the left.

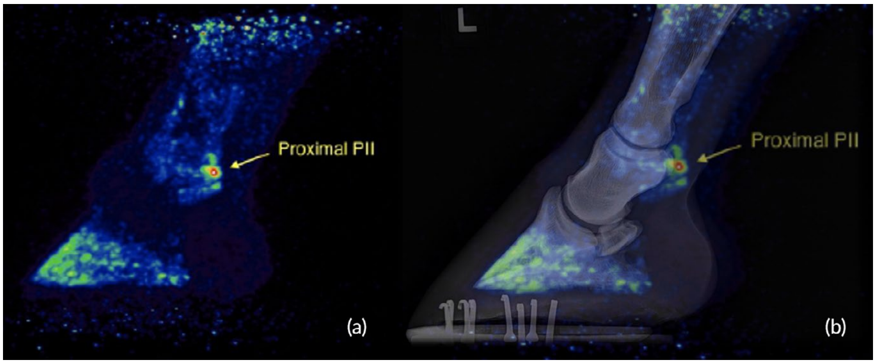

FIGURE 4 Positron Emission Tomographic image (a) of the same horse as in Figure 3. Increased 18F-NaF uptake in the proximal aspect of the left fore middle phalanx, corresponding to the lateral SDFT branch insertion with avulsion fragmentation. The composite image (b) shows the radiograph superimposed with the PET scan image, demonstrating the anatomic location of the increased radiopharmaceutical uptake. Dorsal is to the left.

tendon sheath was identified in five horses (16.7%). Avulsion fragmentation (Figure 3b) was diagnosed ultrasonographically in nine horses (30%, 7 Thoroughbreds, 1 Quarter Horse, 1 American Saddlebred).

Radiography

Radiographic examination was conducted in 19 horses, of which 10 cases (52.6%) had radiographic abnormalities. Seven (36.8%) avulsion fragments were identified (Figure 3a). Osteoarthritis of the proximal interphalangeal joint was identified in three horses, none of which were associated with avulsion fragments.

Magnetic resonance imaging

Magnetic resonance imaging examination was performed in two horses (one Warmblood and one Quarter Horse), which confirmed the ultrasonographically identified SDFT branch injury and also revealed a mild and moderate oblique distal sesamoidean ligament desmitis, respectively, as well as a marked subchondral bone and articular cartilage injury to the distodorsal aspect of the medial condyle of the third metacarpal bone in the latter.

Nuclear scintigraphy

Nuclear scintigraphy was performed in one case in which there was increased radiopharmaceutical uptake in the area of the SDFT branch insertion on the middle phalanx.

Positron emission tomography (PET)

A PET scan was performed in one Thoroughbred, which indicated severe bone (re-)modelling of the proximopalmar aspect of the middle phalanx in the area of the SDFT branch insertion (Figure 4) as well as subchondral bone (re-)modelling of the dorsal aspect of the condyle of the third metacarpal bone. Increased radiopharmaceutical uptake in the area of insertion of the deep digital flexor tendon on the distal phalanx was also noted.

Concurrent pathology

Diagnoses in addition to the SDFT branch injury but considered less severe were found in 8 Thoroughbreds consisting of mild osteoarthritis in the proximal interphalangeal joint ($n=3$), straight sesamoidean desmitis ($n=2$), ipsilateral oblique sesamoidean desmitis ($n=2$), suspensory desmitis (body, $n=1$), osteochondral fragment of the dorsomedial aspect of the proximal phalanx ($n=1$), incomplete frontal plane fissure fracture of the proximal phalanx in the other limb ($n=1$) and SDF tendonitis in the contralateral metacarpal region ($n=1$). Other breeds were also diagnosed with oblique distal sesamoidean desmitis ($n=3$) and subchondral bone and articular cartilage injury ($n=1$).

Treatment – all breeds

Five horses (23.8%) received corticosteroids, either via peritendinous infiltration of the affected branch ($n=4$), followed by or solely systemically (oral medication, $n=3$), or intra-synovial injection into the DFTS ($n=1$). Eight horses (38.1%) were treated with extracorporeal shockwave therapy, and 14 horses (66.7%) received stem cells. Of the latter, 13 received an initial dose of allogenic stem cells at the time of diagnosis, and all 14 horses had bone marrow aspirated for autologous stem cell culture at the time of diagnosis and returned for follow-up examination and insertion of the autologous cells once expanded. Four horses had stem cells administered via intravenous regional limb perfusion; 10 had stem cells inserted as a peritendinous injection. None received stem cells via intralesional treatment.

In some cases, a combination of the treatment modalities was implemented (extracorporeal shockwave and stem cells, $n=5$, corticosteroids and stem cells on subsequent visits, $n=4$) (Figure 5). Eight horses (38.1%) were treated with rest and a controlled exercise regimen alone. Lameness grade was not associated with the choice of treatment ($p=0.65$).

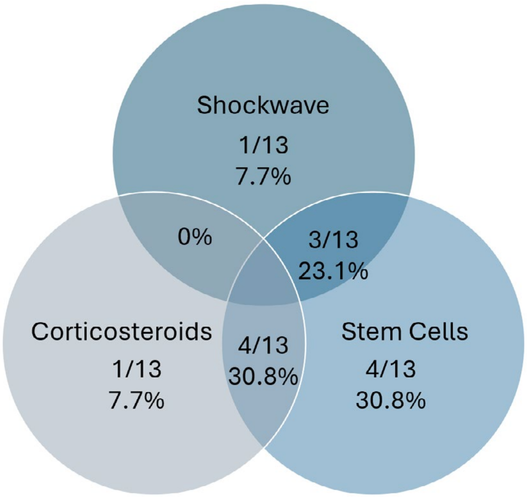

FIGURE 5 Venn diagram showing the adjunctive treatments (corticosteroids, shockwave, stem cells) implemented in the Thoroughbreds ($n=13$) only. Seven horses had more than one treatment performed.

Ultrasound and lameness (clinical) follow-up in Thoroughbreds

The Thoroughbreds ($n=14$) were presented for at least 1 follow-up examination (range: 1–7 follow-up examinations; mean follow-up time 251 days, range 59–933 days). The mean time between first admission and first re-examination was 67 days. Of these, 12 horses had an ultrasonographic examination demonstrating return to normal echogenicity of the affected branch. Persistent enlargement despite normal echogenicity was recorded in three cases (25%). Time from initial diagnosis to first record of return to normal ultrasonographic echogenicity ranged from 37 to 162 days, median 104 days [IQR 23, 68 days]. Eight horses (66.7%) were free of lameness at the time of normal ultrasonographic appearance, three horses (25%) were sound before, and one horse was still lame. Time from initial diagnosis to first record of complete resolution of lameness was recorded for 13 horses and ranged from 19 to 397 days, median 93 days [IQR 25, 74 days].

Outcome and racing performance in Thoroughbreds

One horse, a 29-year-old gelding that had raced 48 times before the injury, was retired at the time of diagnosis and euthanised due to a considered poor prognosis. All other Thoroughbreds were discharged from the hospital.

Race records were available for 20/21 Thoroughbreds. Thirteen Thoroughbreds (65%) raced prior to injury. Nine out of 20 horses (45%) raced after injury. Of the horses that had raced prior to injury, seven horses (53.8%) returned to racing. Whether the horse had raced or not before injury was not associated with a statistically significant difference in return to racing ($p=0.11$).

The time between initial diagnosis and return to racing ranged from 144 to 584 days (4.5 to 22 months), with a median time to return to racing of 298 days [IQR 71, 212 days].

No treatment group was significantly associated with a higher probability of return to racing. Ancillary treatment (including all treatment groups) compared to no ancillary treatment (rest and controlled exercise alone) did not change the outcome with regard to return to racing ($p=0.66$). There was no association of any treatment with lifetime earnings other than administration of corticosteroids, which statistically resulted in higher lifetime earnings (mean ± SD earnings no corticosteroids \$111,640 ± 184,074 vs. mean ± SD earnings corticosteroids \$398,487 ± 321,444; $p=0.03$).

Whether the injury involved an avulsion fracture or not did not affect the return to racing. However, horses with avulsion fractures ($n=7$) had less lifetime earnings (median lifetime earnings of \$48,874 [IQR \$27,850, \$83,550]) than horses without avulsion fractures ($n=14$, median lifetime earnings of \$95,375 [IQR \$174,192,

$522,575]), although the difference in earnings was not statistically significant ($p=0.09$). Horses that had not raced prior to injury were more likely to have an avulsion fracture, although this difference was not quite statistically significant ($p=0.056$).

Overall, re-injury of any branch occurred in four horses (19%). More horses did not re-injure ($p=0.003$). Two horses (9.5%) re-injured the same branch, one horse injured an SDFT branch in the contralateral limb, and one horse re-injured the same branch and subsequently a branch on the contralateral limb. However, horses that re-injured had significantly ($p=0.04$) higher lifetime earnings.

DISCUSSION

Injury to the branches of the SDFT was more commonly diagnosed in the forelimb, similar to previous reports (Kasashima et al., 2004; Mitchell et al., 2021; Reef & Genovese, 2010; Reimer, 1997; Tricaud et al., 2017). While it has been considered a site for secondary injury to the SDFT, no horses had previous, concurrent, or at follow-up detected SDFT injuries, and only one horse had a history of previous metacarpal SDFT injury in the contralateral limb, suggesting that these are unique injuries. The cause of injury to this site, compared to the more common metacarpal site, is unknown. However, the most commonly detected concurrent injury was desmitis of the distal sesamoidean ligaments (7/14 concurrent pathologies). The close proximity of these structures and functional similarities in providing palmar/plantar support to the distal limb further support the concept of distal overstrain pathophysiology for SDFT branch injuries (Kümmerle et al., 2018; Smith & Goodship, 2004).

There was an even frequency of injury to both the medial and lateral branches in this study, which is in contrast to what has been described previously for both Thoroughbreds and Standardbreds, where the lateral branch was more commonly affected (73%–80%) (Gibson et al., 1997; Tricaud et al., 2017). There is currently no published explanation why the medial or lateral side could be more prone to injury; breed and occupation do not seem to play a role. Theoretically, distal limb conformation (toed-in or -out) might have an effect on asymmetrical loading of the two branches, but this has not been confirmed scientifically. Biaxial and bilateral injuries were seen, but at a low frequency. The breed distribution (mainly Thoroughbreds) is in line with the hospital population, and no conclusions should be drawn whether Thoroughbreds are overrepresented or not.

Contrary to our hypothesis, the implementation of ancillary treatments did not result in a different outcome with regard to return to racing, although the variation in treatment chosen and the small number that did not receive ancillary treatment made the statistical power too low to make confident conclusions as to the inefficacy of these treatments. This limitation must be kept in mind when interpreting the results presented here. Nevertheless, rest and controlled exercise alone seemed to result in the same outcome, although it is possible that the horses not receiving additional treatment were less severely affected. Lameness grade was, however, not significantly associated with any form of treatment. While stem cell therapy of metacarpal SDFT lesions has been linked to increased odds of returning to racing (Godwin et al., 2012; Salz et al., 2023), the small numbers prevented us from being able to demonstrate the same effect within this population. In addition, delivery routes were peritendinous or via a vascular route, which may not be as effective as intralesional implantation (Becerra et al., 2013; Geburek et al., 2016; Sole et al., 2013).

Our second hypothesis was also rejected, as horses with avulsion fractures did not have a decreased likelihood to return to racing. The most statistically significant factors associated with avulsion fractures were younger age and not having raced prior to injury. Based on post-mortem evaluation of the strength of other tissues, such as the suspensory apparatus, training was hypothesised to strengthen soft tissues more rapidly, explaining the more common occurrence of sesamoid fracture in trained horses (Bukowiecki et al., 1987). Assuming that younger, unraced horses underwent overall less training than raced horses, the higher proportion of avulsion fragments in this sub-population was in contrast to this hypothesis. Furthermore, while most of the avulsions occurred in Thoroughbreds (7/9), this injury does not seem to be unique to racehorses, as there were also two non-Thoroughbred horses that presented with this feature.

Articular fractures carry a better prognosis if the fragments are removed arthroscopically (Fretz et al., 1984; Schnabel et al., 2006, 2007), which raises the question of whether SDFT branch avulsion fragments could be treated in a similar way. However, these fragments appear to be largely embedded within the branch (see Figure 3) and therefore likely to be non-articular. This conclusion is supported by the finding that no cases with avulsion fractures showed osteoarthritis of the proximal interphalangeal joint at the time of diagnosis or, for the horses where this information was available, on subsequent examinations. Furthermore, none of the horses in this population were treated with surgical removal, with no difference in return to racing when compared to horses that had no avulsion. Hence, it can be concluded that surgical removal is not indicated in this kind of lesion.

Effusion of the digital flexor tendon sheath was a concurrent finding in 30% of the affected limbs. Medical records did not reveal any suggestions that there was a connection of the affected branch injuries to the tendon sheath synovial cavity. However, one horse with bilateral forelimb lateral SDFT branch injuries associated with digital flexor tendon sheath effusion responded positively to intrasynovial anaesthesia and improved to bilateral medication of the digital flexor tendon sheath with corticosteroids. Tears of the SDFT branch have been described as accessible for tenoscopic debridement, which is a possible surgical treatment option for this condition (Smith & Wright, 2006). However, none of the cases presented here underwent tenoscopy.

Another possible accompanying pathology to SDFT branch lesions that has been described previously is adhesions to adjacent structures, such as the digital annular ligaments (Gibson et al., 1997; Reef & Genovese, 2010). In the 14 Thoroughbreds presented for ultrasonographic re-evaluation, none of these horses had ultrasonographic evidence of any adhesions. This may be the result of the lesions involving the non-thecal side of the structure, or a more aggressive rehabilitation programme, or the use of corticosteroid treatment, but this remains speculative.

The detected significance for higher earnings after treatment with corticosteroids and following re-injury was unexpected. One of the horses treated with corticosteroids had exceptionally high earnings throughout its career and, given the small group size, might have influenced the outcome. Administration of corticosteroids can delay healing and may be contraindicated in the acute phase of injury, but in more chronic cases, the anti-inflammatory effects may provide symptomatic relief at resolving persistent inflammation and pain (Coombes et al., 2010; Dean, Franklin, et al., 2014; Dean, Lostis, et al., 2014).

The re-injury rate of metacarpal SDFT lesions ranges between approximately 40% in sport horses to as high as 90% for horses used in flat racing (Godwin et al., 2012), whereas re-injury in the branches occurred in only 19% in our population, suggesting that this injury fares better than its more proximal counterpart. In addition, horses that re-injured had significantly higher lifetime earnings. One possible explanation for this finding is that horses that were raced longer and in higher classes, hence accumulating higher earnings, were at increased risk for re-injury compared to horses that were retired. Given the low rate of re-injury found here, the overall low return to racing was surprising and reasons for this remain unknown.

Previous studies suggest that regional limb perfusion of stem cells delivered fewer stem cells than by intralesional injection (Becerra et al., 2013; Dudhia et al., 2015; Sole et al., 2012). While some Thoroughbreds were treated with regional perfusion with stem cells, the vast majority receiving stem cells (8/11 Thoroughbreds) were treated with local peritendinous delivery. This delivery route has not been evaluated with respect to the efficiency of delivery or efficacy.

The main limitations of this study include the mentioned small sample size of the treatment groups with heterogeneous treatment regimens and a lack of standardised rehabilitation. Further limitations include the incidence of concurrent pathologies, although these were considered less relevant with regard to performance limitation compared to the primary diagnosis of the SDFT branch injury.

In summary, 45% of Thoroughbred racehorses with the diagnosis of SDFT branch injury returned to racing, and the presence of avulsion fractures did not decrease the likelihood of return to racing. Ancillary treatments did not appear to have an effect on the overall outcome compared with conservative management of rest and physical rehabilitation.

CLINICAL RELEVANCE

- The prognosis for return to racing of horses diagnosed with SDFT branch injuries was 45% (9/20) in this population of Thoroughbred racehorses, which was lower than reported in previous studies (57%).
- None of the ancillary treatments (stem cell therapy, corticosteroids, extracorporeal shockwave therapy) had a statistically significant effect on the likelihood of return to racing.
- The overall re-injury rate of SDFT branch injuries (19%) appeared comparable to previous studies (22%).
- The presence of avulsion fractures did not influence return to racing.

AUTHOR CONTRIBUTIONS

P. Spiesshofer: Conceptualization; writing – original draft; investigation; methodology; writing – review and editing; data curation; resources; visualization; project administration; formal analysis; software; validation. **V. O'Hara:** Conceptualization; investigation; writing – review and editing; formal analysis; data curation; software; validation; methodology; visualization; resources. **K. S. Garrett:** Conceptualization; investigation; writing – review and editing; supervision; data curation; resources; methodology; validation; visualization. **R. K. Smith:** Conceptualization; investigation; writing – review and editing; visualization; methodology; project administration; supervision; resources; data curation; validation.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest with respect to the research, authorship, or publication of this article.

ETHICS STATEMENT

Given the retrospective nature of the study, no institutional ethical approval was obtained.

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