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Surgical management of superficial digital flexor tendon luxation in dogs

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Summary

OBJECTIVES: To report the outcome, frequency of complications and potential prognostic factors associated with surgical repair of superficial digital flexor tendon (SDFT) luxation in dogs.

MATERIALS AND METHODS: Medical records from 10 referral hospitals were reviewed retrospectively for cases of SDFT luxation in dogs that underwent surgical stabilisation. Signalment, clinical presentation, diagnostic imaging, surgical method, type and length of post-operative limb immobilisation, nature of and length of exercise restriction, presence of post-operative complications and outcomes were recorded. Data were summarised descriptively and prognostic risk factors assessed for association with surgical outcome using risk ratios.

RESULTS: Forty-eight cases were included. A successful surgical outcome was recorded in 35/48 (73%) cases. Re-luxation of the SDFT occurred in 7/48 (15%). Six out of 48 (13%) had a persistent lameness despite a stable non-luxating SDFT. A high frequency of post-operative complications occurred (71%), with the majority resolved medically. The risk of surgical failure was 60% higher (risk ratio 1.6, 95% confidence interval 1.1 to 2.4) where absorbable suture material was used compared to non-absorbable suture material. Surgical failure was more common in cases managed with non-rigid immobilisation post-operatively (57% failure) compared to cases managed with rigid immobilisation (19% failure), although this result was not statistically significant. Limb immobilisation of 6 weeks or longer did not

significantly affect surgical outcome, compared to shorter periods of exercise restriction or limb immobilisation.

CLINICAL SIGNIFICANCE: A good outcome can be expected following surgical stabilisation of SDFT luxation. The use of non-absorbable suture was associated with a more successful surgical outcome.

Keywords

Luxation, superficial digital flexor, tendon, retinaculum, common calcaneal tendon

Introduction

Luxation of the superficial digital flexor tendon (SDFT) is an infrequent condition in dogs. The SDFT is part of the common calcaneal tendon, along with the gastrocnemius tendon and the combined tendon of the biceps femoris, semitendinosus and gracilis (Evans & de Lahunta 2013). The following anatomical description of the SDFT is obtained from Evans & de Lahunta, 2013. Proximally the SDFT arises on the lateral head of the femur and on the lateral sesamoid. The SDFT has medial and lateral retinacular attachments to the tuber calcanei, and a synovial bursa is present deep to the tendon on the tuber calcanei. Distally the tendon continues over the plantar aspect of metatarsals II to V and inserts on the middle phalanges. Rupture of the medial or lateral retinacular insertion of the SDFT on the tuber calcanei results in luxation of the tendon. Lateral luxations of the SDFT tend to occur more commonly than medial luxations (Bernard 1977, Mauterer *et al.* 1993, DeCamp *et al.* 2016). The degree of lameness on presentation can vary from mild to severe and may be intermittent (Slatter 2003, Johnston & Tobias 2017). Often there is swelling of the calcaneal bursa and this may be evident on lateral radiographs as a soft tissue opacity at the proximal aspect of the calcaneus of the affected tarsus. A popping sensation may also be appreciated during flexion and extension of the hock, due to the tendon luxating (Slatter 2003, DeCamp *et al.* 2016, Johnston & Tobias 2017).

Non-surgical treatment with exercise restriction and administration of anti-inflammatory medications, with or without external coaptation, has been shown to result in persistent lameness and an incomplete return to normal function (Mauterer *et al.* 1993, Hoscheit 1994).

Surgical reconstruction of the torn retinacular attachment of the SDFT is the treatment of choice to restore normal function to the injured limb. Previous studies have reported success

rates of 83% and 100% following surgery (Bernard 1977, Houlton & Dyce 1993, Mauterer *et al.* 1993, Hoscheit 1994, Reinke & Mughannam 1994). However, there is a paucity of cases within each of these studies, which range from individual case reports to a case series involving only 12 dogs, and hence these success rates should be viewed with caution.

Surgical stabilisation of the SDFT luxation involves suturing the torn retinacular attachment at the calcaneus to the adjoining tissue to maintain the tendon in a central position within the groove of the tuber calcanei (Slatter 2003, DeCamp *et al.* 2016, Johnston & Tobias 2017). The use of non-absorbable monofilament suture has been recommended (Houlton & Dyce 1993, Mauterer *et al.* 1993, Reinke & Mughannam 1994, DeCamp *et al.* 2016, Johnston & Tobias 2017). Some surgeons prefer polydioxanone (PDS) suture (personal communication) rather than non-absorbable monofilament suture although this has not been previously evaluated. In cases where the SDFT is permanently displaced and irreducible, a tension-releasing incision may be made in the fascia on the side of the luxation, and in some cases redundant fibrous tissue opposite the side of luxation may be imbricated or excised (Houlton & Dyce 1993, Mauterer *et al.* 1993, Hoscheit 1994, Reinke & Mughannam 1994, Gatineau & Dupuis 2010). Reinforcement of the retinaculum with polypropylene mesh has been described in three dogs after failure of the initial surgery (Houlton & Dyce 1993).

Post-operative external coaptation has been recommended for 2-4 weeks (Slatter 2003, DeCamp *et al.* 2016, Johnston & Tobias 2017). The nature of external coaptation varies between reports. Some suggest that a soft padded bandage is sufficient (Reinke & Mughannam 1994, Slatter 2003, Johnston & Tobias 2017), while others propose a more rigid immobilisation using a lateral splint or a cast (Houlton & Dyce 1993, Hoscheit 1994, DeCamp *et al.* 2016). The recommended duration of exercise restriction also differs. Some

studies suggest 2-5 weeks of restricted exercise is adequate (Bernard 1977, Houlton & Dyce 1993, Mauterer *et al.* 1993, DeCamp *et al.* 2016), while others suggest 6-8 weeks is required (Hoscheit 1994, Reinke & Mughannam 1994). The lack of uniformity and evidence in the existing literature on the type and duration of external coaptation and the duration of exercise restriction creates challenges for surgeons deciding on appropriate management options.

The objective of this retrospective cohort study was to document the surgical outcome and frequency of complications following surgical stabilisation of SDFT luxation in dogs, and to evaluate potential factors that may be associated with a higher risk of surgical failure rate. We hypothesised that using non-absorbable suture material for reconstruction of the ruptured SDFT retinaculum would be associated with a higher likelihood of surgical success than the use of absorbable suture. An additional hypothesis was that post-operative rigid immobilisation of the affected hock for 6 weeks with concurrent exercise restriction for 6 weeks or greater would be associated with increased surgical success compared to those dogs without post-operative rigid immobilisation, or immobilisation for a duration of less than 6 weeks.

Materials and methods

Inclusion criteria

Cases were recruited from 10 veterinary referral hospitals (2 academic institutions and 8 private practices) in Australia, New Zealand and the United Kingdom. All dogs that presented with luxation of the SDFT that were surgically treated between January 2005 and June 2020 were included in this study. Medical records of all available affected cases that were referred to the various surgical referral centres were reviewed. Cases where surgical stabilisation of the SDFT luxation was declined or where salvage surgery was performed

were excluded. Cases that had other concurrent orthopaedic or other disease conditions affecting the hock were also excluded.

Case details

Data collected for each case included signalment, history, presence of concurrent orthopaedic conditions, and findings on clinical examination and diagnostic imaging studies. The surgical method, type and length of post-operative immobilisation, nature of and length of exercise restriction, post-operative complications, requirement for revision surgery, and outcome were recorded.

All cases were diagnosed by a board-registered specialist small animal surgeon or a resident under the supervision of a board-registered specialist small animal surgeon. The degree of lameness was recorded as mild, moderate or severe to non-weight bearing, or subjectively graded on a scale of 1 to 10, with 10 being non-weight bearing lame. Using a modified equine lameness scale (May & Wyn-Jones 1988), the severity of lameness was then categorised as mild (1-3 out of 10), moderate (4-6 out of 10), severe (7-9 out of 10) or non-weight bearing (10 out of 10) in this study.

As previously defined by Cook *et al*. (2010), complications reported in the clinical records were categorised as perioperative (pre-, intra-, and post-operative) if occurring within 3 months, short-term if occurring within 3 to 6 months, mid-term if occurring within 6 to 12 months and long term if occurring more than 12 months. Complications were classified as major if the complication required further surgical or medical intervention to resolve and complications were defined as minor if the complication resolved without any surgical or medical treatment (Cook *et al.* 2010).

In this study, the method of post-operative limb immobilisation used was classified as none, non-rigid (soft padded bandage) or rigid immobilisation. Forms of rigid immobilisation included the placement of calcaneotibial screws, or the use of splints, casts or trans-articular external skeletal fixators (TA-ESFs). Cases were also divided into those that had less than 6 weeks of post-operative limb immobilisation (or less than 6 weeks of exercise restriction where no immobilisation was applied), and those that had 6 weeks or more of post-operative limb immobilisation (or 6 weeks or more of exercise restriction where no immobilisation was applied). A 6-week timepoint was chosen based on the biology of tendon healing and the return of tensile strength to a surgically repaired tendon sufficient to withstand limited exercise (Elliott 1967, Hirsch 1974, Dueland & Quentin 1980, Slatter 2003, Johnston & Tobias 2017).

Success of surgery was defined as having no recurrence in luxation of the SDFT to the end-point of the follow-up available and the patient having no signs of lameness 8 weeks post-operatively. Failure was defined as a re-luxation of the SDFT, or lameness that persisted beyond 8 weeks after the surgical procedure.

Follow-up

During the immediate post-operative period, re-examinations were performed within the first 2 weeks following surgery, and weekly thereafter. Bandage changes were either performed at the referral hospital by a board-registered specialist small animal surgeon, a resident or an intern under supervision, or at the general practice clinic by the referring clinician. During each revisit, the bandages were assessed for degree of strikethrough and the limb assessed for evidence of bandage-related morbidity. Cases with TA-ESFs were assessed for stability of

the construct and for evidence of pin tract infection such as adjacent soft tissue swelling or discharge relating to the pins. The stability of the SDFT and its positioning on the proximal calcaneus also assessed at each visit. The decision to either replace or remove the external coaptation or TA-ESF was made by a board-registered specialist small animal surgeon or resident under supervision.

Statistical analysis

A case was defined as an affected limb, as there was a small number of bilaterally affected cases in the study population. The outcome of interest was surgical failure. Prognostic factors of interest were all treated as dichotomous and included suture material used (absorbable or non-absorbable), immobilisation (rigid or non-rigid), and the post-surgical duration of immobilisation (<6 weeks or ≥6 weeks). Two cases were excluded from the univariable analysis of suture material due to missing data. Three cases that were only exercise restricted without any immobilisation post-operatively were excluded from analysis of both immobilisation and duration of immobilisation. Data were analysed descriptively, with continuous data visually assessed to be non-normal and therefore presented as median and range. The data from various referring hospitals was collated in an Excel file. All statistical analysis was undertaken using R statistical software (R version 4.04, Vienna, Austria). The association between each prognostic factor and surgical outcome was assessed using *epi.*2by2 function from epiR (Stevenson *et al.* 2021), with results reported as risk ratios with Wald 95% confidence intervals (CI) and p-values from Chi-square tests. P-values ≤0.05 were considered statistically significant. Due to the limited sample size, further statistical analysis including accounting for repeated measures was not pursued.

Results

Signalment

Forty-eight cases (45 dogs) met the inclusion criteria (Supplemental Table 1). The most commonly affected dogs were Labrador Retrievers (*n* = 11), Shetland Sheepdogs (*n* = 7) and cross-breeds (*n* = 7). The 48 cases included 34 females and 14 males. The median age and weight at initial presentation was 31 months old (range 8 months-12 years old) and 27 kg (range 7-78 kg) respectively.

History and clinical findings

Physical examination revealed swelling over the calcaneus in all cases. In 46/48 cases the SDFT could be manually displaced and reduced. There were 42 unilateral SDFT luxations and three bilateral SDFT luxations. There were two dogs that had bilateral SDFT luxations on presentation, while one dog developed luxation of the contralateral SDFT within a month of surgical stabilisation of the initial SDFT luxation. 40/48 luxations were lateral, 5/48 luxations were medial and the remaining 3/48 cases had both lateral and medial luxations.

An acute onset of hind limb lameness was reported in 45/48 cases, whereas chronic hind limb lameness was reported in three cases. The severity of lameness on presentation ranged from no lameness to intermittent non-weight bearing lameness, with mild lameness reported most frequently. A skipping lameness was reported in six cases. One case had intermittent collapsing lameness of the affected limb, and another case had displayed a degree of hyperflexion of the tarsal joint of the affected limb. In 27 cases the circumstances in which the lameness initially developed could not be identified by the owners, in 20 cases the lameness developed during rough play or heavy exercise and one case occurred as the result of a road traffic accident.

Diagnostic investigations

All affected hocks were radiographed. Where recorded in the medical histories, the radiographic views obtained included caudocranial and mediolateral projections of the hock. Radiographic findings were similar in all cases demonstrating a soft tissue opacity indicative of swelling at the proximal aspect of the calcaneus in the affected limb. The presence of enthesophytes and an abnormal shape to the calcaneus with sloping of the proximal calcaneus towards the direction of the luxation were noted in some medical records.

Surgical procedure

The surgical procedure undertaken was broadly similar in the majority of cases as previously described (Slatter 2003, DeCamp *et al.* 2016, Johnston & Tobias 2017). An incision was made along the calcaneus on the side opposite to the luxation, the bursa incised and fibrinous material removed. Redundant retinacular tissue was either imbricated or excised. The SDFT was reduced and stabilised using interrupted suture patterns. The SDFT was permanently laterally luxated in one case and required a lateral releasing incision to allow the SDFT to return to its normal position on the proximal calcaneus. Absorbable suture material (PDS) was used in 22 cases, while non-absorbable material (polypropylene, nylon or primary repair augmented with polypropylene mesh) was used in 24 cases. In one case, two 1.5 mm bone tunnels were created in the calcaneus to allow placement of nylon sutures through the bone tunnels which were used to stabilise the repair of the retinaculum. The suture material used was not recorded in two cases.

Post-operative management

In 17/48 cases, no rigid immobilisation of the limb was undertaken (no external coaptation in three cases, and soft padded bandages used in 14 cases) post-operatively. The hock was

rigidly immobilised in 31/48 cases post-operatively (calcaneotibial screws placed in two cases, splints used in 14 cases, bivalve casts used in 10 cases, TA-ESFs used in five cases), and of these, 24/31 cases were immobilised for less than 6 weeks (range 2-4 weeks), while the remaining 7/31 cases were immobilised for 6 weeks or more post-operatively (range 6-7 weeks).

All cases received post-operative discharge instructions that included restriction of exercise to controlled lead walks only for a prescribed duration of time. Details of exercise restriction for all cases were comparable; owners were instructed to take their dogs out for toilet walks only for the first 4-6 weeks, followed by a gradual increase in controlled lead walks by 5-minute 2-3 times a day per fortnight. During this period of exercise restriction, it was advised to avoid stairs, running or jumping. There were eight cases that were exercise restricted for less than 6 weeks (range 3-4 weeks), and 40 cases that were exercise restricted for 6 weeks or more (range 6-16 weeks).

Outcome and complications

The median duration of follow-up was 3 months (range 2-60 months). A successful surgical outcome was recorded for 35/48 (73%) cases. Post-operative complications were recorded in 34/48 (71%) cases, all of which were classified as major complications. Of these cases, complications resolved with symptomatic medical treatment only in 59% (20/34). Six cases had more than one major complication. Recurrence of luxation was encountered in seven cases which required revision surgeries. Re-luxation occurred within a median time of 6 weeks (range 3-20 weeks) post-operatively. Six cases had persistent lameness that ranged from mild intermittent to occasionally non-weight bearing lame. These cases were lame despite a non-luxating SDFT and required ongoing analgesia and exercise restriction to

manage the lameness. There were two cases that developed progressive severe common calcaneal tendinopathy and tendonitis, with subsequent collapse and hyperflexion of the hock following removal of the external coaptation. Finally, one case had recurrence of lameness associated with a suture (PDS) protruding from the surgical site, which was initially managed with antibiotics but ultimately required surgical removal of the suture to resolve the lameness. Twenty of 34 complications were directly related to the external coaptation applied and were all during the perioperative period. These included bandage-related issues including rub sores, pressure sores, swelling of digits, dermatitis or pyoderma, or pin tract infections associated with TA-ESFs. These resolved with symptomatic management and subsequent removal of the external coaptation or TA-ESF.

Potential predictors of surgical failure

Contingency tables and risk ratios for the associations between the prognostic factors of interest and surgical failure are presented in Table 1 and risk ratios (RR) are visualised in Figure 1. Use of absorbable suture material was associated with 1.6 times (i.e. 60% higher risk of failure) increased risk of surgical failure (95% CI: 1.1 to 2.4, p = 0.01), compared to the use of non-absorbable suture material. Surgical failure was more common with non-rigid immobilisation post-operatively (57%) compared to cases receiving rigid immobilisation (19%), although this result was not statistically significant (RR 1.25, 95% CI 0.8 to 1.9, p = 0.42). When comparing different types of rigid immobilisation, successful outcomes occurred in 2/2 (100%) of cases with calcaneotibial screws placed, 13/14 (93%) of cases with splint and 8/10 (80%) of cases with casts, compared to 2/5 (40%) of those with TA-ESFs applied. Limb immobilisation (or exercise restriction where no immobilisation was applied) of 6 weeks or longer did not significantly affect surgical outcome, compared to shorter periods of exercise restriction or immobilisation (RR 1.19, 95% CI 0.7 to 1.9, p = 0.69).

Discussion

Surgical stabilisation of SDFT luxation in this cohort was successful in 73%. This is lower in comparison to the success rates previously reported. Earlier studies have indicated a highly successful outcome associated with surgery, with a low rate of recurrence in luxation and no ongoing lameness following surgery (Bernard 1977, Houlton & Dyce 1993, Mauterer 1993, Hoscheit 1994, Reinke & Mughannam 1994). The overall frequency of post-operative complications of 71% in this study is high, though more than half resolved with medical symptomatic treatment.

In this study the risk of post-operative failure was significantly associated with suture material, with a 60% higher risk of failure where absorbable suture was used, compared to non-absorbable suture. The recommendation for the use of non-absorbable suture over absorbable suture in the repair of the torn retinaculum has not been previously investigated, and this advice may have been extrapolated from knowledge surrounding primary tendon repair or reattachment of tendon onto bone (Johnston & Tobias 2017). Non-absorbable sutures such as polypropylene or nylon, are frequently used in tissues which require prolonged suture strength such as in tendon repair or fascia closure (Chu *et al.* 1997, Johnston & Tobias 2017), which may consequently represent a more appropriate choice in repair of the torn retinaculum. The use of polypropylene mesh to reinforce the repair of the retinaculum has been previously documented in three cases of revision surgery where the initial repair has failed (Houlton & Dyce 1993). Its usefulness as an augmentation of the primary repair could not be properly evaluated in this study due to the small number of cases that had this form of repair. Our study supports the use of non-absorbable suture material to repair the SDFT retinaculum and this finding is also in agreement with a previous study which described a

successful outcome in 10/12 dogs (83%) using non-absorbable suture (Reinke & Mughannam 1994).

This study evaluated the use of non-rigid immobilisation post-operatively and while no significant association was detected, there were three times as many surgical failures in cases managed with non-rigid immobilisation compared to rigid immobilisation. Previous studies have stated that external coaptation is required following surgery repair (Houlton & Dyce 1993, Hoscheit 1994, Reinke & Mughannam 1994, Slatter 2003, DeCamp *et al.* 2016Johnston & Tobias 2017), which is supported by findings from this study where 2/3 cases with no immobilisation post-surgery failed. However due to the small number of cases, a clear conclusion on the surgical outcome in cases without external coaptation was not able to be made. Additionally, depending on the type of immobilisation applied, the degree of stability provided post-operatively is considerably different. In this study, cases where calcaneotibial screws were placed, or splints or casts were used, experienced fewer surgical failures compared to TA-ESFs, although the strength of this association is difficult to assess due to small numbers receiving each type of immobilisation. Further research into each type of rigid immobilisation and its impact on surgical outcome is needed in order to make recommendations following surgical repair of SDFT luxation.

Our study did not find an association between limb immobilisation (or exercise restriction for cases with no immobilisation applied) of 6 weeks or more and surgical failure. Notably, cases with limb immobilisation for 2-4 weeks had fewer failures (21%) compared to those with limb immobilisation maintained for 6-7 weeks (36% failures). This finding may suggest that the application of limb immobilisation for a prolonged duration of time may not be necessary, and in fact, represent an avoidable additional cost to owners, particularly when considering

the high proportion of bandage related complications. Alternatively, prolonged limb immobilisation may be associated with a confounding factor, for example, if less experienced surgeons who may have higher rates of surgical failure also tended to maintain immobilisation for a more conservative 6-week period. Ultimately this finding has to be interpreted with caution; clinical recommendations cannot be reliably made based on these results and further research into the optimal duration of immobilisation is required.

The most commonly affected breed in this study were Labrador Retrievers, followed by Shetland Sheepdogs. Breed frequency was not corrected for the distribution of breeds in the population at risk, so the number of Labrador Retrievers affected may represent a true predisposition or may simply reflect the popularity of this breed. The apparent overrepresentation of Shetland Sheepdogs aligns with the work of other authors, who postulate that SDFT luxations occur more often in Shetland Sheepdogs and Collies (Bernard 1977, Houlton & Dyce 1993, Mauterer *et al*. 1993, Hoscheit 1994, Reinke & Mughannam 1994, DeCamp *et al.* 2016). It has been suggested that lateral luxation of the SDFT is inherited as a simple autosomal recessive trait in Shetland Sheepdogs (Solanti *et al.* 2002). A conformational abnormality of the proximal calcaneus resulting in a shallow to absent groove, and/or a distolateral or distomedial slant to the calcaneus, may increase instability of the tendon and predispose to its luxation (Reinke & Mughannam 1994, Gatineau & Dupuis 2010). Shetland Sheepdogs in general tend to have taller and thinner calcanei with shallow grooves in comparison to other species of similar weight and size, which may predispose the SDFT to luxate (Reinke & Mughannam 1994). All Shetland Sheepdogs and the Rough Collie in this study had lateral luxations of the SDFT and it is plausible that these anatomical differences are contributing to luxation. However, further investigation for example through longitudinal breed club studies would be required to give evidence for predisposition.

Lateral luxations of the SDFT were more common than medial luxations across all breeds in this study, representing 40/48 (83%). This is consistent with previous reports (Bernard 1977, Mauterer *et al.* 1993), and may be the result of differences in the medial and lateral retinacular insertions of the SDFT or on the morphology of the surface of the calcaneus (Mauterer *et al.* 1993). A cadaveric study involving 10 dogs found that the medial retinacular insertion of the SDFT on the calcaneus was less well defined and may therefore rupture more easily, resulting in increased observations of lateral luxations (Mauterer *et al.* 1993). In addition to the caudocranial and mediolateral views of the hock, it may be useful to perform computed tomography or obtain alternate radiographic views such as a skyline projection of the tuber calcanei. This would permit evaluation for an abnormal shape and shallow depth of the groove of the tuber calcanei as a risk factor for SDFT luxation, or re-luxation after surgical stabilisation. Additional research into the anatomical differences between the shape of the calcaneus and the retinacular insertion of the SDFT on the calcaneus in clinically affected dogs would be required to elucidate this as a potential predisposing cause of SDFT luxation.

The majority of affected dogs in this study presented with an acute onset of lameness, with 20/48 developing lameness during heavy exercise or rough play. This is in agreement with previous studies that SDFT luxation seemed to be associated with vigorous activity, and may be attributed to a rotational force acting on the point of insertion at the tuber calcanei (Mauterer *et al.* 1993, DeCamp *et al.* 2016). In a case report of a longitudinal tendon tear concurrent with bilateral medial luxation of the SDFT in a dog, it was suggested that repetitive and cumulative stress leading to progressive weakening of the tendon may also induce the SDFT to tear, in addition to the luxation (Gatineau & Dupuis 2010). The presence

of enthesophyte formation at the insertion of the calcaneal tendon on radiographs may indicate a more chronic repetitive strain component to the pathogenesis of SDFT luxations. Enthesophytosis at the insertion of the calcaneal tendon is also a feature of common calcaneal tendinopathy which may have been not initially recognised as a clinical entity on presentation. This may also be contributing to the ongoing lameness post-operatively. It is also possible that intermittent luxation of the SDFT over time may induce microfiber injury to the tendon and predisposing it to tear. These microtears may not be grossly appreciable in surgery, however if present could certainly be contributing to the persistent ongoing lameness seen in a few cases post-operatively despite a non-luxating SDFT. Histopathological analysis of the SDFT and retinaculum would be helpful in investigating the integrity of the tendon. Furthermore, the surgical technique chosen or its execution, or subsequent formation of adhesions between the SDFT and adjacent tissue preventing normal movement may also contribute to persistent lameness post-operatively.

The limitations of this study include its retrospective design, the heterogeneity of the sample population with regards to the type and duration of limb immobilisation and the duration of exercise restriction, and the modest number of cases that could be sourced for inclusion. Firstly, there was a lack of standardization of criteria used to assess for outcome of the surgery. The main factors assessed were the stability of the SDFT in its central position within the calcaneal groove, and whether lameness was evident. These factors formed the basis of the definition of a successful surgery. Given that in most cases these dogs are either highly active in nature, or have sustained the injury during heavy exercise or rough play, it is not known whether a successful outcome in these dogs meant a full return to function with the ability to perform vigorous exercise once more, or whether a more conservative lifestyle had been adopted. Subjective owner assessment using a questionnaire may have been helpful

in evaluating long-term functional outcome and owner satisfaction. Secondly, the follow-up period (median 3 months) may have been insufficient. Though re-luxation occurred within a median of 6 weeks in the study population, in one case it was diagnosed 5 months post-operatively. Hence the limitation of a short follow-up period could also mean that recurrence of luxation may be missed in some cases, meaning our results may present overly optimistic frequency of positive surgical outcomes. Finally, statistically significant results for both type of immobilisation and duration of immobilisation were not achieved due to a small sample size. Therefore, a type II error (where a biological effect is present but could not be detected statistically) cannot be excluded. Post-hoc power analysis showed that to detect statistically significant risk ratios for these measures in a population with this distribution of outcomes, approximately three times the number of cases would be required. This is unlikely to be achievable given the infrequency of SDFT luxation and the need for comparable surgical and post-operative management in cases included. A prospective longitudinal study to answer these questions would be ideal, however would require an unrealistic extended amount of time to recruit the required number of cases.

In conclusion, our study shows that a good outcome can be expected following surgical repair of SDFT luxations, with success in 73%. Re-luxation following surgical stabilisation of the SDFT occurred in 7/48 (15%) for which revision surgery was required. 6/48 (13%) had a persistent lameness post-operatively despite a stable non-luxating SDFT. Post-operative complications were common (71%) though majority were related to the use of external coaptations or TA-ESFs and were resolved medically. The use of non-absorbable suture was found to be associated with having a more successful outcome and should be considered over the use of absorbable suture.

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Tables

Table 1. Frequency of prognostic factors and their association with surgical outcomes for 48 cases of surgically treated superficial digital flexor tendon luxation in dogs. A risk ratio >1 indicates an association with an increased risk of surgical failure.

Figures

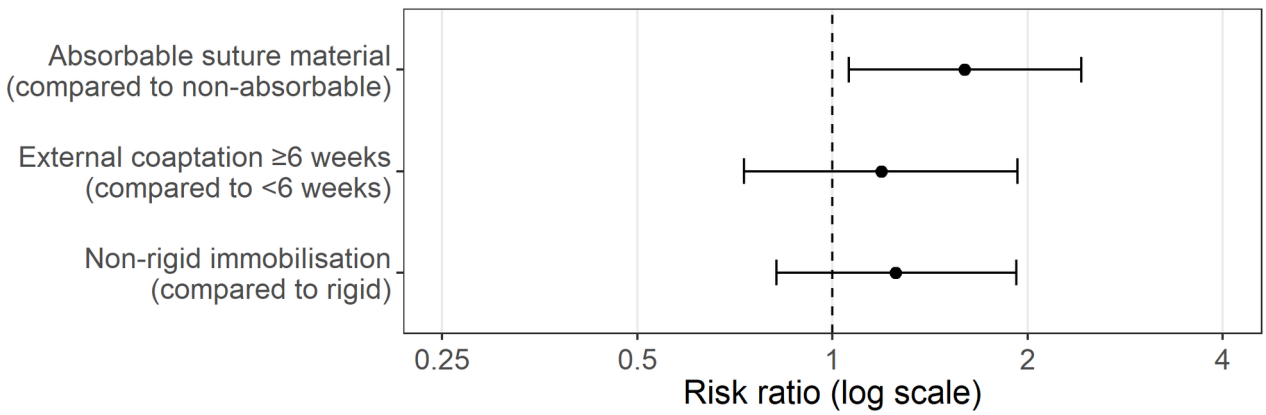
Figure 1. Forest plot to visualise risk ratios plotted on log scale from a study of prognostic factors and their association with surgical outcomes for 48 cases of surgically treated superficial digital flexor tendon luxation in dogs.

The error bars depict 95% confidence intervals.

Supporting information

Supplemental Table 1. Summary of 48 cases of surgically treated superficial digital flexor tendon luxation in dogs.

Legend: TA-ESF, trans-articular external skeletal fixator; kg, kilograms; SDFT, superficial digital flexor tendon



JSAP_13448_Figure 1. Risk ratio.tiff

Table 1. Frequency of prognostic factors and their association with surgical outcomes for 48 cases of surgically treated superficial digital flexor tendon luxation in dogs. A risk ratio >1 indicates an association with an increased risk of surgical failure.

Prognostic factor		Case count	Surgical outcome[1]				Results of univariable analysis		
			Success		Failure		Risk ratio[3]	95% CI[2]	p-value
Suture material	Non-absorbable	24	21	(87%)	3	(13%)	Ref.[4]		
	Absorbable	22	12	(55%)	10	(45%)	**1.60**	**1.1 to 2.4**	**0.01***
	Not recorded	2	2	(100%)	0	(0%)	N/A[5]		
Immobilisation type	Rigid	31	25	(81%)	6	(19%)	Ref.[4]		
	Non-rigid	14	6	(43%)	8	(57%)	1.25	0.8 to 1.9	0.42
	None	3	1	(33%)	2	(67%)	N/A[5]		
Duration of immobilisation	2-4 weeks	34	27	(79%)	7	(21%)	Ref.[4]		
	6-7 weeks	11	7	(64%)	4	(36%)	1.19	0.7 to 1.9	0.69
	No coaptation	3	1	(33%)	2	(67%)	N/A[5]		

[1]Surgical outcome reported as count (percentage of all cases in that prognostic factor category). [2]95% CI = 95% confidence interval of risk ratio. [3] A risk ratio >1 indicates an association with an increased risk of surgical failure. [4]Ref = Reference category for risk ratio calculation. [5]Excluded from analysis due to small sample size.
*Denotes statistically significant result.