

Surgical management of luxation of the superficial digital flexor muscle tendon (SDFT) using a modified block recession calcaneoplasty without subsequent tarsal joint immobilization

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Abstract

Objective: This study aimed to evaluate surgical management of superficial digital flexor tendon (SDFT) luxation by modifying the morphology of the calcaneal tuberosity to (1) reduce the risk of recurrent luxation and (2) challenge the need for tarsal joint immobilization postoperatively.

Study design: Prospective observational study.

Sample population: A total of 11 surgeries in nine client-owned dogs.

Methods: Dogs with SDFT luxation and no concurrent disease underwent modified block recession calcaneoplasty without joint immobilization. Follow-up at 6 weeks and 12 months included pressure-sensitive walkway analysis, ultrasonography, and computed tomography.

Results: A total of 11 limbs in nine dogs were treated using the described technique. All achieved full function at 12 months, with the symmetry index improving from 0.20 ± 0.13 preoperatively to 0.05 ± 0.03 at long-term follow-up ($p = .03$). Five complications occurred (45% overall): two major (18%) requiring revision surgery and three minor (27%) resolving without intervention.

Conclusion: The modified block recession calcaneoplasty without subsequent tarsal joint immobilization led to a significantly improved symmetry index ratio and clinical function at the long-term follow-up compared with preoperative values. No recurrent luxation occurred except one case that suffered fracture of the medial wall of the calcaneal tuberosity. This was successfully revised and no further reluxation occurred.

Clinical significance: The modified block recession calcaneoplasty technique can be considered a complement to previously described surgical methods for treatment of SDFT luxation in dogs.

Preliminary results of the current study were presented at the Nordic Veterinary Orthopedic Society Forum Meeting in Stockholm, Sweden January 24, 2025.

1 | INTRODUCTION

Luxation of the superficial digital flexor tendon (SDFT) is a relatively rare condition causing varying degrees of pain and hind limb lameness in dogs. The superficial digital flexor is one of the main digital flexors of the hindlimb of the dog and it originates from the lateral supracondylar tuberosity of the caudo-distal femur and the lateral fabella.¹ It courses underneath the gastrocnemius muscles before winding around medially to the caudal aspect of the common calcanean tendon. The SDFT runs over the calcaneal tuberosity attached medially and laterally via a retinaculum continuous with the crural fascia. The tendon continues distally to its insertion on the plantar aspect of the middle phalanx of digit II-V.^{2,3} The most common cause of luxation of the SDFT is strenuous exercise and trauma causing rupture of the retinaculum resulting in a luxation which is most often lateral.³⁻⁵ Genetics have been suggested to play a role,⁵ especially in predisposed breeds of dogs like Collies and Shetland sheepdog,⁴⁻⁸ as well as morphological abnormalities of the calcaneal tuberosity predisposing to luxation.^{5,9,10} The condition is usually unilateral but bilateral cases do occur.^{2-4,8,9} Clinical signs vary from an acute non-weightbearing lameness to intermittent skipping with the affected hindlimb.^{4-7,11} Clinical examination frequently reveals marked swelling around the calcaneal tuberosity with a varying degree of pain and discomfort upon palpation, and a popping sensation as the tendon luxates during flexion of the hock joint.^{2,4,6,8,11-13} Ultrasonographic examination frequently identifies displacement of the tendon from the calcaneal tuberosity.^{12,14} Treatment options include conservative as well as surgical techniques. Conservative treatment consists of external coaptation, analgesic and anti-inflammatory medication and rest, and is usually less successful compared to surgical management.^{3,4,6,7} In a small number of cases with mild clinical signs, the SDFT may undergo natural tenodesis in its luxated position or stabilize so that surgery might not be indicated.^{8,15} Currently, numerous surgical techniques have been described including variations of suture and imbrication of ruptured retinaculum, placement of restraining pins stabilizing the tendon in correct position,^{8,14} and deepening of the calcaneal tuberosity concavity using different methods such as abrasion calcaneoplasty, calcaneal chondroplasty-like technique, and block recession calcaneoplasty.^{13,14,16} However, no gold standard surgical technique exists. Current recommendations include tarsal joint immobilization postoperatively to allow soft tissues to heal without stress.^{4-7,9} Previous studies describing the outcome of surgical techniques for SDFT luxation report recurrence rates ranging between 8% and 17%.^{4,6,8,11} Recurrent luxation of the tendon

causes pain and suffering for the animal and additional economic cost for the owner as revision surgery usually is advocated. By reducing the risk of recurrent luxation, the overall outcome after surgical management of this condition will be improved. At our hospital we have received several cases referred for revision surgery due to previous failure and recurrent luxation of the SDFT, thus acknowledging the need for supplementary surgical methods for this condition. By adhering to the same principles as with block recession trochleoplasty in patellar surgery, we have performed the modified block recession technique for SDFT luxations at our hospital since 2015. The objective of this prospective observational study was to document surgical intervention of SDFT luxation by modifying the morphology of the calcaneal tuberosity and (1) thereby minimizing the risk of recurrent luxation and (2) challenge the need for joint immobilization during the postoperative period. The authors hypothesized that seating the tendon firmly in a deeper groove via a modified block recession calcaneoplasty will eliminate the need for postoperative tarsal joint immobilization and thereby reduce coaptation-related complications,¹⁷ and prove a reliable surgical management of SDFT luxation without recurrence.

2 | MATERIALS AND METHODS

2.1 | Animals

The current prospective observational study was conducted at a private small-animal referral hospital. Consecutive cases of SDFT-luxation were collected between March 2020 and August 2023. Written owner consent was obtained for all cases. Ethical approval was not applied for as the technique already was the standard method for surgery of luxation of the SDFT at the hospital. All dogs were examined preoperatively by a single board-certified surgeon (ECVS diplomate) and the presence and orientation of SDFT luxation was confirmed either by palpation or by ultrasonography. Dogs were excluded from the study if the protocol was not followed. Only dogs assessed as clinically healthy, without known comorbidities, and classified as ASA grade I-II were included in the study.

2.2 | Preoperative examination protocol

The initial examination protocol consisted of signalment, medical history, and a general physical and orthopedic examination followed by an objective gait analysis on a pressure sensitive walkway (Tekscan animal walkway

system. Tekscan, Inc. Norwood, Massachusetts). **Ultrasonography** was performed when needed to confirm the diagnosis and determine the direction of the luxation. Finally, a **computed tomographic** (CT ingenuity DS 128, Philips, Solna, Sweden) study of the hindlimbs was obtained for surgical planning and used as a reference value for evaluation of bone healing and remodeling in the follow-up period. Given the lack of objective grading systems, **the assessment of the calcaneal tuberosity was subjectively defined as normal or shallow, depending on whether there was a visual concavity present or not.** Ground reaction forces and spatiotemporal parameters were measured, and a symmetry index (SI) ratio was obtained using peak vertical force (PVF) for each hindlimb measured. The PVF of the left hindlimb was divided by the PVF of the right hindlimb, and perfect symmetry was defined as $SI = 1.0$. A value of <1 indicates a left hindlimb lameness and >1 indicates a right hindlimb lameness. All dogs were trotted on a leash over the pressure sensitive walkway multiple times to achieve five valid passes; an average was calculated and used as the SI ratio. The difference from 1.0 was then calculated to compare the degree of hindlimb asymmetry.

2.3 | Anesthetic protocol

The anesthetic protocol was individually adapted and designed to meet the specific individual's requirements. Preanesthetic medication included methadone (Dechra Veterinary Products AB, Sweden; 0.2–0.4 mg/kg subcutaneously or IM) and a sedative, either acepromazine (Pharmaxim AB, Sweden; 50 µg/kg) or dexmedetomidine (Orion Pharma AB Animal Health, Solna, Sweden; 2–7 µg/kg subcutaneously). After preoxygenation the patients were induced with propofol (Zoetis Animal Health ApS, Denmark) titrated to effect. Patients were then intubated, and anesthesia was maintained with isoflurane (Zoetis Animal Health ApS) in a 50:50 mixture of oxygen and medical air. Vital parameters were monitored throughout the anesthetic period, the dogs received either an epidural or an ultrasound-guided peripheral nerve block with bupivacaine. (Aspen Nordic, Denmark; 1 mg/kg). The dogs were positioned in sternal recumbency with hindlimbs extended, the affected hindlimb was clipped and aseptically prepared for surgery with chlorhexidine scrub (Fresenius Kabi AB, Uppsala, Sweden) followed by chlorhexidine solution (Fresenius Kabi AB). Standard aseptic preparation and draping were performed, with the calcaneal tuberosity covered by incise film (3M Health Care, St. Paul, Minnesota).

2.4 | Surgical procedure

A parasagittal skin incision was made over the calcaneal tuberosity contralateral to the direction of luxation. Subcutaneous tissues were dissected and the entire calcaneal tuberosity with soft tissues was exposed. The calcaneal bursa was incised longitudinally on one or both sides of the SDFT as needed for a tension free reduction, and **the underlying calcaneal tuberosity was inspected.** A **modified block recession calcaneoplasty was planned measuring half of the total width of the calcaneal tuberosity, leaving a medial and lateral wall approximately 25% of the total width** (Figure 1). Osteotomies were executed with an **oscillating saw** (Synthes, Johnson & Johnson MedTech, New Jersey); two slightly convergent vertical osteotomies were made on the lateral and medial aspect of the calcaneal tuberosity respectively (Figure 2) and another osteotomy was placed horizontally in a caudal to cranial direction between the two vertical osteotomies aiming for the craniodorsal edge, creating a cartilage-covered bone flap free in the caudal aspect but hinged in the cartilage at the craniodorsal aspect adjacent to the insertion of the common calcaneal tendon (Figure 3). Once the flap was created, another horizontal osteotomy was made parallel and **2 mm** distal to the first one (Figure 4) and the resultant this slice of bone was removed. After flushing with saline, the flap was reduced and seated into the deepened sulcus (Figure 5). The SDFT was then repositioned in the created trochlea, **redundant parts of the bursa trimmed off, and the bursa was imbricated alongside the SDFT with USP 3–0 polydioxanone** (Johnson & Johnson MedTech) horizontal mattress sutures. The subcutis and skin were closed routinely with USP 3–0 polydioxanone and polyamide (Johnson & Johnson MedTech). Computed tomographic (CT) images were obtained postoperatively (Figure 6). A polyurethane compress was placed over the suture line as a contact layer, **and the foot was covered by a soft padded bandage left for three days to be removed at home by the owner.** No coaptation was applied after day three. **Nonsteroidal anti-inflammatory medication was prescribed for 28 days, and the owners were instructed to start physical rehabilitation three weeks postoperatively.**

2.5 | Postoperative treatment and follow-up protocol

The first follow-up examination was performed according to established routines at the surgical department **six weeks postoperatively, consisting of an orthopedic examination, pressure sensitive walkway gait analysis and an ultrasonographic examination of the position and integrity of the SDFT.** The long-term follow-up was performed

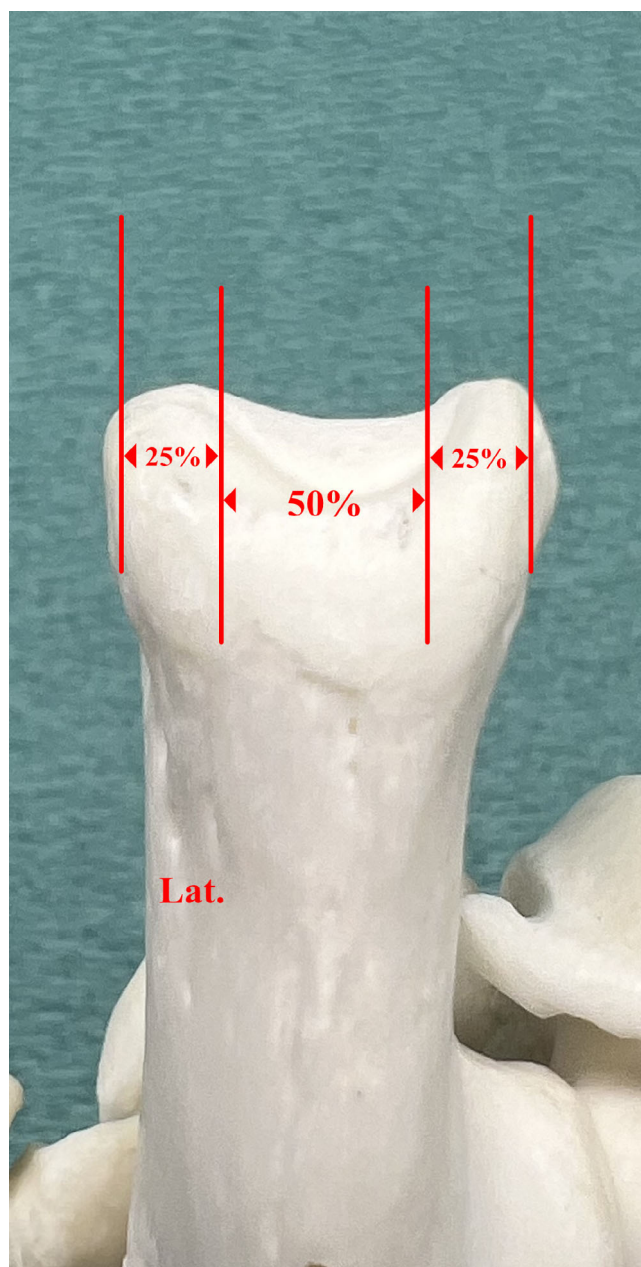


FIGURE 1 Preoperative planning of the two vertical osteotomies.

at a minimum of 12 months after surgery and consisted of an orthopedic examination, an ultrasonographic examination, a walkway gait analysis and a CT examination of the hindlimbs.

2.6 | Definitions and criteria

In this current observational study, we used the following defined time frames: perioperative; 0–3 months, short-term >3–6 months, mid-term >6–12 months and long term >12 months after surgical procedure.¹⁸



FIGURE 2 Intraoperative image demonstrating the position of the two parallel vertical osteotomies on a left sided calcaneal tuberosity with the superficial digital flexor tendon (SDFT) displaced to the left in the image.

Outcomes were defined as: full function meaning return to activity level as prior to injury without need of medication. An acceptable function is restoration to, or maintenance of, intended activities and performance from preinjury or predisease status that is limited in level or duration and/or requires medication to achieve. Unacceptable function is all other outcomes.¹⁸

Complications were grouped into catastrophic, major and minor. A catastrophic complication resulted in either amputation or euthanasia of the animal, a major complication was defined as one that requires surgical or medical intervention to resolve. A minor complication was defined as a deviation from the expected plan but without the need for additional surgery or medical treatment to resolve.¹⁸

2.7 | Statistical analysis

Walkway analysis SI ratio averages were compared using a Mann–Whitney test for non-normally distributed data. Symmetry index ratios obtained preoperatively were

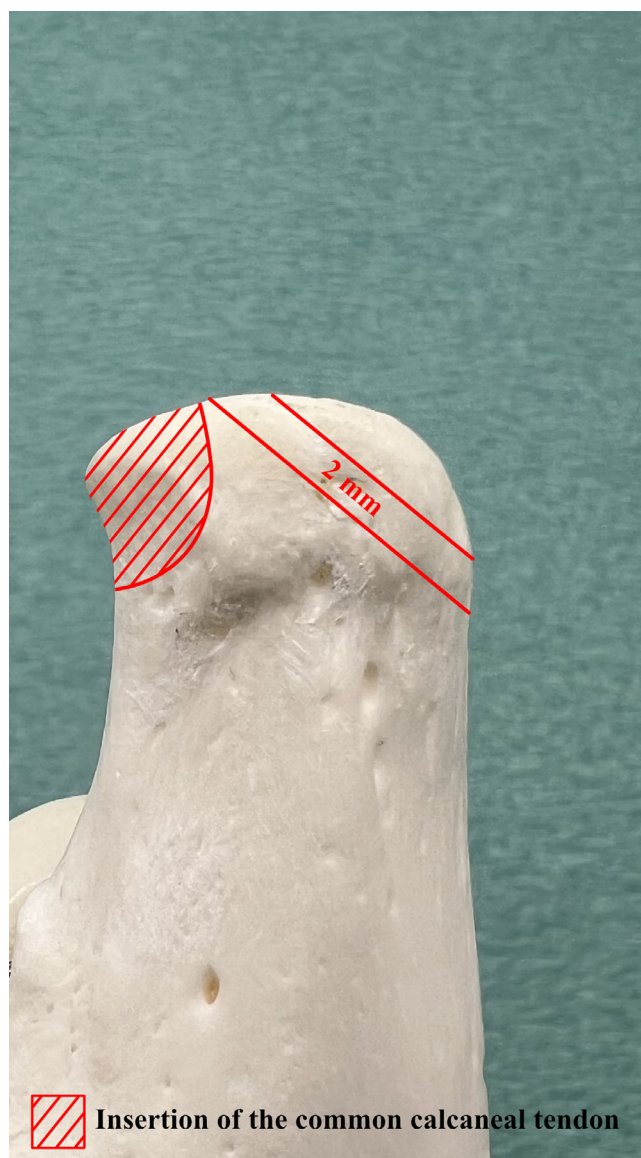


FIGURE 3 Preoperative planning of the two horizontal osteotomies.

compared with perioperative and long-term follow-up values, as well as between perioperative and long-term follow-ups. Data are presented as mean $\pm$ SD. Software Microsoft Excel (2016) and Minitab version 18 were used for analysis. The level of significance was set to $p < .05$.

3 | RESULTS

3.1 | Signalment and history

A total of **nine dogs and 11 limbs** were included in the current study from March 2020 to August 2023. **Seven** dogs were presented for **initial surgery** and **two** were presented for **revision**. **Eight dogs were Shetland sheepdogs**, and one



FIGURE 4 Intraoperative image after the two horizontal osteotomies has been executed, leaving a slice of bone to remove to allow recession of the block.

was a Norrbottenspets. Four dogs were entire males, four were entire females and one was a neutered female (Figure 1). Two cases had bilateral disease, with the contralateral limb becoming affected 3 months and 3 years after the index surgery respectively. The **average bodyweight was 8.2 $\pm$ 2.6 kg** (median 7.3, range 5.5–14.5 kg). The average age at the time of injury was 781 days (median 689, range 239–1698 days). Of 11 limbs, six were right-sided and five left-sided (Table 1).

The cause of the luxation was relatively minor trauma in all cases; nine occurred during play and two occurred when the dogs jumped out of a car. At preoperative orthopedic examination all dogs exhibited weightbearing lameness assessed using a one to five grading system (1 = minor lameness; 5 = non-weightbearing lameness). The severity of lameness varied from intermittent skipping ($n = 1$), mild grade 1 lameness ($n = 6$) to moderate grade 2–3 lameness ($n = 4$). All 11 limbs were markedly swollen over the calcaneal tuberosity with 5/11 showing discomfort or pain upon palpation/manipulation. A total of 10 dogs (10/11) exhibited asymmetry using the symmetry ratio index on the pressure sensitive walkway prior to surgery. Nine of these dogs had a lower PVF on the



FIGURE 5 Intraoperative image displaying the deepened sulcus after a modified block recession calcaneoplasty. The cartilage hinged bone flap has been press fitted into the recession after removal of the underlying bone.

affected limb. One dog had an increased PVF on the affected limb which could not be accounted for by the orthopedic examination. One dog was symmetrical despite having a subjective lameness of the affected limb. Preoperatively the average walkway results deviated from 1 by 0.20 ± 0.13 (median 0.2, range 0.0 to 0.43), indicating a 20% decrease in PVF compared to the non-affected limb. CT was conducted in all 11 cases. In five of 11 limbs, the calcaneal tuberosity was judged as normal and 6/11 had a shallow groove on the calcaneal tuberosity. Two dogs had staged bilateral disease separated by 3 months and 3 years for cases 3 and 7, respectively; both calcaneal tuberosities were morphologically similar in each case (normal and shallow, respectively). In the remaining cases (7/11) the affected limbs calcaneal tuberosity was either morphologically symmetrical to non-affected limb (5/7) or shallower (2/7).

3.2 | Surgical findings

All reported cases suffered from a lateral luxation of the SDFT, 6/11 were permanently luxated (nonreducible by

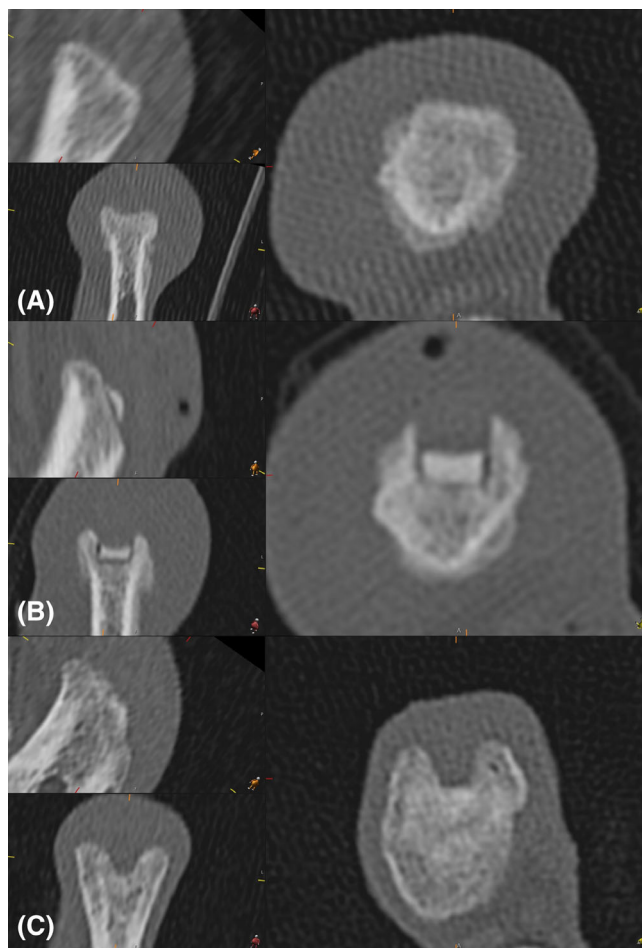


FIGURE 6 Multiplanar reformation of left calcaneus in case 4 (A) preoperatively, (B) direct postoperatively and (C) 1026 days postoperatively.

digital manipulation) and 5/11 were reducible. The surgical time was mean 39 ± 5.9 min (median 38, range 30–50 min). The surgical approach was consistent and predictably for all cases and gave a good view of the calcaneal tuberosity. The osteotomies were executed according to plan in all but one case where the medial vertical osteotomy came too close to the outer wall, identified as a narrow medial wall on postoperative imaging and eventually leading to a fracture and loss of medial support to the SDFT identified at follow-up 6 weeks later. The notably dense and hard calcaneal bone structure requires an oscillating saw and ample lavage to prevent thermal injury to the bone.

3.3 | Perioperative follow-up

The first follow-up was carried out in 10 cases, mean: 44 ± 5.2 days (median 42, range 38–57) postoperatively. One case was examined earlier than scheduled due to an early major complication, partial common calcaneal

TABLE 1 Results.

Variable	Result
Sex	
Female	5 (45.5%)
Neutered female	1 (9%)
Male	5 (45.5%)
Neutered male	-
Bodyweight (kg)	
Median (range)	7.3 (5.5–14.5)
Age (days)	
Median (range)	689 (239–1698)
Follow up time	
Short term (days)	
Median (range)	42 (38–57)
Long term (days)	
Median (range)	847 (420–1586)
Symmetry index (SI)	
Preoperatively	
Mean (SD)	0.20 ($\pm$ 0.13)
Short term follow-up	
Mean (SD)	0.32 ($\pm$ 0.19)
Long term follow-up	
Mean (SD)	0.05 ($\pm$ 0.03)
<i>p</i> -values SI	
Long-term compared to preoperatively	0.03
Long-term compared to perioperative	0.003

Note: Summarizing results including signalment, surgical findings and gait analyses. The software divides PVF of the left by the right hindlimb resulting in a SI <1.0 for lameness of the left compared to values >1.0 for lameness of the right hindlimb. The numbers indicate the deviation from 1.0 which is exact symmetry.

tendon avulsion, and therefore had an altered postoperative plan. Soft tissue swelling over the calcaneal tuberosity was present in all cases (10/10), 3/10 had some degree of discomfort upon palpation and manipulation, 6/10 walked with a minor lameness including one dog with hyperflexion of the talocrural joint on the affected side, 2/10 had moderate lameness, and 2/10 were free of lameness. During ultrasonographic examination the correct position of the tendon was confirmed in 9/10 limbs. The tendon in the remaining limb was medially luxated due to a fractured medial recession wall. All (10/10) tendons showed varying degrees of swelling over the calcaneal tuberosity, 6/10 tendons had an altered, more heterogeneous fiber structure, and 4/10 tendons had a normal fiber structure.

All cases were asymmetrical on objective walkway analysis, with a mean SI ratio difference of 0.32 ± 0.19

(median, 0.32; range 0.03–0.60). In nine of 10 cases, the surgically managed limb showed greater asymmetry, indicating increased lameness compared with preoperative values. Although a difference was observed, it was not statistically significant ($p = .17$).

3.4 | Long-term follow-up

Nine cases were available for long term follow up with two cases having been examined 344 and 346 days after surgery respectively. Mean follow up time were 814 ± 369 days (median 847, range 420–1586 postoperatively). All cases were subjectively free of lameness, 2/9 had a completely normal orthopedic examination, 7/9 were thickened and widened over the calcaneal tuberosity, 1/9 had a reduced range of motion of the tarsal joint (case 5, with the partial common calcanean tendon avulsion), and 1/9 walked with mild hyperflexion of the talocrural joint. All cases had returned to full clinical function. Ultrasonography was performed in 9/9 cases, the correct position of the SDFT was confirmed in all limbs, and all tendons showed a normal fiber structure. Case 1 suffered at that time from renal failure and the owners allowed only for gait analysis and plain radiographs of the tarsus without sedation. Palpation revealed normal position of the tendon. CT was performed in 8/9 cases (case 1 had orthogonal radiographs because the dog was not suited for sedation) and all surgically managed calcaneal tuberosities had healed unremarkably with a varying degree of osseous remodeling. The degree of new bone formation and remodeling around the calcaneal tuberosity was graded as mild in 3/8 cases, moderate in 4/8, and one case (case 5) had severe remodeling. This case had periosteal reactions preoperatively on the lateral aspect of the calcaneal tuberosity in addition to the impact of surgical revision and application of an external skeletal fixator (ESF). All cases had a persistent deepening in the caudoplantar aspect of the calcaneal tuberosity, slightly narrower with a typically rounded shape compared to the square shape direct postoperatively (Figure 6). Objective pressure-sensitive walkway analysis was performed in all nine cases, yielding a mean SI ratio of 0.05 ± 0.03 (median, 0.05; range 0.01–0.09). This represented a significant improvement in lameness compared with both perioperative ($p = .003$) and preoperative values ($p = .03$).

3.5 | Complications

A total of five complications were reported, of which three were minor and two major both requiring revision

surgery. In case 2 the medial wall of the calcaneal tuberosity was left too narrow after creation of the trochleoplasty which subsequently resulted in fracture of the medial wall and re-luxation of the SDFT. This was discovered at the first follow-up examination 44 days after surgery. Revision was performed and a 1.5 mm stainless-steel locking compression plate was placed on the medial aspect of the calcaneus, protruding a few millimeters proximal to the calcaneal tuberosity as support for the tendon. This case had no further complications. Case 5 suffered a partial avulsion of the common calcaneal tendon 20 days postoperatively. The insertion part of the tendon was debrided, and the tendon reattached to the calcaneal tuberosity with sutures through bone tunnels. To support the repair the tarsal joint was immobilized in extension with a type-II ESF for 54 days. Both cases had returned to full function by the final follow-up. Of the three minor complications reported, two cases had minor erythema from the postoperative soft-padded bandage, both healed without treatment. One case had a persistent mild hyperflexion of the talocrural joint but without pain or discomfort.

4 | DISCUSSION

In our study, all dogs with luxation of the SDFT treated with the modified block recession technique returned to full function by the final follow up. To the authors' knowledge, this is the first prospective study to objectively assess the short- and long-term functional outcome after surgical management of luxation of the superficial digital flexor tendon in dogs. No cases of recurrent luxation were observed within the study period except the one case that suffered fracture of the medial wall of the calcaneal tuberosity. This was successfully revised and no further relaxation occurred. In a previous study where a restraining pin were used to keep the tendon from luxating, a soft padded bandage was used only for a short period (mean 7 days).⁸ Two of 23 cases had recurrent luxation but this was after removal of the restraining pin months after the initial surgery and it is questionable whether a prolonged time of external coaptation would have prevented this complication. In another study evaluating the outcome after SDFT surgery with soft tissue repair only, the authors concluded that surgical failure was more common in cases managed with non-rigid immobilization compared to cases managed with rigid immobilization (57% and 19% failure, respectively).¹¹ **This supports our hypothesis that providing structural support to the tendon in the form of a deepened sulcus might reduce the need for external coaptation which is advantageous as it can** lead to significant morbidity in

terms of skin wounds. In a retrospective study by Meeson et al., as many as 63% of the animals treated with rigid coaptation of the distal limb developed cast associated soft tissue injuries of which 20% were severe. The financial cost for treating these injuries varied from 4% to 121% the cost of the original procedure.¹⁷ In a more recent publication, 59% of the complications after SDFT surgery were directly related to the external coaptation.¹¹

The first major complication in this study concerned case 2 where the osteotomy resulted in the medial wall of the calcaneal tuberosity being too narrow which lead to fracture and subsequent relaxation of the SDFT. It is possible that postoperative immobilization of the limb in this case could have reduced mechanical stress on the osteotomy and theoretically prevented failure. This case underlines the importance of meticulous planning as well as sufficient surgical equipment for proper execution of the osteotomies in these small bones. This case was revised by placing a small locking compression plate on the medial aspect of the calcaneus protruding a few millimeters proximal to support the tendon. This technique could potentially be used as a primary repair of luxation of the SDFT as the calcaneus can accommodate a plate on either side depending on the orientation of the luxation. Except for the extra implant cost and possible increase in surgical time it seems a logic and acceptable method, though it might rise concerns of abrasion of the tendon rubbing against the edge of a metal plate. The actual case in our study showed no signs of chronic influence on the tendon on the long-term follow-up, but further studies on this method are warranted. The second major complication (case 5) was a partial loss of integrity of the insertion of the common calcaneal tendon at the calcaneal tuberosity. The reason for this is not known, and despite no injury to the tendon itself being noted during surgery, iatrogenic damage remains possible. The dog had a good function after surgery, and the owner had difficulties with restraining the dog's activity. During revision surgery severe inflammatory changes were observed in the area from the calcaneal tuberosity and proximal along the common calcaneal tendon. The reason for the semi-plantigrade stance could be iatrogenic or a concurrent pathology within the calcaneal tendon. Potentially there could be a correlation between partial common calcaneal tendon rupture and SDFT luxation as documented in a previous report.¹⁰

In the current study the majority of the dogs were Shetland sheepdogs, which is consistent with previous studies^{4,6,8} indicating a heritability trait for the condition in this breed.⁵ Previous reports show conflicting results regarding sex distribution; while some studies report a majority of females,^{5,11,13} others show an even sex distribution⁸ as seen in our study. All 11 cases of SDFT

luxation in the present study are lateral which is in coherence with previous studies where lateral luxation is evidently more common than medial ones.^{3-6,8,13,19} Maurterer et al. dissected tarsi from 10 cadavers of mixed breed dogs and found that the area of insertion of the medial part of the retinaculum was less distinct compared to the lateral, suggesting a possible explanation to the predominantly lateral direction of displacement.⁴ It is also indicated in the current literature, that bilateral disease is an infrequent but possible occurrence,^{4,5,8,11,13} as in this study where two out of nine dogs suffered bilateral disease. The true incidence of bilateral disease is unknown but may be more frequent in predisposed breeds.

During surgery six tendons (6/11) were considered permanently luxated due to the inability to be reduced to its normal position. It is thought that natural tenodesis of the tendon in its luxated position may diminish clinical signs and reduce pain compared to when the tendon luxates actively causing discomfort and pain. Despite this, and lack of spontaneous luxation and reduction during gait, all these dogs displayed a minor to moderate lameness on the affected limb indicating that conservative treatment might not be a viable option in all cases.^{4,8} It is also likely that the original function of the tendon to flex the digits is impaired when positioned lateral or medial to the calcaneal tuberosity, losing tension compared to the normal position over the tuberosity.

In the current literature there is a lack of information regarding inflammatory changes within the SDFT after trauma and luxation, repair and subsequent recovery. For obvious reasons histopathologic examination is not applicable for clinical cases, hence the physiological changes of the tendon are unknown. In the present study we used ultrasonography to document the position of the tendon but additional information regarding the architecture of the SDFT was also collected, showing that just over half of the tendons had a heterogenous fiber structure at six weeks, but were all normal at the long-term follow-up.

All CT examinations were studied by a European College of Veterinary Diagnostic Imaging diplomate and resident. The morphology of the calcaneal tuberosities pre- and postoperatively as well as the degree of remodeling and new bone formation at the long-term examination was analyzed and graded. No consistent clear findings were made preoperatively regarding the calcaneal tuberosity morphology, even though the majority were subjectively shallow. However, there have been no conducted studies defining the normal morphology or concavity of the calcaneal tuberosity, rendering our assessment subjective. The findings in the current study may indicate that the calcaneal tuberosity depth does play a part in the pathogenesis of this condition and that

a shallow calcaneal tuberosity increases the risk of luxation as proposed in previous studies^{5,9,10} but this could not be confirmed in our data. **The varying degree of bony remodeling seen on the calcaneal tuberosity at long term follow-up did not appear to be clinically relevant during the examination.** The new bone formation seen were abaxial **medially and laterally** located, hence not affecting the SDFT as it runs centrally and caudal over the bone. Most of the cases had only a slight contour disturbance around the tuberosity, and further complications related to this change is less likely but cannot entirely be ruled out. Larger studies with much longer follow up are required to fully evaluate the implications of remodeling of the calcaneal tuberosity.

The first objective of the current study was to observe whether the risk for recurrent SDFT luxation could be minimized by approaching SDFT luxation with a modified block recession calcaneoplasty technique. Larger studies are required to assess whether the rate and severity of major complications are true and the benefit of the procedure outweighs the risk. All dogs regained functional use of the affected limb after surgery with minor residual gait changes in one case.

The second objective of the study was to challenge the need for joint immobilization postoperatively. This would limit complications related to external coaptation, a commonly reported event in previous studies.^{8,11,13} Although immobilization still may have a protective role during early healing after SDFT repair, the results of our study suggest that immobilization may not be required with this technique, but further controlled or comparative studies would be required to substantiate this finding.

There are several limitations in this study. Our low number of cases makes the data difficult to interpret and lowers the credibility of the statistical results. Furthermore, this study lacks control groups to compare this novel surgical method to other described methods regarding safety, risk for complications, recurrence rate and overall outcome.

In conclusion the described method with the modified block recession calcaneoplasty could be considered as a complement to previously described surgical methods in treating luxation of the superficial digital flexor tendon in dogs but this warrants further and larger prospective studies.

AUTHOR CONTRIBUTIONS

Viskjer S, DVM, DECVS (Small Animal): Design of study (lead), performed all surgeries (lead), writing – review and editing (lead). Glovéus A, DVM: Interpretation and summary of data (lead), writing – original draft (lead) and editing (supporting).

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest to declare from any of the authors.

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