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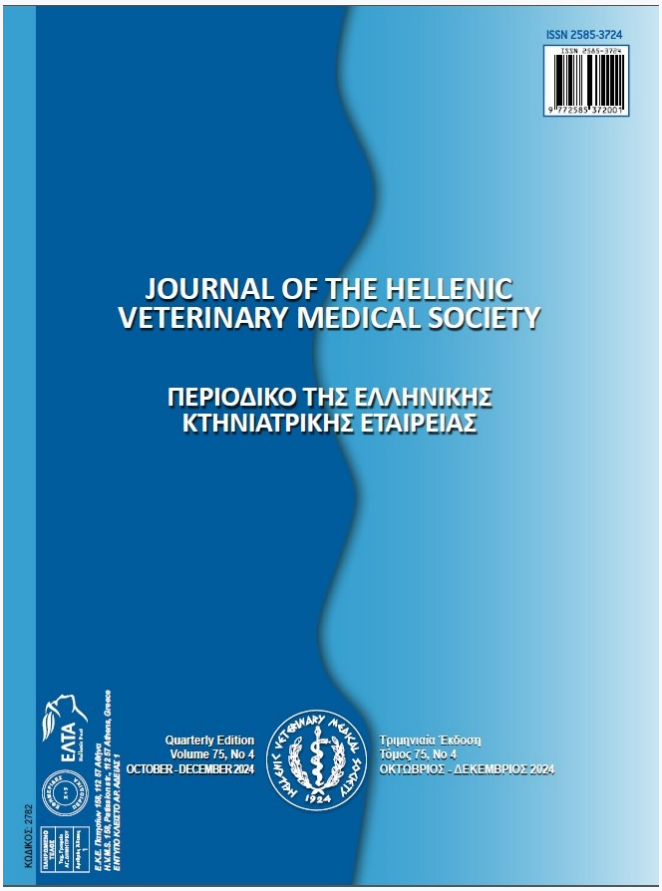

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Research article
Ερευνητικό άρθρο

A myocutaneous flap variation for management of distal hindlimb wounds in the cat

E. Dermisiadou[1], I. Panopoulos[2], D. Psalla[3], S. Georgiou[1], A. Sideri[1], A. Galatos[1], E. Flouraki[1], V. Tsioli[1]*

[1]*Clinic of Surgery, Faculty of Veterinary Science, University of Thessaly, Karditsa, Greece*

[2]*Alphavet, Veterinary Diagnostic Imaging Center, Athens, Greece*

[3]*Laboratory of Pathology, Faculty of Veterinary Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece*

ABSTRACT: Management of complex feline hindlimb defects is challenging. However, the use of a split semitendinosus myocutaneous (SST) flap for coverage has not yet been reported. The objective of this study was to describe the SST flap and compare it with second-intention healing for the management of complex tibial defects in cats. Two wounds were created on each tibia of 12 purpose-bred laboratory DSH cats. Wounds in group A (n=12) were covered with SST flaps and those in group B (n=12) were left to heal by second intention. In both groups, clinical assessment scoring and planimetry were performed between 1 and 30 postoperative days. CT angiography (CTA) and histologic examination were performed on days 0, 10, and 30 and days 0, 14, 6, and 12 months postoperatively, respectively. Group A had significantly higher assessment scores on days 7 ($p=0.002$), 14 ($p<0.001$), 21 ($p=0.001$), and 30 ($p=0.008$). The time to complete healing in group A (32,42 days) was significantly higher than that to complete epithelial coverage in group B (24.67 days) ($p=0.001$). On CTA, significant differences were observed in ST muscle density which was higher on day 10 compared to 0 on the proximal (dP) ($p<0.001$) and medial (dM) points ($p=0,020$, $p<0,001$, $p<0,001$ respectively) in all three different phases. For the distal (dD) point, the measurement was significantly higher in the precontrast phase ($p=0.001$) and on day 10 compared today 30 at all points in all three phases ($p<0.001$). The caliber of the distal caudal femoral artery and vein and the proximal gluteal artery and vein were significantly higher on day 10 than on day 0 ($p<0.001$), on days 10 to 30 ($p<0.001$), and on days 30 to 0 ($p=0.004$, $p=0.006$, $p=0.011$, $p=0.007$, respectively). Histologically significant differences were observed in inflammation and muscle cell degeneration which were higher on day 14 than on day 0 and 6 months ($p<0.001$, $p<0.001$, $p<0.001$, $p=0.007$ respectively). Neovascularization and fibrosis were significantly higher on day 14 than on day 0 ($p=0.010$ and $p=0.009$, respectively). In conclusion, although the ST muscle can be safely longitudinally split and cover tibial defects, the SST flap is less efficient than second-intention healing in terms of the time to complete wound healing.

Key words: cat; hindlimb defects; split semitendinosus myocutaneous flap

Corresponding Author:
Vassiliki Tsioli, Department of Surgery, Faculty of Veterinary Science, School of Health Sciences, University of Thessaly, 224 Trikalon str., 43100 Karditsa, Greece
E-mail address: vtsioli@vet.uth.gr

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INTRODUCTION

The treatment of wounds in the distal aspect of the hind limbs in small animals is often difficult, and muscle or myocutaneous flaps offer an alternative treatment option, especially in wounds complicated by extended soft tissue loss and orthopaedic injuries (Beardsley and Schrader, 1995; Aper and Smeak, 2003; 2005; Fowler, 2006; Hosgood, 2006; Corr, 2009). These wounds benefit from a one-stage reconstruction using vascularised tissue (Mathes and Nahai, 1981; Pavletic, 1990).

Myocutaneous flaps are composed of skeletal muscle with its overlying skin, with direct cutaneous vessels exiting from the muscle and supplying the skin. Myocutaneous flaps provide a considerable amount of tissue to cover complex or large defects and improve healing times and tissue vascularisation (Pavletic et al., 1987; Weinstein et al., 1988; 1989; Chambers et al., 1990; 1991; 1998; Puerto and Aronson, 2004). The Semitendinosus muscle (ST) is a type III muscle with two dominant vascular pedicles that can cover the muscle's blood requirements in case of ligation (Solano et al., 1995; Puerto and Aronson, 2004). The proximal gluteal artery supplies the proximal half of the muscle, and the distal caudal femoral artery supplies the distal half. ST muscle depending on the blood supply of the proximal gluteal artery and vein, or the distal caudal femoral artery and vein has been reported in a case series of three dogs and one cat (Chambers and Rawlings, 1991; Puerto and Aronson, 2004; Vnuk et al., 2005). The use of a ST myocutaneous flap based on the distal caudal femoral artery and vein has been recently reported for the coverage of hindlimb defects in cats (Dermisiadou et al., 2023; 2024). The use of the proximal half of the ST after transverse division of its fibres has been reported for reconstruction of the perineum in three dogs (Chambers and Rawlings, 1991; Morello et al. 2015). The use of the distal half of the ST, after longitudinal division of its fibers, has been reported in cases of Achilles tendon rupture in dogs (Baltzer and Rist, 2009) and the proximal half in dogs with perineal hernia (Morello et al., 2015). Transposition of the proximal half of the ST has been reported for treatment of fecal incontinence in dogs and rectal wall repair in dogs and cats (Doust and Sullivan, 2003; Riggs et al., 2018; Kim et al., 2023). The authors have recently published an article comparing the use of the ST to the SST myocutaneous flap as a reconstructive technique for the management of complex tibial defects in cats (Dermisiadou et al., 2024).

The objective of this study was to compare the SST flap as a reconstructive technique to second-intention healing for the management of complex tibial defects in cats. This study was designed to assess the efficacy and clinical outcomes of the SST flap over second-intention healing. The hypothesis evaluated during the study was that in cats, advancement of the SST flap would be more successful in treating distal limb defects than second-intention healing.

MATERIALS AND METHODS

All procedures were approved by the National Animal Ethics Committee (license number: 2734/12-6-2015), in accordance with the European Union directive 2010/63/EU, and by the Animal Ethics Committee of the Faculty of Veterinary Science, University of Thessaly (license number: 15/16-6-2015). The licence also determined the minimum number of animals possible, based on welfare considerations. Twelve purpose-bred laboratory DSH cats, aged 1-4 years (7 castrated males and 5 spayed females) and weighing 3-4 kg, were included in this study. Health status was based on physical examination, complete blood count, serum biochemistry analysis, and fecal parasitology. Screening for feline immunodeficiency virus and feline leukaemia virus was performed. No drugs were administered two months before the experiment. The animals included in this study had no skin pathology or musculoskeletal conditions. After completion of the study, all cats were given for adoption.

In each cat, two identical wounds were created on the distal medial surfaces of both tibial areas. Wounds were randomly allocated into two groups (A and B) using a computer program (Random Number Generator). Six animals had SST flaps on the right hind limb, and the remaining six were on the left. The wounds in group A (n=12) were covered with SST flaps and those in group B (n=12) were left to heal by second intention. In both groups, clinical assessment scoring and planimetry were performed 0, 7, 14, 21, and 30 days postoperatively. Computed tomography-angiography (CTA) and histological examination were performed on days 0, 10, and 30 and on days 0, 14, 6, and 12 months postoperatively, respectively.

Presurgical Management

The cats received premedication with dexmedetomidine (20 μg/kg b.w., intramuscularly (IM), Dexdomitor 0.5 mg/ml; Elanco, Greece), and butorphanol (0.3 mg/kg b.w., IM, Dolorex 10 mg/ml; MSD,

Greece). Anaesthesia was induced with propofol 1% (2-4 mg/kg b.w., intravenously (IV), Propofol MCT/LCT 1%; Fresenius Kabi Hellas, Greece) and maintained with isoflurane (2%, Isoflo; Abbott Laboratories, UK) in oxygen (2 L/min). Normal Saline 0.9 % solution IV was administered at a rate of 4 ml/kg/h during anaesthesia. Preoperatively, amoxicillin and clavulanic acid (20 mg/kg b.w., subcutaneously (SC), Synulox RTU Inj.; Zoetis, Greece) and carprofen (2 mg/kg b.w., IV, Rimadyl; Zoetis, Greece) were administered.

Surgical procedure

A full-thickness skin defect 2 cm in length and 1 cm in width was created on the medial surface of the distal tibia of each hind limb, 1 cm cranial to the tarsal joint, as previously described by Dermisiadou et al. (2023). The tibial periosteum was then surgically removed. In group B, skin edges were tacked to the underlying tissues by simple interrupted sutures to leave the bone denuded (Fig.1). Sutures were removed on day 7 after firm adhesion had formed between the skin and underlying tissues (Winkler et al. 2002).

In group A, the SST flap was raised, as previously described by Dermisiadou et al. (2024). The SST flap was formed from the medial half of the semitendinosus muscle, preserving the proximal gluteal artery and vein (Fig.2). The semitendinosus muscle was split by the separation of its fibers parallel to the longitudinal axis from the ischial tuberosity to the level of the stifle. Flap length ranged from 10.45 to 11.17 cm and the flap width from 1.78 to 2.09 cm. A bridging skin incision was made between the base of the SST flap and the defect on the medial surface of the distal tibia, and the flap was rotated 150-170^{o} distally, to cover the defect (Fig.3).

Postoperative management

Morphine hydrochloride (0.2 mg/kg b.w., IM, Morfina cloridrato; Molteni, Italy) was administered for analgesia at the end of surgery and every 4-6 hours for two days. Amoxycillin and clavulanic acid (20 mg/kg b.w., SID, SC, Synulox RTU Inj.; Zoetis,

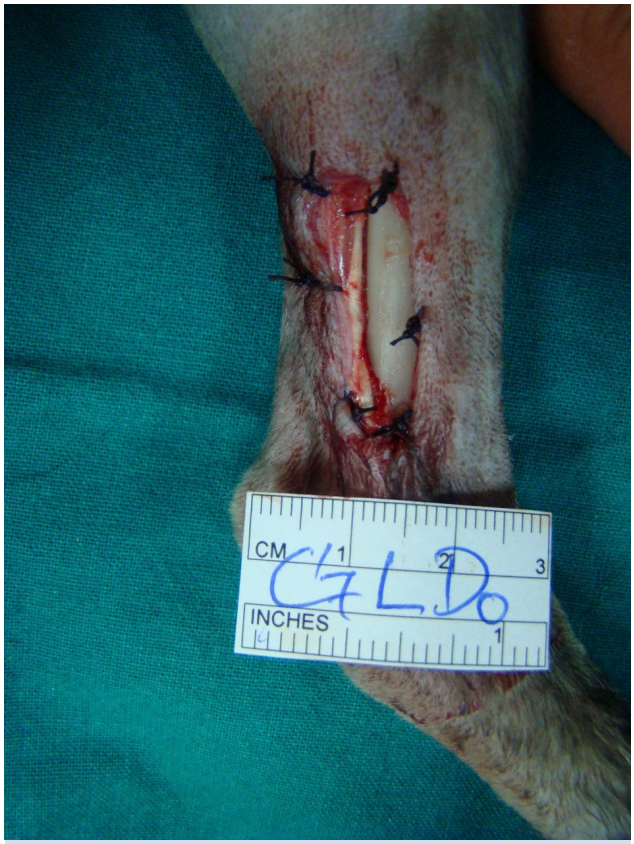

Figure 1. Full-thickness skin defect of the distal tibia (medial surface). In group B, the skin edges were tacked to the underlying tissues by simple interrupted sutures. The caudal tibial and medial digital flexor muscle tendons were both retracted caudally, and the periosteum was incised to expose the bone.

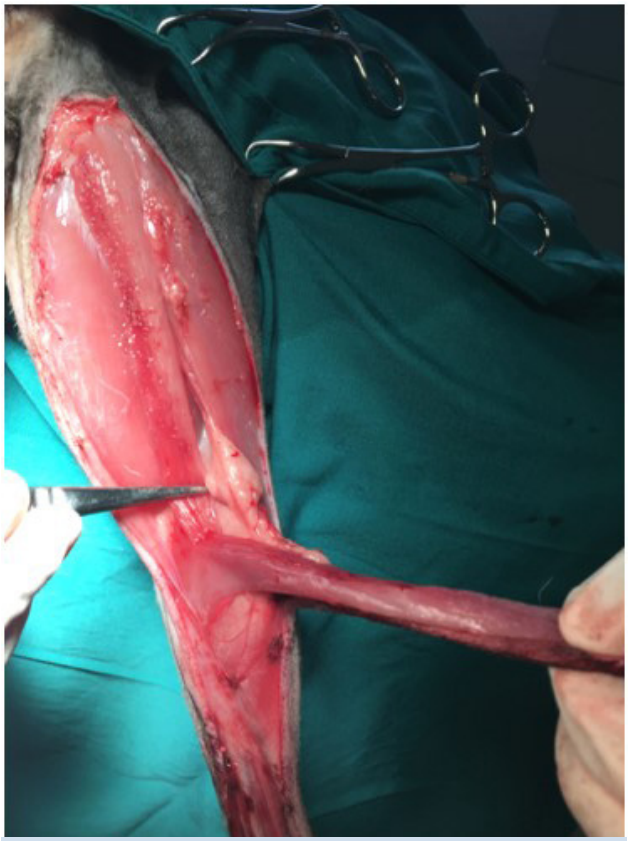

Figure 2. SST flap elevation in group A. The pedicle of the distal caudal femoral artery and vein, visible in the popliteal fat, remained intact during the surgical separation of the ST muscle fibers.

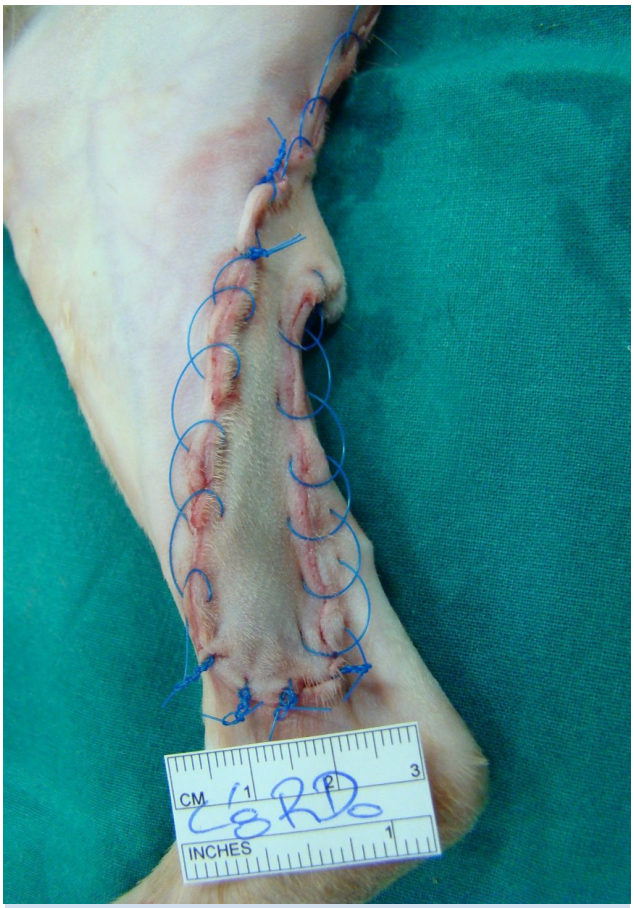

Figure 3. SST flap covering the defect in the recipient area.

Greece) until complete healing and carprofen (2 mg/kg b.w., sid, SC, Rimadyl; Zoetis, Greece) for 5 days were administered. Elizabethan collars were used in all cats. All wounds were covered with a 3-layer padded bandage which was changed daily during the first week and then, every other day until complete healing. During bandage changes and planimetry measurements, cats were sedated with a combination of dexmedetomidine (20 μg/kg b.w., IM, Dexdomitor 0.5 mg/ml; Elanco, Greece) and butorphanol (0.2 mg/kg b.w., IM, Dolorex 10 mg/ml; MSD, Greece).

Clinical Assessment Scoring

In both groups, clinical assessment was performed by the same clinician (ED) at 0, 7, 14, 21, and 30 days after surgery. Pain was evaluated using the Colorado State University Feline Acute Pain Scale (Mathews et al., 2014; Epstein et al., 2015) while cats were alert before and after bandage changes. A scoring system was used to quantify all clinical observations related to the healing process of flaps and wounds in both groups. Healing scores were calculated based on the criteria described in recent reports on wound assessment (Lazarus et al., 1994; Grey et al., 2006; Ousey and Cook, 2012; Dermisiadou et al. 2023; 2024).

Planimetry

Digital images of the wounds and computer software (AutoCAD, version 2018, Autodesk, San Rafael, CA) were used for the planimetry evaluation. In group A, planimetry of the SST flaps was used to measure the flap length, width (cm), initial total flap area (cm2) (skin flap surface on day 0), final total flap area (cm^2) (percentage of skin flap area viable on day 30), and percentage of flap necrosis on days 7, 14, 21, and 30, according to previous reports (Bohling et al., 2004; 2006; Bohling and Henderson, 2006; Dermisiadou et al. 2023; 2024).

In group B, planimetry was used to estimate the initial wound area, area covered by the epithelium, and unhealed area. The percentage of epithelialisation, wound contraction, and total wound healing were calculated for each wound according to previously reported formulas (Bohling et al., 2004; 2006; Bohling and Henderson, 2006; Dermisiadou et al. 2023; 2024).

CT-angiography

CTA of the pelvis and hindlimbs, pre- and post-intravenous contrast medium administration, iobitridol (2 ml/kg, IV, Xenetix® inj. sol. 300 mg/ml; Guerbet, France) was used to evaluate the arterial and venous phases. The same anaesthetic protocol described in the Presurgical Management was used during CTA. The following parameters were evaluated in a dedicated workstation on a soft tissue window: ST muscle length (cm) and width (cm), caliber of the proximal gluteal and distal caudal femoral artery and vein (mm), and density of the ST muscle (Hounsfield unit [HU] at 10 mm^2) at three different points (dP: proximal, dM: medial, and dD: distal) in three different phases (pre-contrast agent, arterial, and venous phase) (Fig. 4).

Histologic evaluation of the SST Myocutaneous Flap

Tissue samples were collected using a 6 mm biopsy punch (Biopsy punch; Kruuse, Langeskov, Denmark). Specimens were obtained from the distal tip of the flap on day 0 and from the most medial part of the distal edge of each flap on day 14 to avoid disturbing flap microcirculation. Specimens 1 cm in width × 2 cm in length were collected from the middle of the

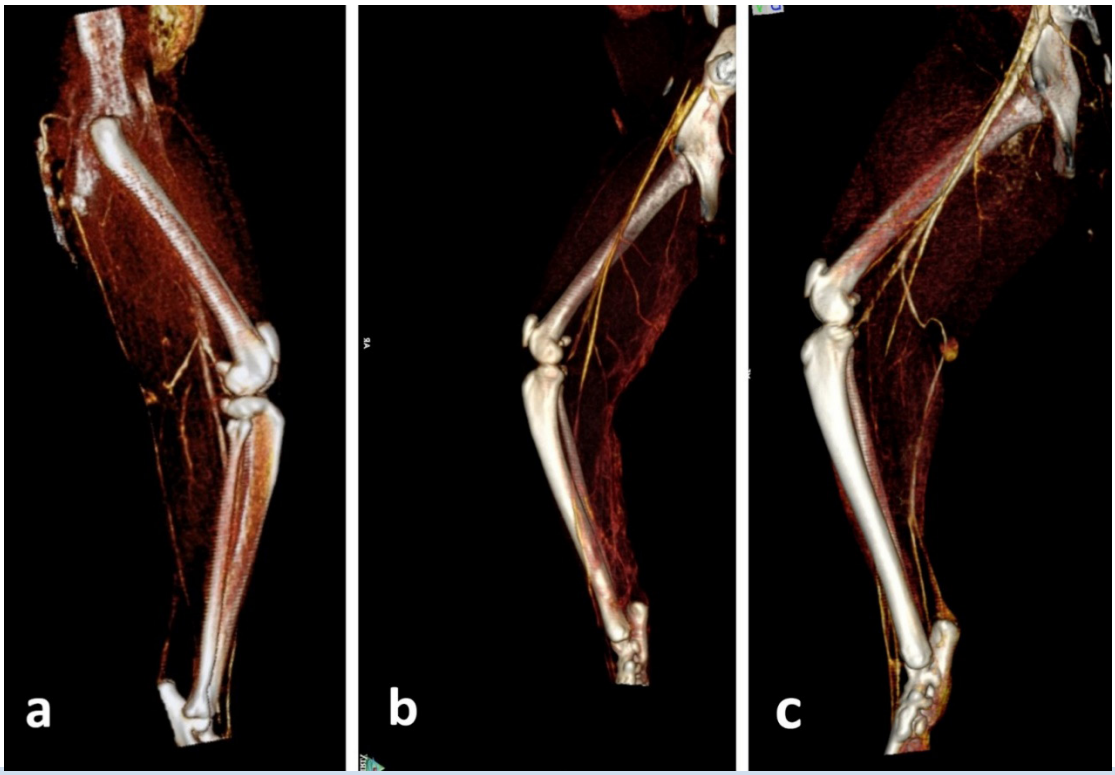

Figure 4. (a) 3-dimentional CT angiography on day 0 (lateral view). (b) 3-dimentional CT angiography on day 10 (medial view). (c) 3-dimentional CT angiography on day 30 (medial view). Note the normal vascular patterns on the pre-surgical examination (fig. 4 a), and the neovascularization of the SST flap and anastomoses at the donor site on days 10 (fig. 4 b) and 30 postoperatively (fig. 4 c).

medial part of all flaps, including only the muscular tissue, at 6- and 12-months.

All samples were processed using standard techniques and stained with haematoxylin and eosin. Stained sections were evaluated to assess inflammation, muscle cell degeneration, muscle cell necrosis, neovascularization, fibrosis, and oedema quantitatively classified as: 0 (normal), no alterations present; 1 (+), alterations of up to 33%; 2 (++), alterations of between 34 and 66%; and 3 (+++), alterations of between 67 and 100% (Siemionow et al., 1995; Degner et al., 1996; Costa et al., 2012; Greaves et al., 2013).

Statistical analysis

G-power analysis was performed for sample size calculation and showed an actual power of 94.5%. Continuous data are presented as mean ± SD (e.g. days to complete flap healing, CTA measurements), while ordinal data are presented as median and range (R) (clinical assessment score, histologic score). Qualitative data are presented as frequencies and percentages.

The Shapiro-Wilk test was used to evaluate the normality of the continuous data. To examine differences in continuous data following normal distribution, we employed one-way ANOVA with repeated measures and paired t-tests for comparisons within the same group and t-tests for comparisons between the two groups. To evaluate differences in ordinal data and continuous data rejecting the hypothesis of normality, Friedman and Wilcoxon Signed Rank tests (comparisons in pairs) were performed for tests within the same group, and the Mann-Whitney U test was used to examine differences between the two groups.

Pearson's correlation coefficient was used to evaluate the linear relationship between two continuous variables.

SPSS Statistical software was used in this study to perform all tests required (SPSS, version 28.0, IBM-SPSS Science, Chicago, IL, USA). Statistical significance was defined as $p < 0.05$.

RESULTS

Clinical Assessment Scoring

The clinical assessment scores of groups A and B are shown in Table 1. Statistically significant differences were observed in group A between days 7

and 14 (p=0.034), 14 and 30 (p=0.017), and 21 and 30 (p=0.001). In group B, statistically significant differences were observed between days 7 and 14 (p=0.003), 14 and 21 (p<0.001), 21 and 30 (p=0.003), 7 and 30 (p<0.001), and 14 and 30 (p<0.001).

Statistically significant differences were found between the median time to complete flap healing in group A (32.42 days, range: 23-40, SD ± 5.90) and complete epithelial coverage in group B (24.67 days, range: 19-28, SD ± 3.03), which was higher in group A (p=0.001). Group A showed significantly higher assessment scores on days 7 (p=0.002), 14 (p<0.001), 21 (p=0.001), and 30 (p=0.008) than group B.

Planimetry

Planimetric measurements of groups A and B are shown in Tables 2 and 3, respectively. In group A, a statistically significant difference was observed in the % flap necrosis between days 7 and 14 (p=0.020) and between days 21 and 30 (p=0.043). In group B, significant differences were found between days 7 to 14, 14 to 21, and 21 to 30 in % epithelialisation (p<0.001, p<0.001 and p<0.001), % wound contraction (p<0.001, p<0.001 and p=0.001), and % total wound healing (p<0.001, p<0.001 and p=0.001) respectively. A significant positive correlation was found between the flap assessment score and neovascularization (histological parameter) on day 14 (p=0.012).

CT-angiography

The parameters studied on CTA in group A are shown in Table 4. Significant differences were observed in ST muscle density, which was higher on day 10 than on day 0 at the proximal (dP) (p<0.001) and medial (dM) points (p=0.020, p<0.001, p<0.001, respectively) in all three phases. The density of the distal (dD) point was significantly higher on day 10 than on day 0 only in the pre-contrast phase (p=0.001). Significant differences were observed in the ST muscle density, which was higher on day 10 than on day 30 at all points in all three phases (p<0.001). Significant differences were observed in the calibers of the distal caudal femoral artery and vein and the proximal gluteal artery and vein which were higher on day 10 than on day 0 (p<0.001), on days 10 to 30 (p<0.001), and on days 30 to 0 (p=0.004, p=0.006, p=0.011, p=0.007, respectively).

No significant correlations were observed on any day between % flap necrosis and muscle density, % flap necrosis and caliber of the distal caudal femoral artery and vein, histologic parameters and muscle density, histological parameters, and caliber of the distal caudal femoral artery and vein.

Histologic evaluation of the SST Myocutaneous Flap

The results of the histologic evaluation of various parameters examined in the tissue samples are shown in Table 5.

Significant differences were observed in inflammation and muscle cell degeneration which were higher on day 14 than on days 0 and 6 (p<0.001, p<0.001, p<0.001, p=0.007, respectively). Neovascularization and fibrosis scored significantly higher on day 14 than on day 0 (p=0.010 and p=0.009, respectively) (Fig. 5). No statistically significant differences in any of the parameters were observed between the time interval of 6 and 12 months.

Table 1. Clinical assessment scores. Values are presented as median and range (R).

	Day 7	Day 14	Day 21	Day 30
Clinical assessment score in group A	10 (7-15) ^{ai}	12.50 (8-18) ^{abj}	12 (0-20) ^{ck}	7 (0-18) ^{bcl}
Clinical assessment score in group B	7 (5-9) ^{dgi}	5.50 (5-7) ^{dehj}	2 (1-5) ^{efk}	1 (1) ^{fghl}

$^{a-h}$ Same superscripts within the same row indicate significant differences between respectively marked groups
$^{i-l}$ Same superscripts within the same column indicate significant differences between respectively marked groups
^{a,b} Same superscripts within the same row indicate significant differences between respectively marked groups

Table 3. Planimetric measurements in group B. Values are presented as mean ± standard deviation (SD).

	Day 7	Day 14	Day 21	Day 30
% epithelialization ± SD	0 $^{\bullet a}$	46.1 ± 14.03 ^{ab}	77.3 ± 11.76 ^{bc}	100 ^{c}
% wound contraction ± SD	-0.6 ± 15.79 ^{*a}	43.4 ± 19.53 ^{ab}	80.5 ± 8.55 ^{bc}	89.5 ± 4.48 ^{c}
% total wound healing ± SD	-0.6 ± 15.79 ^{*a}	66.7 ± 16.08 ^{ab}	94.7 ± 4.19 ^{bc}	100 ^{c}

$^{\bullet}$ There is no detectable epithelialization on day 7
* Negative numbers indicate enlargement of wound size due to retraction of the wound edges from sutures placement
$^{a-c}$ Same superscripts within the same row indicate significant differences between respectively marked groups

Table 4. Parameters studied on CT-angiographies in group A. Values are presented as mean ± standard deviation (SD).

	Day 0	Day 10	Day 30
Muscle length (cm)	11.01 ±1.05	NA *	**NA ***
Muscle width day (cm)	1.95 ± 0.10	NA *	NA *
Proximal gluteal artery caliber (mm)	0.83 ± 0.21^{ac}	1.02 ± 0.05^{ab}	0.86 ± 0.02^{bc}
Proximal gluteal vein caliber (mm)	1.23 ± 0.04^{ac}	1.39 ± 0.03^{ab}	1.28 ± 0.02^{bc}
Distal caudal femoral artery caliber (mm)	0.84 ± 0.02^{ac}	1.02 ± 0.05^{ab}	0.89 ± 0.05^{bc}
Distal caudal femoral vein caliber (mm)	1.25 ± 0.03^{ac}	1.40 ± 0.05^{ab}	1.27 ± 0.02^{bc}
Muscle density at the proximal point when no contrast agent given (dP)	52.16 ± 2.46 ^{d}	56.20 ± 2.65^{e}	54.40 ± 2.63^{f}
Muscle density at the medial point when no contrast agent given (dM)	54.15 ± 1.92^{g}	55.06 ± 2.31^{h}	53.32 ± 2.31 ^{i}
Muscle density at the distal point when no contrast agent given (dD)	52.85 ± 2.52^{j}	53.51 ± 2.38^{j}	52.09 ± 1.13^{j}
Muscle density at the proximal point - arterial phase (dPa)	65.77 ± 3.47 ^{d}	85.51 ± 4.42^{e}	80.34 ± 2.91^{f}
Muscle density at the medial point - arterial phase (dMa)	70.09 ± 3.87^{g}	79.04 ± 2.20^{h}	74.51 ± 2.19 ^{i}
Muscle density at the distal point - arterial phase (dDa)	67.59 ± 3.47	66.46 ± 9.51	63.42 ± 8.93
Muscle density at the proximal point - venous phase (dPv)	71.87 ± 4.63^{d}	92.48 ± 5.18^{e}	86.91 ± 3.12 ^{f}
Muscle density at the medial point - venous phase (dMv)	74.52 ± 3.59^{g}	86.28 ± 4.39 ^{h}	79.62 ± 2.33^{i}
Muscle density at the distal point - venous phase (dDv)	73.12 ± 4.11	76.56 ± 4.76	70.62 ± 6.34

Abbreviation: NA, not applicable

* Parameters could not be measured as the semitendinosus muscles were transferred to the new area in order to cover the defect

$^{a\text{-}c,j}$ Same superscripts within the same row indicate significant differences between respectively marked groups

$^{d\text{-}i}$ Same superscripts within the same column indicate significant differences between respectively marked groups

Table 5. Results of the various parameters studied during histologic evaluation of tissue samples in group A. Values are presented as median and range (R).

Histologic score	Day 0 (n=12)	Day 14 (n=12)	6 months (n=6)	12 months (n=6)
Inflammation	0 (0)^{ab}	2.50 (0-3)^{a}	0 (0-1)^{b}	0 (0-2)
Degeneration/necrosis	2 (1-3)^{a}	3 (1-3)^{ab}	1 (0-1)^{b}	1 (0-1)
Neovascularization	0 (0) ^{a}	1 (0-2)^{a}	0 (0)	0 (0-1)
Fibrosis	0 (0) ^{a}	1 (0-2)^{a}	1 (0-1)	1 (0-1)
Edema	1 (0-1)	1 (0-3)	0 (0-1)	0.50 (0-1)

^{ab} Same superscripts within the same row indicate significant differences between respectively marked groups

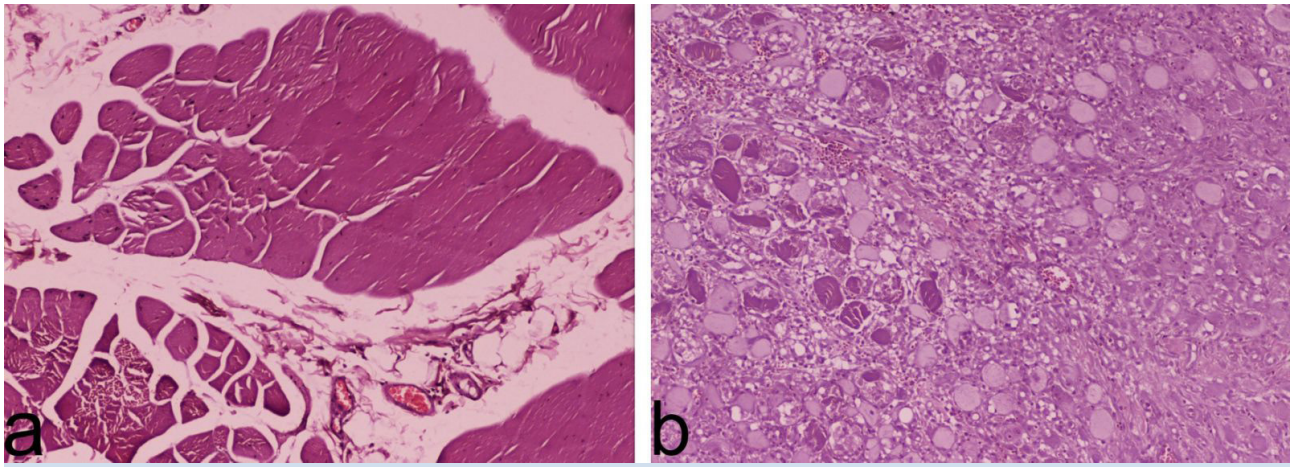

Figure 5. (a) Histologic images of the SST muscle: A sample mostly characterised by perimyseal oedema on day 0 (haematoxylin and eosin stain, x100 magnification). (b) Histologic images of the SST muscle: loss of striation and disruption of myofibers, severe diffuse perimysial and endomysial inflammatory infiltration, and necrosis on day 14 (haematoxylin and eosin stain, x100 magnification).

DISCUSSION

The effectiveness of the SST muscle flap as a distal limb reconstructive technique in cats has been recently studied by the authors (Dermisiadou et al. 2024). The findings of the present study indicate that the SST flap is less efficient than second-intention healing of wounds of such dimensions. Although the SST flap did not affect the motor function of the cat hindlimbs and successfully covered the defects of the distal tibia, the technique did not achieve better healing times when compared to second-intention healing, as the results differed between the two groups.

SST flap development was technically more demanding than a non-sutured wound and offered effective coverage of tibial wounds. Second-intention healing of such complex wounds in cats, although the simplest, requires prolonged open management, is likely more expensive, and has a higher risk of infection (Campbell, 2006; Corr, 2009). Furthermore, wounds with exposed bones benefit from early reconstruction using tissues with a vascular supply, such as pedicled muscle flaps, especially in areas such as the distal hindlimb where axial-pattern skin flaps cannot be used (Chambers and Rawlings, 1991; Puerto and Aronson, 2004; Vnuk et al., 2005; Baltzer and Rist, 2009; Corr, 2009).

The SST flap fulfilled the major requirements for transposition flaps. It is of an adequate size to reach and cover tibial defects, is superficial and accessible, and is functionally expendable.

The higher clinical assessment scores in group A compared to group B on all days might be attributed to focal vascular disruption due to skin and subcutaneous tissue detachment from the underlying fascia, mainly at the most distal part of the flaps (Pavletic, 1980). Although both the proximal and distal vascular pedicles were spared in group A, tissue handling was more intense to isolate and then longitudinally split the SST. Thus, shearing forces on the overlying skin could not be avoided. Furthermore, the clinical scoring of the flaps concerned their entire surface which was significantly larger than that of the controls. Clinically, the skin of the flaps was scored as erythematic and congested in the first two days, possibly due to alterations in blood perfusion and restricted venous drainage that were reported after the flap was raised. (Pavletic, 1981; 1990). Gradually, after day 6, the skin regained its normal colour (one cat) or focal necrotic areas developed (11 cats). Necrotic lesions of the skin appeared to be stable by day 21. On day 30, the mean viable final total skin area of the flap was 49%. Skin flap necrosis was evident at the central or distal part of the flaps in 11 of 12 cats (91.6%). Skin necrosis could be attributed to the disruption of branches of cutaneous vessels or haemodynamic changes (e.g. thrombosis and reperfusion injury), leading to insufficient nourishment of the skin (Pang, 1990; Kerrigan and Stotland, 1993). Using the entire length of the muscle increases the risk of vascular compromise as it may be overtensioned (Kim et al., 2023). However, the SST muscle underneath the skin surface remained viable in all cases (100%), which is also supported by the postoperative CTAs on day 10, which confirmed no restriction of the blood flow, as there was no injury, kinking, twisting, or thrombosis of the pedicles. This is in accordance with Puerto et al. (2004), who used an ST myocutaneous flap to reconstruct a defect overlying an open tibial fracture. They reported 100% survival of the muscular portion of the flap and ischaemic necrosis at the most distal portion of the skin, which was attributed to extended skin dissection beyond the angiosome, supported by the distal caudal femoral artery. The time to complete healing was shorter in group B. Based on these results, it seems that the split of the ST flap negatively affects the overlying skin. This might be because splitting the muscle could disturb the vascularity of the flap and reduce the thickness of the transposed muscle, which would decrease the perfusion of the overlying skin.

Transection of sympathetic fibers during muscle splitting may have led to angiogenesis from the pre-existing vascular network. This is reinforced by the higher neovascularization observed on histological evaluation on day 14 and CTAs findings. On CTAs, the statistically significant larger caliber measurements of both vascular pedicles on day 10 compared to day 0, and the increase in the muscle density observed on day 10 compared to day 0 indicates that gradual vasodilatation, growth of capillaries, and new choke anastomoses were developed.

CTAs also revealed that there was a significantly larger caliber of both pedicles on day 10 compared to day 30 and a significantly larger diameter of the proximal gluteal vein and the distal caudal femoral artery on day 30 compared to day 0. On day 10, the blood flow was higher to nourish half of the semitendinosus transferred and the other half that remained at the donor area.

Histologic examination revealed no major muscle necrosis during the experimental procedure, as the

two pedicles can effectively regulate blood flow to the SST flaps (Pavletic, 1990; Solano et al., 1995; Greaves et al., 2013). On day 14, significantly higher scores were recorded in almost all parameters (excluding oedema) compared to day 0, probably because of the inflammatory phase of healing, blood flow restriction, and reperfusion injury that normally develops at the most distal part, where the samples were harvested (Siemionow et al., 1995; Degner et al., 1996; Costa et al., 2012; Greaves et al., 2013). The samples on the 6- and 12- month histologic evaluation were characterised by muscle cell degeneration, with no significant differences between these time intervals, due to muscle cell replacement by fatty and fibrous tissue after neurovascular division (Degner et al., 1996; Dermisiadou et al., 2023).

The limitations of the study include the small number of animals included. Clean surgical wounds in healthy cats supported a favourable outcome even in wounds healed by second intention, whereas the management of larger or infected wounds in clinical cases may influence the outcome. The evaluation of clinical scores could not be performed blindly, although scoring included many objective monitoring parameters. Imaging methods to assess flap skin perfusion have not yet been developed. Therefore, the use of specific evaluation methods (laser Doppler flowmetry, fluorescein dye, tissue oxygen tension, near-infrared spectroscopy, and tissue spectrophotometry) may have provided information regarding the potential influence of blood flow on the overlying skin (Lanthier et al., 1990; Losken et al., 2008; Pratt et al., 2012). The extent of the arc of rotation of the SST flap has not been defined; therefore, further research is required.

CONCLUSIONS

In conclusion, the SST flap based on the distal vascular pedicle cannot be considered a reliable method for one-stage management of complex distal limb defects in cats. Based on our results, the SST flap is less efficient than second-intention healing in terms of the time to complete wound healing. Nevertheless, it seems that the ST muscle can be safely split longitudinally, and its transposition can adequately cover tibial defects.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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