COMPARISON OF TWO INTRADERMAL SUTURE PATTERNS TO OPTIMIZE BLOOD FLOW IN FELINE SKIN: A WITHIN ANIMAL RANDOMIZED CONTROLLED TRIAL

Thesis

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ABSTRACT

Given the propensity for wound dehiscence and decreased perfusion in the feline skin compared to other species, optimizing perfusion to the skin through surgical technique is critical. The standard continuous horizontal mattress intradermal pattern (SP) takes dermal bites close to and paralleling the wound edge, possibly limiting further perfusion, whilst the modified continuous Allgower-Donati pattern (mAD) takes dermal bites at 90 degrees to the wound edge, which may spare more capillary feeders. The study objective was to compare the effect of SP with mAD on acute changes in cutaneous perfusion in feline patients undergoing ovariohysterectomy. Feline patients were recruited from three animal shelters. Within each feline patient, the cranial half of the incision was randomized to SP or mAD, while the caudal half received the alternate pattern. Changes from baseline in cutaneous perfusion were measured for each pattern using Laser Doppler Perfusion Imaging. Analysis from thirty-two feline patients revealed significant differences. With mAD, cutaneous perfusion increased a mean of 59.7 ± 124.1 BPU from baseline, while SP showed a mean decrease of 20.2 ± 119.9 BPU ($p<0.01$). No feline patients re-presented for incisional complications. The findings show that a simple modification of the commonly performed intradermal pattern notably enhances cutaneous perfusion along the incision margin. Study limitations included the absence of active long-term follow-up due to the shelter setting and of perfusion measurement over a single period of time. Incorporating the modified continuous Allgower-Donati pattern into wound management protocols could be beneficial in feline patients at a high risk for wound dehiscence.

BIOGRAPHICAL SKETCH

Sylvia Bayrakdarian, a Westchester, NY native, was born in 2001 with a passion for animals that would shape her academic and professional trajectory. Sylvia began her undergraduate studies at The Ohio State University before transferring to Cornell University her sophomore year. At Cornell, she successfully attained her Bachelor of Science degree in Animal Science with a concentration in Pre-Veterinary Medicine in 2023. Motivated by her positive experiences at Cornell University, Sylvia chose to further her academic journey by pursuing her Master of Professional Studies (MPS) in Animal Science with a concentration in Animal Health. As Sylvia approaches the end of her MPS journey, she remains steadfast in her commitment to contribute meaningfully to the field of veterinary medicine and animal welfare.

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INTRODUCTION

The closure of cutaneous wounds following surgical incisions or penetrating injuries is a common procedure in feline veterinary practice. Over 40% of feline patents presenting for trauma management exhibit cutaneous wounds.[1] Managing traumatic wounds in feline patients can be challenging, with certain wound presentations having a heightened risk of dehiscence and reconstructive failure.[2] Moreover, seemingly routine reconstructions and surgical closures can be complication prone[3-5], at times resulting in unexpected late wound opening.[6]

Some of these challenges may be explained by differences in cutaneous anatomy and wound healing between felines and other species. In comparison to dogs, feline skin has a lower vascular density and is less well perfused[7,8], thereby leading to slower granulation and tensile strength recovery.[7] Thus, the use of wound closure techniques that optimize perfusion to the skin margin may therefore offer particular advantages in feline cases.

In recent years, cutaneous closure using absorbable suture in a continuous horizontal mattress intradermal or subcuticular pattern has gained in popularity in small animal surgical practice.[8] This trend likely owes to several factors: the lack of external suture may reduce patient interference, post-operative wound appearance is highly cosmetic, and the lack of suture removal contributes to shortened or elimination of re-check appointments.[8] However, the standard intradermal pattern requires multiple suture bites be taken parallel and close to the wound margin,[9] potentially compromising perfusion at the dermal margin. While this may not pose significant issues in species with robust cutaneous perfusion, it may be problematic in feline patients, particularly following closure of traumatic wounds. Conversely the Allgower-Donati suture pattern[10] is minimally recognized in the small animal surgical literature. The pattern relies

on dermal bites taken at 90 degrees rather than parallel to the incision line and can be performed as either an interrupted or continuous pattern.[10,11] Notably, this pattern was shown to enable superior cutaneous perfusion compared to both vertical mattress[10] and horizontal mattress patterns[12] in human patients undergoing ankle surgery, a group prone to incisional dehiscence. For the purpose of this study, a modified continuous Allgower-Donati pattern was investigated, in which all suture was maintained in a buried position.

The purpose of this study was to compare the effect of the modified Allgower-Donati pattern with a standard horizontal mattress intradermal pattern on acute changes in cutaneous perfusion at the incision line in feline patients undergoing ovariohysterectomy.

METHODS

Study Design and Inclusion Criteria

A randomized controlled trial (IACUC protocol no. 2023-0181) was conducted across three animal shelters located in the upstate New York area between December 2023 and January 2024. These shelters provided sterilization services provided by a single local non-profit corporation, Shelter Outreach Services. The sterilization services met or exceeded the guidelines set by the Association of Shelter Veterinarians for high-quality, high-volume spay-neuter programs.[13] Adult cats presenting for elective ovariohysterectomy underwent skin closure with two different intradermal suture patterns after obtaining informed client/ caretaker consent. The skin incision was divided in two halves, and one of two intradermal suture patterns was randomly assigned to either the cranial or caudal half of the incision using a random number generator (www.calculator.net/randomnumber). Randomization was performed within blocks of

10. All procedures were conducted by a board-certified surgeon accredited by the American College of Veterinary Surgeons. Feline patients exhibiting skin irritation, mixed skin pigmentation, or a surgical scar at the intended surgical site were excluded from the study. The two suture patterns under examination were a standard intradermal continuous horizontal mattress pattern, where the dermal bites were taken parallel to the incision (SP group), and a continuous intradermal pattern, where the dermal bites were taken at 90 degrees to the incision with all suture buried (mAD group)[11] (**Figure 1**).

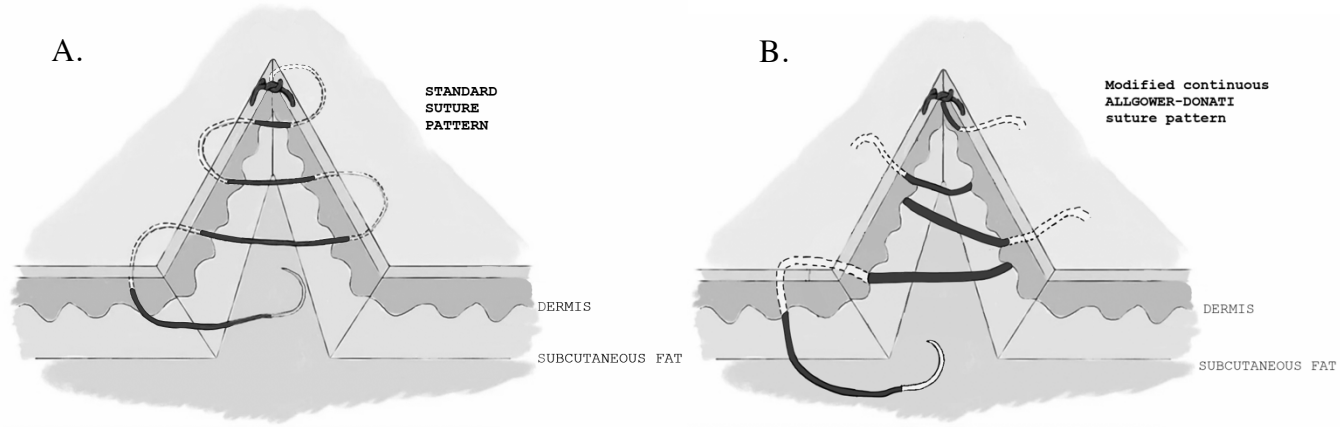

Figure 1. Comparison of suture closure techniques A. standard continuous horizontal mattress intradermal pattern (SP) and B. modified continuous Allgower-Donati intradermal pattern (mAD).

Data Collection and Outcomes

Following routine premedication, induction of general anesthesia, and intubation, the feline patient was positioned in dorsal recumbency, clipped, and an initial skin preparation was performed using a chlorhexidine scrub solution. A skin temperature probe was secured to the ventral abdominal skin through the use of adhesive rings. Using a sterile marker pen, a 4cm

distance was marked in the appropriate location for a midline spay incision, and the incision divided into two 2cm halves (**Figure 2**).

Figure 2. Incision closed with mAD (left of arrow) and SP (right of arrow)

The marks were positioned away from the intended surgical incision. Baseline cutaneous blood flow was measured every second for a 30 second period for each half of the incision using a laser Doppler flowmeter equipped with a cutaneous probe (*AD instruments*), and the average value was recorded for each location (cranial and caudal) in blood perfusion units (BPU). Cutaneous perfusion in humans and animal species including cats has been measured using laser Doppler perfusion imaging. A probe containing a light source transmits laser light into the tissue, where it contacts both stationary cells and circulating red blood cells. Photons are scattered randomly when the laser light strikes the tissues. When the light strikes the moving red blood cells, the incident photons are doppler shifted. This is recorded at the probe head and converted

to an electrical signal proportional to blood flow.[7] A routine ovariohysterectomy was performed using standard techniques. The linea alba was closed using 2/0 polydioxanone (PDS, Ethicon), and the subcutaneous fat was closed with 4/0 poliglecaprone (Monocryl, Ethicon) in a quilting pattern[14] when a subcutaneous fat layer was present. The cranial half of the incision was closed using either the standard intradermal pattern or the modified Allgower-Donati pattern as dictated by randomization, using 4/0 poliglecaprone (Monocryl, Ethicon) on a 13mm 3/8c reverse cutting needle. Following skin closure, cutaneous blood flow was again measured at each incision half, with the probe positioned in the center of each half, 1mm lateral to the incision. Skin temperature was recorded at the start and end of surgery. Perioperative analgesia was administered in all cases.

The primary outcome measure was the change in cutaneous microcirculation blood perfusion units from baseline for each of the two suture patterns assessed. Data were also collected on known or estimated feline patient age, bodyweight, body condition score, and surgical time (**Table 1**). Active follow-up of individual feline patients participating in the study was not feasible due to the shelter setting; however, data was collected on any feline patients re-presenting with incisional complications in the 30 days following surgery.

Statistical Methods

Power analysis identified a group size of 32 to be sufficient for detecting a 30% between group difference in blood flow change from baseline, based on prior reported data.[12] The study was concluded after sufficient enrollment to satisfy power calculations. Continuous data was assessed for normality using a Shapiro-Wilk test. Means and standard deviation (SD) were reported as population descriptors where the data was normal, and median (range) where the data was not normal. Baseline perfusion was subtracted from post-suturing perfusion to obtain a delta

effect for each suture pattern (**Table 1**). Normal data groups paired within feline patients were compared using a paired t-test.

Variables	A-D Cranial (n=16)	A-D Caudal (n=16)	*P*-value
Demographics			
Age, y	0.96 (0.3-2)	2.1 (0.3-10)	<.001
BW, kg	3.2 ± 0.76	3.1 ± 0.46	.76
Skin Temp. Difference, °F	0.079 (-2.52- 2.54)	0.48 (-1.55- 2.53)	.54
Rectal Temp. Difference,°F	-2.04 (-4.5- -0.2)	-1.81 (-4.5 - 0)	.78
SBP Difference, mm Hg	-35.5 (-61- -10), n=2	-3.86 (-21-10), n=8	.36
HR Difference, bpm	10.44 ± 19	0.06 ± 36	.40
SpO2, %	-0.38 (-4-4)	0 (-2-4)	.71
Procedure Characteristics			
Surgical Duration, min	20.3 (12-27)	18.3 (12-25)	.31
Induction to Procedure, min	16.3 (7-27)	13.6 (7-24)	.21

Table 1. Baseline characteristics of feline patients in the A-D cranial suture placement and A-D caudal suture placement groups.

RESULTS

Baseline Population Data

A total of 35 feline patients were initially recruited, meeting the requirements of power calculations (n=35). However, data from three feline patients were discarded due to issues with inconsistent signal acquisition from the laser Doppler flowmeter. Among the remaining group of 32 feline patients eligible for data analysis, the cranial half of the incision was closed with the modified Allgower-Donati pattern and the caudal half with the standard pattern on 16 occasions, while the caudal half of the incision was closed with the modified Allgower-Donati pattern and the cranial half of the incision with the standard pattern on another 16 occasions. Three of the

feline patients lacked sufficient subcutaneous fat to perform a subcutaneous closure. The median known or estimated age was 1 year (range 0.3-10 year, with a mean (±SD) body weight of 3.1kg ± 0.6kg. All feline patients were intact females. The mean interval from anesthesia induction to baseline blood flow measurements was 14.9 ± 4.9 minutes, and the mean (± …SD) surgical time was 19.3 minutes ± 4.1 minutes. Skin temperature at the incision site increased by a mean of 0.28°F (± 1.39°F) over the course of surgery, and did not parallel rectal temperature change, which decreased by a mean of 1.92°F (± 1.37°F) over the same period of time.

Cutaneous Perfusion Data

At baseline, cutaneous perfusion was slightly higher in the cranial half of the incision compared with the caudal half (109.0 ± 74.1 BPU vs 84.3 ± 83.2 BPU, $p = 0.15$), although this difference did not reach statistical significance. The change in cutaneous perfusion with intradermal suturing varied substantially between the modified Allgower-Donati pattern and the standard suture pattern. Use of the modified Allgower-Donati pattern resulted in a mean increased cutaneous perfusion of 59.7 ± 124.1 BPU from baseline, compared with a decrease of 20.2 ± 119.9 BPU from baseline for the standard suture pattern ($p < 0.01$) as shown in **Figure 3**. These changes reflected a mean 115.3 ± 261.2 % increase from baseline with the modified Allgower-Donati pattern, contrasting with a mean decrease of 24.1± 130.3% from baseline with the standard suture pattern.

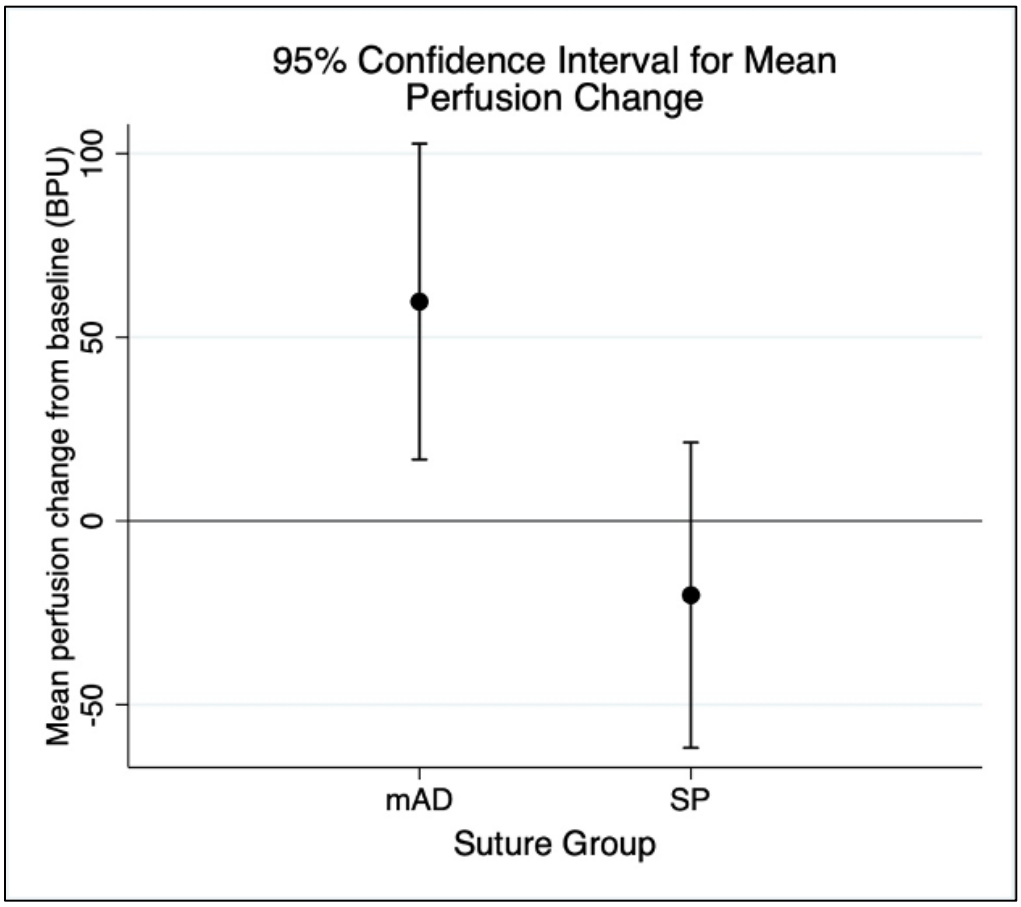

Figure 3. Perfusion changes from baseline by suture pattern group.

Follow-up Data

No feline patients were re-presented for management of incisional complications in the 30-day period following the study.

DISCUSSION

Consistent with previous studies, this study found a perfusion-sparing effect from the mAD pattern.[10,11] With the mAD pattern, wound margin perfusion increased from baseline, likely reflecting natural vasodilation following the inflammation generated by a surgical incision.

Conversely, with the SP pattern, perfusion decreased from baseline despite incision, presumably due to suture line compression impeding capillary flow at the wound margin. Interestingly, despite the relative inferiority of SP to mAD observed in this data, a study comparing SP to interrupted vertical mattress and to skin staples found SP to compromise perfusion less than the two alternatives.[15]

In this study, two buried suture patterns that fundamentally differed only in the direction of the suture bites relative to the incision line were evaluated. Several variants of the Allgower-Donati pattern are available, including an interrupted version with the knot tied externally[16] and a continuous version where the running component is passed external to the skin surface.[17] When evaluated in human skin, no difference in perfusion effect was found between the interrupted and continuous variants of the pattern.[17] In this study the continuous Allgower-Donati pattern was modified further to provide a veterinary version where the running component was passed through the subcutaneous space rather than externally, with the hypothesized advantage that this would be less prone to patient breakage. The perfusion findings suggest that this modification has not compromised the perfusion sparing nature of the pattern.

The mechanisms by which the Allgower-Donati patterns exert their perfusion sparing effect have not been characterized, but studies comparing them to traditional interrupted patterns have offered several theories.[12,16] These include less kinking of feeder arterioles, intradermal plane anchoring sparing the cutaneous microcirculation, and increased ease of correcting tension relative to other patterns. Although a substantial effect was still seen with both patterns anchored intradermally and at a shared, an additional theory could be considered. Wounds are almost invariably closed in the direction of lowest tension, which typically places the closed incision in a position parallel to the feeder vessel of the angiosome in which the wound was made. The

tributaries of the local direct cutaneous artery are therefore often approaching the wound at an oblique angle rather than directly parallel to it. By taking a bite of the intradermal layer at 90 degrees to the wound rather than parallel to it, more of the feeder vessels are spared and perfusion is optimized.

Similar to other studies,[12,18,19] this study utilized laser Doppler imaging to provide an objective measure of wound perfusion. Because blood flow is not being directly measured, units of measure are relative, making the technology ideal for intra-subject comparisons. This study was able to use a within animal randomized design[20] in which two concurrent interventions were evaluated. Analyzing changes from baseline also allowed each animal to act as its own control.

Studies in other species have found heterogeneity in the perfusion of different regions of abdominal skin.[21,22] For this reason, the intervention was randomized over the two different incision zones to avoid the risk of systematic bias.

Although the overall group difference between the two patterns was highly significant, substantial within-group variation, particularly in the SP group, was noted and likely due to variability in whether the probe was positioned within or outside of the suture bite.

This study suffered from several limitations. There is no known perfusion threshold below which wound healing is known to be compromised. Laser Doppler was used to measure perfusion, but this technology is sensitive to patient movement and thus requires anesthesia or heavy sedation for accurate measurements. This limits perfusion measurement to a single immediate post-surgery time period. Further investigation is needed to determine whether the effect of the mAD pattern on perfusion is temporary or sustained. In addition, while no incisional complications prompted re-presentation to the shelters for any feline patient in the study, active follow-up was not performed. Additionally, the suturing intervals for each pattern were not

timed, although it was the researchers' clinical impression that the two suture patterns took the same amount of time to perform. Lastly, the researchers involved in the perfusion measurements could not be blinded due to the visible differences between closure techniques, and only two suture patterns were assessed.

In conclusion, the modified Allgower-Donati intradermal pattern offers an alternative to the standard continuous horizontal mattress intradermal pattern, maintaining all of the advantages of a buried pattern while improving perfusion to the wound margin, at least in the acute setting. Although we cannot currently correlate the clinical implications of a higher mean incision perfusion with wound outcome, surgeons may wish to take this perfusion effect into consideration when deciding on wound closure technique in feline patients.

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