Effects of fascial abrasion, fasciotomy, and fascial excision on cutaneous wound healing in cats

Akiko Mitsui, DVM; Kyle G. Mathews, DVM, MS; Keith E. Linder, DVM, PhD; Meghan A. Kruse, DVM; Simon C. Roe, BVSc, PhD

Objective—To evaluate the effects of fascial abrasion, fasciotomy, and fascial excision on cutaneous wound healing in cats.

Animals—Eight 1- to 3-year-old domestic shorthair cats.

Procedures—8 evenly spaced 4-cm^2 skin wounds were created on each cat's dorsum, and the underlying subcutaneous tissue was removed to expose the epaxial muscle fascia. Wounds were randomized to receive 1 of 4 treatments (2 wounds/treatment/cat): fascial abrasion, fasciotomy, fascial excision, or control treatment (muscle fascia not disturbed). Bandages were changed and digital photographs and acetate tracings of the wounds were obtained for planimetry daily for 1 week, every other day for 2 weeks, and then every third day for 3 weeks (ie, 40-day observation period). Digitized images were evaluated for granulation tissue formation, wound contraction (surface area measurements), and area of epithelialization.

Results—The epithelialized area and open and total wound areas did not differ among treatments at any time point. Time to the first appearance of granulation tissue was significantly shorter for all treatment groups, compared with that of the control group. Time to achieve granulation tissue coverage of wound base was significantly shorter following fasciotomy (9.6 days) and fascial excision (9.0 days), compared with that of control treatment (18.5 days) or abrasion (16.7 days). Numbers of wounds that developed exuberant granulation tissue following fascial excision (9/16) and control treatment (3/16) differed significantly.

Conclusions and Clinical Relevance—Fasciotomy and fascial excision facilitated early granulation tissue development in cutaneous wounds in cats. In clinical use, these fascial treatments may expedite secondary wound closure or skin grafting. (*Am J Vet Res* 2009;70:532–538)

In cats, the duration of healing of large open wounds is often prolonged. With the loss of overlying skin, exposed muscle fascia is frequently the tissue that comprises much of the wound bed. Compared with dogs, the formation of granulation tissue over the exposed underlying muscle fascia is markedly delayed in cats, which results in subsequent delays in skin grafting, secondary closure, or second intention healing.[1] Granulation tissue is a capillary-dense repair tissue that acts as an excellent surface for epithelial cell migration from the wound edges and that is also required for wound contraction.[2] Delayed formation of granulation tissue may result in an increased infection risk, as well as increased treatment costs, pain, and likelihood of euthanasia.

To the authors' knowledge, methods to promote granulation tissue formation on exposed muscle fascia in cats have not been studied. Dermabrasion—the removal of the epidermis with a variety of abrasive instruments—has been used to speed healing and improve cosmetic outcome following excision of hypertrophic burn scars and has had positive effects on type I collagen synthesis when used to treat photodamaged skin in humans.[3–6] Tissue abrasion has also been reported[7] to speed the healing of partial-thickness meniscal tears in humans, presumably via stimulation of fibrin clot formation and vascular ingrowth. Although abrasion of nonbleeding tissues in wound beds has been reported anecdotally to stimulate granulation tissue formation, we could find no veterinary medical literature to support this concept. Osteostixis, forage, and curettage involve the drilling or scraping of poorly vascularized bone or cartilage lesions to promote vascular penetration and granulation tissue formation in people, horses, and dogs.[8–15] A similar technique to enhance granulation tissue coverage of exposed fascia has seemingly not been reported. It is known that, in rats, the fibroblasts derived from incised fascia have properties that result in improved wound healing, compared with those derived from the dermis.[16–18] This suggests that fibroblasts that are derived from these 2 sites are phenotypically different.[16] Results of both in vitro and in vivo studies[16–18] have indicated that proliferation and subsequent col-

Received February 20, 2008.
Accepted June 16, 2008.
From the Departments of Clinical Sciences (Mitsui, Mathews, Kruse, Roe) and Population Health and Pathobiology (Linder), College of Veterinary Medicine, North Carolina State University, Raleigh, NC 27606. Dr. Mitsui's present address is Sonora Veterinary Specialists, 4015 E Cactus Rd, Phoenix, AZ 85032.
Supported by a North Carolina State University College of Veterinary Medicine Research Grant.
Address correspondence to Dr. Mathews.

lagen production of fibroblasts derived from the fascia in a wound bed are markedly increased, compared with proliferation and collagen production of fibroblasts derived from the dermis at the wound edge. In rats, the combination of a rapid increase in fibroblast number and associated collagen production in fascial wounds results in a more rapid return to expected wound strength compared with findings in skin wounds.[17] Therefore, it is possible that fascial incisions at the base of an open wound may result in high numbers of fibroblasts in the wound bed with more rapid migration kinetics and increased collagen production.

Although the vascular supply to the deep fascia that overlies the dorsal thoracolumbar region of cats and dogs has not been described to the authors' knowledge, it is our impression that vascular penetration through the intact fascia is sporadic at best. Therefore, it is possible that exposure of the underlying highly vascular muscle may also improve granulation tissue formation and wound oxygenation.

The purpose of the study reported here was to evaluate the effects of fascial abrasion, fasciotomy, and fascial excision on cutaneous wound healing in cats. Our null hypothesis was that there would be no differences between any of the 3 surgical treatments and a control treatment (no disturbance of muscle fascia) with regard to wound area, epithelialization, or granulation tissue formation.

Materials and Methods

Cats—Eight sexually intact male domestic shorthair cats (1 to 3 years old) were used in the study. Each cat was apparently healthy on the basis of findings of a physical examination, serum biochemical analyses, CBC, urinalysis, and microscopic examination of feces and negative results of FeLV antigen and anti-FIV antibody testing. Among the 8 cats, mean weight was 5.0 kg at the start of the study (range, 3.2 to 6.4 kg). Cats were individually housed and fed a maintenance diet (canned and dry food) twice daily; each was assigned a number (1 through 8). Cats were adopted at the end of the study. The experimental protocol was approved by the North Carolina State University Institutional Animal Care and Use Committee.

Procedures—The cats were acclimated to wearing a body stocking[a] for 1 week prior to surgery. On the day prior to surgery (day –1), a fentanyl patch (12 µg/h) was placed on the left tarsal region of each cat. The patch was replaced 4 days after surgery and then maintained for an additional 5 days. On the day of surgery (day 0), each cat was premedicated with acepromazine (0.02 mg/kg, IM) and butorphanol tartrate (0.4 mg/kg, IM), and anesthesia was induced with ketamine hydrochloride (5 to 10 mg/kg, IV) and midazolam (0.3 mg/kg, IV). Cats were intubated, and anesthesia was maintained with 1% to 3% isoflurane and oxygen. A single dose (0.1 mg/kg) of preservative-free morphine (1 mg/mL) was administered epidurally. A dose of ampicillin (22 mg/kg, IV) was also administered before surgery, immediately after induction of anesthesia. Lactated Ringer's solution was administered continuously throughout the procedure (10 mL/kg/h, IV). Each cat was placed in sternal recumbency, the hair over the thoracolumbar region of the dorsum was removed with a No. 40 clipper blade, and the area was aseptically prepared with povidone-iodine scrub solution and alcohol.

For each cat, 1 of 8 treatment maps was randomly assigned to ensure that the 4 treatments were evenly distributed with regard to cranial through caudal wound locations and body side among the 8 cats. A sterile acetate template and skin marker were used to mark the location of each wound. Eight full-thickness square

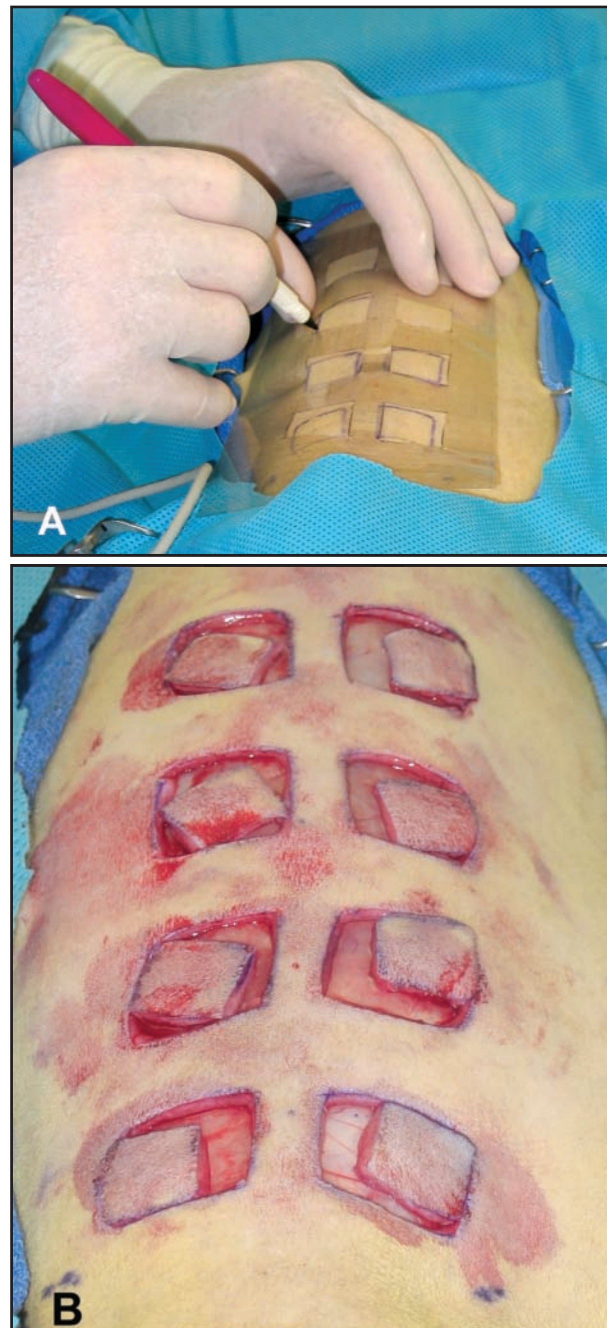

Figure 1—Photographs illustrating the creation of 8 wounds on the dorsum of a cat. A—Photograph of the placement of a sterile acetate template on the skin surface to allow wound positions (cranial, midcranial, midcaudal, and caudal) to be outlined by use of a skin marker. The cat's head is toward the top of the image. B—Photograph of the surgical area following skin incisions and prior to application of wound treatments.

(2 × 2 cm) skin wounds (4/body side) were created with a scalpel blade in each cat; the wound locations were designated as cranial, midcranial, midcaudal, and caudal in a cranial to caudal direction. All subcutaneous tissues, including panniculus muscle and fat, were removed so that the underlying muscle fascia was exposed in the wound bed. The axial border of each wound was located 5 mm lateral to the dorsal midline. The caudal border of each caudal wound was located at the level of the wing of the ilium. A distance of 2 cm of undisturbed skin separated the ipsilateral wounds (**Figure 1**). To prevent shifting of the skin over the wound bed, a single interrupted suture (4-0 nylon suture material) was placed between the skin and the underlying muscle fascia at each of the 4 corners of each wound. Each cat was neutered during the same anesthetic episode to improve the likelihood of adoption. Skin sutures were removed 7 days after surgery.

Wounds were assigned to receive 1 of 4 treatments (2 wounds/treatment/cat). For the control treatment (group C), the muscle fascia was not disturbed. In wounds undergoing fasciotomy (group F), the muscle fascia was perforated with a 3-mm-diameter dermal biopsy punch in a 2-cm-wide grid pattern with 9 evenly spaced perforations (starting at the wound edges; **Figure 2**). Each 3-mm-diameter fascial specimen was then excised, and care was taken to leave the underlying muscle undisturbed. In wounds undergoing fascial abrasion (group A), the underlying fascia was abraded by scraping a scalpel blade across, and perpendicular to, the fascial surface until it bled. This was repeated for any fascia that was not covered by granulation tissue at subsequent bandage changes. In wounds undergoing fascial excision (group X), a section of fascia (2 × 2 cm) was removed from the wound bed without incision of the underlying muscle.

Following wound creation, the wound margins were traced on a sterile, acetate sheet with sterile markers. Digital photographs of each wound (with a metric ruler in the image frame) were also acquired. The wounds were covered with a nonadherent dressing[b] that was secured to the skin with adhesive tape[c] cranially and caudally. Cotton cast padding[d] was wrapped around the abdomen, around the trunk, and between the forelimbs; the padding was lightly compressed with a similarly placed layer of elastic roll gauze[e] followed by a layer of flexible self-adherent wrap material.[f] The bandage materials were covered with a body stocking.[a] After surgery, buprenorphine (10 µg/kg) was administered sublingually every 8 hours for pain relief for the first 48 hours and then as needed. In addition, all cats received buprenorphine sublingually during the bandage change if fascial abrasion (group A) was performed. All cats received ampicillin (22 mg/kg, SC, q 12 h) prophylactically starting the day of surgery and continuing until the end of the study (day 40) or discontinued earlier if closure of all wounds occurred before day 40.

Cats were sedated with ketamine (7 to 10 mg/kg, IM) and medetomidine (6 to 10 µg/kg, IM) for subsequent bandage changes and wound measurements. Bandages were changed daily for 1 week, then every other day for 2 weeks, and then every third day for the final 3 weeks. At each bandage change, rectal temperature was recorded. Once the bandage was removed, the wounds were gently blotted with sterile sponges soaked with saline (0.9% NaCl) solution, blotted dry, and then photographed (with a metric ruler in the image frame) by use of a digital camera. In addition, a sterile acetate sheet was placed on the wound surfaces, and the wound and epithelial margins were traced with an indelible marker. At each bandage change, any fascia that was not yet

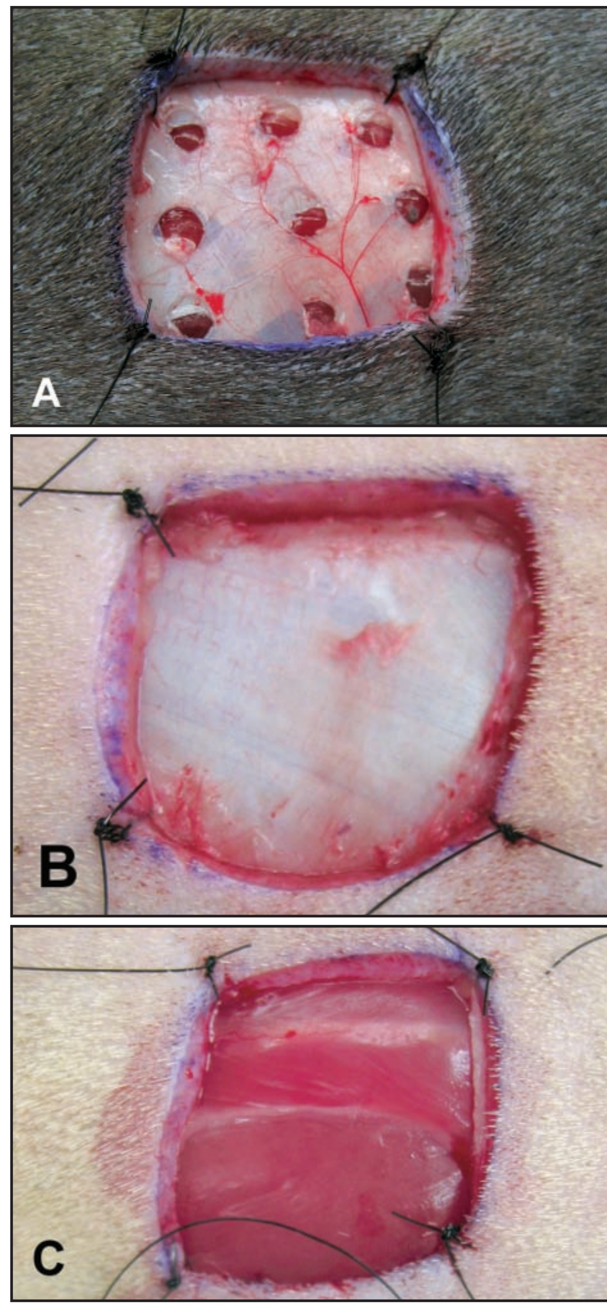

Figure 2—Representative photographs of full-thickness square (2 × 2 cm) skin wounds that underwent fasciotomy (group F; A), fascial abrasion (group A; B), or fascial excision to expose the epaxial musculature (group X; C) in a cat. In the group F wound, a 3-mm-diameter dermal biopsy punch was used to remove fascia at 9 evenly spaced locations. In the group A wound, dense epaxial fascia is visible. A single interrupted suture is placed at each corner of each wound. For assessment purposes, wounds were photographed with a label and a ruler in the frame (not shown).

covered with granulation tissue in group A wounds (2 wounds/cat) was abraded with a scalpel blade to induce bleeding. Exuberant granulation tissue (ie, granulation tissue that extended from the level of the surrounding skin surface), when present, was trimmed back level to the surface of the untreated skin by use of a No. 10 scalpel blade. Wound location, cat, treatment group (C, F, A, or X), and date of the trimming were recorded. All excised exuberant granulation tissue was placed in neutral-buffered 10% formalin. The bandage and body stocking were reapplied as previously described. Atipamezole (0.03 to 0.05 mg/kg) was administered IM to each cat.

Planimetry—Digital photographic images of each wound were analyzed by use of computer-imaging software.[g] Images were imported and calibrated by use of the metric ruler included in each view. Acetate drawings were digitally photographed and calibrated only if the digital file containing the photograph of the wound could not be opened or the image was out of focus (day 2 for cats 3 and 4, day 3 for cats 1 and 2, and day 1 for cat 6 [right side only]). The interface between the untreated normal skin and the wound epithelium was traced, and the total wound area was calculated. Similarly, the margin between the new wound epithelium and open wound was outlined, and the area of epithelialization was calculated. This process was repeated for all 64 wounds (8 wounds/cat) on days 0 through 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 31, 34, 37, and 40. In addition, the times (intervals in days) from wound creation to first appearance of granulation tissue in the wound bed, to coverage of the wound bed surface with granulation tissue, and to complete filling of the wound bed with granulation tissue were recorded.

For descriptive purposes, percentage epithelialization and percentage contraction of each wound at each time period were calculated by use of the following formulas:

$$\text{Epithelialization (\%)} = \left(\frac{\text{Epithelial area [mm}^2\text{] on day}_n}{\text{Original wound area [ie, 400 mm}^2\text{]}}\right) \times 100$$

$$\text{Contraction (\%)} = 100 - \left(\left[\frac{\text{Total wound area \{mm}^2\text{\} on day}_n}{\text{Original wound area \{ie, 400 mm}^2\text{\}}}\right] \times 100\right)$$

where day_n is the day on which the wound had completely healed or the last day of the study (day 40) for those that had not completely healed.

Formalin-fixed tissues were routinely processed as paraffin-embedded blocks for preparation of 4- to 6-µm H&E-stained sections. Central cross-sections of the excised tissues were subjectively evaluated by a board-certified veterinary pathologist (KEL).

Statistical analysis—A mixed-effects repeated-measures ANOVA[h] was used to evaluate cat, treatment, and wound position effects on total wound area, open wound area, and epithelialized area over time as well as to evaluate cat, treatment, and wound position effects on time to first appearance of granulation tissue, time to coverage of the wound base with granulation tissue, and time to complete filling of wound with granulation tissue. By use of least squares means, pairwise comparisons with a Bonferroni adjustment were conducted to assess significant effects. A Pearson χ^2 test was used to evaluate the effect of treatment and wound position on the number of wounds that developed exuberant granulation tissue. Significance was set at a value of $P \leq 0.05$.

Results

None of the cats became pyrexic and all continued to gain weight during the study. All cats developed a superficial accumulation of a mucopurulent discharge on the wounds and surrounding skin until the wounds were healed.

Analysis revealed no significant cat effects on wound healing. The cranial wound position had significantly less total wound area over time, compared with the midcaudal and caudal wound positions ($P = 0.03$ and $P < 0.001$, respectively). Cranial wound position also had significantly less open wound area over time, compared with the caudal position ($P = 0.009$); at the cranial position, significantly fewer wounds required trimming of exuberant granulation tissue, compared with wounds at the midcaudal ($P = 0.022$) and caudal wound positions ($P = 0.049$). The midcranial wound position was not significantly different from other wound positions in regard to open or total wound areas or the number of wounds that developed exuberant granulation tissue. There were no significant ($P \geq 0.20$) effects of wound position on the area of epithelialization, time to coverage of wound base with granulation tissue, or time to complete filling of the defect (level with the surrounding skin) with granulation tissue.

Wounds healed primarily by contraction with minimal epithelialization. At the end of the study (day 40) or when a wound had completely healed for wounds in groups C, A, F, and X, mean contraction was 92.4%, 92.5%, 90.2%, and 90.5%, respectively, and mean epithelialization was 4.6%, 5.6%, 6.0%, and 5.1%, respectively. With regard to the number of wounds that had completely healed by day 40, there were no differences among groups (9/16 wounds in groups C, F, and X and 11/16 wounds in group A; **Figure 3**). Subjectively, all wounds appeared to contract and epithelialize equally from all sides, which resulted in an x-shaped scar.

At any time point, there were no significant differences in the area of epithelialization, open wound area, or total wound area among treatment groups. However, granulation tissue formation differed significantly in several respects among treatment groups. The time to the first appearance of granulation tissue was significantly shorter for all surgical treatment groups, compared with the control group; the mean ± SD value for the control group was 6.3 ± 1.9 days, whereas the value was 3.7 ± 1.1 days for group F wounds ($P < 0.001$), 4.2 ± 1.2 days for group X wounds ($P < 0.001$), and 5.0 ± 1.4 days for group A wounds ($P = 0.047$). In group F wounds, granulation tissue developed significantly ($P = 0.01$) more rapidly than it did in group A wounds. However, the time to the first appearance of granulation tissue did not differ between group A and group X wounds or between group X and group F wounds. The time to coverage of the base of the wound with granulation tissue was significantly shorter for group F wounds (9.6 ± 3.6 days) and group X wounds (9.0 ± 4.1 days), compared with times for group C wounds

(18.5 ± 8.1 days; $P < 0.001$) or group A wounds (16.7 ± 6.1 days; $P = 0.004$). However, values for group A and group C wounds and values for group F and group X wounds did not differ significantly ($P = 0.39$ and $P = 0.74$, respectively). There were no significant ($P > 0.68$) treatment effects on the time to complete filling of wounds (to the level of the surrounding skin) with granulation tissue; mean values were 22 to 23 days for all treatment groups. Of the 16 wounds in each treatment group, the number of wounds that required trimming of exuberant granulation tissue was 9 in group X (5 wounds were trimmed once, 2 were trimmed twice, 1 was trimmed 3 times, and 1 was trimmed 5 times), 6 in group F (all trimmed once), 5 in group A (4 wounds were trimmed once and 1 was trimmed twice), and 3 in group C (2 were trimmed once and 1 was trimmed twice). The number of wounds that required trimming of exuberant granulation tissue differed significantly ($P = 0.03$) only between group X and group C.

Histologically, all excised tissues consisted of raised and ulcerated proliferative granulation tissue that contained a mild to marked infiltrate of neutrophils and few mononuclear cells. Scattered giant cells were observed in several samples, alone or occasionally associated with entrapped cornified material. A thin to thick mat of fibrin and entrapped neutrophils superficially covered the ulcerated surface. Uniform granulation tissue consisted of regular, linearly arranged, small blood vessels that were oriented perpendicular to the surface. There was increased collagenous stroma in deeper areas, compared with the amount in the superficial areas. Superficial granulation tissue was occasionally dis-

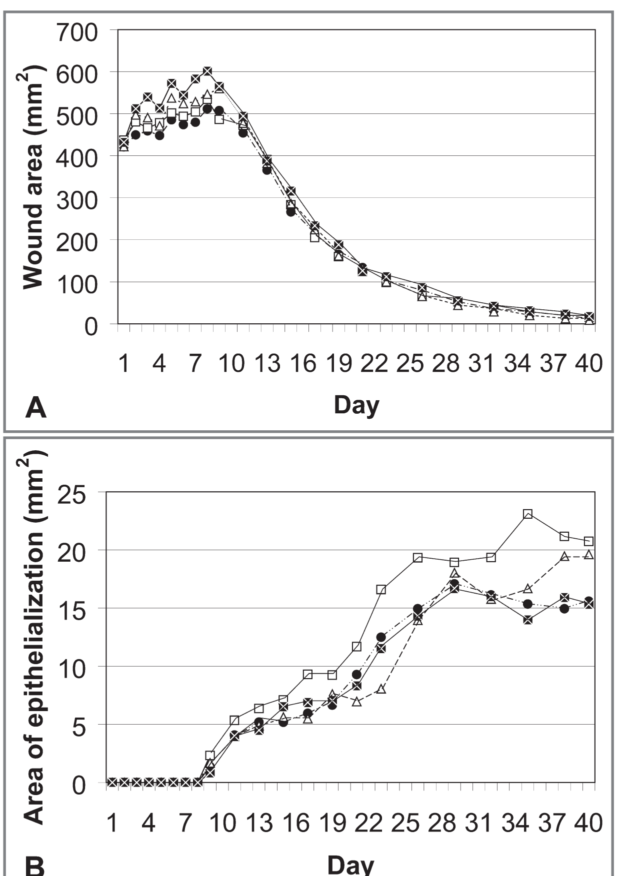

Figure 3—Mean open wound area (A) and mean area of epithelialization (B) in cutaneous wounds that were created (day 0) over the dorsum in 8 cats and that underwent fasciotomy (group F; white squares), fascial abrasion (group A; white triangles), fascial excision (group X; black squares), or a control treatment (muscle fascia not disturbed; black circles); assessments were made on days 0 through 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 31, 34, 37, and 40. For each cat, 1 of 8 treatment maps was randomly assigned to ensure that the 4 treatments were evenly distributed with regard to cranial through caudal wound locations and body side (2 wounds/treatment/cat [4 wounds/body side]).

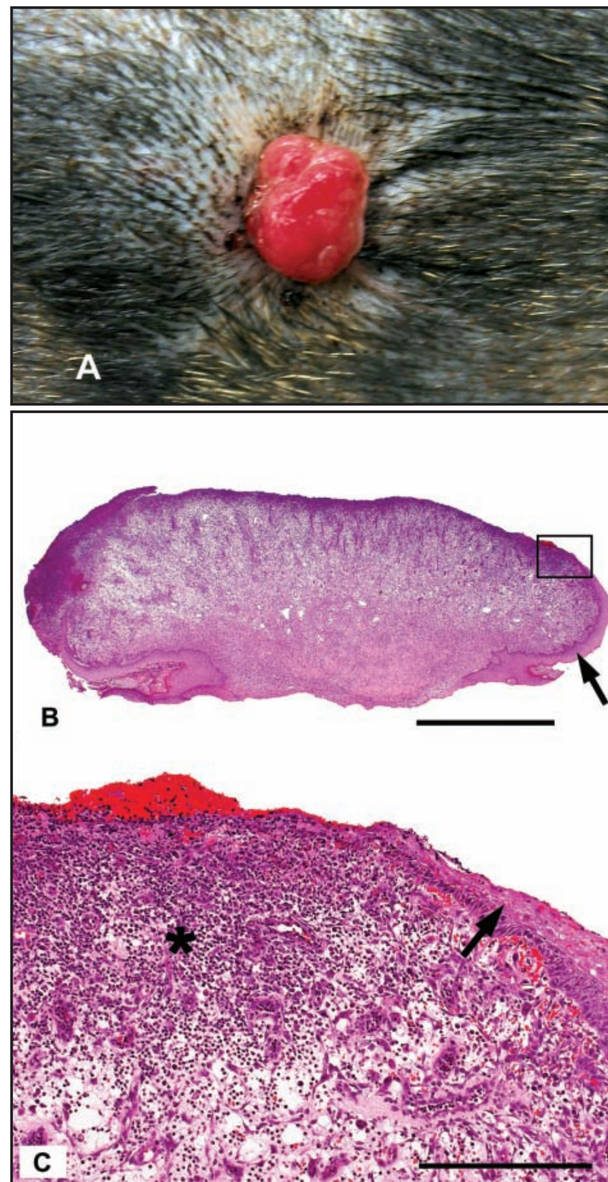

Figure 4—Photograph of a cutaneous wound in a cat 28 days after the wound was created and underwent fascial excision (A) and photomicrographs of a section of excised proliferative granulation tissue (B and C). In panel A, notice the presence of exuberant granulation tissue that has impeded wound healing. The wound has healed primarily by contraction with little epithelialization. Panel B illustrates the entire tissue section. In the tissue section, there is a central ulcer, which is bordered by a margin of epithelialization (arrow). In panel C, the high-magnification view of the outlined area from panel B reveals mild to moderate inflammation dominated by neutrophils (asterisk) and a tapered margin of epithelialization (arrow). H&E stain; bar = 1.5 mm and 250 µm in panels B and C, respectively.

rupted by shallow necrosis. In several tissue specimens, the tissue margins were covered with a moderately to markedly hyperplastic epidermis (**Figure 4**). Granulation tissue specimens from wounds that were trimmed more than once did not appear histologically different over time.

Discussion

The goal of the present study was to compare the effects of 3 different fascial treatments on cutaneous wound healing in cats. Although no differences were detected among groups with regard to epithelialization and contraction, significant differences in granulation tissue formation were evident. The importance of the subcutaneous tissues in cutaneous wound healing in cats has been described.[1] Results of that prospective study indicated that the removal of subcutaneous tissue caused marked reduction in the rate of granulation tissue production, decreased wound contraction, and decreased rate of wound epithelialization. In concordance with those results, the findings of the present study also indicated that cutaneous wounds with loss of subcutaneous tissues heal primarily by contraction in cats. Percentage wound contraction at wound healing or end of study (day 40) ranged from 90.2% to 92.5% with minimal contribution to wound healing from epithelialization. As the data from the present study confirmed, even fairly small (4-cm^2) feline cutaneous wounds heal slowly if the subcutaneous tissues have been removed such that the underlying muscle fascia is exposed. Granulation tissue formation in particular is delayed in cats, compared with that in dogs, when the subcutaneous tissues have been removed.[1] Fascial treatments that promote the rapid development of granulation tissue would therefore be beneficial in that secondary closure or skin grafting of the wound could be expedited.

Some of the digital photographic images of wounds obtained soon after wound creation were damaged or out of focus, which precluded their use in the analyses of the present study; therefore, acetate drawings of those wounds were used instead. In a previous study[1] to evaluate the role of the subcutaneous tissues in cutaneous wound healing in dogs and cats, wound surface areas were also traced on to acetate sheets. In our study, few changes had occurred in the wounds for which acetate wound tracings were relied upon, and it is known that there is a strong correlation between findings obtained via either of the 2 methods for wound surface area measurement; thus, this variation in methods likely had little effect on the results.[19,20]

In the present study, there were no differences in the area of epithelialization, open wound area, or total wound area among treatment groups. Minimal epithelialization may have been attributable in part to delayed granulation tissue formation in group C and group A wounds, inadequate attachment of the skin edges to the underlying fascia in all groups because the skin margins were initially sutured to the fascia only at the wound corners, or epithelial disturbance during bandage changes. Despite earlier coverage of wounds with granulation tissue in groups F and X, skin mobility at the wound margins distant from the corners may have delayed epithelial attachment and migration across the granulation bed. This same phenomenon would be expected in large skin wounds in clinical cases. Although the degree of skin mobility was not measured, some mobility between the wound corners was evident during bandage changes in all groups. A lack of attachment between the edge of the skin wound and the underlying fascia would also be expected to impede contraction. It is possible that contraction was negatively affected to a similar degree in all treatment groups. The reason that epithelialization would be more affected than contraction is unclear. Epithelial trauma during bandage changes was not detected, although the repeated bandage changes may have resulted in a less than optimal environment for epithelialization to develop. All wounds healed primarily by contraction, and wounds at the cranial position contracted more rapidly than wounds at the caudal-most wound position, regardless of treatment group. This may have been a result of relatively increased laxity of skin in the scapular area, regional differences in the blood supply to the underlying muscle and fascia, or interference with contraction in caudal wounds because of the development of exuberant granulation tissue.

The most striking difference between wounds in group C and those in the surgical treatment groups was associated with formation of granulation tissue. Mean time to first appearance of granulation tissue in group C was 6.3 days, similar to that determined in a previous study (6.5 days).[1] However, mean time to first appearance of granulation tissue was significantly shorter for all surgical treatment groups, compared with findings in group C. These values were 5.0 days for group A wounds, 4.2 days for group X wounds, and 3.7 days for group F wounds, respectively. The number of days required for granulation tissue to cover the wound bed was also significantly shorter for group F (mean, 9.6 days) and group X wounds (mean, 9.0 days), compared with the required interval in group C (mean, 18.5 days). In a previous study[1] in 6 cats, subcutaneous tissues were removed from 4-cm^2 wounds (1 wound/cat) and none were covered with granulation tissue by the end of the study period (21 days). Those wounds were all located in a position similar to the cranial wound position in the cats of the present study. In the present study, wound position did not influence mean time to first appearance of or time to wound coverage with granulation tissue. Sample size differences may account for the variance between the 2 reports. In the present study, 13 of 16 group C wounds were eventually covered with granulation tissue by the end of the study (day 40).

Granulation tissue filled the wound to the level of the surrounding skin at 22 to 23 days in the present study, with no significant differences among treatment groups or cranial through caudal wound positions. The presence of exuberant granulation tissues in many of the wounds was not expected given that cats are expected to develop granulation tissue poorly when the subcutaneous tissues have been removed.[1,21] Of the 16 wounds in each treatment group, exuberant granulation tissue formed in 9 in group X, in 6 in group F, and in 5 in group A; in group C, only 3 wounds developed exuberant granulation tissue. The difference between groups X and C was significant. Additionally, the mid-caudal and caudal-most wound positions developed exuberant granulation tissue more often than did the cranial wound position. In those locations, the granulation tissue, which extended out from the skin surface, may have interfered with wound contraction by acting as a physical barrier. It is also possible that delayed contraction in the caudal wound positions allowed for the formation of exuberant granulation tissue. Although the formation of exuberant granulation tissue in the study cats was affected by both wound position and treatment, further investigation is required to determine the underlying cause of its development.

The increased rate of formation and amount of granulation tissue following fasciotomy or fascial excision may be partly attributable to the exposure of underlying highly vascularized muscle, which may have improved wound oxygenation and have allowed capillary buds (a critical component of granulation tissue) to develop at the muscle surface. Additionally, previous studies[16–18] have revealed that the number, migration kinetics, and collagen production of fibroblasts that originate from the underlying fascia are increased, compared with fibroblasts that originate from the wound margins. Excision or fenestration of the underlying fascia may improve access of phenotypically more mobile and productive fibroblasts to the wound, thereby helping to promote early formation of granulation tissue. Once the wound bed is covered with granulation tissue, delayed wound closure or skin grafting may be performed. Given that this occurred at 9 days in group F and group X wounds but at 18 days in group C wounds, duration of hospitalization and patient morbidity may decrease considerably if these treatments are used in cats with large open wounds. It is also possible that these treatments may decrease the likelihood of incisional dehiscence that is associated with so-called pseudo-healing in cats when skin wounds are closed after removal of subcutaneous tissues.[21] Compared with the control treatment, fascial abrasion of wounds resulted in fewer improvements in granulation tissue variables than did the other 2 treatments in the present study and cannot be recommended. To our knowledge, this is the first prospective study to evaluate the contribution of the underlying fascia in wound healing in cats. Further investigation is needed to determine the underlying mechanism by which these fascial treatments enhance granulation tissue formation in cats with open cutaneous wounds in which the subcutaneous tissues have been destroyed or removed. On the basis of the data obtained in our study, we failed to reject the null hypothesis that there would be no differences between any of the 3 surgical treatments and a control treatment with regard to wound area or epithelialization. The hypothesis that there would be no differences between any treatment group and the control group with regard to granulation tissue formation was rejected.

a. Surgi-Sox, Pacific Features LLC, Edmonds, Wash.
b. Telfa, Tyco Healthcare Group LP, Mansfield, Mass.
c. Elastikon, Johnson & Johnson, Skillman, NJ.
d. Specialist Cast Padding, BSN Medical Ltd, Brierfield, England.
e. Conform, Kendall Healthcare Products Co, Mansfield, Mass.
f. Vetwrap, 3M Animal Care Products, Saint Paul, Minn.
g. Image-Pro Plus, version 3.0.1, Media Cybernetics Inc, Bethesda, Md.
h. SAS, version 9.02, SAS Institute Inc, Cary, NC.

References

1. Bohling MW, Henderson RA, Swaim SF, et al. Comparison of the role of the subcutaneous tissues in cutaneous wound healing in the dog and cat. *Vet Surg* 2006;35:3–14.
2. Hosgood G. Wound repair and specific tissue response to injury. In: Slatter D, ed. *Textbook of small animal surgery.* 3rd ed. Philadelphia: WB Saunders Co, 2002;66–86.
3. Silfen R, Amir A, Feinmesser M, et al. Subdermabrasion in the treatment of post-burn facial hypertrophic scars. *Aesthetic Plast Surg* 2002;26:139–141.
4. Holmes JD, Rayner CRW, Muir IFK. The treatment of deep dermal burns by abrasion. *Scand J Plast Reconstr Surg* 1987;21:237–240.
5. Nelson BR, Majmudar G, Griffiths CE, et al. Clinical improvement following dermabrasion of photoaged skin correlates with synthesis of collagen I. *Arch Dermatol* 1994;130:1136–1142.
6. Harmon CB, Zelickson BD, Roenigk RK, et al. Dermabrasive scar revision: immunohystochemical and ultrastructural evaluation. *Dermatol Surg* 1995;21:503–508.
7. Tetik O, Kocabey Y, Johnson DL. Synovial abrasion for isolated, partial thickness, undersurface, medial meniscus tears. *Orthopedics* 2002;25:675–678.
8. Latenser J, Snow SN, Mohs FE, et al. Power drills to fenestrate exposed bone to stimulate wound healing. *J Dermatol Surg Oncol* 1991;17:265–270.
9. Launois T, Desbrosse F, Perrin R. Percutaneous osteostixis as treatment for avulsion fractures of the palmar/plantar third metacarpal/metatarsal bone cortex at the origin of the suspensory ligament in 29 cases. *Equine Vet Educ* 2003;15:126–138.
10. Wright IM, Platt D, Houlton JEF. Management of intracortical fractures of the palmaroproximal third metacarpal bone in a horse by surgical forage. *Equine Vet J* 1990;22:142–144.
11. Smith MM, Vasseur PB, Morgan JP. Clinical evaluation of dogs after surgical and nonsurgical management of osteochondritis dissecans of the talus. *J Am Vet Med Assoc* 1985;187:31–35.
12. Vachon A, Bramlage LR, Gabel AA, et al. Evaluation of the repair process of cartilage defects of the equine third carpal bone with and without subchondral bone perforation. *Am J Vet Res* 1986;47:2637–2645.
13. Bouwmeester PSJM, Kuijer R, Homminga GN, et al. A retrospective analysis of two independent prospective cartilage repair studies: autogenous perichondrial grafting versus subchondral drilling 10 years post-surgery. *J Orthop Res* 2002;20:267–273.
14. Clark GN. Bone perforation to enhance wound healing over exposed bone in dogs with shearing injuries. *J Am Anim Hosp Assoc* 2001;37:215–217.
15. Lee AH, Swaim SF, Newton JC, et al. Wound healing over denuded bone. *J Am Anim Hosp Assoc* 1987;23:75–84.
16. Dubay DA, Wang X, Kirk S, et al. Fascial fibroblast kinetic activity is increased during abdominal wall repair compared to dermal fibroblasts. *Wound Repair Regen* 2004;12:539–545.
17. Franz MG, Smith PD, Wachtel TL, et al. Fascial incisions heal faster than skin: a new model of abdominal wall repair. *Surgery* 2001;129:203–208.
18. Spyrou GE, Watt DAL, Naylor IL. The origin and mode of fibroblast migration and proliferation in granulation tissue. *Br J Plast Surg* 1998;51:455–461.
19. Wunderlich RP, Peters EJG, Armstrong DG, et al. Reliability of digital videometry and acetate tracing in measuring the surface area of cutaneous wounds. *Diabetes Res Clin Pract* 2000;49:87–92.
20. Etris MB, Pribble J, LaBrecque J. Evaluation of two wound measurement methods in a multi-center controlled study. *Ostomy Wound Manage* 1994;40:44–48.
21. Bohling MW, Henderson RA. Differences in cutaneous wound healing between dogs and cats. *Vet Clin North Am Small Anim Pract* 2006;36:687–692.