A disposable, canister-free negative-pressure wound therapy device proves feasible, but of inferior efficacy to conventional therapies for treating cutaneous wounds in dogs

Mila Freire, DVM, PhD, DACVS1*; Chloé Job, DVM, IPSAV1; Ida Hassanpour, DVM1; Javier Benito, DVM, PhD, MSc1; Daniel S. J. Pang, BVSc, PhD, DACVAA, DECVA, MRCVS2; Marilène Paquet, DVM, MSc, DACVP3; Christine L. Theoret, DVM, PhD, DACVS4

1Department of Clinical Sciences, Faculty of Veterinary Medicine, Université de Montréal, St-Hyacinthe, Québec, Canada
2Faculty of Veterinary Medicine, University of Calgary, Calgary, Canada
3Department of Pathology and Microbiology, Faculty of Veterinary Medicine, Université de Montréal, Saint-Hyacinthe, Québec, Canada
4Department of Biomedical Sciences, Faculty of Veterinary Medicine, Université de Montréal, Saint-Hyacinthe, Québec, Canada

*Corresponding author: Dr. Freire (m.freire.gonzalez@umontreal.ca)

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OBJECTIVE
To assess the feasibility of a canister-free negative-pressure wound therapy (NPWT) device (PICO™ 1.6, Smith & Nephew Medical Ltd) and evaluate its effect on early phases of wound healing in canine experimental cutaneous wounds.

ANIMALS
5 adult spayed female research Beagles.

PROCEDURES
In a pilot experimental study, 1 full-thickness 2-cm X 2-cm cutaneous wound was surgically created on each hemithorax in each dog. Wounds were treated with either NPWT or a conventional wound dressing for 14 days. Bandage changes and wound evaluations were done at 7 time points. First macroscopic appearance of granulation tissue, smoothness of granulation tissue, and percentages of wound contraction and epithelialization were compared between treatments. Wounds were sampled at 3 time points for histopathologic analyses and semiquantitative scoring.

RESULTS
NPWT dressings were well tolerated by all dogs. Complete seal of the dressing required the application of adhesive spray, and maintenance of the vacuum lessened over time. Self-limiting skin irritations appeared in all dogs and hampered the attainment of negative pressure. Granulation tissue developed faster and was more abundant in control wounds. Wound contraction, epithelialization, and fibroblast proliferation were greater in control wounds at the end of the study.

CLINICAL RELEVANCE
This canister-free NPWT device is feasible but problematic in maintaining a vacuum, requiring frequent revisions of the dressing. Further studies are necessary to evaluate the effect of this device on early phases of wound healing. Its benefits in wound healing remain unknown.

The introduction of commercial negative-pressure wound therapy (NPWT) systems more than 2 decades ago revolutionized the management of different types of wounds. These systems create an environment favorable for wound healing by increasing blood flow, promoting angiogenesis, reducing wound surface area for certain wounds, modulating the inhibitory contents of wound fluid, and inducing cell proliferation.1–4 The first NPWT devices were large and cumbersome, compromising mobility and limiting the use of this treatment to hospitalized patients. To overcome these problems and the elevated cost of medical care associated with hospitalization during treatment, the devices have become smaller and more portable. In veterinary medicine, the benefits of NPWT have been shown, but the application of this treatment requires cage confinement and hospitalization for the duration of the treatment because most available devices rely on bulky canisters for the collection of wound exudates.5–10

The NPWT system (PICO™ 1.6, Smith & Nephew Medical Ltd) used in the study reported here is a
single-use, canister-free device that employs an absorbent and highly evaporative 4-layer dressing for exudate collection connected to a small vacuum unit through flexible plastic tubing. The device is portable as a result of its small size and, being lightweight, allows near-normal mobility to human patients, thereby decreasing hospitalization time and total cost of treatment. Miller et al reported the use of this device in a clinical case series of 7 canine patients to protect full-thickness skin grafts in open surgical wounds on the distal extremities, showing successful clinical outcome. They found the application and maintenance of the device straightforward. Conversely, the feasibility of this system was explored recently in experimental open wounds in horses, and the authors found the dressing unsuitable for use in this application because of difficulties with adhesion and seal of the dressing to the skin, and consequent failure to maintain an effective vacuum. This canister-free portable NPWT device could potentially provide an option for open wound management in canine patients treated as outpatients, with the consequent benefits of increased patient mobility, and decreased cage confinement and hospitalization. However, the feasibility of this device for the treatment of open wounds and the effect of this system on wound healing in dogs remains undetermined.

The primary aims of the pilot study reported here were to assess the feasibility of this canister-free portable NPWT device to administer continuous negative pressure to experimental open wounds in dogs and to determine patient tolerance of the device. A secondary aim was to evaluate the effects of the device on early phases of wound healing compared to a standard wound dressing. We hypothesized that the use of this wound dressing would be feasible and well tolerated, and that wounds treated with this device would show superior wound healing compared with wounds treated with a standard wound management protocol.

Materials and Methods

Study design

This study was designed as a pilot experimental study. Each dog served as its own control and was measured repeatedly over time. A prospective power analysis was performed to ensure an appropriate sample size to document a 20% to 25% difference for main wound macroscopic and microscopic factors assessed, with an α of 0.05 and a power 1 – β of 0.80, resulting in 5 animals.

NPWT device

For each dog, an NPWT device (PICO™ 1.6, Smith & Nephew Medical Ltd) was used, and the device was a canister-free, single-use system that consisted of a 4-layer dressing connected to a small vacuum unit through flexible plastic tubing. This device is programmed to work for 7 consecutive days at a single preset pressure of –80 mm Hg. The vacuum unit is 6 X 7 X 2 cm, weighed 70 g, and is powered by 2 AA lithium batteries. The unit has 3 lights that communicate its status: a continuously flashing green light indicates correct application of treatment, a flashing amber light indicates that there is an air leak requiring attention, and a different amber light flashes to indicate that the batteries require changing (Figure 1). The pump also vibrates intermittently if an air leak is detected. The 4-layer dressing consists of a silicone layer in contact with the wound surface, an airlock layer that acts to distribute the negative pressure evenly, an absorbent layer that wicks exudate away from the wound, and an external film with high moisture vapor transmission that allows 1-way transpiration of the exudate. The dressing is designed for wounds with small to moderate amounts of exudate because the dressing does not have a canister to collect fluid. To achieve negative pressure, the dressing must adhere and seal without leaks, for which the manufacturer recommends applying bands of adhesive polyurethane film (Opsite®, Smith & Nephew) over the silicone edges of the dressing. Following the manufacturer’s instructions, the dressing could be applied directly in contact with the wound, and the addition of foam or gauzes would only be needed for deep or irregular wounds to ensure contact and good distribution of the negative pressure. The dressing used in this study was the smallest available (10 cm X 20 cm).

Experimental wound creation

On day 0, each dog was anesthetized with alfaxalone (1 mg/kg IV) following hydromorphone (0.05 mg/kg IV). After endotracheal intubation, anesthesia was maintained with a constant rate IV

Figure 1—Representative image of a single-use canister-free negative-pressure wound therapy (NPWT) device (PICO™ 1.6, Smith & Nephew Medical Limited) in place over a full-thickness skin wound that had been surgically created on the lateral aspect of the thorax of a 3-year-old spayed female research Beagle. This was part of a preliminary clinical trial with an experimental part conducted between March 28 and July 31, 2017 to evaluate the feasibility and effects on early phases of wound healing for NPWT-treated wounds versus standard wound dressing (control wounds). The vacuum unit has 3 lights: a green light indicates correct application of treatment, an amber light (not lit in this image) indicates an air leak, and a second amber light (not lit in this image) indicates batteries require changing.
infusion of alfaxalone (0.06 to 0.09 mg/kg/min), and 100% oxygen was provided. Intraoperative monitoring included capnography, ECG, and pulse oximetry (Life Window LW6000, DigiCare Animal Health). Both hemithoraces were clipped and prepared for aseptic surgery. Using a sterile marker and ruler, a 2-cm X 2-cm square was marked. A subcutaneous local block was performed at a distance of 1 cm around the marked area using bupivacaine 0.5% (1 mg/kg; Figure 2). Full-thickness skin wounds were created surgically with a scalpel blade. Wounds were blotted with sterile gauze until hemostasis was achieved. Left hemithorax wounds were treated with the NPWT system using a 10-cm X 20-cm dressing (Figure 1). Right hemithorax wounds were treated with a conventional wound treatment protocol that consisted of the application of a paraffin gauze dressing (Bactigras®, Smith & Nephew) over the wound, covered by sterile gauze moistened with sterile saline. The thorax was bandaged with secondary (cotton) and tertiary (self-adhesive cohesive wrap) layers that covered both wounds and the NPWT dressing. The vacuum unit was protected under the tertiary layer in the dorsum of the animal, leaving a window for monitoring the unit light indicators. Signs of pain were evaluated every 4 hours using a short-form of the Glasgow composite pain scale14; when needed (total score > 5), oral transmucosal buprenorphine (0.02 to 0.03 mg/kg, every 6 to 8 hours as needed) was administered. Dogs were monitored every 2 hours during the day (from 8 AM to 8 PM) and every 4 hours during the night (from 8 PM to 8 AM) throughout the study to verify the functioning of the vacuum unit.

On days 2, 4, 6, 8, 10, and 12, bandages were changed according to an aseptic technique. Wounds were cleaned with sterile, saline solution-soaked gauze sponges, and photographs were taken, including a carefully positioned millimeter measurement scale. For wound cleaning, the dressing was lifted only partially for NPWT-treated wounds. If negative pressure was not achieved after applying the same dressing, a new one was applied. For conventionally treated wounds, the paraffin gauze wound dressing was replaced with a new one and then again covered by sterile gauze moistened with sterile saline. The thorax was then bandaged with secondary and tertiary layers as indicated for day 0. On days 4 and 8, in addition to a bandage change and wound cleansing, a tissue sample of the wound bed was taken using a 4-mm sterile dermal biopsy punch (from the right upper corner of the wound on day 4 and the lower left corner of the wound on day 8). Dogs were sedated, and analgesia provided, with hydromorphone (0.05 mg/kg IV), dexametomidine (2 µg/kg IV), and a splash block with bupivacaine 0.5% to facilitate tissue sampling. Signs of pain were evaluated, and rescue analgesia was provided if needed according to the same protocol described earlier. The vacuum unit, programmed to stop working after a week of having been set, was replaced on day 7 for all dogs (NPWT dressings were not manipulated at this time unless it was needed to maintain negative pressure). On day 14, dogs were anesthetized using the same protocol described for wound creation. Both hemithoraces were prepared for aseptic surgery, and photographs were taken for the final evaluation of the wounds. An elliptic incision was performed around the wounds, and these were fully excised. The freshly created surgical wounds were closed in a routine manner, and the excised tissues were used, along with the tissue samples obtained on days 4 and 8, for histopathologic evaluation. Postoperative analgesia was provided with hydromorphone (0.05 mg/kg IV), meloxicam (0.2 mg/kg SC), and oral transmucosal buprenorphine (0.02 to 0.03 mg/kg, every 6 to 8 hours as needed). During the study, dogs were kept in large runs with toys to enrich their environment. Their exercise was restricted to leash walks of variable duration (5- to 30-minute walks) and, sporadically, they were left off leash under direct supervision in an enclosed area where they were not stimulated to jump or run, and they were prevented from doing so.

**Wound macroscopic evaluation**

Photographs of the wounds with a millimeter measurement scale were taken on days 0, 2, 4, 6, 8, 10, 12, and 14. Upon completion of the study, images were randomized and planimetry software (ImageJ®NIH, http://rsbweb.nih.gov/ij/index.html) was used to calibrate and trace the open wound area (defined as the area of pregranulation or granulation tissue) and total wound area (defined as the open wound area and the surrounding area of new epithelium lacking hair follicles) as reported previously.1 Three area measurements were taken for each photograph.

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Figure 2—Intraoperative images before (A) and after (B) surgical wound creation on the lateral aspect of the thorax of a dog enrolled in the study described in Figure 1, with a sterile surgical ruler visible for scale. A—A sterile marker has been used to mark a 2 X 2-cm square and the sites of subcutaneous injection of bupivacaine 1 cm from the planned incision lines. B—Five minutes after bupivacaine injection, the skin was incised with a surgical blade to excise the marked square, creating a full-thickness cutaneous wound.
(observer blinded to treatment), and the median value was calculated. The open and total wound areas were used to calculate the percentage of wound contraction \((\text{Total wound area day } 0 - \text{Total wound area day } n)/\text{Total wound area day } 0 \times 100\) and percentage of epithelialization \(\left(\text{Total wound area day } n - \text{Open wound area day } n\right)/\text{Total wound area day } n \times 100\) with respect to size on day 0. Time (days) to first macroscopic appearance of granulation tissue was also recorded.

**Wound microscopic evaluation**

Tissue samples taken on days 4 and 8, and a strip of the excised wound including granulation tissue, neo-epithelium, and surrounding intact skin taken on day 14 were submitted for histopathologic examination. Specimens were fixed with neutral-buffered 10% formalin and processed routinely for light microscopy. Samples were stained with hematoxylin, eosin, phloxine, and saffron. Microscopic evaluation of the samples was performed by a board-certified veterinary pathologist who was blind to the sample grouping. The degree of edema, hemorrhage, fibrin, neutrophilic infiltration, necrosis and fibroblast proliferation was scored using semiquantitative parameters: 0, none; 1, minimal; 2, light; 3, moderate; and 4, profound.

**Statistical analysis**

This was a paired design, with each dog serving as its own control, and each dog being measured repeatedly over time. Continuous numeric data from macroscopic evaluation of the wounds (open and total wound areas, percentage contraction, and percentage epithelialization) were tested for normality distribution using the Kolmogorov–Smirnov test and analyzed with the use of 1-way ANOVA corrected with Sidak multiple comparisons test, and percentage epithelialization \(\left(\text{Total wound area day } n - \text{Open wound area day } n\right)/\text{Total wound area day } n \times 100\) with respect to size on day 0. Time (days) to first macroscopic appearance of granulation tissue was also recorded.

**Feasibility of using the disposable, canister-free NPWT device**

Complete seal of the NPWT dressing and effective vacuum was achieved only after application of adhesive spray (PreTape®, Mueller). The use of bands of adhesive polyurethane film (Opsite®, Smith & Nephew) over the edges of the dressing did not improve adhesion without the adhesive spray. The NPWT dressing needed to be manipulated very carefully to ensure good apposition to the skin to prevent wrinkles that impeded complete sealing. The first application of the dressing using the adhesive spray was easy, and negative pressure was achieved quickly. Occasionally, air leaks occurred during the first 24 hours after the application of the dressing, and required adjustments and reappraisal of adhesive spray. However, subsequent applications of the NPWT dressings were more difficult and time-consuming, requiring more spray and occasionally the use of a new dressing. Toward the beginning of the second week and the end of the study, achieving a vacuum became consistently more difficult and required cleaning of the skin with an adhesive remover spray (Remover®, Mueller), clipping of the hair having regrown on the surrounding intact skin, and application of a new dressing with adhesive spray. For 1 dog, the study was terminated prematurely 24 hours early (dog 2, day 13) because of the impossibility of achieving a complete vacuum. The dressing lost vacuum, the amber light was flashing, and the pump was vibrating every few seconds, indicating an air leak that required attention. The skin was cleaned thoroughly with adhesive remover spray, the hair on the surrounding intact skin was clipped, and 2 new dressings were reapplied using adhesive spray, but these efforts were unsuccessful in achieving negative pressure.

Negative pressure was maintained continuously throughout the majority of the study; however, the unit indicated air leaks at different time points for all dogs. For dog 1, minor dressing detachment from the skin caused loss of vacuum on day 7, which was corrected by applying a new dressing. Because of the schedule checks, the maximum time negative pressure could have been lost in this dog was 2 hours. Dog 2 developed irritation of the skin early during the study and the unit had intermittent vibrations noticed at different times; however, the unit continued to flash a green light, indicating correct application of the treatment. The NPWT dressing was adjusted multiple times with the application of more adhesive spray, and the dressing was replaced on day 8, which corrected the vibrations temporarily. These vibrations became continuous on day 13, and multiple attempts to achieve negative pressure were unsuccessful such that the NPWT dressing was finally removed, terminating the study for this dog. Dog 3 partially removed the bandage on day 3, which caused disconnection of the vacuum unit. Because of the schedule checks, the maximum time negative pressure could have been lost was 1.5 hours. A new
NPWT dressing was placed on day 6 and day 11. On day 12, the vacuum unit was found to have been switched off during the evening; it was restarted and continued to work properly. Because of the schedule checks, the maximum time negative pressure could have been lost was 4 hours. For dog 4, the vacuum unit had intermittent vibration the first day the NPWT dressing was applied, and loss of vacuum was detected the morning of day 1. Because of the schedule checks, the maximum time negative pressure could have been lost was 4 hours. A new NPWT dressing was applied on day 6, but it continued to indicate air leaks and, during the evening, loss of vacuum occurred for a maximum of 8 hours. Until the end of the study for this dog, the NPWT dressing was changed 2 more times, on days 8 and 10, in an attempt to stop the intermittent vibration. The vacuum indicated correct functioning apart from these 2 times at which the vacuum was lost. For dog 5, the vacuum was lost during the evening of day 8 for a maximum of 8 hours. Otherwise, the vacuum unit indicated correct functioning for the duration of the study, and the NPWT dressing was changed 3 times during the study period, on days 6, 8, and 10.

The dressings and carriage of the vacuum unit seemed to be well tolerated by all dogs. Animals remained comfortable throughout the study and none required rescue analgesia at any time points. They did not seem to be bothered by the intermittent vibrations that occurred sporadically during the study. Two dogs tried removing their bandages (1 time for one of them and 2 times on 2 different days for the other), and 1 dog rubbed its thorax against the wall and floor of the enclosure intermittently. These behaviors could have been secondary to the NPWT or conventional dressings, or the NPWT device hardware, although they were not directly related to the periods when intermittent vibrations were present, nor were they continuous throughout the study period. The subjective impression was that they were secondary to having a bandage around the thorax, as is sometimes observed in the clinic with general bandages. Toward the second week of the study, all dogs developed skin irritations at the site where the NPWT dressing adhered to the skin (Figure 3). The lesions were self-limiting and disappeared shortly after the dressings and bandage were removed, following application of topical skin ointment (Zincoderm®, Vetoquinol), but resulted in mild discomfort and hampered the attainment of complete negative pressure during the study.

**Wound macroscopic evaluation**

Open wound area on day 0 was not significantly different \( (P = .99) \) between NPWT-treated wounds (median, 6.84 cm²; range, 6.4 to 7.42 cm²) and control wounds (median, 7.29 cm²; range, 6.54 to 8.29 cm²). For the NPWT-treated wounds, the open wound area became significantly smaller \( (P < .001) \) than the original wound at day 12 (median, 5.64 cm²; range, 4.55 to 7.56 cm²), and total wound area became significantly smaller \( (P < .001) \) than the original wound at day 14 (median, 5.28 cm²; range, 4.92 to 6.73 cm²). For the control wounds, the open wound area (median, 4.01 cm²; range, 3.73 to 6.24 cm²) and total wound area (median, 4.49 cm²; range, 3.87 to 6.66 cm²) became significantly smaller \( (P < .001 \text{ and } P = .001, \text{ respectively}) \) than the original wound at day 8. At the end of the study, open wound area of control wounds (median, 1.32 cm²; range, 0.81 to 1.64 cm²) was significantly smaller \( (P < .001) \) than that of NPWT-treated wounds (median, 4.45 cm²; range, 4.23 to 6.06 cm²), and this difference was present from day 8 onward. Total wound area was also significantly smaller \( (P < .001) \) at the end of the study for control wounds (median, 2.02 cm²; range, 1.97 to 2.49 cm²) compared to NPWT-treated wounds (median, 5.28 cm²; range, 4.92 to 6.73 cm²), and this difference was also present from day 8 onward (Figure 4, Supplementary Table S1).

The percentage of wound contraction at the end of the study was significantly greater \( (P < .001) \) for control wounds (median, 70.52%; range, 62.38 to 75.61%) compared to NPWT-treated wounds (median, 20.89%; range, 1.62 to 29.93%), and this difference was present from day 8 onward. First appearance of epithelialization was observed between days 4 and 6 for all wounds, regardless of treatment;
however, at the end of the study, the percentage of epithelialization was significantly greater ($P < .001$) for control wounds (median, 34.30%; range, 25.69 to 67.0%) compared to NPWT-treated wounds (median, 17.98%; range, 9.30 to 19.34%), and this difference was present from day 12 onward (Figure 4, Supplementary Table S1).

Granulation tissue was first noted macroscopically at day 2 for all control wounds, and it was more variable for NPWT-treated wounds, in which granulation tissue appeared between day 2 and day 8. Granulation tissue was more abundant, covering the entire wound surface earlier in the control wounds than in the NPWT-treated wounds. In some instances, the granulation tissue in control wounds was exuberant, raising over the skin level. In NPWT-treated wounds, the granulation tissue was smooth and less exuberant than in control wounds, never raising over the skin level (Figure 5, Supplementary Table S1).
Wound microscopic evaluation

Median histopathologic scores for edema, fibrin, and neutrophilic infiltration were significantly higher ($P < .025$, $P < .032$, and $P < .008$, respectively) on day 4 for control wounds (3, 4, and 4, respectively) compared to NPWT-treated wounds (2, 2, and 1, respectively; Supplementary Table 2). Median histologic scores for fibroblast proliferation were significantly higher ($P < .045$) on day 14 for control wounds (median score, 4) compared with NPWT-treated wounds (median score, 3).

Discussion

Results of this study partially rejected the hypotheses that were tested. This pilot study confirmed the feasibility, albeit problematic, of using a small, canister-free, portable NPWT device (PICO™ 1.6, Smith & Nephew Medical Ltd) to administer negative pressure to experimental open wounds in dogs; however, wounds treated with the device did not show superior healing compared with wounds treated with standard wound protocols. The animals showed good tolerance to the dressing (they ignored the device and behaved normally for most of the study period), and the pump was easy to carry. However, application of the wound dressing and maintenance of vacuum required time, patience, and the use of adhesive spray. The use of a polyurethane film did not improve adhesion, and achieving vacuum would have been impossible following only the company recommendations, without the use of adhesive spray. The ease of achieving vacuum decreased with subsequent dressing applications as a result of the accumulation of spray on the skin, hair regrowth, and development of skin irritations. If treatment is prolonged and multiple applications are necessary, correct adhesion and achievement of vacuum may be challenging. Continuous monitoring of the system was necessary because air leaks and loss of vacuum were frequent. The manufacturer recommends that the dressing not be covered by a bandage so that exudate can evaporate through the fourth layer of the dressing; however, with the challenges we experienced in maintaining vacuum, we anticipate it might be difficult to ensure appropriate operation of the system if it is not held in place with a bandage. Miller et al12 reported that application and maintenance of the device was easy and technically straightforward. In that clinical case series, they used this system to protect skin grafts on the lower limbs of dogs during the immediate postoperative period (for a duration of 4 to 7 days, depending on the patient), and they also protected the dressing with a bandage. The location of the wounds (lower limbs vs thorax), different clinical use of the system (skin graft protection vs open cutaneous wounds), and length of treatment may explain the differences in ease of application and maintenance of vacuum. In addition, in our study the dressings were lifted partially every 2 days to take photographs and tissue samples of the wounds, and this might have affected the adherence of the dressings, making it more difficult to maintain vacuum. In human clinical practice, the manufacturer’s instructions indicate that the dressing can be left untouched for up to 7 days. It should be changed if the dressing is 75% or more saturated or per the doctor’s discretion, depending on the type of wound and stage of healing.

Although other NPWT systems can be adapted to the size and shape of the wound, the dressings of this system have a predetermined size that cannot be modified (different sizes are commercially available). This fact limits its use to wounds that can be covered completely by the selected dressing. Consequently, for a smaller wound, a large area around the wound needs to be clipped to achieve adhesion of the dressing and vacuum. In our study, wounds were 2 cm X 2 cm, and the smallest available dressing is 10 cm X 20 cm, requiring a large area of intact skin to be shaved. This might be an advantage for moderately exudative wounds where the dressing will serve to collect the exudate (the company recommends that the size of the wound should be no more than 25% of the dressing pad area for moderately exudative wounds); however, it might also negatively impact the possibility of using this system, depending on the location and size of the wound.

Our study failed to demonstrate that this NPWT system promotes faster formation of granulation tissue than conventional wound treatment. The initial macroscopic appearance of granulation tissue was noted between days 2 and 8 for NPWT-treated wounds, whereas for conventionally treated wounds, granulation tissue started to appear by day 2 for all wounds. The amount of granulation tissue present (fibroblast proliferation) at the end of the study was graded microscopically as “profound” for all conventionally treated wounds, and it varied from mild to moderate for NPWT-treated wounds. Significant differences for fibroblast proliferation were achieved only at day 14, and was greater for conventionally treated wounds. The reason why NPWT wounds were slower to granulate than conventionally treated wounds in our study is unknown and likely multifactorial. The NPWT system we used is designed to deliver a subatmospheric pressure of –80 mm Hg, whereas traditional NPWT systems permit modulating the level of pressure applied and, historically, a value of –125 mm Hg has been recommended.13,14 This recommendation is based on the fact that this subatmospheric value maximizes the increase in blood flow, and the premise that optimal tissue growth occurs at maximal blood flow. Morykwas et al13 demonstrated that cutaneous wounds treated with higher (–500 mm Hg) or lower (–25 mm Hg) values of subatmospheric pressure failed to form granulation tissue within the wound bed at the same rate as when –125 mm Hg is applied. They used NPWT devices in which a polyurethane foam was in contact with the wound. Nuutila et al14 on the other hand, demonstrated feasibility and superior healing of wounds using a novel, simplified device when –50-mm Hg and – 80-mm Hg pressures were applied. They evaluated full-thickness burn wounds in pigs, and their novel system consisted of an impermeable,
embossed polyurethane membrane in direct contact with the wound. Although the pressure applied in the study by Nuutila et al. is similar to the NPWT value in the device we used, the wound type, location, and species differences preclude direct comparisons, and these other variables are likely to play a role in the effectiveness of the NPWT. Controversy persists regarding the optimal therapeutic pressure of NPWT for each type of wound, and further studies are necessary. Moreover, we did not measure the pressure delivered by the system; therefore, it was assumed that the true value of subatmospheric pressure applied was less than −80 mm Hg. Although the durations during which the negative pressure had been lost seemed negligible considering the overall study duration, this should also be considered a contributing factor to the observed delay in the formation of granulation tissue.

In addition, although traditional NPWT systems use an open-pore polyurethane foam covered by a semicocclusive dressing, this system has a silicone layer in contact with the wound. Physical properties of the polyurethane foam could contribute to the efficacy of the NPWT treatment and, to our knowledge, there are no studies in which a dressing with a silicone layer in direct contact with the wound is used with −125 mm Hg subatmospheric pressure, so whether this observation is the result of the difference in applied pressure or the type of dressing in contact with the wound remains unknown. Moreover, it could be argued that the number of cases in our study was not sufficient to demonstrate the superior effect on wound healing of the NPWT system; however, a similar study shows statistical differences between wounds using a similar number or fewer animals per group, and power analysis for the main wound macroscopic and microscopic factors assessed resulted in the need of 5 animals to document 20% to 25% difference. Efficiency of NPWT devices varies with different types of wounds, thus the results of our study should not be extrapolated to all wound types. Although granulation tissue did not develop faster in the wound, it had a smoother surface and never raised over the skin level (as for the control wounds) when NPWT was applied, similar to a previous study. This characteristic is of great value when skin grafts are to be used after the wound is covered with granulation tissue.

Wounds treated with this NPWT device failed to demonstrate wound contraction until day 12 when the open wound area became significantly smaller than the original wound area compared with wounds treated with conventional dressing, which became significantly smaller than the original wound and NPWT-treated wounds on day 8. The decrease in contraction in NPWT-treated wounds is explained in part by the fact that delayed granulation tissue formation will affect wound contraction onset and rate negatively. This decrease in wound contraction has been described in other studies and it is believed that the dressing under subatmospheric pressure holds the edges of the wound apart, limiting the contraction of the wound. Demaria et al. have also proposed location of the wound as a possible factor affecting wound contraction. A decreased percentage of wound contraction might not always be a dire consequence of application of negative pressure to a wound. Excessive contraction may, in some cases, create tension of the surrounding skin, leading to anatomic dysfunction, and if a joint is involved, decreased range of motion may result. It is therefore a desirable effect that can be targeted in the treatment of certain wounds.

Our study had limitations, including type and location of wounds, inclusion of only female animals, and the fact that the dressings were lifted partially every 2 days, which would not have been done in a clinical setting. Study design, type of dressing, and wound model (other anatomic locations and wounds with exposure of muscles/bone) limited comparisons of our results with other studies, and extrapolation of our findings to clinical patients should be avoided. Despite these limitations, some important differences in the macroscopic and microscopic evaluations of the wounds were observed that may have indicated an inferior efficacy of this NPWT device to stimulate granulation tissue formation compared with conventional wound treatment in dogs.

In summary, our findings indicated that NPWT used in our study is a feasible system to treat open cutaneous wounds in dogs; however, it was problematic in maintaining vacuum, requiring frequent revisions of the dressing, and was of inferior efficacy to conventional therapies for treating cutaneous wounds in dogs. The characteristics of this device are different from other NPWTs currently being used to stimulate granulation tissue formation in cutaneous wounds in dogs and, although the efficacy of this NPWT device seems inferior to conventional wound treatment, further studies comparing it to other NPWT systems are necessary.

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Supplementary Materials
Supplementary materials are posted online at the journal website: avmajournals.avma.org