Conclusion

These studies demonstrate that the V.A.C. GranuFoam Silver® Dressing, which is specifically engineered for use with V.A.C.® Therapy, provides sustained release of silver ions and is an effective antimicrobial against common wound pathogens including gram-negative bacteria, gram-positive bacteria, antibiotic-resistant bacteria and fungal organisms. The dressing retains the physical properties of standard V.A.C.® GranuFoam® Dressings to assist granulation tissue formation as demonstrated in a non-infected, acute wound swine model. The porous nature of the foam and negative pressure environment allow for a direct and complete tissue-to-dressing interface during ionic silver release. Animal testing revealed greater amounts of silver at the dressing/wound interface with the V.A.C. GranuFoam Silver® Dressing when compared to an adjoining silver dressing used with the V.A.C.® Therapy System.

In summary, the V.A.C. GranuFoam Silver® Dressing serves as an effective barrier against bacterial penetration and may help reduce infection, while helping to promote wound healing.

References

20. KCI data on file.
23. KCI data on file.

V.A.C. GranuFoam Silver® Dressing
A New Antimicrobial Silver Foam Dressing Specifically Engineered for Use with V.A.C.® Therapy
Introduction

Infection control

Infections complicate the treatment of wounds and impede the healing process by damaging tissue, reducing wound tensile strength and inducing an undesirable inflammatory response. Thus, controlling or preventing infections is essential in order for the healing process to progress normally.

The V.A.C.® (Vacuum Assisted Closure®) Therapy System helps promote wound healing by removing fluid and infectious materials through the application of localized negative pressure to the wound. Ionic silver has long been recognized as an effective antimicrobial against a broad spectrum of pathogens and is considered to be biocompatible with mammalian tissue. V.A.C.® Therapy with silver can be an effective therapy to help promote wound healing by combining the benefits of localized negative pressure therapy with the antimicrobial activity of silver. A new dressing, V.A.C. GranuFoam Silver® Dressing, has been designed for this purpose. It is an open-cell, reticulated polyurethane foam that has been microbonded with metallic silver via a proprietary metallization process. During V.A.C.® Therapy, exposure of the dressing to wound fluid results in oxidation of metallic silver to ionic silver, allowing the continuous, sustained release of silver ions for antimicrobial activity against microorganisms that come in contact with the ions.

Bacterial resistance

The resurgence of interest in silver products for wound care stems from the increase in the level of bacterial resistance to traditional antibiotics. For example, rates of methicillin-resistant Staphylococcus aureus (MRSA) infections increased steadily over the past decade from about 30% in 1989 to approximately 40% in 1997 among ICU patients. Unlike traditional antibiotics, ionic silver binds to and damages microbial cell walls at multiple sites and has various mechanisms of action. The existence of these multiple sites and various mechanisms of action make it difficult for microorganisms to develop resistance to silver because they would have to undergo several mutations in order to develop defense mechanisms against the multi-pronged attack of silver. Thus, silver became the antimicrobial of choice when the V.A.C. GranuFoam Silver® Dressing was designed.

While not specifically recommended or promoted by KCI, other adjunctive antimicrobial dressings have been reported to be used with V.A.C.® Therapy. These dressings are placed underneath the wound-contacting surface of the current V.A.C.® GranuFoam® Dressing. The use of such adjunctive dressings may inhibit negative pressure and granulation. As a one-step solution, the V.A.C. GranuFoam Silver® Dressing simplifies dressing application by combining the attributes of the standard V.A.C.® GranuFoam® Dressing with the antimicrobial activity of silver. The result can be user-friendly, simple, fast and more effective dressings. Additionally, the V.A.C. GranuFoam Silver® Dressing has been specifically engineered for use with V.A.C.® Therapy while adjunctive antimicrobial dressings have not. The V.A.C. GranuFoam Silver® Dressing is the only silver dressing that allows the GranuFoam® pores to come in direct and complete contact with the wound.
Foam Structure

In in-vitro models, application of V.A.C.® Therapy induces micromechanical effects at the dressing-to-tissue interface resulting in tissue undulations and cellular microdeformation (Figure 2). This reinforces the importance of maintaining the open-cell, reticulated foam structure of the dressing. These are key design characteristics necessary to help promote wound healing by assisting tissue granulation and ultimately contributing to successful clinical outcomes.15-17

Effective therapy

As a design requirement for the V.A.C. GranuFoam Silver® Dressing, it was essential to maintain the open-cell, reticulated foam structure with a pore dimension of approximately 400-600 microns (µm) to assist granulation tissue formation. The structure of the V.A.C. GranuFoam Silver® Dressing and thickness of the silver coating was examined using scanning electron microscopy (SEM) to ensure equivalency to non-coated V.A.C.® GranuFoam® Dressing. Pieces of the foam were freeze-fractured, and the fractured pieces were placed on adhesive-backed conductive disks and mounted on SEM studs for subsequent imaging. An artist’s rendering illustrates the highly porous, reticulated structure of the V.A.C.® GranuFoam® Dressing (Figure 3), which allows uniform pressure distribution during V.A.C.® Therapy. SEM further details a uniform silver coating thickness of approximately 3 µm (Figure 4), thus preserving the 400-600 µm pore size of the dressing.

Granulation

A non-infected porcine model of acute wound healing was used to determine if granulation formation rates would be compromised through the introduction of the silver component in the V.A.C. GranuFoam Silver® Dressing as compared to the uncoated V.A.C.® GranuFoam® Dressing while under negative pressure.

A total of nine domesticated Yorkshire pigs (55-63 kg) received 5cm full-thickness dorsal wounds on each side of the spine under a protocol approved by an Institutional Animal Care and Use Committee. Each treatment group consisted of a total of 24 full-thickness wound sites. A three-factor repeated measure of variance (location, treatment, and time) was performed to compare rates of granulation based on wound volume measurements for the V.A.C.® GranuFoam® Dressing and V.A.C. GranuFoam Silver® Dressing treatment groups.

On an intra-treatment assignment basis, changes from baseline (Day 0) were evaluated using a paired-difference t-test. Each dressing was sized to fit the shape of each wound and sealed with a V.A.C. Drape. A V.A.C. Therapy unit was then applied at 125 mmHg of continuous therapy, and dressing changes occurred every 48 hours. A total of four dressing changes occurred through the duration of the study, with full granulation achieved on Day 8. Volumetric wound measurements were taken following wound creation on Day 0 and upon removal of the dressings on Days 2, 4, 6 and 8. The methodology to quantify wound volume involved covering and sealing each wound site with an adhesive drape, injecting a known amount of sterile saline with a 25cc syringe and completely filling the void in the wound bed with saline to be flush with the adjacent intact skin.

Figure 5. Shows the rates of granulation measured by differences in wound volume. No significant differences were detected among the baseline volume measurements, suggesting that the initial wound volumes were equivalent between the two treatment groups. The data revealed that the addition of the silver component in the V.A.C. GranuFoam Silver® Dressing did not impede granulation rates, and resulted in no significant difference (95% confidence interval) when compared to the non-silver V.A.C.® GranuFoam® Dressing.
Sustained Silver elution

Exposure of V.A.C. GranuFoam Silver® Dressing to an aqueous environment causes oxidation of metallic silver, which results in the sustained release of silver ions. While the concentration of silver ions released impacts antimicrobial efficacy, too high a concentration could lead to tissue toxicity. The V.A.C. GranuFoam Silver® Dressing was engineered to release a sufficient amount of silver that would produce the desired antimicrobial activity. Additionally, biocompatibility studies based on ISO 10993 International Standards test for tissue and bone contact simulating use on open wounds have shown that V.A.C. GranuFoam Silver® Dressing is non-toxic and non-sensitizing.

An in-vitro silver elution study showed that V.A.C. GranuFoam Silver® Dressing provided sustained release of ionic silver up to 72 hours (Figure 6). The approximate concentration of silver in the extract solution at 72 hours for V.A.C. GranuFoam Silver® Dressing (3 ppm) was shown to be between that of Acticoat™ Ag (ConvaTec, Princeton, NJ dressing (<1 ppm) and Acticoat™ 7 Day (Smith and Nephew, Largo, FL) dressing (20 ppm)) under identical experimental conditions.

Figure 6. Silver elution profile of V.A.C. GranuFoam Silver® Dressing in aqueous media determined using a silver ion selective electrode.

It is important to note that this elution testing was performed under ideal laboratory conditions without the benefit of negative pressure wound therapy. In-vivo results may differ depending on the wound size, dressing surface area, exudate volume, temperature and biological complexity of the wound fluid present.

Animal testing suggests that V.A.C. Therapy plays an important role for providing silver at the dressing/wound interface. The V.A.C. GranuFoam Silver® Dressing was engineered specifically for use with V.A.C. Therapy. Under the identical protocol used to evaluate rates of granulation, 3mm wound biopsies were taken at the treatment sites in swine to determine localized levels of silver concentration (µg Ag/g of tissue) for all treatment groups (V.A.C. GranuFoam Silver® Dressing + Acticoat™ Dressing, V.A.C. GranuFoam Silver® Dressing, V.A.C. GranuFoam Dressing). The V.A.C. Therapy units were set at the standard default mode of 125mmHg of continuous negative pressure therapy. Baseline biopsies were taken prior to dressing placement on Day 0 and were not found to contain a significant difference between the mean silver concentration values for all treatment groups comparing Day 0 to Day 8 values, while both intra-treatment comparisons of V.A.C. GranuFoam Silver® Dressing + Acticoat™ Dressing and V.A.C. GranuFoam Silver® Dressing were determined to be significantly different from Day 0 to Day 8.

Previous research indicates that the ability of a silver-containing dressing to conform to the contours of a wound is important to reduce areas of noncontact where bacteria may proliferate. The compressible foam under negative pressure allows the V.A.C. GranuFoam Silver® Dressing to obtain excellent contact with the surface of the wound bed. Although in-vitro data showed V.A.C. GranuFoam Silver® Dressing to have lower elution concentrations than an adjunctive silver dressing, animal tests performed under negative pressure conditions revealed V.A.C. GranuFoam Silver® Dressing to result in less as much silver available at the wound site.

Sustained antimicrobial activity

Zone of inhibition (ZO). The zone of inhibition test is a quick and relatively inexpensive qualitative test that indicates whether or not a test article is antimicrobial against a given microorganism. It is therefore a useful screen if several organisms are to be tested. The test is conducted with a piece of the dressing that is placed on an agar plate previously inoculated with the challenge organism. After 24 hours of incubation, the zone of inhibition, defined as the zone with no organism growth, is noted. The presence of a zone of inhibition indicates that the sample is antimicrobial against the challenge organism. The V.A.C. GranuFoam Silver® Dressing demonstrated a zone of inhibition after a 24-hour contact with over 150 different microorganisms tested.

Quantitative Antimicrobial Test. Of the organisms that have been tested by the ZOI method, a subset of clinically relevant pathogens was selected for quantitative antimicrobial testing. The test was carried out by an independent laboratory following the ASTM E2149 standard test method for determining antimicrobial activity using the following challenge organisms: Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Candida albicans, Methicillin Resistant Staphylococcus aureus (MRSA) and Vancomycin Resistant Enterococcus (VRE). A sample of the dressing was added to 50 mL of the challenge organism at a concentration of approximately 105 CFU/mL and incubated at 37°C. At 0.5, 1, 2, 6, 24, 48 and 72 hours, the surviving organisms were plated and triplicate counts were performed to determine concentration of surviving organisms. For comparison, Acticoat™ Dressing and Aquacel® Ag Dressing were also tested.

The results indicated that the V.A.C. GranuFoam Silver® Dressing and Acticoat™ 7 Day Dressing had very similar efficacy against all the organisms tested, with both showing significant antimicrobial activity after only 30 minutes of contact with all the organisms (Figures 8-9). For example, after 30 minutes of contact between the dressing and the MRSA inoculum, the measurement of the concentration of surviving organisms was identical for V.A.C. GranuFoam Silver® Dressing and Acticoat™ Dressing being highly effective against the bacteria at the 30-minute time point (Figure 11). Aquacel® Ag Dressing did not produce a similar reduction in bacterial concentration at the 30-minute time point. Although in-vitro data showed V.A.C. GranuFoam Silver® Dressing to have lower elution concentrations than the Acticoat™ Dressing, V.A.C. GranuFoam Silver® Dressing maintains a comparable level of antimicrobial performance. The V.A.C. GranuFoam Silver® Dressing releases sufficient amounts of silver that can help achieve effective antimicrobial activity.

Figure 7. Endpoint for silver concentration in wound biopsies.

Figure 8. Antimicrobial activity of V.A.C. GranuFoam Silver® Dressing against six pathogens during a 72-hour period.

Figure 9. Antimicrobial activity of V.A.C. GranuFoam Silver® Dressing, Acticoat™ Dressing, and Aquacel® Ag Dressing against six pathogens during a 24-hour period.

Figure 10. Antimicrobial activity of V.A.C. GranuFoam Silver® Dressing, Acticoat™ Dressing, and Aquacel® Ag Dressing against MRSA at early time points.

Figure 11. Antimicrobial activity of V.A.C. GranuFoam Silver® Dressing, Acticoat™ Dressing, and Aquacel® Ag Dressing against VRE at early time points.