

# Evaluation of Chronic Wound Treatment with the SNaP Wound Care System versus Modern Dressing Protocols

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**Background:** Traditional negative-pressure wound therapy systems use an electrically powered pump to generate negative pressure at the wound bed. The SNaP Wound Care System is a novel, ultraportable device that delivers negative-pressure wound therapy without the use of an electrically powered pump.

**Methods:** At an outpatient wound care clinic, 21 subjects with difficult-to-treat lower extremity ulcers received treatment with the SNaP System and were evaluated for wound healing for up to 4 months. Outcomes were then compared with 42 patient-matched controls treated at the same center with modern wound care protocols that included the use of Apligraf, Regranex, and skin grafting.

**Results:** In the SNaP-treated group, 100 percent of subjects demonstrated improvement in wound size and 86 percent (18 of 21) exhibited a statistically significant healing trend ( $p < 0.05$ ). Using Kaplan-Meier estimates of wound healing, SNaP-treated subjects healed in an average of  $74.25 \pm 20.1$  days from the start of SNaP treatment and the matched controls healed in an average of  $148.73 \pm 63.1$  days from the start of conventional treatment. This significantly faster healing time represents a 50 percent absolute reduction in time to healing ( $p < 0.0001$ ) for subjects treated with the SNaP device.

**Conclusions:** The findings reported here for the SNaP Wound Care System are similar to published reports for powered negative-pressure wound therapy devices for the treatment of highly challenging lower extremity wounds. This study suggests that the SNaP Wound Care System may be a useful addition to the techniques available to the wound care clinician. (*Plast. Reconstr. Surg.* 126: 1253, 2010.)

Chronic wound treatment with negative-pressure wound therapy is an important clinical tool, with multiple published studies reporting improved granulation tissue formation and decreased time to wound healing.<sup>1-3</sup> Numerous negative-pressure wound therapy systems are available on the market today, including the KCI (Kinetic Concepts, Inc., San Antonio, Texas) wound vacuum-assisted closure device and the Smith & Nephew (London, United Kingdom) Renasys systems. However, these systems have a number of drawbacks, including their size and bulk, noise,

need for an electrical power source, difficult procurement process, and cost. This study evaluates the SNaP (Smart Negative Pressure) Wound Care System (Spiracur, Inc., Sunnyvale, Calif.) (Fig. 1), a novel ultraportable negative-pressure wound therapy device that does not require an electrically powered pump. Instead, the SNaP System uses specialized springs to generate continuous negative pressure at the wound bed. Because of the special configuration of the springs, a near constant level of negative pressure is delivered over time to the wound, even in the face of exudates.

The SNaP System consists of five basic elements: the cartridge, activation/reset key, hydro-

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**Fig. 1.** The SNaP Wound Care System. The  $-125$ -mmHg cartridge is shown.

colloid dressing layer with integrated nozzle and tubing, holster with strap, and an antimicrobial gauze wound interface layer. The cartridge is currently capable of delivering three different preset pressure levels ( $-75$  mmHg,  $-100$  mmHg, and  $-125$  mmHg), and is small enough to be worn on a patient's leg, arm, or belt and completely hidden under normal clothing. The cartridge portion of the device weighs less than 3 ounces and has a canister capacity of approximately 60 ml for wound exudates. Because there is no electrical pump, operation of the SNaP System is silent. The SNaP System is also entirely disposable, eliminating the added administrative and support costs of the current rental-based system used by most electrically powered pumps.

Previous studies have shown that negative-pressure delivery by the SNaP System has similar characteristics to powered pumps in biomechanical testing and an animal wound-healing model.<sup>4</sup> In addition, an earlier clinical series at an academic outpatient clinic demonstrated that the SNaP System can be used safely and effectively for treating a subset of less refractory chronic wounds.<sup>5</sup>

The goal of this study was to evaluate the SNaP System for the treatment of more difficult chronic wounds of the lower extremity. Specifically, we wanted to evaluate the impact of integrating the SNaP System as an adjunct to modern wound treatment protocols for diabetic and venous ulcers using both prospective observational analysis and retrospective match-controlled comparisons.

## PATIENTS AND METHODS

Prospective observational and retrospective match-controlled clinical studies were performed to evaluate the safety and efficacy of the SNaP System for the treatment of difficult lower extremity wounds. The studies were performed at the O'Connor Wound Care Center in San Jose, California, with the approval of the O'Connor Hospital Institutional Review Board.

### Prospective Observational Study

Potential subjects were screened for eligibility on referral to or during routine treatment visits at the O'Connor Wound Care Center. Written informed consent was obtained for those patients who met the study eligibility criteria, and negative-pressure wound therapy was initiated using the SNaP System. Subjects were followed for up to 4 months or to wound closure, whichever came first. Wound measurements, wound photographs, adverse events, and treatment data were captured on a biweekly basis.

Patients were included in the study if they were older than 18 years, presented with a chronic wound on the lower extremity less than 10 cm in greatest diameter and greater than 1.5 cm in narrowest diameter, and surrounded by 2 cm or more of intact epithelium around the wound edges. In addition, the wound must not have healed following greater than 14 days of use of traditional treatments.

Patients were excluded from the study if they had active wound infection, no pedal pulse assessable by Doppler, a history of malignancy at the wound site, or thick eschar at the base of the wound after débridement, or if the wound location was not amenable to forming a reliable dressing seal. Also, patients were excluded if the ulcers were attributable to inflammatory conditions (i.e., pyoderma gangrenosum, rheumatoid arthritis, vasculitis, cryoglobulinemia, necrobiosis lipoidica diabetorum, lupus or pancreatic panniculitis, cryofibrinogenemia, calcinosis cutis, scleroderma, or Raynaud syndrome); the patients had current warfarin anticoagulation; had wounds with exposed bone, blood vessels, or tendon; or were pregnant. In addition, patients unable to give informed consent or comply with study procedures (including lack of telephone access) were excluded from the study.

All outpatients underwent standard wound care clinic intake evaluations, including history, physical examination, and wound assessment. Débridement of necrotic tissue was performed ac-

cording to standard of care for the specific wound type. Duration of negative-pressure wound therapy was determined by the treating clinician, and negative-pressure wound therapy was discontinued if the clinician felt that adequate healing had occurred to no longer require its use.

For the prospectively treated SNaP subjects, photographic wound surface area analysis was performed using imaging software (UTHSCSA Image Tool, Version 3.0; University of Texas Health Sciences Center, San Antonio, Texas). These tracing data were used to provide a precise assessment of wound surface area. A linear regression model based on the number of days in the study was performed to evaluate the trend toward healing of wounds treated with the SNaP System. Because of the variability between subjects and wound characteristics in the SNaP-treated group, the analysis was performed on a per-patient basis.

### Retrospective Comparison Study

In the retrospective phase of the study, patients treated at the O'Connor Wound Care Center over the past 4 years were screened by means of chart review to identify retrospective controls that matched the wound characteristics and comorbidities of the SNaP-treated subjects. The O'Connor Wound Treatment Database allowed for potential matches to be generated based on wound type and wound size. Once potential matches were identified, charts were reviewed individually to identify a match based on patient age

( $\pm 10$  years), wound type (venous or diabetic), wound age ( $\pm 25$  percent), initial wound size ( $\pm 25$  percent surface area), and the presence or absence of diabetes and peripheral vascular disease. To be considered a match, the retrospective subject had to satisfy each of the matching criteria for a specific SNaP-treated subject. Two unique matches were identified for each SNaP-treated subject, and after confirming the match, all available wound treatment and demographic data were captured retrospectively for comparative wound-treatment analysis. To minimize bias in the retrospective group, matches were generated before reviewing wound treatment data and patient outcomes.

The SNaP-treated subjects and the matched controls were grouped into a treatment and a control group, respectively, and a Kaplan-Meier survival analysis was performed to evaluate the differences in time required for healing.<sup>6,7</sup> As no photographic or tracing data were available for the historical controls, surface area measurements and closure data from the patient chart were used for both groups to allow for more similar comparisons. Wound characteristics and demographics were also compared to evaluate the degree of similarity between the groups. Data analyses were performed using SAS version 9.0 (SAS Institute, Inc., Cary, N.C.).

## RESULTS

Subjects were enrolled prospectively into the first phase of the study starting in August of 2008,

**Table 1. Study Demographics**

	Match (n = 42)	SNaP (n = 21)	p
Matching characteristics			
Age, yr	66.8 $\pm$ 13.4	64.0 $\pm$ 15.5	0.485
Male	45.2% (19/42)	42.9% (9/21)	0.857
Diabetes	57.1% (24/42)	57.1% (12/21)	1.000
PVD	42.9% (18/42)	47.6% (10/21)	0.720
Wound type diabetic	50.0% (21/42)	47.6% (10/21)	0.858
Wound type venous	50.0% (21/42)	52.4% (11/21)	0.858
Wound length, mm	32.2 $\pm$ 21.0 (42)	36.6 $\pm$ 26.8 (21)	0.515
Wound width, mm	21.2 $\pm$ 16.4 (42)	21.9 $\pm$ 13.5 (21)	0.858
Wound depth, mm	3.4 $\pm$ 3.2 (42)	5.0 $\pm$ 3.2 (21)	0.069
Wound age, yr	0.6 $\pm$ 1.5 (40*)	0.7 $\pm$ 1.4 (20*)	0.800
Comorbidities			
Immunosuppressive/steroid use	9.5% (4/42)	23.8% (5/21)	0.146†
History of osteomyelitis	4.8% (2/42)	23.8% (5/21)	0.036†
Previous amputation	14.3% (6/42)	9.5% (2/21)	0.708†
Smoker	20.0% (8/40)	42.9% (9/21)	0.068
History of cancer	14.3% (6/42)	4.8% (1/21)	0.408†
Pulmonary disease	9.5% (4/42)	19.0% (4/21)	0.423†
Hypertension	88.1% (37/42)	76.2% (16/21)	0.259
Hyperlipidemia	42.9% (18/42)	52.4% (11/21)	0.474

PVD, peripheral vascular disease.

\*Patient 018 and patient 018's matched controls were excluded as outliers (no close matches were found for a 19-year-old SNaP-treated wound).

†Fisher's exact test was used because of small samples sizes in either one or both groups.

and the last subject completed treatment with the SNaP System in September of 2009. There were a total of 36 subjects enrolled prospectively in the first phase of the study, and 21 subjects completed treatment with the SNaP device. Of the 15 subjects that did not complete the study, two subjects were hospitalized for unrelated medical issues and subsequently removed from the study, six subjects were not compliant with the protocol requirements and follow-up, and seven subjects had complications that required premature termination of SNaP treatment. Of these seven subjects, one had an allergic skin reaction to the hydrocolloid dress-

ing, one developed a wound infection requiring discontinuation of therapy, one was discontinued after bleeding from débridement prevented reapplication of the device, one was discontinued because of worsening lower extremity edema, and three patients developed maceration severe enough to require discontinuation of therapy. Data for these dropped patients were incomplete and thus not included in the final analysis.

The demographic analysis for the SNaP-treated patients who completed the study revealed a group of highly refractory wounds (Table 1). The historical control subjects closely matched the treatment group for major wound-healing risk factors. Matching characteristics were expected to be close to identical, as they were the basis for the match; however, it is of note that the additional comorbidities captured were also similar between the groups. History of osteomyelitis was the only comorbidity that was found to be significantly different ( $p < 0.05$ ) between the groups. It should be noted that for wound age, one of the SNaP-treated patients had a wound present for 19 years, and this patient and his matches were excluded from the analysis because no matches could be identified with wound age of comparable duration.

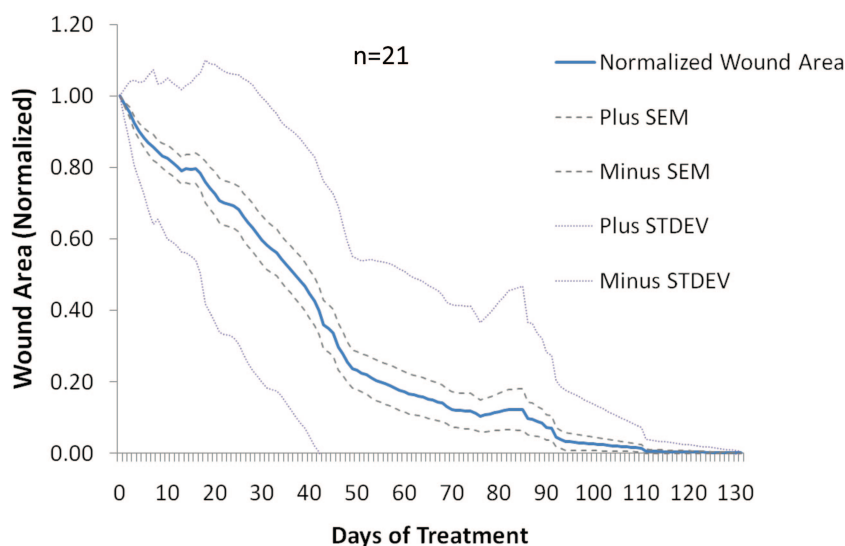
### Prospective Results

In the SNaP-treated group, 75 percent of subjects (21 of 28) participating in the study tolerated treatment without complications. The seven subjects that could not tolerate treatment were discontinued from the study because of complications and were considered treatment failures. No further data were captured for these patients. In

**Table 2. Regression Analysis on SNaP-Treated Subjects**

Patient ID	Slope	<i>p</i>
001	-0.022	<0.0001*
003	-0.040	0.0335*
004	-0.031	0.0101*
005	-0.021	0.0002*
008	-0.005	0.1812
009	-0.032	0.0825
011	-0.015	0.0013*
012	-0.013	0.0849
014	-0.026	0.0213*
015	-0.056	0.0012*
016	-0.042	<0.0001*
018	-0.116	0.0044*
019	-0.040	<0.0001*
022	-0.058	<0.0001*
023	-0.045	<0.0001*
024	-0.028	0.0002*
026	-0.029	<0.0001*
028	-0.050	0.0002*
030	-0.056	<0.0001*
034	-0.069	0.0097*
036	-0.060	0.0092*

\* $p < 0.05$ .



**Fig. 2.** Normalized wound area tracing data over time for SNaP-treated patients.



the SNaP-treated subjects that tolerated treatment, 100 percent of subjects demonstrated improvement in wound size and 86 percent (18 of 21) exhibited a statistically significant healing trend ( $p < 0.05$ ). As shown in Table 2, regression analysis of wound healing over time for each of the 21 subjects resulted in consistently negative slopes of varying magnitude, demonstrating that although the speed of healing varied for each subject, all 21 subjects experienced a trend toward wound healing over the 4-month study period. Average treatment time using the SNaP System was  $7.44 \pm 3.78$  weeks. Normalized average wound size is shown in Figure 2 with the SEM and SD. Case examples of some of the subjects treated are shown in Figures 3 through 7.

### Retrospective Comparison

Kaplan-Meier estimates of wound healing at 1, 2, 3, and 4 months of treatment were 0, 20, 66.2, and 83.1 percent, respectively, for the SNaP-treated subjects.<sup>6,7</sup> Compared with the matched controls, there was a 47.4 percent absolute improvement in the percentage of wounds healed when subjects were treated with the SNaP device as compared with modern dressings over a 4-month period (Table 3).

Because so few of the matched-controlled wounds healed in the 4-month time frame as compared with the SNaP-treated subjects, data beyond 4 months were gathered for the matched controls and were evaluated with a Kaplan-Meier survival analysis to provide a more meaningful comparison of the relative time it took for wounds to heal in each treatment group (Fig. 8).<sup>6,7</sup> For those subjects with wound healing, average time to healing was found to be significantly reduced ( $p < 0.0001$ ) in those subjects treated with the SNaP System as compared with matched subjects receiving modern dressings.

In those reporting wound healing, the SNaP-treated subjects healed in an average of  $74.25 \pm 20.1$  days from the start of SNaP treatment, and the matched controls healed in an average of  $148.73 \pm 63.1$  days from the start of conventional treatment ( $p < 0.0001$ ). This significantly faster healing time represents a 50 percent absolute reduction in time to healing for those treated with the SNaP System. There was also less variation observed in the SNaP-treated subjects than in the matched controls, with an SD of 20 days as compared with the 63-day SD reported for the matched controls. It is of note that this reduced variability was identified in a group with half the sample size of the matched controls.

When each individual SNaP-treated subject was analyzed as compared with their matched



**Fig. 3.** Case 1. (Above) An 88-year-old woman presented with a venous ulcer. Comorbidities included diabetes mellitus, peripheral arterial disease, rheumatoid arthritis, venous insufficiency, hypertension, asthma, and prednisone use. Wound history included diabetic/venous stasis ulcer present for over 1 year without wound closure despite over 1 year of treatment in a wound care center with compression and multiple modern dressings/therapies, including topical Regranex. Negative-pressure wound therapy consisted of treatment with the SNaP Wound Care System for 11 weeks. (Below) Wound closure was achieved at 12 weeks following initiation of negative-pressure wound therapy.

controls, time to healing also appeared to be reduced in the SNaP-treated subjects as compared with the matched controls. The average difference in time to healing between each SNaP-treated subject and their matched control(s) was  $54.27 \pm 28.1$  days ( $p < 0.0001$ ) in favor of the SNaP-treated subjects.

### Apligraf Application

The difference in Apligraf application was also evaluated for each treatment group. Because the matched-controlled subjects were followed for a longer period than the SNaP-treated subjects, an



**Fig. 4.** Case 2. (Left) A 77-year-old woman presented with a mixed diabetic/venous/arterial wound. Comorbidities included diabetes mellitus, severe peripheral arterial disease, smoking, chronic obstructive pulmonary disease, hypertension, hyperlipidemia, bone cancer, and severe malnutrition (weight, <90 pounds). Wound history included a venous ulcer present for over 8 months, continuing to enlarge despite wound care with modern dressings and treatment with Apligraf (Organogenesis, Inc., Canton, Mass.). (Center) Negative-pressure wound therapy consisted of treatment with the SNaP Wound Care System for 11 weeks until full granulation of the wound bed was achieved. Apligraf was then applied. (Right) Wound closure was achieved at 4 months following initiation of negative-pressure wound therapy.



**Fig. 5.** Case 3. (Left) A 65-year-old man presented with a diabetic foot wound. Comorbidities included insulin-dependent diabetes mellitus, hypertension, and hyperlipidemia. Wound history included osteomyelitis and gangrene requiring second-toe amputation. Negative-pressure wound therapy consisted of treatment with the SNaP Wound Care System for 4 weeks. (Right) Wound closure was achieved at 5 weeks following initiation of negative-pressure wound therapy.

absolute comparison of the number of Apligraf dressings applied was not appropriate. Rather, the rate of graft application was calculated for each subject based on the number of Apligraf dressings applied and the number of days in the study to provide an equal comparison of Apligraf dressing applica-

tion in each group. In the SNaP-treated subjects, Apligraf dressing application occurred at less than half the rate ( $0.0099 \pm 0.0087$  grafts per day) than in the matched-controlled subjects ( $0.0219 \pm 0.0267$  grafts per day). This difference was statistically significant, with a value of  $p = 0.0355$ .





**Fig. 6.** Case 4. (Left) A 68-year-old man presented with a diabetic foot wound. Comorbidities included diabetes mellitus, smoking, peripheral vascular disease, coronary artery disease, chronic obstructive pulmonary disease, hypertension, and hyperlipidemia. Wound history included trauma to dorsal foot from a door. (Center) Negative-pressure wound therapy consisted of treatment with the SNaP Wound Care System for 3 weeks until full granulation of the wound bed was achieved. Apligraf was then applied. (Right) Wound closure was achieved at approximately 9 weeks following initiation of negative-pressure wound therapy.



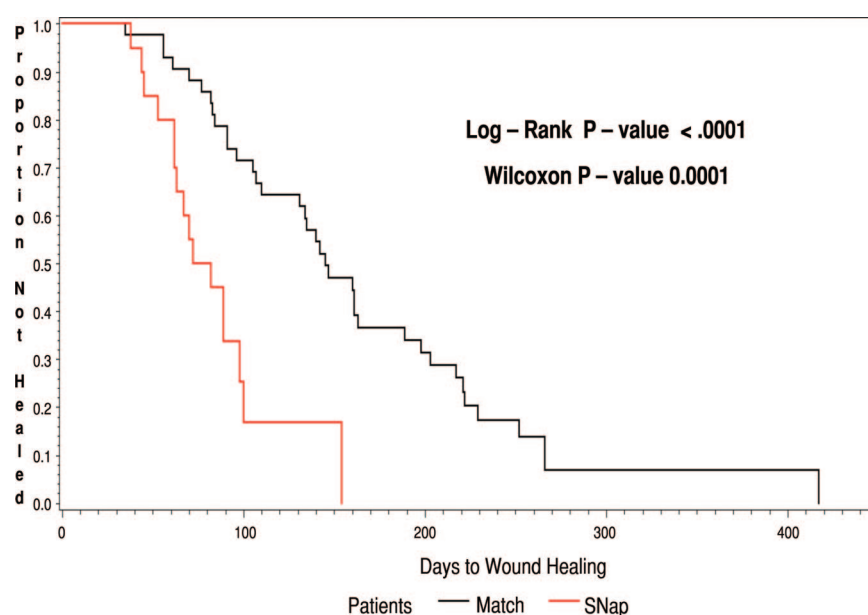
**Fig. 7.** Case 5. (Left) A 62-year-old woman presented with a diabetic foot wound. Comorbidities included type 1 diabetes mellitus, hypertension, and hyperlipidemia. Wound history included osteomyelitis and gangrene requiring second- and third-toe amputations. The wounds were slow to heal after 1 month of traditional dressings. (Center) Negative-pressure wound therapy consisted of treatment with the SNaP Wound Care System for 4 weeks until full granulation of the wound bed was achieved. Apligraf was then applied. (Right) Wound closure was achieved at 10 weeks after initiation of negative-pressure wound therapy.

## DISCUSSION

Chronic wounds of the lower extremity, including diabetic foot ulcers and venous stasis ulcers, are major health care problems. Negative-pressure wound therapy has been shown to be effective in treating these types of wounds.<sup>1,2</sup> However, the most widely used negative-pressure wound therapy devices are bulky and noisy, require an electrical power

**Table 3. Kaplan-Meier Estimates of Wound Healing**

	1 Month (%)	2 Months (%)	3 Months (%)	4 Months (%)
Match ( <i>n</i> = 42)	0.0	7.1	21.4	35.7
SNaP ( <i>n</i> = 21)	0.0	20.0	66.2	83.1



**Fig. 8.** Kaplan-Meier survival analysis.<sup>6,7</sup> In those reporting wound healing, the SNaP-treated subjects healed in an average of  $74.25 \pm 20.1$  days from the start of SNaP treatment, and the matched controls healed in an average of  $148.73 \pm 63.1$  days from the start of conventional treatment ( $p < 0.0001$ ). This significantly faster healing time represents a 50 percent absolute reduction in time to healing for those treated with the SNaP System.

source, are difficult to procure, and are costly to use. This study examines the clinical effectiveness of a new ultraportable negative-pressure wound therapy device with a prospective observational study and retrospective case-control comparison to modern wound care protocols.

Patients treated in this study were a group with highly refractory lower extremity diabetic and venous ulcers. For these types of wounds, treatment with the SNaP System resulted in statistically significant reduced healing time and a higher rate of wound closure than treatment with standard modern dressing therapy. These results are similar to published reports treating similar wounds using electrically powered negative-pressure wound therapy devices.<sup>1,2</sup>

In our clinic, we use multiple modalities to heal wounds, including the frequent use of Apligraf, a bilaminar tissue-engineered biological dressing that has established effectiveness in treating diabetic and venous ulcers.<sup>8,9</sup> Because the adherence and effectiveness of Apligraf and other tissue-engineered dressings depend on adequate wound bed preparation, negative-pressure wound therapy may play an important role in speeding the preparation of the wound bed before their use. Because Apligraf was used in both SNaP and control patient groups, the data from this study

suggest that using Apligraf together with negative-pressure wound therapy may result in better wound-healing outcomes than use of Apligraf alone. We successfully used the SNaP System to prepare wounds before initiating Apligraf treatment. Using this serial therapy approach, we found that the use of Apligraf and total healing times were decreased in those patients treated with the SNaP System.

Although the early clinical outcomes with the SNaP Wound Care System may be similar to those of other powered systems, there are a number of less obvious potential advantages of the SNaP System over traditional negative-pressure wound therapy systems. In a comprehensive overview of negative-pressure therapy for the treatment of lower extremity ulcers, Capobianco and Zgonis<sup>10</sup> identify a number of key disadvantages of traditional negative-pressure wound therapy systems, including decreased patient autonomy, increased anxiety levels during treatment, high cost and unavailability of the therapy for patients in less medically sophisticated countries, and the potential for exsanguination. Because of its unique design, the SNaP System may prove to better address some of these other disadvantages of powered negative-pressure systems.



The SNaP System is a gauze-based negative-pressure wound therapy system. Recent studies support that gauze-based systems have results comparable to foam dressings when used in negative-pressure wound therapy.<sup>11</sup> Using an in vivo porcine wound model, Borgquist et al. showed that the resultant microdeformation and macrodeformation of the wound bed after negative-pressure therapy are similar with foam and gauze.<sup>12</sup> Clinically, the data in this study support the findings of the retrospective evaluation performed by Campbell et al. that demonstrated similar clinical outcomes using a gauze-based negative-pressure wound therapy system to those reported with foam.<sup>11</sup>

Although the data presented in this study are promising, several considerations should be taken into account when interpreting these results. First, retrospectively controlled studies are inherently limited by design. Second, patients treated in the SNaP arm of the study may have benefited from the effects of being in an experimental environment. Moreover, consistent with most longitudinal wound care studies, this study also had a relatively high dropout rate. Finally, study subjects had twice-weekly dressing changes while being treated with the SNaP System compared with the more variable follow-up in the control group. This may have also resulted in differences in débridement frequency. Although it is doubtful that the very large treatment effects seen in the data are solely attributable to the issues above, they must be considered in the interpretation of these results.

### CONCLUSIONS

The SNaP Wound Care System can be an effective tool in treating highly refractory chronic diabetic and venous ulcers. The advantages in size and convenience for both patients and clinicians, as compared with powered devices, would make the SNaP Wound Care System for us a desirable choice for patients with appropriate wounds that would benefit from negative-pressure wound therapy. This study suggests that the SNaP Wound Care System may be a useful addition to the techniques available to the wound care clinician. An

ongoing randomized controlled trial of the SNaP Wound Care System, which is currently in progress, may further elucidate the value of this novel system in the application of negative-pressure therapy for wound treatment.

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### REFERENCES

1. Armstrong DG, Lavery LA. Negative pressure wound therapy after partial diabetic foot amputation: A multicentre, randomised controlled trial. *Lancet* 2005;366:1704–1710.
2. Vuerstaek JD, Vainas T, Wuite J, Nelemans P, Neumann MH, Veraart JC. State-of-the-art treatment of chronic leg ulcers: A randomized controlled trial comparing vacuum-assisted closure (V.A.C.) with modern wound dressings. *J Vasc Surg*. 2006;44:1029–1037; discussion 1038.
3. Argenta LC, Morykwas MJ, Marks MW, DeFranzo AJ, Molnar JA, David LR. Vacuum-assisted closure: State of clinic art. *Plast Reconstr Surg*. 2006;117(Suppl):127S–142S.
4. Fong KD, Hu D, Eichstadt S, et al. The SNaP System: Biomechanical and animal model testing of a novel ultraportable NPWT system. *Plast Reconstr Surg*. 2010;125:1362–1371.
5. Fong KD, Hu D, Eichstadt SL, et al. Initial clinical experience using a novel ultraportable negative pressure wound therapy device. *Wounds* (in press).
6. Kalbfleisch JD, Prentice RL. *The Statistical Analysis of Failure Time Data*. New York: Wiley; 1980.
7. Lee ET. *Statistical Methods for Survival Data Analysis*. 2nd ed. New York: Wiley; 1992.
8. Edmonds M. Apligraf in the treatment of neuropathic diabetic foot ulcers. *Int J Low Extrem Wounds* 2009;8:11–18.
9. Barber C, Watt A, Pham C, et al. Influence of bioengineered skin substitutes on diabetic foot ulcer and venous leg ulcer outcomes. *J Wound Care* 2008;17:517–527.
10. Capobianco CM, Zgonis T. An overview of negative pressure wound therapy for the lower extremity. *Clin Podiatr Med Surg*. 2009;26:619–631.
11. Campbell PE, Smith GS, Smith JM. Retrospective clinical evaluation of gauze-based negative pressure therapy. *Int Wound J*. 2008;5:280–286.
12. Borgquist O, Ingemansson R, Malmjö M. Negative pressure wound therapy using gauze and foam: An in-detail study of the effects on the wound bed including macro- and microdeformation, tissue ingrowth and wound bed histology. Paper presented at the 24th Annual Clinical Symposium on Advances in Skin & Wound Care; October 22–25, 2009; San Antonio, Texas.