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Use of a New Dressing Protocol in Chronic Lower Extremity Wounds on Homebound Patients: A Retrospective Study

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Use of a New Dressing Protocol in Chronic Lower Extremity Wounds on Homebound Patients: A Retrospective Study

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ABSTRACT

BACKGROUND: Chronic, nonhealing wounds significantly impact older patients and overall health care spending. Frequent outpatient treatment visits and dressing changes are the primary cost drivers. This dynamic changed during the COVID-19 pandemic when care shifted to patients' homes to minimize patient and provider exposure to the virus. **PURPOSE:** The objective of this study was to determine if the use of a new dressing protocol—an advanced wound matrix dressing consisting of collagen, alginate, carboxymethyl cellulose, and ethylenediaminetetraacetic acid combined with ionic silver and a secondary 5-layer absorptive dressing containing superabsorbent polymer with a silicone border—applied by advanced practice certified wound care nurses at the patient's residence could be effective in rapid wound resolution. **METHODS:** A retrospective review of 30 adult homebound patients with chronic leg wounds that were treated twice weekly with the new dressing protocol was performed. **RESULTS:** Prior to implementing the new dressing protocol, the average wound treatment time was 20.9 ± 8.9 weeks. Following the adoption of the new dressing protocol, the average time to complete wound closure was 5.7 ± 2.0 weeks. Time to heal was reduced by 73% compared with the prior treatment regimen, which utilized an ovine forestomach–derived extracellular matrix and bordered gauze dressing. **CONCLUSION:** The unique design of the dressings used with the new protocol is theorized to be the reason for the accelerated healing. In addition to accelerated healing time, the reduced need for physician visits and frequent dressing changes has the potential to have a positive impact on treatment cost and patient quality of life.

KEY WORDS: collagen, wound healing, wound matrix dressing, carboxymethyl cellulose, ethylenediaminetetraacetic acid, absorptive dressing, superabsorbent polymer, silicone dressing

Chronic, nonhealing wounds are a condition that primarily affect older patients. Of the population older than 65 in the United States, 3% have a chronic, nonhealing wound.[1] This prevalence has a significant economic impact on the health care system with more than 8 million Medicare beneficiaries accounting for $28 to $97 billion in health care spending related to wound management.[1] The primary cost driver in the treatment of chronic, nonhealing wounds is outpatient management, which includes treatment visits (facility and home health) for dressings and adjunctive therapies.[1,2] Use of home health care as an adjunctive measure to help reduce the need for frequent outpatient appointments has recently increased sharply in response to the global COVID-19 pandemic. However, these appointments are still major drivers of the overall cost of care.[3]

At the onset of the COVID-19 pandemic, wound care was deemed a nonessential service. As a result, outpatient services were limited in order to reduce the potential for virus exposure among care providers and patients, many of whom were considered immunocompromised or at greater risk of contracting the SARS-CoV2 virus.[4] However, delayed, limited, or nonexistent management of chronic wounds can quickly lead to serious complications such as infection, hospitalization, need for surgery, amputation, and potentially death.[1,4] Providers had to adapt quickly to the new environment to continue to provide necessary patient care while minimizing contact and the potential for virus transmission.[5] The optimal way in which to do this would be to provide wound treatment that would accelerate resolution while minimizing the need for frequent dressing changes and patient–provider interaction. To that end, the objective of this study was to determine the efficacy of a new dressing protocol—a primary dressing with an advanced wound matrix consisting of collagen, alginate, carboxymethyl cellulose (CMC), and ethylenediaminetetraacetic acid (EDTA) with silver and a secondary 5-layer absorptive dressing containing superabsorbent polymer (SAP) with a silicone border—to heal lower extremity wounds in homebound patients.

METHODS

This was a retrospective study of prospectively collected data on 30 consecutive patients treated in their homes with

a new dressing protocol for management of lower extremity ulcerations. Patients included in the study were 18 years of age or older, homebound, had adequate perfusion for healing determined by a vascular surgeon, and had a chronic wound that had failed to progress with ≥ 4 weeks of current standard-of-care treatment. All patients gave written informed consent to participate in the study.

Patients were seen twice weekly in their homes by advanced practice certified wound care nurses for dressing changes. Wound evaluations were performed once a week and consisted of written and photo documentation of the wound and periwound skin. Wound measurements were taken at each weekly visit by recording the greatest length, width, and depth of the wound, documenting any undermined or tunneled areas. Aggressive debridement was then performed to remove necrotic tissue in the wound bed. The study dressing protocol was implemented when healthy, red, granular tissue appeared in the base of the wound bed. An advanced wound matrix dressing consisting of collagen, alginate, CMC, and EDTA with antimicrobial silver (ColActive PLUS Ag, Covalon Technologies, Ltd) was applied directly to the wound bed. A secondary dressing consisting of a 5-layer absorptive dressing containing SAP with a silicone border (Zetuvit Plus Silicone Border, Paul Hartmann AG) was then applied. The 5 layers of the secondary dressing consisted of 1) a silicone contact layer and border to prevent wound bed adherence and to minimize potential trauma during dressing changes, 2) a diffusion layer for quick and uniform distribution of exudate, 3) a superabsorbent core for exudate sequestration, 4) a water-repellent layer to prevent fluid entry into the dressing, and 5) a protective backing that was showerproof, breathable, and bacterial- and viral-proof for further protection of the wound from the outside environment. Compression bandage systems were not used in patients with venous leg ulcers (VLUs) to avoid pain. Wound resolution was defined as a wound 100% reepithelized, with no presence of drainage and not requiring a dressing.

Statistical analysis. Patient demographics and wound characteristics were abstracted from patients' medical records. All data were calculated using descriptive statistics and reported as average ± standard deviation.

RESULTS

The study involved 30 patients with chronic lower extremity ulcerations. Ten of these patients had pressure injuries of the lower extremity. The remaining 20 patients had lower extremity wounds (7 patients had arterial leg ulcer and 13 patients had venous leg ulcer). None of the patients had a diabetic foot ulceration. The average patient age was 80.8 ± 12.2 years (range, 42.2–103.7). The average wound treatment time prior to the implementation of the new dressing protocol was 20.9 ± 8.9 weeks (range, 8–40). The average baseline wound size at the start of treatment was 36.9 ± 40.7 cm^2 (range, 1.4–183.0). The average time to healing after implementation of the new dressing protocol was 5.7 ± 2.0 weeks (range, 2.0–10.0) (Table 1). Patient characteristics and wound types are presented in Table 2.

DISCUSSION

The results of this study demonstrate that the use of a new dressing protocol consisting of an advanced wound matrix of collagen, alginate, CMC, EDTA, and antimicrobial silver combined with a 5-layer absorptive SAP dressing with a silicone border led to resolution of chronic lower extremity ulcerations in less than 2 months. The ideal dressing for chronic lower extremity ulcerations is one that 1) creates an environment conducive to healing, 2) treats and prevents biofilm formation within the wound and on the dressing, 3) manages exudate while maintaining a moist wound environment to promote healing, 4) provides protection from the external environment, 5) does not stick to the wound to minimize trauma with dressing changes, 6) has a good moisture vapor transmission rate, and 7) is cost-effective.[6,7] The combination of the advanced collagen wound matrix and layered SAP secondary dressing, implemented in conjunction with standard of care, possesses each of the key characteristics above and effectively advanced healing in this group of patients.

A wound environment conducive to healing is one that stimulates growth and addresses factors that can delay healing. This includes maintaining a delicate balance between matrix metalloproteinases (MMPs) and tissue inhibitors of metalloproteinases (TIMPs) to preserve a functional and supportive extracellular matrix, allowing for cellular infiltration and vessel in-growth to occur.[8-11] Research on the imbalance of MMP and TIMP levels in the exudate of chronic wounds has shown significantly increased levels of MMP-1 and MMP-3 and reduced levels of TIMPs.[11] This imbalance, favoring activity of MMPs, leads to a persistent inflammatory state due to continuous degradation of extracellular matrix components, growth factors, cytokines, and other factors essential to wound healing, ultimately stalling the healing process.[9,10] A dressing that effectively manages moisture by absorbing and retaining MMP-containing exudate away from the wound bed not only removes MMPs from newly formed tissues, but also prevents periwound skin maceration/excoriation that can further damage tissue and lead to increased wound size. The extended tissue damage also increases the risk of localized tissue infection.[12] To ensure inadequate moisture management does not hinder the healing progress, care must be taken to select dressings capable of handling varying levels of exudate for the duration required by the care plan.

Both dressings used as part of the study protocol were equipped to manage exudate, performing well in the areas of fluid absorption and retention. The advanced wound matrix forms a hydrated gel that maintains a moist healing environment and has greater

Table 1. Patient Age, Wound Size, Wound Duration, and Time to Heal

Patient no.	Age (years)	Baseline wound size (cm^2)	Average treatment time (weeks)[a]	Time to heal (weeks)[b]
1	42.2	17.2	28.0	6.0
2	63.9	22.8	18.0	2.0
3	69.7	64.8	15.0	6.0
4	70.4	70.6	16.0	7.0
5	72.5	5.0	16.0	5.0
6	73.0	18.0	12.0	5.0
7	74.1	183.0	40.0	10.0
8	75.9	48.0	32.0	6.0
9	76.0	45.5	28.0	6.0
10	77.0	15.0	26.0	7.0
11	77.0	12.0	16.0	3.5
12	77.5	6.0	20.0	5.0
13	77.6	15.0	32.0	6.0
14	77.6	71.4	16.0	5.0
15	78.6	9.0	12.0	4.0
16	79.6	10.0	23.0	3.0
17	81.3	15.8	16.0	4.0
18	81.8	110.9	36.0	10.0
19	82.2	6.7	16.0	4.5
20	82.6	67.5	8.0	7.0
21	84.5	105.0	35.0	10.0
22	87.6	23.1	36.0	8.0
23	87.7	9.7	16.0	5.0
24	91.2	15.0	20.0	4.0
25	91.2	14.4	12.0	5.0
26	91.6	60.0	12.0	5.0
27	94.0	8.1	12.0	5.0
28	100.3	18.0	19.0	4.0
29	102.8	1.4	12.0	4.0
30	103.7	39.0	28.0	8.0
Mean ± standard deviation	**81.5 ± 12.2**	**36.9 ± 40.7**	**20.9 ± 8.9**	**5.7 ± 2.0**

[a]Prior to switching to the new dressing protocol.
[b]Average time of treatment after switching to the new dressing protocol.

absorbency than other collagen-based wound dressings, likely due to the combination of alginate and CMC within its formulation.[13] The alginate, naturally derived from seaweed, and CMC, a nontoxic, seminatural polymer that is biocompatible, both have a high affinity for water,[14,15] conferring superior water absorption and swelling capabilities.[7] Preclinical trials demonstrated the ability of CMC to absorb fluid while maintaining a moist wound environment to prevent necrosis and promote fibroblast proliferation.[7,14,15] The SAP of the secondary dressing absorbs fluids via the matrix, locking the exudate into the core of the dressing to protect surrounding skin and increase time between dressing changes. Together, the advanced wound matrix and 5-layer SAP dressing functioned well to manage a range of wounds with varying exudate levels while maintaining a moist environment, showing a capacity to limit the number of dressing changes to twice weekly.

The study dressing protocol addresses MMPs through a multimodal approach. In addition to removing MMP-containing exudate away from the wound bed, the introduction of denatured collagen provides a sacrificial substrate for proteases, potentially sparing new tissue from degradation. Furthermore, the EDTA contained within the advanced wound matrix is a chelator of zinc ions, required for MMP activity.[9,10] EDTA's ability to bind zinc within the wound environment offers a more direct mechanism for addressing elevated protease activity known to contribute to wound chronicity.

Ethylenediaminetetraacetic acid (a nontoxic, metal chelating agent) was developed to prevent biofilm formation on medical devices due to its antimicrobial effects against gram-positive and gram-negative bacteria, yeasts, amoeba, and fungi.[6] Biofilms are complex structures that consist of an exopolymeric substance (EPS) and provide a barrier to host immune response and antibiotic penetration, allowing for selection and persistence of a variety of antibiotic-resistant bacteria, viruses, protozoa, and fungi.[16] The EPS structure of biofilm is dependent on metal ions for development, sustainability, and maintenance.[17] Chelation of metals (such as calcium, magnesium, zinc, and iron) reduces cross-linking, increases water solubility of the EPS, destabilizes cell walls (leading to biofilm disruption), and increases antimicrobial penetration (improving susceptibility to traditional antimicrobial agents).[6,17,18] Furthermore, bacterial adhesion is also inhibited by EDTA, potentially blocking biofilm formation on the wound bed and the dressing, preventing the dressing from serving as a biofilm/bacterial reservoir. Brief exposure of 24- and 48-hour biofilms to low-percentage EDTA solutions has been shown to significantly reduce cell density of *Staphylococcus aureus* and *Pseudomonas aeruginosa*.[17] In addition, irrigation with EDTA in wound models with and without exposed bone or hardware inoculated with bacterial strains commonly encountered in open fractures, including antibiotic-resistant strains, resulted in a significant decrease in time to heal and the number of surgical procedures required to achieve culture-negative wounds when compared to irrigation with olive oil–based soap, benzalkonium chloride, and bacitracin, all of which can be toxic to tissues.[18] Incorporation of EDTA into dressings is a recognized strategy for addressing biofilms and elevated protease activity.[9,10]

As the most abundant protein in the body, collagen plays a critical role in wound healing. A recent systematic review confirmed the utility of collagen in wound healing, regardless of source or processing methods.[19] In the current study, the collagen-based contact layer used as part of the new dressing protocol helped to stimulate healing and address factors that commonly lead to chronicity in lower extremity ulcerations. The results reported here are consistent with those reported in a recent case series on the use of the same advanced wound matrix to treat complex, chronic VLUs

Table 2. Patient Characteristics and Wound Types

Characteristics	No. (%) (N = 30)
Sex	
Male	13 (43%)
Female	17 (57%)
Race	
White, Non-Hispanic	6 (20%)
African American	6 (20%)
Hispanic	16 (53%)
Other	2 (7%)
Type of wound	
Arterial leg ulcer	7 (23%)
Venous leg ulcer	13 (43%)
Pressure injury	10 (33%)

for which the baseline mean wound duration was 25 months and wound size was 11.3 cm^2.[20] Increased wound duration and size are both known risk factors for delayed healing.[21] Despite an average wound duration of over 2 years, use of the same primary dressing in the case series by Alavi et al[20] on chronic VLUs accelerated healing, resulting in an average decrease in wound size by 73% at 8 weeks. Although the baseline wound duration prior to the implementation of the new dressing protocol in the current study is less than reported by Alavi et al, the average wound size is much greater (11 vs 37 cm^2).[20] All 30 patients in the current study achieved complete resolution at an average of 5.7 weeks. These results provide further evidence to support the efficacy of the new dressing protocol in the treatment of chronic lower extremity wounds of increased duration and size.

Dressing removal has the potential to harm new tissue within the wound bed and the periwound skin, particularly for elderly patients and those with compromised skin integrity. Use of silicone contact layers has been shown to reduce wound and periwound trauma, resulting in less pain during dressing changes.[12] An open-label, noncomparative trial of 52 patients treated with the secondary dressing used in this study reported that exudate management as the primary objective was achieved in 94% of the wounds.[12] The dressing's performance related to exudate management decreased the occurrence of maceration from 45% to 28% in the wound and 28% to 15% on the periwound area. Pain during dressing changes was also reduced from 2.5 to 1.4 on the 10-point Visual Analog Pain scale and, importantly, a shift to extended wear time with use of the SAP silicone border dressing was also observed, with 72% of patients' dressing changes being every third day or longer.[12] Similar findings were seen in the current study, in which dressing changes needed to be performed only twice weekly due to the absorptive properties of the secondary dressing.

Decreasing the frequency of provider visits and dressing changes has the potential to reduce health care expenditure related to the management of chronic, nonhealing wounds, thus having a positive impact on the patients' healing journey and the health system as a whole. A Markov economic model on the use of the secondary SAP dressing used in this study for the treatment of VLUs found the regimen to be the most cost-effective when compared with 4 other similar dressing types due to reduced frequency of dressing changes needed and improved healing rates.[22]

Before implementing the new dressing protocol reviewed in this study, the author used an ovine forestomach–derived dressing processed to retain extracellular matrix proteins (Endoform, Aroa Biosurgery Limited) with a bordered gauze dressing (ReliaMed, Cardinal Health) as a secondary dressing. Healing rate reported with dressing changes occurred once to twice weekly on a variety of wounds, with treatment time ranging between 8 and 22 weeks.[23-25] Use of the new dressing protocol presented in this paper reduced the average healing time by 73% compared to the prior wound care protocol. The following 2 representative cases from this series highlight the healing achieved following the transition to the new dressing protocol.

The first patient was a 77-year-old obese White/Hispanic female with long-standing diabetes (20 years) and bullous pemphigoid ulcerations on the lower left leg. Baseline wound measurements were 35.5 cm × 29.9 cm × 0.2 cm. After 2 weeks of treatment, the wound had reduced in size by 78.6%. Wound resolution was achieved at 5 weeks of

Figure 1. Patient 1. **A)** At admission. **B)** At midpoint of treatment. **C)** Wound resolved.

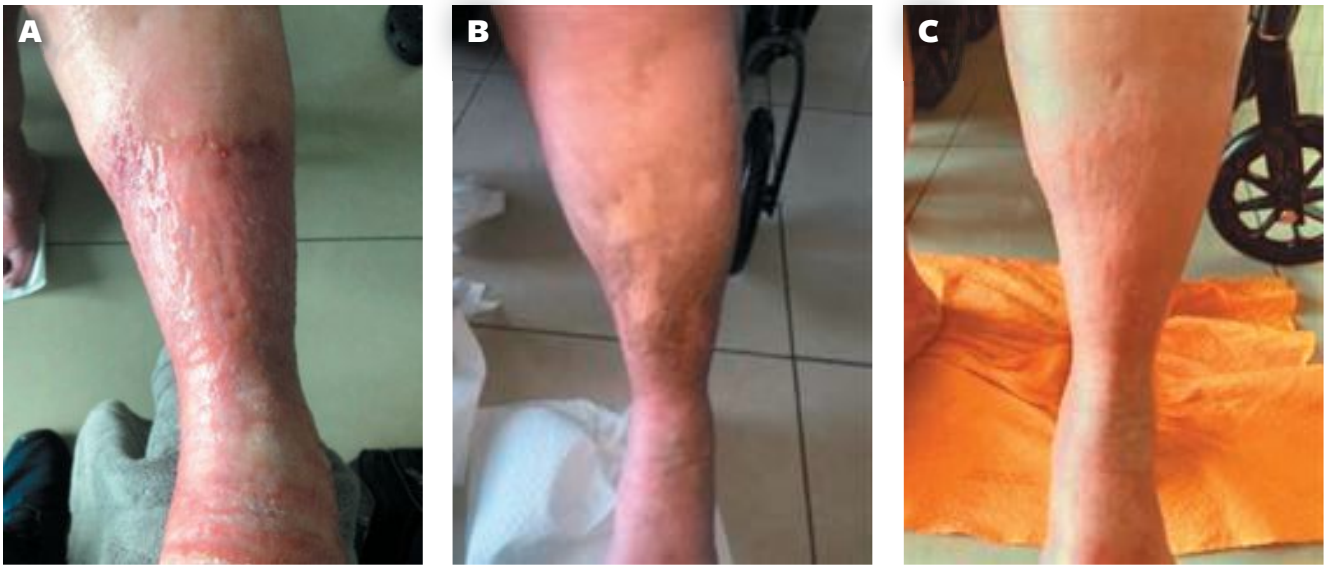

Figure 2. Patient 2. **A)** At admission. **B)** At midpoint of treatment. **C)** Wound resolved.

treatment (Figure 1). The second patient was a 76-year-old obese White/Hispanic female with congestive heart failure and long-standing diabetes (15 years) with a VLU on the lower left leg. Baseline wound measurements were 15.6 cm × 22.9 cm × 0.2 cm. After 4 weeks of treatment, the wound had reduced in size by 78.2%. Wound resolution was achieved at 7 weeks (Figure 2).

Although compression therapy is the standard of care in VLU and lower limb ulceration treatment, neither of the patients were able to utilize this intervention. The first patient had intolerable pain with initial attempts at compression. Compression therapy was not used in the second patient due to their congestive heart failure diagnosis. Despite the inability to use compression therapy, rapid wound resolution was achieved with the new dressing protocol.

The observed acceleration of healing rates associated with the use of the new dressing protocol is hypothesized to be due to the unique composition of the primary dressing combined with the functional design of the secondary dressing used in this study. The combination of collagen, alginate, CMC, EDTA, and antimicrobial silver within the primary dressing as well as the secondary 5-layer absorptive SAP dressing with a silicone border optimized the wound environment to stimulate healing, assist in moisture management, and control biofilm. These evidenced-based results combined with the author's personal experience led to the adoption of the new dressing protocol presented in this study as the standard of care in the author's practice.

The author is an Advanced Wound Care Specialist and CEO of MedSource Consultants, which is a walk-in clinic in Miami, Florida, located inside a community pharmacy. Providers at this facility treat patients ages 13 and older on a walk-in or appointment basis, with services provided by a staff of 4 individuals who are advanced practice nurses holding either a Master of Science in Nursing or Doctor of Nursing Practice with board certification in wound care. Guiding values of this clinic are patient-centered, compassionate, and attentive care delivered by experienced providers. In addition, care received in the clinic is followed by an average of twice-weekly house calls at patient private homes, skilled nursing facilities, and assisted living facilities.

Importantly, use of the new dressing protocol presented minimizes the need for physician oversight and frequent dressing changes. The positive clinical outcomes demonstrated in this study were the result of the unique and interactive dressing combination and the implementation of a distinctive patient treatment model that includes a combination of wound clinic visits and house calls by the providers. The prevalence of patients with a chronic wound in the United States has overwhelmed clinics and physician providers.[1] In a 5-year retrospective study of patients with nonhealing wounds managed in outpatient wound care centers, 66% of all patients experienced healing with an average time to heal of 15 weeks (range, <1 week–5 years).[2] Half of these patients experienced healing in a moist healing environment without the use of advanced therapies (ie, hyperbaric oxygen therapy, skin substitutes, or negative pressure wound therapy). Patients that did not experience healing were seen for an average of 16 weeks, with 10% continuing to be seen for up to 39 weeks. These cases with extended treatment durations that span many months or

years have a significant negative impact on cost of care.

Decreasing the frequency of dressing changes and physician outpatient visits while accelerating healing can reduce the financial impact of wound care and improve patients' quality of life and care experience. The ability of up to 50% of patients to experience healing and the reduction of healing time, need for physician assessment, frequent dressing changes, and outpatient visits show the potential impact of this new dressing protocol on the cost of care. Delivery of care in this fashion also minimized potential for spread of infectious diseases, such as COVID-19, in this at-risk population.

LIMITATIONS

The main limitation of this study is the lack of data reporting on the healing results seen with the dressings used before implementation of the new dressing protocol. Although this was not performed, there is extensive literature published on the healing results seen with the ovine forestomach–derived dressing used previously.[22-24] The largest study included 2222 patients, of which 1150 were treated with the ovine forestomach–derived dressing and 1072 were treated with a collagen/oxidized regenerated cellulose dressing.[22] Healing rates for these two dressings were 15 weeks and 16 weeks, respectively. This average healing rate mirrors the average 15-week healing rate seen in patients who experience healing in the 5-year retrospective review of patients treated at the outpatient wound care centers presented above.[2] Thus, a 15-week average healing rate with the prior dressing used by the provider is likely a realistic average.

CONCLUSION

Treatment of chronic, nonhealing wounds has a significant impact on older patients and health care costs. Management of wounds during the COVID-19 pandemic served as the impetus to manage these wounds by the most effective means with a minimal amount of patient–provider face-to-face contact to reduce exposure to the novel coronavirus. The new dressing protocol used in this study provided an environment conducive to healing, managed biofilm and exudate, protected the wound, and was cost-effective. Accelerated wound healing was achieved due to a reduced need for patient-provider visits and frequent dressing changes. Further studies are needed to provide additional support regarding the clinical use and cost-effectiveness of this new dressing protocol.

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