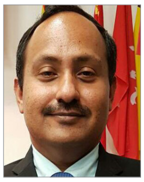
Use of a unique bioelectric dressing in chronic wound healing



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Antimicrobial wound dressings are one of the many dressings available on the market for the management of wounds. They provide a moist wound healing environment, which is suitable for partial- and full-thickness chronic wounds, such as pressure ulcers (PU), diabetic foot ulcers (DFU) and venous ulcers. The aim of this study was to evaluate the efficacy of a unique bioelectric dressing in chronic wound healing. This case series reviews five patients selected randomly with chronic non-healing wounds; one chronic venous ulcer, two DFUs, one vasculitic ulcer and one post-surgical non-healing wound. Wounds were assessed using the TIMES concept before being cleansed with distilled water. Debridement was performed where necessary. Amorphous gel was applied as conduction fluid before the application of a bioelectric dressing. The wound was covered with a foam dressing. A crepe bandage was used for the post-surgical wound, vasculitis and diabetic foot ulcers. A two-layer compression bandage was applied to the chronic venous ulcer. DFUs were offloaded using padding. In this case series, all five wounds healed completely and there were no adverse events reported. Bioelectric dressings have proven to be effective in managing infection and promoting wound healing. The limitation of this case series is the small sample number, which might not represent the larger population.

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It is estimated that up to 2% of the population in developed countries suffer from chronic wounds (Nussbaum et al, 2018). Research from MedMarket Diligence (2018) and Wound Research Foundation (2013–2019) showed that billions were spent on wound products globally, with at least 6.7 million Americans and 20 million worldwide treated for chronic wounds per year. The annual cost of providing chronic wound care services in the US is projected to be US$ 20–50 billion per year (MedMarket Diligence, 2018) and in developed countries, consumes 3–5% of total healthcare expenditure (Järbrink et al, 2017).

It is well known that chronic ulcers such as pressure ulcers (PU), diabetic foot ulcers (DFU) and venous ulcers are hard-to-heal wounds. In addition, it is also important to note that the recurrence rates of these chronic wounds is very high. Research by Bruin Biometrics (2013) showed that the recurrent rate of pressure ulcers (PU) is 31–79%. A study by Lavery et al (2016) stated that DFUs have a recurrence rate of 8–59%. As for venous ulcers, a recurrence rate of 70% was estimated by Wound Research Foundation (2013–2019).

In a study by Sen (2019), it was demonstrated that the recurrence rate of chronic wounds may be as a result of the presence of biofilm, due to the aggregation of microbes. Biofilm infections can hinder wound healing or cause defective wound closure, leading to wound recurrence. In a different systematic review and meta-analysis study, Malone et al (2017) showed that 78% of wounds are infected by bacterial biofilm. This is the key cause of delayed wound healing, as it shields the infection from the patient's immune response and antibiotics (Sen, 2019).

Skin, the largest organ of the body acts as a first-line defence mechanism to protect the body against microorganism. Electric fields, which exist naturally in the skin, create the surface energy potential (voltage) known as transepithelial potential (TEP). Therefore, the skin is deduced as the largest battery in the body. In intact skin, it is approximated that the human skin electric potential is between 0.010–0.060V. When the skin is wounded, TEP is disrupted (Foulds and Barker, 1983; Zhao, 2009; Dubé et al, 2010). TEP disruption induces an electric field directed toward the middle of the wound (Dubé et al, 2010). This initiates cell migration and re-epithelialisation (Foulds and Barker, 1983; Zhao, 2009; Dubé et al, 2010). When skin regeneration is completed, TEP is restored (Moulin et al, 2012).

Antimicrobial wound dressings are one of the many dressings available on the market for the management of wounds. They provide a moist wound healing environment, which is suitable for partial and full-thickness chronic wounds, such as PUs, DFUs and venous ulcers. The newest V.Dox™ technology incorporated in antimicrobial dressings resulted in the production of a unique bioelectric dressing. This unique bioelectric dressing, patented with V.Dox technology, employs moisture-activated microcell batteries that are designed to mimic the skin's electric energy. Hence, this dressing may substantially reduce the risk of infection by killing a broad spectrum of bacteria without antibiotics, while supporting the body's natural healing process (Kim and Izadjoo, 2015).

In vitro studies by Banerjee et al (2015) and Kim and Izadjoo (2015) showed that bioelectric dressings were effective against both monospecies, as well as multispecies biofilm-forming bacteria. It was also proven that silver dressing alone are unable to disrupt *Pseudomonas aeruginosa* biofilms (Banerjee et al, 2015). Bioelectric dressings exhibited bacterial activity against antibiotic-sensitive multidrug-resistant strains and multiple antibiotic-resistant strains of wound pathogens, but *Enterococcus* species are bacteriostatic (Kim et al, 2014). Also, human keratinocytes exposed to bioelectric dressing demonstrated significantly accelerated cell migration (Banerjee et al, 2014). In a prospective case series, skin graft harvested sites demonstrated significantly greater re-epithelialisation with bioelectric dressing, when compared with standard dressings (Blount et al, 2012).

Objective

To evaluate the efficacy of a unique bioelectric dressing in chronic wound healing.

Methodology

This study was done by simple randomisation, which involved the application of a bioelectric dressing on five patients with chronic non-healing wounds. The study was carried out in an outpatient setting at the Wound Care Unit, Kuala Lumpur Hospital, Malaysia (WCUHKL). Patients were given standard of care by a WCUHKL nurse. Wounds were assessed using the TIMES concept. The wound was cleansed using distilled water and debridement was performed where necessary. Amorphous gel was applied as conduction fluid before the application of a bioelectric dressing. The wound was covered with a foam dressing. A crepe bandage was used for the post-surgical wound, vasculitis and DFUs.

Case study 1

A 55-year-old Indian woman who had previously been in a motor vehicle accident, which resulted in a fracture of the right ankle. She had no known medical illness. Internal fixation was done on the right ankle. The patient was referred with a post-surgical non-healing ulcer. Wound size was 1.0cm x 1.0cm, with biofilm suspected. The wound comprised of 80% granulation tissue and 20% epithelial tissue, with moderate exudate levels *(Figure 1a)*. The results showed that there was a significant reduction in the wound size percentage and the wound healed in 22 days *(Figure 1b)*.

Figure 1a. Day 1:
On 02 December 2019,
Wound size measured 1.0cm x 1.0cm

Figure 1b. Day 22:
On 23 December 2019, the wound was healed

Case study 2

A 58-year-old Indian man with underlying hypertension, dyslipidemia and gout. The patient was referred with a vasculitic ulcer over the left lower limb lateral malleolus. The wound measured 3.5cm x 2.0cm and comprised of 80% granulation tissue and 20% sloughy tissue, with surrounding dry skin *(Figure 2a)*. The results showed that there was a significant reduction in the percentage of ulcer size and the wound healed in 43 days *(Figure 2b)*.

Figure 2a. Day 1:
On 14 January 2020,
Wound size measured 3.5 cm x 2.0 cm

Figure 2b. Day 43:
On 25 February 2020, the wound was healed

Case study 3

A 71-year-old Indian woman, with underlying type 2 diabetes mellitus. The patient was referred with a diabetic foot ulcer over the left foot. Wound size was 3.0cm x 2.0cm. Biofilm was suspected. Wound edges were macerated, with moderate exudate levels. The wound was not tender, erythematous or warm and there was no sign of pus discharge *(Figure 3a)*. The results showed that there was a significant reduction in ulcer size percentage and the wound healed in 93 days *(Figure 3b)*.

Figure 3a. Day 1:
On 21 October 2019,
Wound size measured 3.0 cm x 2.0 cm

Figure 3b. Day 93:
On 25 February 2020, the wound was healed

Case study 4

A 55-year-old Malay man, with underlying type 2 diabetes mellitus. The patient was referred with a diabetic foot ulcer over the right ankle region *(Figure 4a)*. The wound measured 9.5cm x 7cm and comprised of 90% granulation tissue and 10% epithelial tissue, with surrounding dry skin *(Figure 4b)*. The results showed that there was a significant reduction in ulcer size percentage and the wound healed in 92 days.

Figure 4a. Day 1:
On 14 January 2020,
Wound size measured 9.5 cm x 7.0 cm

Figure 4b. Day 92:
On 14 April 2020, the wound was healed

Case study 5

A 63-year-old Chinese woman with underlying eczema and varicose veins. The patient was referred with a right venous leg ulcer at the lower 3rd lateral aspect. The wound comprised of 80% granulation tissue and 20% sloughy tissue, with surrounding dry skin and yellowish moderate exudate identified. The wound measured 4.0cm x 2.5cm *(Figure 5a)*. The results showed that there was a significant reduction in ulcer size percentage and the wound healed in 92 days *(Figure 5b)*.

Figure 5a. Day 1:
On 02 December 2019,
Wound size measured 4.0 cm x 2.5 cm

Figure 5b. Day 92:
On 23 December 2019, the wound was healed

Table 1. Case study summary

Case	Diagnosis	Last day of treatment	Percentage reduction (%)	Size before treatment (cm^2)	Size after treatment (cm^2)
1	Post-surgical non-healing wound	22	100.00	1.00	0.00
2	Vasculitic ulcer	43	100.00	7.00	0.00
3	Diabetic foot ulcer	93	100.00	6.00	0.00
4	Diabetic foot ulcer	92	100.00	66.50	0.00
5	Chronic venous ulcer	92	100.00	10.00	0.00

A two-layer compression bandage was applied to the chronic venous ulcer. DFUs were offloaded using padding.

The study was performed in accordance with the principles of good clinical practice guidelines, in compliance with the declaration of Helsinki and with approval by the hospital review board. Informed consent and permission to use clinical images and case details for publication/research purposes were obtained before the study.

Results

A total of five patients were recruited; consisting of one chronic venous ulcer, two DFUs, one vasculitic ulcer and one post-surgical non-healing wound. All five wounds healed completely and there were no adverse events reported *(Cases 1–5 and Table 1)* .

Discussion

The unique bioelectric dressing used in this study was Procellera™ Antimicrobial Wound Dressing. The dressing is powered by V. Dox, is a polyester substrate with embedded microcell batteries made of elemental silver and elemental zinc, optimal for wound healing. Research by McCaig et al (2005) and Banerjee et al (2014) demonstrated that electric fields regulate fundamental cell behaviour throughout the human body. Published studies on this one-of-a-kind non-antibiotic wound dressing have demonstrated it's ability to kill a broad-spectrum of microbes, including multidrug-resistant and biofilm-forming bacteria, thereby disrupting established biofilm infection and preventing biofilm from reforming (Banerjee et al, 2014; Kim et al, 2014; Banerjee et al, 2015; Kim and Izadjoo, 2015).

Conclusion

Bioelectric dressings are designed to mimic the skin's electrical energy, working within the same physiologic range as the skin's current during injury, which is essential for cell migration and wound healing. In the case series presented here, the non-healing wounds showed remarkable wound closure. Infection is one of the common factors which inhibits wound closure and a cause of non-healing wounds. Therefore, this bioelectric dressing is effective in managing these types of wounds. The limitation of this case series is the small sample number, which might not represent the larger population. A more robust randomised clinical trial is being planned to show the significant efficacy of this unique dressing. WAS

Declaration of interest:
Vomaris supplied the unique bioelectric dressings (Procellera) used for this study. The author has no conflicts of interest to declare.

References

Banerjee J, Ghatak PD, Roy S et al (2014) Improvement of human keratinocyte migration by a redox active bioelectric dressing. *PLoS One* 9(3):e89239

Banerjee J, Ghatak PD, Roy S et al (2015) Silver-zinc redox-coupled electroceutical wound dressing disrupts bacterial biofilm. *PLoS One* 10(3):e0119531

Blount A, Foster S, Rapp D et al (2012) The use of bioelectric dressings in skin graft harvest sites: a prospective case Series. *J Burn Care Res* 354–57

Bruin Biometrics (2013) *Pressure Ulcer Formation: Patients Populations at Highest Risk*. White Paper 1–7

Dubé J, Rochette-Drouin O, Lévesqueet P et al (2010) Restoration of the transepithelial potential within tissue-engineered human skin in vitro and during the wound healing process in vivo. *Tissue Eng* Part A 16(10): 3055–63

Foulds IS, Barker AT (1983) Human skin battery potentials and their possible role in wound healing. *Br J Dermatol* 515–22

Järbrink K, Ni G, Sönnergren H et al (2017) The humanistic and economic burden of chronic wounds: a protocol for a systematic review. *Syst Rev* 6(1):15

Kim H, Makin I, Skiba J et al (2014) Antibacterial efficacy testing of a bioelectric wound dressing against clinical wound pathogens. *Open Microbil J* 8: 15–21

Kim H, Izadjoo MJ (2015) Antibiofilm efficacy evaluation of a bioelectric dressing in mono- and multi-species biofilms. *J Wound Care* 24(Suppl2): S10–4

Lavery LA, Davis KE , Berriman SJ et al (2016) WHS guidelines update: diabetic foot ulcer treatment guidelines. *Wound Repair Regen* 24(1): 112–26

Malone M, Bjarnsholt T, McBain AJ et al (2017) The prevalence of biofilms in chronic wounds: a systemic review and meta-analysis of published data. *J Wound Care* 26(1): 20–5

McCaig C, Rajnicek AM, Song B et al (2005) Controlling cell behaviour electrically: current views and future potential. *Physiol Rev* 85(3): 943–78

MedMarket Diligence, LLC (2018) *Billions in global wound product sales, yet chronic wounds remain a chronic problem.* https://bit.ly/3aOYLfv (accessed on 29 April 2020)

Moulin VJ, Dubé J, Rochette-Drouin O et al (2012) Electric potential across epidermis and its role during wound healing can be studied by using an in vitro reconstructed human skin. *Adv Wound Care (New Rochelle)* 1(2):81–7

Nussbaum S, Carter JM, Fife CE et al (2018) An economic evaluation of the impact, cost, and medicare policy implications of chronic nonhealing wounds. *Value Health* 21(1):27–32

Sen C (2019). Human wounds and its burden: an updated compendium of estimates. *Adv Wound Care (New Rochelle)* 8(2): 39–48

Wound Research Foundation (2013–2019) The challenge. when was the last time you said "ouch!"? www.woundreach.org/why-wounds/the-challenge (accessed on 29 April 2020)

Zhao M (2009) Electrical fields in wound healing. an overriding signal that directs cell migration. *Semin Cell Dev Biol* 20(6): 674–82