Occlusive Wound Dressings Suitable for Use with Electrical Stimulation

Gerard J. Bourguignon, PhD, PT
David A. Marshall, MBA
Kang Chang, MS, EE
William Eaglstein, MD

ABSRACT: The electrical resistivity of eighteen different occlusive dressing was determined in order to identify those occlusive dressings which are suitable for applying electrical stimulation directly to wounds. Our results indicate that all six of the standard polyurethane film dressings tested have electrical resistivities which are too high (>10^9 ohm x cm^2) for use with the commonly available, clinical electrical stimulators. However, the hydrocolloid dressings (fully hydrated), hydrogel dressings, and two of the modified polyurethane dressings tested have sufficiently low resistivities for use in direct stimulation of the wound.

WOUNDS 1991;3(3):127-129

From the Department of Dermatology & Cutaneous Surgery, University of Miami School of Medicine, Miami, FL.

Address for correspondence: Department of Dermatology & Cutaneous Surgery (R-250), University of Miami School of Medicine, 1600 N.W. 10th Avenue, Miami, FL 33101.

Electrical stimulation is gaining attention as a treatment modality in wound healing – particularly with regard to non-healing or delayed healing wounds.[1-4] The most common method of applying electrical stimulation to wounds involves placing one of the electrodes directly over the wound. In most cases, it is advantageous not to remove the dressing every time electric stimulation is applied to the wound. Consequently, the wound dressing in place during stimulation must be able to conduct sufficient electrical current to produce the desired effect on the wounded tissue.

Table 1.

Electrical Resistivity of Occlusive Dressings

A. Polyurethane Film Dressings

Bioclusive™	6×10^9 ohm cm^2
Blisterfilm®*	2×10^9 ohm cm^2
Op-Site®	6×10^9 ohm cm^2
Tegaderm®	1×10^{10} ohm cm^2
Uniflex™	6×10^9 ohm cm^2
Visulin™	5×10^9 ohm cm^2

B. Modified Polyurethane Film Dressings

Omiderm™	3×10^5 ohm cm^2
Spandra®	1×10^{10} ohm cm^2
Viasorb™	3×10^7 ohm cm^2

C. Hydrocolloid Dressings (Hydrated)

Duoderm®	2×10^5 ohm cm^2
Intact™	7×10^6 ohm cm^2
J & J Ulcer Dressing™	8×10^6 ohm cm^2
Restore™ CX	2×10^5 ohm cm^2
Sween-A-Peel™	2×10^5 ohm cm^2
Ultec™	2×10^5 ohm cm^2

D. Hydrogel Dressings

Cutinova®	4×10^3 ohm cm^2
Elasto-Gel™	4×10^3 ohm cm^2
Vigilon® (with one film removed)	1×10^7 ohm cm^2
Vigilon® (with both films removed)	3×10^5 ohm cm^2

*non-adhesive area

Today, occlusive dressings are frequently utilized in the treatment of chronic wounds in order to maintain a moist wound environment which increases the rate of wound healing.[5] There are, however, many different types of occlusive dressings available; and they vary considerably in their physical and chemical properties.[6,7] Consequently, we decided to measure the electrical resistivity of eighteen different, commercially available occlusive wound dressings in order to determine which ones may be suitable for direct application of electrical stimulation through the wound dressing. These dressings have been categorized broadly as (a) polyurethane films, (b) modified polyurethane films, (c) hydrocolloids or (d) hydrogels.

Methods

Electrical resistance measurements were taken on a sample of each dressing (surface are = 2.2 cm^2) placed between two carbon-impregnated rubber electrodes which were connected to a Keithley 614 Electrometer. Since the actual resistance of any dressing is inversely proportional to the surface area of that dressing, all resistance measurements were standardized by converting to units of resistivity (ohm x cm^2). “Background” resistance (i.e. no dressing between the electrodes) was approximately 20 ohms which was insignificant compared to the resistance of the dressings tested (>10^5 ohms).

Before measuring the resistance, all dressings (except the standard polyurethane dressings and Spandra®) were “wet” (i.e. thoroughly moistened) by the addition of saline solution. Since the standard polyurethane dressings and Spandra® do not absorb water, they were measured “dry” with a small amount of conductivity gel (about ¼ cc) added to ensure good electrical contact between the electrode and the dressings. Soaking the standard polyurethane dressings for several hours in saline solution did significantly lower their resistivity.

The hydrocolloid dressings were all soaked in saline solution for several hours before measuring their resistance, since these dressings retain extremely high electrical resistivity values (> 10^9 ohm x cm^2) unless they are fully hydrated.

Results and Discussions

The electrical resistivity values obtained for eighteen different occlusive dressings, selected from four broad categories, are given in Table 1. Clearly, there is a very wide range of resistivity values – from about 10^5 to 10^{10} ohm x cm^2. Not surprisingly, the standard polyurethane film dressings have much greater resistivities (>10^9 ohm x cm^2) than either the hydrated hydrocolloid or hydrogel dressings (10^5 to 10^7ohm x cm^2). It is noteworthy that two of the modified polyurethane film dressings have much lower electrical resistivities (Omiderm™ 3 x 10^5 ohm x cm^2; Viasorb 3 x 10^7 ohm x cm^2) than the standard polyurethane film dressings.

With regard to the application of electrical stimulation, there is increasing evidence that the current density delivered to the wound should be in the microrampere / cm^2 range in order to enhance healing. [8-10] The maximum peak voltage produced by currently available, clinical electric stimulators is 500 volts. Using Ohm's Law (I = V/ R), one can determine that any dressing with a resistivity greater than 5 x 10^8 ohm x cm^2 will prevent passage of the minimum amount of current density required to affect the healing tissue (i.e. 10^{-6} amp / cm^2) even with a maximum applied voltage of 500 volts.

Therefore, all the standard polyurethane film dressings plus Spandra® (resistivities > 10^9 ohm x cm^2) appear to be suitable for direct application of electric stimulation through the wound dressing using the currently available clinical electrical stimulators. All of the other dressings tested, however, have low enough resistivities for use in direct electric stimulation of the wound. It should be noted that hydrocolloid dressings must be completely hydrated in order to allow sufficient electric current to pass through the dressing.

References

1. Weiss DS, Kirsner R, Eaglstein WH: Electrical stimulation and wound healing. *Arch Derm* 126;222-225:1990.
2. Kloth LC, Feedar JA: Accleration of wound healing with high voltage, monphasic pulsed current. *Phys Ther* 68;503-508:1988.
3. Carley PH, Wainapel SF: Electrotherapy for acceleration of wound healing: low intensity direct current. *Arch Phys Med Rehab* 66;443-446:1985.
4. Alvarez OM, Mertz PM, Smerbeck RV, Eaglstein WH: The healing of superficial skin wounds is stimulated by external electrical current. *J Invest Derm* 81;144-148:1983.
5. Eaglstein WH: Experiences with biosynthetic dressings. *J Am Acad Derm* 12;434-440:1985.
6. Falanga V: Occlusive wound dressing. *Arch Derm* 124;872-877:1988.
7. Alvarez, Rozint J, Wiseman D: Moist environment for healing: Matching the dressing to the wound. *Wounds* 1;35-51:1989.
8. Reich JD, Tarjan PP: Electrical stimulation of skin. *Int J Derm* 29;395-400:1990.
9. Picker RI: Low-volt pulsed microamp stimulation. *Clin Manag Phys Ther* 9;10-14:1989.
10. Biedebach MC: Accelerated healing of skin ulcers by electrical stimulation and intracellular physiological mechanisms involved. *Int J Acupunc Electro-ther* 14;43-60:1989.

Acknowledgment

Dressings for this study were provided by the Wound Care Information Institute, University of Miami School of Medicine, Miami, FL 33101.