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Occlusive Dressings and the Healing of Standardized Abrasions

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Context: Acute skin trauma during sport participation, resulting in partial-thickness abrasions, is common. The limited investigations focusing on the acute wound environment and dressing techniques and the subsequent lack of evidence-based standards complicate clinical wound care decisions.

Objective: To examine the effects of occlusive dressings on healing of standardized, partial-thickness abrasions.

Design: Controlled, counterbalanced, repeated-measures design.

Setting: University laboratory.

Patients or Other Participants: Sixteen healthy women (n = 10) and men (n = 6).

Intervention(s): Four standardized, partial-thickness abrasions were inflicted. Film, hydrogel, and hydrocolloid occlusive dressings and no dressing (control) were applied. Participants returned on postwound days 1, 3, 5, 7, 10, and 14 for digital imaging. Wound healing time was measured by change in wound contraction (cm^2) and change in wound color (chromatic red) and luminance in red, green, and blue color values.

Main Outcome Measure(s): Wound contraction, color (chromatic red), and luminance.

Results: A day-by-dressing interaction was found for wound contraction, color, and luminance. Post hoc testing indicated that the film and hydrocolloid dressings produced greater wound contraction than the hydrogel and no dressing on days 7 and 10. Film, hydrogel, and hydrocolloid dressings also resulted in greater wound contraction than the control on day 14. Hydrocolloid dressings produced smaller measures of color and greater measures of luminance than no dressing on day 7. Film, hydrogel, and hydrocolloid dressings also resulted in smaller measures of color and greater measures of luminance compared with no dressing on days 10 and 14.

Conclusions: When compared with the control (no dressing), the film, hydrogel, and hydrocolloid occlusive dressings were associated with a faster healing rate of partial-thickness abrasions across time measured by wound contraction, color, and luminance. Overall, these data indicate that occlusive dressings were more effective in healing than no dressing was.

Key Words: wound management, skin trauma, moist environment

Key Points

- Partial-thickness abrasions treated with film, hydrogel, and hydrocolloid occlusive dressings healed more quickly, as measured by wound contraction, color, and luminance, than those receiving no dressing.
- Additional studies are needed to determine the practicality, cost-effectiveness, and compliance level when occlusive dressings are used in the clinical setting.

Partial-thickness abrasions often are sustained during participation in athletic and recreational activities. The selection and use of appropriate dressing techniques in the management of these wounds is paramount for an orderly and timely healing process to occur. However, a limited number of authors[1,2] have examined acute wounds and dressing techniques to guide clinical decisions. Current practice by athletic trainers may consist of not covering abrasions or using nonocclusive dressings (ie, sterile gauze, adhesive strips, or patches).[3] These techniques likely impede the healing process by cooling and drying the tissue, as well as increasing the risk of cross-contamination and bacterial colonization from *Staphylococcus* and *Streptococcus* pathogens.[4,5]

Past investigators[6–8] researching the effects of dressings on healing rates have traditionally focused on the chronic wound environment. Although these findings are vital to understanding the effects of various dressings, factors such as underlying pathologic conditions associated with the chronic wound environment, as well as various wound sizes, depths, locations, and mechanisms of injury, can influence the clinical outcomes.[9] Additionally, few standardized protocols in the literature describe specific methods to examine acute wound healing.[10,11] Therefore, my purpose was to examine the effects of occlusive dressings on measures of wound healing in standardized, partial-thickness abrasions. Specifically, I adapted a semiautomatic digital imaging processing method to examine the effects of film, hydrogel, and hydrocolloid occlusive dressings and no dressing (control) on healing time, measured by change in wound contraction, wound color (chromatic red), and luminance. I hypothesized that the occlusive dressings would produce greater rates of healing (greater wound contraction and luminance and lower color) when compared with the control.

METHODS

Design and Setting

I used a controlled, counterbalanced, repeated-measures design to compare the effects of 3 occlusive dressings and

no dressing on the healing of partial-thickness abrasions across time. The independent variables were dressing (BlisterFilm, a transparent film dressing [Covidien, Mansfield, MA]; Curagel, a hydrogel dressing [Covidien]; Ultec, a hydrocolloid dressing [Covidien]; and no dressing [control]) and time (postwound days 1, 3, 5, 7, 10, and 14). The dependent variables were change in surface area of the wound (wound contraction) and change in wound color and luminance. Wound contraction was measured as relative surface area in square centimeters and reflects the drawing together of the wound perimeter. Wound color (chromatic red) and luminance were recorded in red, green, and blue color values. Chromatic red represents the change in the color of the wound from a bright red to pale pink as healing occurs.[12] Luminance indicates the change in the consistency of the wound colors from heterogeneous to homogeneous over time.[12] A counterbalanced technique for dressing application was used to control for structural and physiologic differences of the lower leg that might have affected the healing rate. All procedures and data collection were performed in a research laboratory.

Participants

Ten healthy women (age = 22.20 ± 1.81 years, height = 165.86 ± 6.55 cm, mass = 66.90 ± 14.22 kg) and 6 healthy men (age = 21.50 ± 0.55 years, height = 180.34 ± 2.77 cm, mass = 86.94 ± 11.29 kg) volunteered for the study. All participants completed a preparticipation questionnaire to determine eligibility for the study. They were excluded if they reported ever having diabetes mellitus, peripheral vascular disease, deep venous thrombosis, bleeding or clotting disorders, dermatitis, excessive scarring, cancer, systemic bacterial infection, immune suppression, hypertension, cardiac disease, or hypersensitivity to pain or allergies to latex, polyurethane, gelatin, pectin, or lidocaine or prilocaine anesthetic cream. Each volunteer read and completed an informed consent form approved by the university's institutional review board, which also approved the study, and had any questions answered before data collection. The reported nonkicking leg served as the test limb.

Testing Procedures

Wound-Infliction Protocol. The partial-thickness wound model for this study was adapted from Claus et al[1] and Hopkins et al[13] and further developed through pilot testing. Occupational Safety and Health Administration guidelines[14] were followed during all procedures, and a physician was on call during the wound-infliction procedure.

Twenty-four hours before wound infliction, each participant shaved the lower part of the nonkicking leg with a disposable razor to prevent any irritation. Two hours before infliction, volunteers reported to the laboratory. Each participant was placed in a seated position with the nonkicking leg extended on a table, parallel to the surface. I applied an anesthetic ointment (Hi·Tech Lidocaine and Prilocaine Cream [2.5% lidocaine and 2.5% prilocaine]; Hi·Tech Pharmacal Co, Inc, Amityville, NY) to a 21 × 10-cm area on the lateral lower leg and covered this area with BlisterFilm. During the 2 hours, volunteers were allowed to continue their daily activities, excluding bathing, showering, and all physical activity. After 2 hours, the BlisterFilm was removed and a 10-minute ice massage was applied over the area to desensitize the skin and allow it to be abraded more easily. I then cleansed the lateral lower leg with a Betadine surgical scrub (Purdue Pharma LLP, Stamford, CT) and dried the area with sterile gauze pads.

A 21 × 10-cm template made of 0.15-mm clear vinyl was constructed for each participant before wound infliction. Four circles (2.25 cm in diameter) were cut in the template and spaced 4 cm apart. The template was cleansed with isopropyl alcohol and secured to the nonkicking lateral lower leg with Cover-Roll (BSN-Jobst, Inc, Charlotte, NC). The 4 circular holes allowed the skin of the lower leg to protrude through the template.

A weighted (3.70-kg) "sanding sled" (24.5 × 8.5 cm) with an attached handle was constructed to ensure consistent contact and downward pressure over the template and circular holes during infliction. A 24.5 × 8.5-cm piece of 60-grit autoclaved SandBlaster sandpaper (3M, St Paul, MN) was attached to the sled. The sled was centered on the most proximal hole in the template, contacting the protruding skin, and pulled in a medial-to-lateral (1 pass) and then lateral-to-medial (1 pass) direction to the beat of a metronome (60 beats per minute) for 80 passes. I used pilot testing to establish the number of passes to achieve appropriate wound depth. *Appropriate wound depth* was defined as even bleeding from the circular wound, indicating removal of the epidermis, extending partially into the dermis. This procedure was repeated on the next distal wound and continued until all wounds were inflicted. After infliction of the 4 wounds, the template and sandpaper were removed and discarded using Occupational Safety and Health Administration guidelines.[14] I used direct pressure with sterile gauze pads to control bleeding of each abrasion.

Each abrasion was cleansed by irrigation with warm tap water through a 35-mL syringe and 19-gauge hub blunt needle, and the periwound tissues were dried by patting the area with sterile gauze. In accord with the assigned group, I applied the dressings following manufacturer's instructions in a proximal-to-distal direction on the lower leg. No dressing or medication was applied to the control wound throughout the study. Each participant was provided with prepackaged or precut replacement dressings to use if any fell off or lost their barrier capability between wound-imaging days. Volunteers also were given precut strips of Cover-Roll to use if the edges of any dressing began to loosen. Wound care instructions and guidelines for identifying signs of infection, including contact information for the principal investigator, were given to each person. Participants were instructed to continue their normal daily activities, including showering, bathing, and physical activity (excluding aquatics) during the study period. They were provided with PowerFlex (Andover Coated Products, Salisbury, MA) to protect the dressings during showering and bathing.

Wound-Imaging Protocol. Digital imaging of the wound surface was performed on postwound days 1, 3, 5, 7, 10, and 14 within a 1- to 2-hour window based on the time of wound infliction. The imaging procedure began at the most proximal wound on the lower leg with removal of the dressing. I irrigated the wound with warm tap water through a 35-mL syringe and 19-gauge hub blunt needle until all exudate, eschar, and dressing residue were

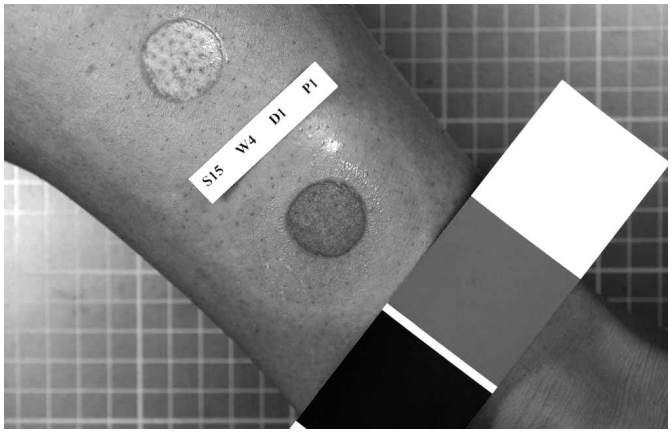

Figure 1. Digital image of abrasions on day 1.

removed from the wound bed and perimeter. If necessary, sterile tweezers were used to remove loose eschar from the wound perimeter. I avoided direct contact with the wound bed and did not observe damage to the tissues (bleeding) with irrigation. Sterile gauze pads were used to dry and remove dressing residue from the periwound tissues. I continued this procedure with the next distal wound until all 4 wounds were cleansed and periwound tissues dried.

The participant was placed with the involved leg in a parallel position directly over the base of a Kaiser RS-2XA camera stand with a RB-218-HF Lighting Unit (Kaiser Fototechnik; GmbH & Co, Buchen, Germany) equipped with two 18-W Dulux fluorescent lamps and reflectors. A Nikon DX1 camera with a manual 60-mm lens (Nikon Corp, Chiyoda-ku, Tokyo, Japan) was mounted 45 cm perpendicular to the lower leg on the stand. A 142 × 40-mm QPCard 101 reference card (QPCard AB, Goteborg, Sweden) with neutral white, gray, and black patches was used to calibrate color values. Starting at the most proximal wound, the reference card was placed on a nonadherent TELFA pad (Covidien) next to the wound on the periwound tissues. A label was placed on the periwound tissues to identify the volunteer, day, and wound and image number. Three digital images (3008 × 1960 pixels, tagged image file format) with standardized camera settings (International Organization for Standardization 200 and f-stop 6.3) were recorded of each wound, for a total of 12 images per session (Figure 1). Manual focus on the center of the original wound area was performed with the first image and remained consistent for the next 2 images. The lighting unit and ambient lighting remained consistent for all participants. This procedure was continued with the next distal wound until all images were recorded. I reapplied the dressings in the same order as previously assigned.

Data Reduction and Processing

The images were entered into Adobe Photoshop CS2 (Adobe Systems, Inc, San Jose, CA) for semiautomatic analysis. Each image was adjusted for color using the reference card in the image. Wound area was determined by tracing the wound perimeter with the mouse cursor (9 pixels, round diameter, single-tipped brush). Wound perimeter was defined as visual differences between the colors of red and pale pink in each image. Each image was viewed at 100% size (5 895 680 pixels) to analyze the color differences. I traced the outside border of the darkest portion of red color for perimeter measurements. Area measurements represented the selected wound area and bounding box automatically calculated by Photoshop. The rectangular box was calculated from the maximum height and width points of the selected wound area. The box was measured in pixels and then converted to square centimeters. If no differences in the colors were detected visually, the wound was considered fully contracted or healed. After the wound perimeter was traced manually, the selected portion of the image (wound area) was used to automatically calculate red, green, and blue color values. When the wound was considered fully contracted, the largest portion of the original wound was selected (approximately 49 000 pixels = 4.75 cm^2) and used for red, green, and blue color values. Wound color (chromatic red) and luminance were calculated from the color values of the defined wound area. The wound width and height measurements and red, green, and blue color values were entered into Microsoft Excel 2003 (Microsoft Corp, Redmond, WA). Wound area was calculated using the formula of width × height. Chromatic red and luminance were calculated using the following computations adapted from Hansen et al[15]:

$$r = (100 \times R)/(R + G + B) \quad (1)$$

$$L = (R + G + B)/3 \quad (2)$$

where R = red, G = green, B = blue, r = chromatic red, and L = luminance.

Intrarater (test-retest) reliability using the intraclass correlation model (3,1) was calculated to determine the consistency of wound contraction, chromatic red, and luminance measurements.[16] I randomly selected 5 participants and analyzed all images (720) during 1 session and again during a second session 45 days later. All images were analyzed following the same format. Measurement recording was blinded with the use of new data sheets. The intraclass correlation coefficient (ICC) was .97 (SEM = 0.164 cm^2) for wound contraction, .83 (SEM = 0.408) for chromatic red, and .94 (SEM = 0.231) for luminance.

Statistical Analysis

Data from postwound days 1, 3, 5, 7, 10, and 14 were used in the analysis. The mean of the 3 images for wound contraction, color (chromatic red), and luminance were used for the data analysis. A 4 × 6 repeated-measures analysis of variance (dressing by time) was used to compare the dressings (film, hydrogel, and hydrocolloid) and control with the change in wound contraction, color, and luminance over time, respectively. I performed a Tukey post hoc test for comparisons. Alpha level was set a priori at $\leq .05$ for all analyses. The data were analyzed using the SPSS statistical software package (version 15.0; SPSS Inc, Chicago, IL).

RESULTS

Wound Contraction, Color, and Luminance

Means and SDs for wound area, color, and luminance are presented in the Table. Additionally, only the clinically

Table. Wound Area, Chromatic Red, and Luminance by Dressing Over Time (Mean ± SD) (n = 16)[a]

Day	Measure	Dressing			
		Film	Hydrogel	Hydrocolloid	Control
1	Wound area	8.52 ± 1.01	9.26 ± 1.10	8.67 ± 1.14	8.60 ± 1.57
	Chromatic red	54.30 ± 7.53	47.62 ± 3.16	61.16 ± 10.97	58.19 ± 12.57
	Luminance	131.19 ± 15.51	150.99 ± 12.98	118.51 ± 20.40	120.19 ± 25.97
3	Wound area	8.21 ± 1.09	8.84 ± 1.14	8.14 ± 1.18	8.38 ± 1.68
	Chromatic red	68.52 ± 11.35	57.23 ± 8.94	69.86 ± 8.91	67.40 ± 8.78
	Luminance	100.46 ± 21.64	125.11 ± 23.66	97.46 ± 18.78	98.39 ± 15.16
5	Wound area	6.89 ± 1.56	8.59 ± 1.06	6.83 ± 1.78	7.75 ± 1.56
	Chromatic red	63.06 ± 9.44	59.59 ± 6.07	58.80 ± 6.33	63.88 ± 7.95
	Luminance	109.36 ± 18.73	115.62 ± 14.49	117.58 ± 19.75	106.55 ± 16.21
7	Wound area	4.67 ± 1.69	7.53 ± 1.40	4.21 ± 2.63	6.71 ± 1.56
	Chromatic red	55.75 ± 8.27	56.88 ± 4.69	52.05 ± 5.04	58.81 ± 7.31
	Luminance	126.07 ± 22.15	119.32 ± 12.41	133.68 ± 16.83	116.27 ± 14.48
10	Wound area	2.24 ± 2.26	4.17 ± 2.75	1.11 ± 1.95	5.02 ± 1.74
	Chromatic red	50.52 ± 7.90	50.73 ± 5.08	48.30 ± 6.51	61.40 ± 8.91
	Luminance	137.59 ± 24.22	136.29 ± 18.54	145.53 ± 19.07	111.71 ± 18.57
14	Wound area	0.94 ± 1.31	0.98 ± 1.75	0.17 ± .52	3.21 ± 1.59
	Chromatic red	47.33 ± 5.08	44.65 ± 2.18	44.99 ± 2.38	57.03 ± 11.64
	Luminance	143.57 ± 18.73	151.89 ± 12.43	152.22 ± 13.44	119.91 ± 20.79

[a] Area (cm^2); chromatic red = (100 × red)/(red + green + blue); luminance = (red + green + blue)/3.

meaningful results for the day-by-dressing interaction are presented and discussed.

Area. A day-by-dressing interaction effect was noted for wound contraction ($F_{15,225} = 9.486$, $P < .001$). The Tukey honestly significant difference test (mean significant difference [MSD] = 1.44) revealed that the film (F) and hydrocolloid (HC) dressings produced greater wound contraction than the hydrogel (HG) dressing and control (C) on days 7 and 10 (the Table and Figure 2). On day 10, the HC also produced greater contraction than C on day 14. The F, HG, and HC demonstrated greater contraction than C on day 14. The associated Cohen d values for day 7 comparisons were 1.05 (F versus C), 1.54 (F versus HG), 0.97 (HC versus C), and 1.33 (HC versus HG). For day 10, Cohen d values were 1.16 (F versus C), 0.65 (F versus HG), 1.79 (HC versus C [day 10]), 0.98 (HC versus C [day 14]), and 1.08 (HC versus HG). For day 14, Cohen d values were 1.31, 1.12, and 2.18 for F, HG, and HC versus C, respectively. Overall, the HC produced the greatest amount of wound contraction (0.17 ± 0.52 cm^2) compared with the

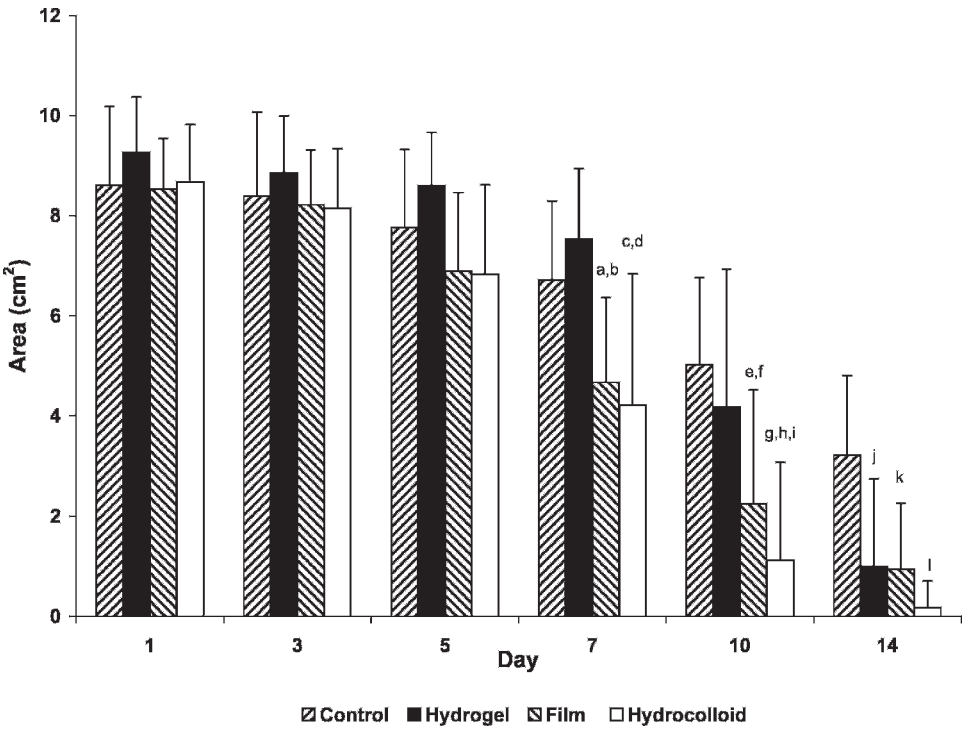

Figure 2. Mean wound areas (cm^2) for dressings and control over time. Differences were demonstrated as follows: [a] between film and hydrogel, [b] between film and control, [c] between hydrocolloid and hydrogel, [d] between hydrocolloid and control, [e] between film and hydrogel, [f] between film and control, [g] between hydrocolloid and hydrogel, [h] between hydrocolloid and control, [i] between hydrocolloid and control (day 14), [j] between hydrogel and control, [k] between film and control, and [l] between hydrocolloid and control.

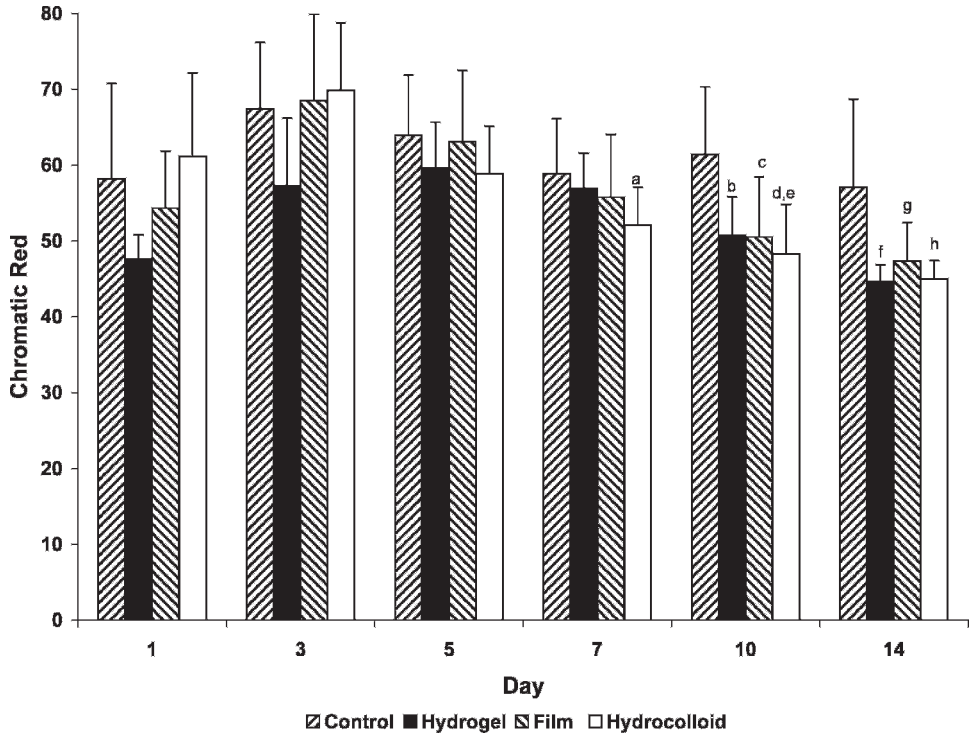

Figure 3. Mean wound color (chromatic red) for dressings and control over time. Differences were demonstrated as follows: [a] between hydrocolloid and control (day 10), [b] between hydrogel and control, [c] between film and control, [d] between hydrocolloid and control, [e] between hydrocolloid and control (day 14), [f] between hydrogel and control, [g] between film and control, and [h] between hydrocolloid and control.

F (0.94 ± 1.31 cm²) and HG (0.98 ± 1.75 cm²) dressings and C (3.21 ± 1.59 cm²).

Color. A day-by-dressing interaction effect was demonstrated for chromatic red ($F_{15,225} = 6.42$, $P < .001$). The Tukey test (MSD = 8.39) revealed that the HC dressing was associated with a lower measure of chromatic red on day 7 compared with C on day 10 (the Table and Figure 3). The F, HG, and HC displayed lower measures of chromatic red than C on days 10 and 14. On day 10, the HC also produced a lower measure of chromatic red than C on day 14. The associated Cohen d value for the day 7 comparison was 1.08 (HC versus C [day 10]). For day 10, Cohen d values were 1.08 (F versus C), 1.23 (HG versus C), 1.41 (HC versus C [day 10]), and 0.77 (HC versus C [day 14]). For day 14, Cohen d values were 0.9, 1.23, and 1.19 for F, HG, and HC versus C, respectively. Overall, the HG dressing produced the lowest measure of chromatic red (44.65 ± 2.18) compared with the HC (44.99 ± 2.38) and F (47.33 ± 5.08) dressings and C (57.03 ± 11.64).

Luminance. A day-by-dressing interaction effect was noted for luminance ($F_{15,225} = 9.41$, $P < .001$). The Tukey test (MSD = 16.65) revealed that the HC produced a greater measure of luminance on day 7 compared with C on days 7 and 10 (the Table and Figure 4). The F, HG, and HC resulted in greater measures of luminance than C on days 10 and 14. On day 10, the F and HC also produced greater measures of luminance compared with C on day 14. The associated Cohen d values for the day 7 comparisons were 0.93 (HC versus C [day 7]) and 1.03 (HC versus C [day 10]). For day 10, Cohen d values were 1.0 (F versus C [day 10]), 0.65 (F versus C [day 14]), 1.11 (HG versus C), 1.5 (HC versus C [day 10]), and 1.07 (HC versus C [day 14]). For day 14, Cohen d values were 1.0, 1.56, and 1.54 for F, HG, and HC versus C, respectively. Overall, the HC dressing produced the greatest measure of luminance (152.22 ± 13.44) compared with the HG (151.89 ± 12.43) and F (143.57 ± 18.73) dressings and C (119.91 ± 20.79).

DISCUSSION

The results support the hypothesis that occlusive dressings were more effective than no dressing in the healing of partial-thickness abrasions measured by wound contraction, color, and luminance. I observed differences between the dressings and control on days 7, 10, and 14. The film, hydrogel, and hydrocolloid produced greater rates of contraction and measures of luminance and lower measures of color than no dressing (Figures 2 through 4). These findings correspond to the greatest amount of healing with each of these measures, greater wound contraction and luminance and less color. Between dressings, the film and hydrocolloid produced greater contraction than the hydrogel on days 7 and 10. Overall, the findings suggest that hydrocolloid dressings were most effective in the healing of partial-thickness abrasions in this study.

Since the early 1960s, authors have demonstrated that occlusive dressings are beneficial to the healing process in various wounds, but the exact mechanisms are not entirely known. Occlusive dressings maintain an environment conducive to healing by trapping moisture next to the wound bed, producing a moist wound environment.[17] Occlusive dressings and a moist wound environment may enhance fibroblast and keratinocyte proliferation and migration,[17–21] the inflammatory response,[22] and autolytic debridement[6]; stimulate angiogenesis[23,24]; increase collagen synthesis[25]; provide thermal insulation[4,5]; prevent tissue

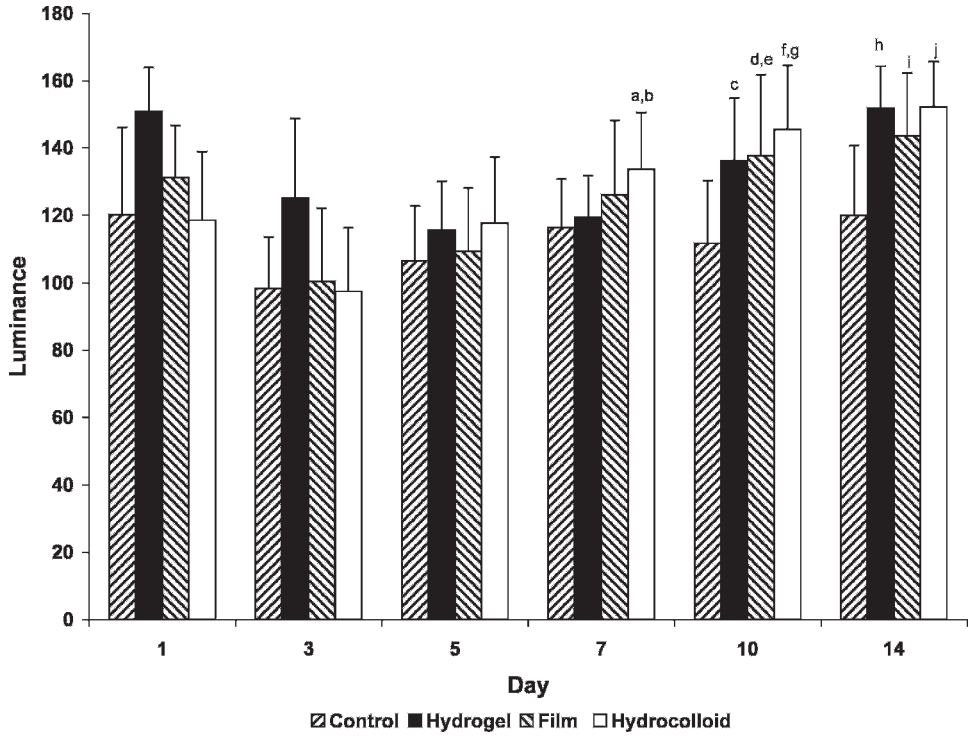

Figure 4. Mean wound luminance for dressings and control over time. Differences were demonstrated as follows: [a] between hydrocolloid and control, [b] between hydrocolloid and control (day 10), [c] between hydrogel and control, [d] between film and control, [e] between film and control (day 14), [f] between hydrocolloid and control, [g] between hydrocolloid and control (day 14), [h] between hydrogel and control, [i] between film and control, and [j] between hydrocolloid and control.

necrosis and wound desiccation[7]; lower rates of cross-contamination and infection[5]; and reduce levels of pain.[4] In comparison, nonocclusive dressings can promote tissue desiccation and increase the risk of infection, delaying the normal healing process.[4,5]

The finding of an increased rate of healing with occlusive dressings is consistent with past investigations and supports the use of these dressings by athletic trainers in the management of acute abrasions.[1,6,7,17–25] Although film, hydrogel, and hydrocolloid occlusive dressings vary in their construction and purpose, each provides advantages over nonocclusive dressings (ie, sterile gauze, adhesive strips, or patches) or no dressing. Occlusive dressings increase rates of re-epithelialization[21] between 30% and 45% and heal acute wounds an average of 3 to 4 days faster[20] than nonocclusive dressings do. Partial-thickness abrasions extend through the epidermis and possibly the superficial dermis and typically heal through a reparative process of re-epithelialization, normally completed within 7 to 14 days.[26] I did not observe full contraction in any wounds before day 7. On day 7, there were 3 (18%) wounds under the hydrocolloid and 1 (6%) under the film that were healed or fully contracted. On day 10, there were 9 (56%) wounds under the hydrocolloid, 7 (43%) under the film, and 2 (12%) under the hydrogel that were healed. On day 14, there were 14 (87%), 11 (68%), and 10 (62%) wounds under the hydrocolloid, hydrogel, and film, respectively, that were healed. Over the 14-day study period, no control wounds achieved full contraction. Occlusive dressings are permeable, semipermeable, or impermeable to water, water vapor, and oxygen, but each provides a physical barrier against cross-contamination and infection from external microorganisms.[4] The dressings protect the wound bed from further trauma, increase patient compliance, are cost-effective and less labor intensive, and can be changed without interrupting the healing process.[4]

The goal in selecting and using a dressing is to create an environment that allows for maximum activity of enzymatic and cellular systems to promote healing.[5] Although film, hydrogel, and hydrocolloid dressings are indicated for partial-thickness abrasions, I found that hydrocolloid was the most effective. This could be due to the ability of hydrocolloids to manage greater amounts of exudate, provide greater insulation and protection to the wound bed based on the thickness of the dressing, and melt within the wound bed to produce a more effective moist healing environment.[4] Hydrocolloids increase the rate of healing and allow earlier return to athletic and recreational activities. The ability of hydrocolloids to remain on the wound bed during normal daily and athletic activities for up to 7 days increases patient compliance and decreases the frequency of dressing changes compared with nonocclusive dressings. Perhaps most important, hydrocolloids can lessen the amount of time and the degree to which the wound is susceptible to cross-contamination and infection. The emergence of methicillin-resistant *Staphylococcus aureus* (MRSA) in the athletic population and the reported risk factors of direct contact with an infected individual and the presence of skin trauma (eg, abrasions) encourage the use of hydrocolloids for abrasions.[27] Prevention guidelines in the literature to address these risk factors include proper cleansing of a wound and application of a dressing to protect and guard against the introduction of bacteria into the wound.[27,28] Hydrocolloid dressings provide a physical, impermeable barrier from the external environment and protect the wound bed against penetration of microorganisms. However, the dressings should not

be used on clinically infected wounds (more than 10^5 organisms per gram of tissue).[4] The use of hydrocolloid dressings may prevent or lessen the transmission of pathogens such as MRSA. Additional research is needed to determine their effectiveness in reducing transmission of *Staphylococcus* and *Streptococcus* pathogens and to characterize the risk factors of direct contact and skin trauma in athletic settings.

Past authors[8,9] examining the effects of occlusive dressings have used animal models as well as chronic wounds when examining measures of healing. The differences in healing among species, wound size and depth, location, and mechanism of injury can significantly affect the clinical outcomes of these studies.[8,9] These differences and the limited number of investigations with acute wounds[1,2] make comparisons among studies difficult. To investigate the effects of dressings on wound healing, it appears that if standardized wounds were inflicted, the differences in healing could be attributed to the intervention, rather than wound variability.[13] Several authors developed a superficial wound model for use with human subjects (forearm) that controls for wound variability.[1,13] Claus et al[1] found that film and hydrocolloid dressings reduced the area of standardized abrasions more effectively than adhesive strips or no dressing over a 10-day period. The model in this study was similar and included standardized abrasions to allow comparisons among the dressings. The data and previous work from Claus et al[1] are a start in the controlled investigation of the effects of dressings on abrasions.

Accurate assessment of wound characteristics over time is essential to determine the progression of healing and the effectiveness of interventions.[29,30] However, few protocols in the literature describe the terminology, methods, or specific variables to monitor.[10,11] Numerous changes occur within the wound bed as healing progresses, and measures such as changes in wound size and color, formation of exudate, and development of slough or eschar can be observed subjectively. In previous work, wound area, color, and luminance have been objectively assessed to investigate the effectiveness of various dressings[1,12,15,31] and laser therapy[13] on healing. These characteristics have been described as important and clinically relevant indicators of wound healing. New growth of epithelium decreases the area of a partial-thickness abrasion over time as epithelium migrates across the wound bed from the edges and reservoirs in hair and sweat and scent glands.[10,31] The wound color changes from bright red, indicating granulation tissue, to pale pink as cellular and chemical activities slow, causing a decrease in the measure of chromatic red as healing progresses.[12,13] Consistency in the color of the wound, initially heterogeneous, becomes more homogeneous over time with healing, resulting in an increase in the measure of luminance.[12,13] In contrast to Hopkins et al,[13] who investigated laser therapy and healing, I found differences in chromatic red and luminance, indicating healing of the wounds. These results and those of others[1,12,15,31] appear to support the use of wound contraction, color, and luminance as quantitative measures of healing in future studies.

Wound area, color, and luminance have been documented with ruler-based assessment, wound tracing, stereophotogrammetry, and automatic and semiautomatic computerized systems. Some[15] have suggested that existing computer imaging systems and software are medically sound and cost-effective to use in assessing these measures. Others[31] have stated that fully automatic computerized assessment systems are not essential due to the variability in wound assessments caused by the absence of consistent measurement factors. Semiautomatic assessments similar to the methods in this study are common and appear clinically relevant in wound-healing investigations. Semiautomatic methods are used with other computerized photogrammetry systems and have demonstrated acceptable psychometric properties in past investigations.[32] The results of this study demonstrate high reliability with semiautomatic assessment of wound contraction, chromatic red, and luminance (ICC = 0.97, 0.83, and 0.94, respectively). From these values, it appears these measurements could provide researchers with an accurate, cost-effective method to assess acute wound healing. This investigation is one of the few to use a standardized wound model and semiautomatic processing method to examine healing rates among occlusive dressings.

Limitations

The wound model used in this study is limited to partial-thickness abrasions on the lateral lower leg. Rates of healing may differ for other areas of the body. The occlusive dressings are limited to films, hydrogels, and hydrocolloids. These dressings are widely available to athletic trainers, and recommendations for use based on wound characteristics (eg, color, amount of exudate) are remarkably similar among manufacturers. Wound area measurements (width $\times$ height) used in the analysis represented the relative size of the wound rather than the specific shape of the wound. This method was found to be reliable and reproducible to examine wound contraction over time. Blinded assessment was not performed with digital imaging of wound healing. Upon removal, each dressing left signs on the skin indicating its presence, resulting in the inability to assess in a truly blinded fashion.[33] It should be noted that the objective nature of the semiautomatic assessment method likely decreased this effect on the results. Variations among the participants with regard to tissue elasticity may have caused differences in the amount of tissue that protruded through the holes of the template during wound infliction.[13]

The removal of the dressings at days 1, 3, 5, 7, 10, and 14 for imaging may have interrupted the healing process. However, this assessment is a more objective measure of healing.[2] The dressings in this study are designed to remain on the wound bed from 3 to 7 consecutive days in the absence of leakage or signs of infection. To lessen interruption of healing, I performed cleansing, digital imaging, and redressing of the wounds in a 20- to 30-minute window. Although more clinically relevant, using the measure of days to complete healing (when dressings can be removed without trauma and pain) introduces the health care provider's error and bias resulting from skill and experience in dressing removal.[2] The wounds inflicted in this study were partial thickness in depth and were healed by the progression of epithelium from the wound edges and reservoirs of epithelium. Some authors[12] have suggested that these wounds demonstrate minimal contraction and that area is not a relevant measure of healing.

CONCLUSIONS

Film, hydrogel, and hydrocolloid occlusive dressings demonstrated a faster rate of healing of standardized, partial-thickness abrasions of the lateral lower leg on postwound days 7, 10, and 14 compared with no dressing. Overall, hydrocolloid dressings are recommended in the management of these wounds. These assessment methods and data are a focused start in the development of evidence-based guidelines for athletic trainers to improve health care services to various populations. Future investigators should continue to examine the effect of occlusive dressings on measures of healing, infection, and pain with standardized acute wounds to determine the most appropriate dressing for healthy populations. Additional studies are needed to determine the practicality (use in competitive athletes), cost-effectiveness (supply costs, personnel time, and follow-up), and level of compliance with the use of occlusive dressings in the clinical setting.

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