Effect of Occlusive Dressings on the Stratum Corneum Water Holding Capacity

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ABSTRACT: Occlusion of the skin is used in clinical dermatology to promote wound healing and to increase the transcutaneous penetration of topically applied drugs. These effects are related to the degree of occlusion exerted and depend on the physicochemical nature of the dressing. We have evaluated the effects of four different materials on the skin barrier and the stratum corneum water holding capacity (WHC) using the Plastic Occlusion Stress Test (POST). The following materials were compared: hydrocolloid dressing, polyurethane film, polyethylene film, and a plastic chamber. These devices were applied on the volar forearm for 24 hours in 10 healthy volunteers (mean age 32 ± 4 years). Upon their removal, the stratum corneum WHC, measured as skin surface water loss (SSWL), was recorded continuously for 25 minutes using an Evaporimeter.

SSWL decay curves showed significant differences between the occlusive materials (analysis of variance, $p < 0.01$). Higher SSWL values were recorded in sites occluded with the plastic chamber, whereas the polyurethane film resulted in poor occlusive capacity. Hydrocolloid dressing and polyethylene gave similar responses with higher WHC values compared to polyurethane ($p < 0.05$). The relevance of these findings to clinical dermatology in terms of wound healing and drug absorption is discussed. KEY INDEXING TERMS: Occlusion; Skin physiology; TEWL. [Am J Med Sci 1992;304(1):25–28.]

Skin occlusion alters skin physiology and biology, eg, epidermal turnover, wound healing, and microbial flora.[1] Occlusion accelerates the healing rate of superficial wounds. The effect may be a result of increased cell migration across the surface[2,3] or of increased collagen synthesis and re-epithelialization.[4] Epidermal turnover is decreased after occlusion.[5,6] Indeed, occlusive therapy is used to treat hyperproliferative skin disorders such as psoriasis.[6]

Several dressings are commercially available to treat skin disease. All claim to bring about improvement of the skin condition related to the occlusive effect.

In the present study, we compared the effect of different dressings on skin hydration and stratum corneum water holding capacity, and hence the occlusive capabilities of these products. Skin occlusion results in increased hydration because of inhibition of water evaporation. Hydration achieved by occlusion results in an increased transepidermal water loss (TEWL) post dressing removal.[7] TEWL measurements of the evaporation of water from the skin surface after occlusion quantifies the skin water holding capabilities and is an indirect measurement of the in vivo water content.[8]

Materials and Methods

Occlusive devices tested were: polyethylene film (Saran Wrap), polypropylene plastic chamber (18 mm diameter; Hill Top, Cincinnati, OH), hydrocolloid dressing (Duoderm; Convatec Squibb, Rome, Italy), and polyurethane film (Tegaderm; 3M, St. Paul, MN). Ten healthy male subjects (mean age 32 ± 4 years) entered the study. Subjects rested 30 minutes prior to the procedures. Occlusive dressings were applied on the volar forearm (left or right, randomized), each on a 4 cm^2 surface (Figure 1). The application sequence was randomized to minimize hydration differences resulting from site. After 24 hours, the dressings were removed. The Evaporimeter probe (ServoMed Ep-1, Kinna, Sweden) was immediately applied on the previously occluded site and TEWL was measured continuously every minute for 25 minutes. The probe was equipped with a gold-plated protection cover with grid (no. 2107) provided by the manufacturer. To avoid heating, the probe was held on the investigation site with a clamp.

Skin temperature was measured on the two forearms with an electronic thermometer (Omega Corp., Stam-

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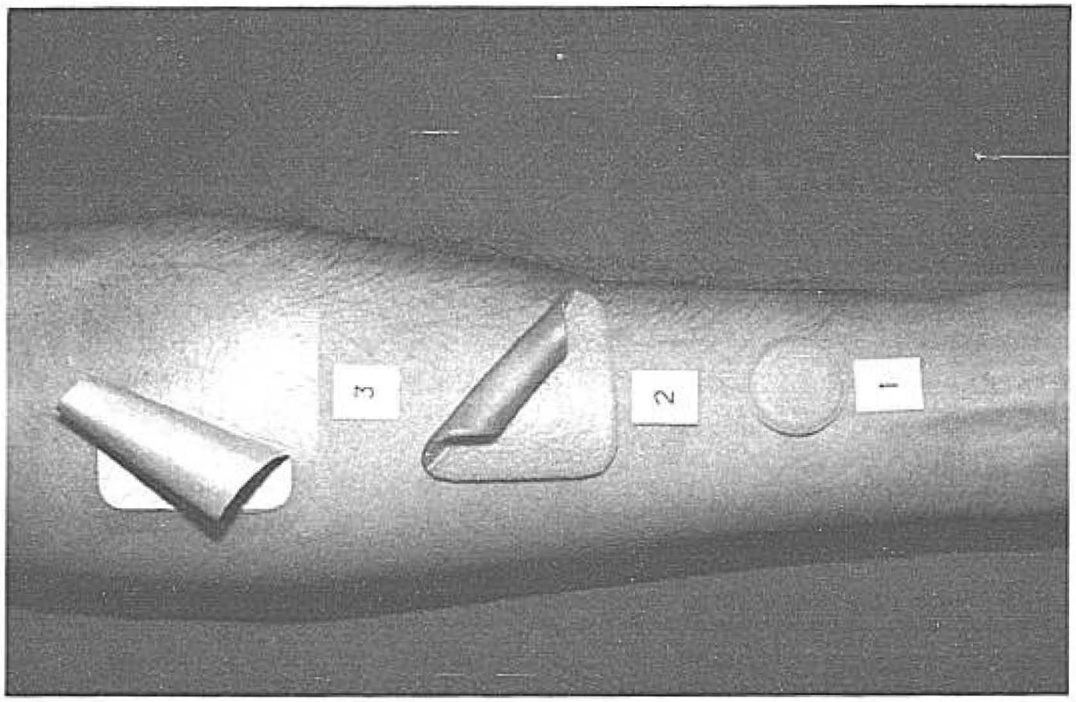

Figure 1. Occlusive dressings that have been compared to polyethylene: (1) plastic chamber; (2) hydrocolloid; and (3) polyurethane (see Materials and Methods).

ford, CT). TEWL values were transformed to logarithms, and values were normalized for a temperature of 30° C, according to Mathias et al.[9] Skin surface water loss decay constants were calculated according to Wagner.[10] The one compartment open model with first order absorption was used. TEWL values are in g/m^2hr.

Statistical analysis of the data was performed using one way analysis of variance and Fisher's PLSD test. The level of $p < 0.05$ was considered significant. Calculations were performed with a software package for statistical analysis (Statview II; Abacus Concepts, Inc., Berkeley, CA).

Results

Results are in Figure 2 and in Tables 1 and 2.

Significant differences in TEWL values at the 1st and 25th minutes were detected among the dressings (analysis of variance = $p < 0.01$). The highest values, representing the highest hydration, were achieved in

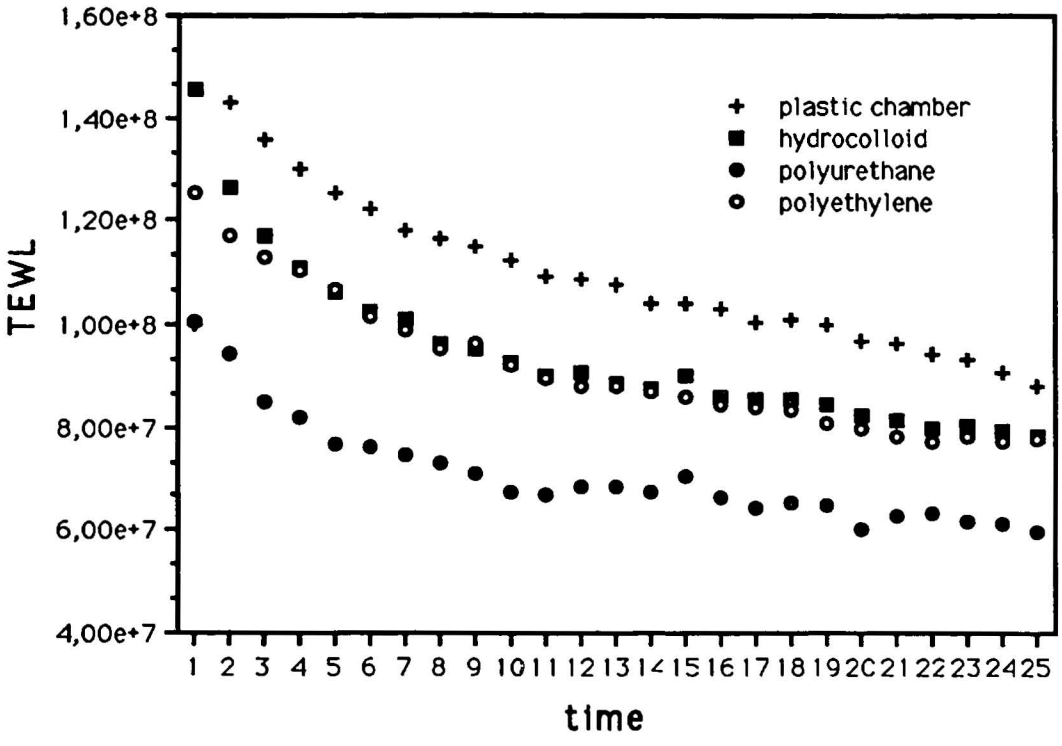

Figure 2. Transepidermal water loss (TEWL) decay curves after removal of the dressings (values in log g/m^2h). Polyurethane film shows the lowest decay curve because of the least occlusive capability compared to the other dressings.

the site occluded with polypropylene chamber (log TEWL = 1.52 and .87 at 1 and 25 minutes, respectively), whereas the lowest were recorded on the site occluded with polyurethane (log TEWL = 1.0 and .59 at 1 and 25 minutes, respectively; Table 1). Polyurethane film produced less occlusion than the plastic chamber, hydrocolloid dressing, and polyethylene (Fisher's PLSD, $p < 0.05$). At the 1st minute, the plastic chamber was significantly higher (Fisher's PLSD, $p < 0.05$) than polyethylene, but not higher than the hydrocolloid dressing.

Decay constants of water evaporation from skin surface are represented in Table 2. Statistically, polyurethane has the lowest decay constant of evaporation ($p < 0.05$) compared to the plastic chamber and the hydrocolloid dressing.

Discussion

Occlusive devices are used in clinical practice for the treatment of wound healing and psoriasis. Their therapeutic effect is related to their occlusive capabilities. Skin occlusion on wounded skin causes increased production of collagen, and consequently increased wound healing rate.[4] The role of oxygen tension beneath the tape is controversial. Rapid reepithelialization is reported when PO_2 is raised and when wounds are treated with oxygen permeable dressings.[11] Nevertheless, a reduced PO_2 stimulates angiogenesis and fibroblast growth.[12] Occlusion reduces epidermal turnover in psoriasis. Fry et al, in 1970,[13] suggested that the increased temperature and hydration induced by the plastic film could influence the enzymatic processes related to keratinization and granular layer formation. Friedman[6] reported the usefulness of hydrocolloid dressings in psoriasis treatment. Hydration induced by occlusion may act as a compensating factor in balancing the damaged water barrier in psoriasis and in eliminating the stimulating factor for increased epidermal proliferation.[14,15]

The present study has recorded significant differences in the occlusive potential of the devices investigated (Figure 2). Hydration, as measured by increased water evaporation at the skin surface after removal of the device, and water holding capacity of the stratum corneum reflect different occlusive capabilities of the products. Table 1 shows the water evaporation from skin surface at the 1st and 25th minutes after the occlusion removal. The sites occluded with the plastic chamber and hydrocolloid dressing give the highest scores. Polyethylene film shows values close to the hydrocolloid dressing, whereas polyurethane film shows lower levels of hydration. The ANOVA is significant between the groups ($p < 0.01$), and the comparison of subgroups (Fisher's PLSD test) gives significant differences between polyurethane film compared to the other dressings at the 1st and 25th minutes. Furthermore, at the 1st minute, immediately after the removal of the dressing, the site treated with the plastic chamber shows a significantly higher level of hydration compared to the polyethylene occluded site ($p < 0.05$). Accordingly (Table 2), the comparison of decay constants of water evaporation from skin surface show significant differences between polyurethane film vs. the hydrocolloid dressing and the plastic chamber ($p < 0.05$). These data are consistent with a lower moisturizing capacity of polyurethane compared to the other dressings. This may be the result of a reduced occlusive potential of polyurethane, even though factors other than simple occlusion may be involved in increasing the hydration and the water holding capacity. Interestingly, polyurethane film and the hydrocolloid dressing closely adhere to skin surface and stick to it, whereas polyethylene film and the plastic chamber do not touch the skin surface and allow water accumulation between the plastic edge and the skin.

The role of hydrocolloid particles in the adsorption of moisture from the stratum corneum is unknown. On the other hand, from a physiologic point of view, polyurethane appears to be the dressing that perturbates the skin microenvironment and barrier function the least. In the light of this data, this dressing might be better tolerated for long-term applications. This study attempts to classify and standardize the occlusive potential of dressings commonly used in clinical practice to treat skin disorders. The correct ranking of the efficacy of these products is needed to organize practical therapeutic regimens, preventing risks and side effects to the patients, especially when occlusion is used to enhance skin penetration of potent drugs, such as top-

Table 1. Water Evaporation After Occlusion

Dressing	1st Minute (Mean ± SD)	25th Minute (Mean ± SD)
Plastic chamber†	1.58 ± 0.37*	0.87 ± 0.12*
Hydrocolloid dressing	1.44 ± 0.13*	0.78 ± 0.12*
Polyethylene film	1.24 ± 0.39*†	0.77 ± 0.25*
Polyurethane film*	1.00 ± 0.27	0.59 ± 0.11

Comparison of transepidermal water loss values (expressed in log and corrected for temperature).

* *Analysis of variance is significant among groups, $p < 0.01$.*

† *Significant differences between subgroups, $p < 0.05$.*

Table 2. Decay Constants of Evaporation

Dressing	Mean ± SD
Plastic chamber	−0.05 ± 0.009*
Hydrocolloid dressing	−0.045 ± 0.009*
Polyethylene film	−0.040 ± 0.025
Polyurethane film*	−0.028 ± 0.022

Decay constants expressed in log transepidermal water loss.

Polyurethane film has the lowest decay of evaporation.

* *$p < 0.05$ vs. the plastic chamber and the hydrocolloid dressing.*

ical corticosteroids or other compounds with systemic effects.

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The Southern Society for Clinical Investigation has established the Tinsley Harrison Award, given by the University of Alabama at Birmingham in memory of Tinsley Randolph Harrison, one of the founders of the SSCI.

The award, given to the author of the best single manuscript published in *The American Journal of the Medical Sciences* during the year, was presented at the recent Southern Clinical Research Meetings

To: Jeffrey M. Milunsky
4th Year Medical Student
Boston University School of Medicine
Boston, Massachusetts
For: "Presymptomatic and Prenatal Diagnosis of Myotonic Muscular Dystrophy"

The Merck, Sharp and Dohme Young Investigator Awards were presented to the following individuals at the recent Southern Society for Clinical Investigation Meeting:

David Calhoun, MD
Associate Fellow
University of Alabama at Birmingham
School of Medicine

"Physical Training Enhances Arterial Baroreflex Control of Heart Rate Sympathetic Nerve Activity"

Scott W. Ebbinghaus, MD
Research Fellow
University of Alabama at Birmingham
School of Medicine

"Triplex Formation Prevents Protein Binding to the HER-2/NEU Promoter"

Daniel Gaitan, MD
Research Fellow
Vanderbilt University
School of Medicine

"Glucocorticoid Receptor Structure and Function in an Ectopic ACTH-Secreting Tumor Cell Line"