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Occlusivity and Effects of Two Occlusive Dressings on Normal Human Skin

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Two occlusive, adhesive dressings – one hydrocolloid (absorptive) and one zinc-medicated (non-absorptive) – were studied regarding their occlusivity and effects when applied to normal human skin for 48 h. Both dressings reduced normal transepidermal water loss by about 70%. As documented by a 7-fold increase in the water loss beneath the dressings compared to untreated skin, water was retained in the stratum corneum by both dressings. No appreciable influence of either dressing on skin temperature was found. The skin surface pH decreased beneath the hydrocolloid while it increased beneath the zinc dressing. *Key words: Transepidermal water loss; Skin temperature; Hydrogen-ion concentration.*

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Occlusive therapy has been practised for several decades in dermatology (1). Only recently, however, have prefabricated occlusive dressings, usually composed of a polymeric sheet coated with an adhesive, become commercially available (2). Since their composition varies, occlusive dressings are likely to differ in terms of physical, functional, and biological properties (1–3).

When applied to wounds, occlusive dressings increase epithelialization and reduce pain by preventing dehydration (3, 4). Optimal water permeability for wound healing is not known, though a permeability of about 90 g/m²/h or more prevents skin maceration and exudate build-up (5). A polyurethane film dressing (OpSite®, Smith & Nephew), with a permeability of 25–35 g/m²/h, on partial-thickness wounds accumulates excessive amounts of wound fluid (6).

Occlusion decreases the mitotic rate of hyperproliferative skin and promotes skin penetration of drugs, e.g. glucocorticoids and zinc (1, 7, 8). For these reasons, occlusive dressings are also used, either alone or in combination with topical steroids, for the treatment of skin disorders such as psoriatic plaques (7, 9).

In this study, two occlusive dressings, Duoderm® and Mezinc®, were evaluated regarding their occlusivity and effect on skin hydration, temperature and pH of normal human skin. These two dressings have been compared earlier in wound healing studies in animals and in humans (4, 10, 11).

MATERIALS AND METHODS

Dressings

The occlusive hydrocolloid dressing (Duoderm®, ConvaTec, Princeton, NJ, USA) is made of a polyurethane foam laminated to an adhesive composed of polyisobutylene, pectin, gelatin and sodium carboxymethyl cellulose. The occlusive zinc dressing (Mezinc®, Mölnlycke AB, Mölnlycke, Sweden) consists of a polyvinyl chloride (surface weight: 100 g/m²) coated cotton fabric (100 g/m²) and an adhesive mass (100 g/m²) composed of zinc oxide (25%), natural rubber, light liquid paraffin and Portuguese gum rosin.

Individuals and experimental conditions

Ten healthy volunteers (7 women, 3 men) aged 22–54 years (33 ± 4 years, mean ± SD) were investigated after giving their informed consent. The individuals were instructed to avoid extreme physical activity during the trial period. Measurements were carried out after an acclimatization period of 15 min with the individuals sitting in the draft-free test room. Indoor temperature was kept at 21°C and relative humidity was 24–26%.

Design

Start (0 h). The two dressing application sites (32 mm in diameter), 5 cm above the wrist and 5 cm apart, on the flexor side of each forearm were marked using a pen with the aid of a plastic template. Measurements were carried out on the application sites ($n = 40$) and on adjacent untreated control (C) sites ($n = 40$) before the dressings were applied. The proximal sites on the left arm were measured first, then the distal sites on the left arm, proximal sites on the right arm and distal sites on the right arm. Discs of both dressings, one of each kind on each arm, were then applied according to an unrestricted randomized design and a different dressing was applied on the contralateral position.

After 48 h of treatment. Measurements were performed above the dressings ($n = 40$) and on adjacent control untreated skin ($n = 40$) before the dressings were removed. Directly after dressing removal the treated skin site ($n = 40$) was measured before the adjacent control skin ($n = 40$). In one individual, measurements were also carried out 10 and 15 min after removal of dressings.

Transepidermal water loss (TEWL)

An evaporimeter Ep1® (ServoMed, Vällingby, Sweden), connected to a pen recorder, was used according to the conditions outlined by the European Society of Contact Dermatitis (12). It typically took 1 min to obtain a stable reading.

Occlusivity (%) was calculated according to the formula (13):

$$(1\text{-}(TEWL_{48\,h}/TEWL_{0\,h} \times TEWL_{C,\,0\,h}/TEWL_{C,\,48\,h})) \times 100$$

where $TEWL_{48\,h}$ = TEWL above dressing before removal at 48 h, $TEWL_{0\,h}$ = TEWL before dressing application at 0 h, $TEWL_{C,\,0\,h}$ = TEWL of adjacent control skin before dressing application at 0 h and $TEWL_{C,\,48\,h}$ = TEWL of adjacent control skin before dressing removal at 48 h.

Skin hydration was estimated indirectly by measuring with the evaporimeter the skin surface water loss (SSWL) immediately (14) after removal of the dressings. Skin hydration was expressed in percentage of adjacent control skin.

A control experiment was performed to mimic total hydration. Bleached cotton fabric (100 g/m²), saturated with distilled water, was attached to a forearm, covered with polyethylene film and measured with the evaporimeter after a 15 min equilibrium period.

Temperature

Skin temperature was monitored with a stick-on thermocouple of copper-constantan (PR 6452A, Philips) attached to the evaporimeter probe and which has an accuracy of 0.05°C.

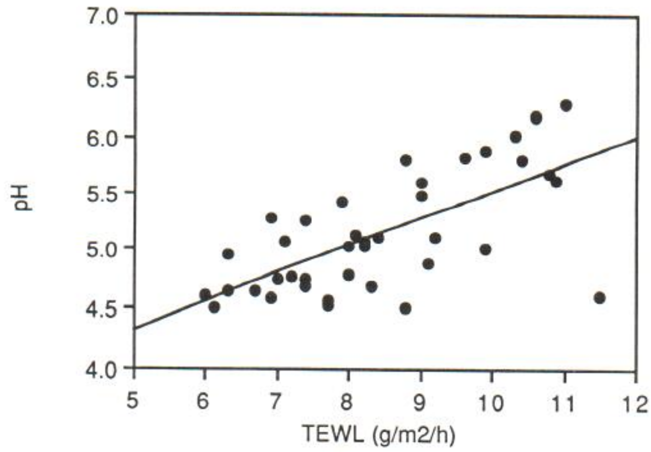

Fig. 1. The correlation between pH and TEWL of untreated normal human skin at 0 h ($n=40$, $r=0.69$).

pH

Using a flat glass electrode (R 242C, Radiometer, Copenhagen, Denmark) coupled with a calomel reference electrode (K 401), pH was measured before and after treatment after the evaporimeter and temperature measurements. Skin sites were moistened with 100 μl distilled water before each pH reading to ascertain equal moisture conditions before and after the occlusive therapy.

The pH of the dressings was determined after the adhesive of unused dressings had been moistened with normal saline (0.9% NaCl) for 1 h at room temperature.

Scanning electron microscopy

The surface of the adhesive of the zinc dressing was studied after treatment of the skin. Specimens were fixed in 10% formalin, air-dried, mounted on stubs (area: 1 cm^2) and sputtercoated with about 300 nm of gold. The specimens were examined in a scanning electron microscope (JEOL) operating at 20 kV.

Statistics

To provide a detailed description of the parameters, all 40 observations in the 10 individuals were used for the calculation of mean ± SD. To test the hypothesis of no change in pH after treatment, care was taken to avoid any dependence between observations. Thus, Student's *t*-test was applied to the 10 observed differences in mean by the treatment (one for each individual). This was repeated for both treatments.

RESULTS

Baseline measurements at 0 h

TEWL of untreated skin was 8.5 ± 1.5 g/m^2/h (mean ± SD), temperature 32.7 ± 0.7°C and pH 5.1 ± 0.5.

Effects of background variables at 0 h

Neither age, sex nor application sites influenced the TEWL or pH values. However, there was a tendency towards lower skin temperature the higher the age of the individuals. An approximately linear positive relation was found between baseline TEWL and pH of untreated skin (Fig. 1).

Effects of treatment

One transient erythematous reaction with the zinc dressing was the only adverse skin reaction observed.

Both dressings reduced the TEWL by about 70% compared with adjacent untreated skin, i.e. 2.0–2.5 g/m^2/h of water vapor passed through them (Table I).

Table I. *The occlusivity and the effect of two occlusive dressings on skin hydration, temperature and pH (mean ± SD) after a 48-h treatment period*

Parameter	Zinc dressing	Hydrocolloid dressing
Occlusivity (%)[a]	67 ± 13	71 ± 11
Skin hydration (%)[b]	740 ± 160	720 ± 120
Temperature (T, °C)	33.1 ± 1.0	33.1 ± 0.9
ΔT (°C)[c]	+0.3 ± 0.9	+0.3 ± 0.9
pH	5.6 ± 0.3	4.8 ± 0.2
ΔpH[c]	+0.5 ± 0.6	−0.3 ± 0.4

[a] reduction in normal TEWL.
[b] relative to adjacent untreated skin.
[c] Δ-values designate absolute differences before and after treatment, i.e. a + sign means and increase and a − sign a decrease in the parameter.

The removal of the dressings caused an immediate rise in the TEWL of adjacent untreated skin from a baseline of 8.0 ± 1.2 g/m^2/h to 12.4 ± 2.6 g/m^2/h. Skin hydration increased 7-fold relative to adjacent skin after treatment with the occlusive dressings. Skin hydration remained elevated when measured after 10 min (120%) and 15 min (40%) of treated compared to untreated skin. No difference in the amount of retained water was found between the two dressings (Table I). Total water saturation gave a 15-fold increase in water loss compared to untreated skin in the control experiment.

Skin surface temperature did not change with either dressing after the 48-h treatment period (Table I).

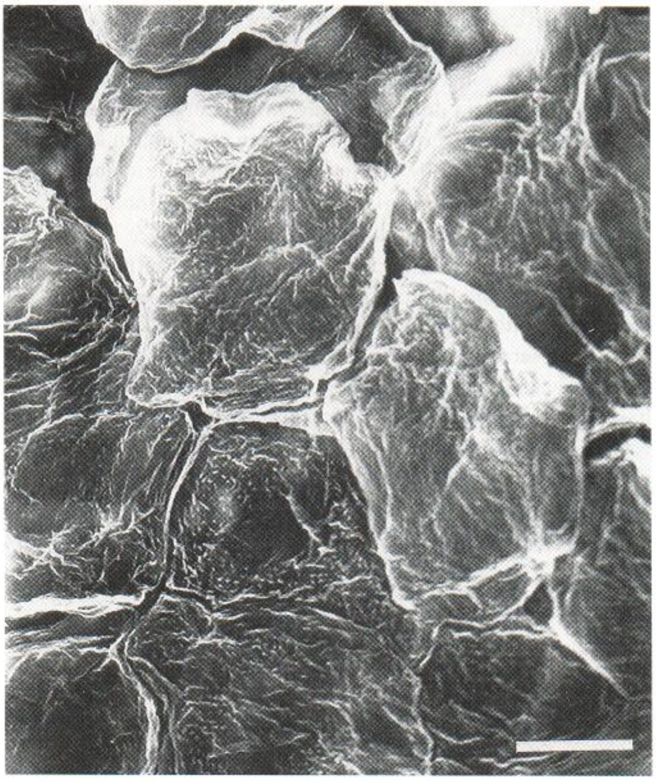

Fig. 2. A representative scanning electron micrograph of corneocytes adhered to the adhesive after treatment of human skin of the forearm for 48 h with the zinc dressing. Bar = 10 μm.

pH was lowered ($p = 0.06$) by the hydrocolloid dressing ($n = 10$) whereas it was increased ($p = 0.03$) by the zinc dressing ($n = 10$) (Table I).

The pH of the adhesive side of hydrocolloid was 4.5 ± 0.03 ($n = 5$) and that of zinc dressing 6.9 ± 0.1 ($n = 5$).

Several layers of corneocytes were detached from the skin at removal of the zinc dressing (Fig. 2).

DISCUSSION

We compared two occlusive adhesive dressings in the treatment of normal human skin. Although both dressings reduced TEWL and thereby promoted skin hydration to about the same extent, about 30% water vapor was transmitted through them. Thus, contrary to the generally held opinion, both dressings are somewhat moisture permeable (2).

Skin temperature did not change after treatment with either occlusive dressing. This finding is in accordance with that of Forslind & Lindberg (15), who found an insignificant change in temperature of skin under occlusion with aluminum Finn chambers.

The two occlusive dressings differed regarding their effect on skin pH: the hydrocolloid dressing maintained or reduced pH, whereas the zinc dressing increased it. One disadvantage of occluding the skin is the increased bacterial growth of the normal flora due to increased moisture and return to physiological pH (16). However, in another study, the hydrocolloid dressing decreased the bacterial counts of *Staphylococcus aureus* and *Pseudomonas aeruginosa* compared to an inert polyvinyl dichloride film (Saran Wrap) (17). The authors speculated that the moderate antibacterial effect was due to the ability of the hydrocolloid to absorb excess moisture on the skin (17). However, our results indicate that water was retained on the skin by the hydrocolloid dressing. Moreover, the hydrocolloid dressing was found less permeable than Saran Wrap when applied to intact skin for 24 h (18). Thus, the maintenance of acidic pH appears to be a more likely explanation for its moderate antibacterial effect on the aerobic normal skin flora.

We identified background factors that influenced the measurements and interpretations if neglected. Skin surface pH correlated with TEWL of normal, untreated skin. Thus pH should preferably be expressed as an absolute change from baseline value. Further dressing removal increased the TEWL baseline value by about 50%, and the degree of skin hydration will be overestimated unless this effect is taken into account. Dressing removal also strips the skin of corneocyte layers, rendering the skin more permeable and causing a slight pH drop (19). This may explain the less dramatic increase in pH by the zinc dressing than that found previously under Saran Wrap film with no adhesive (16).

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