

Glove powder affects skin roughness, one parameter of skin irritation

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Most patients with immediate-type-hypersensitivity to natural rubber latex (NRL) give a history of hand eczema. Susceptibility to allergens is increased by irritant hand eczema due to damage to the skin barrier. Therefore, especially for employees in medical or paramedical professions, reduction in skin irritation is of importance. The present study reports the effect of glove powder on skin roughness, one feature of skin irritancy. Skin replicas, performed before and after wearing different types of gloves, were evaluated by laser profilometry. Significant alteration of skin roughness was evident and determined by different factors. Use of unpowdered Biogel gloves on prepowdered hands results in an increase in skin roughness, in contrast to the use of Biogel gloves on hands without any pre-application. On the other hand, powdered Manex neoderm gloves show no influence on the skin structure, whereas powdered Peha taft gloves also increase the roughness of the skin. Other potential candidates causing skin morphology alteration could be the glove pH, rubber chemicals with irritant potential and other characteristics of gloves, which are already under investigation.

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Occupational irritant hand eczema, caused by wet work, cleansing products and disinfectants, e.g., is a major problem for medical staff (1–3). Damage to the skin barrier can increase penetration of sensitizers through the skin (4) and may result in allergic hypersensitivity to various allergens. Conclusively, hand eczema is one factor responsible for the high prevalence of immediate-type-hypersensitivity to natural rubber latex (NRL) in medical professions. Changes of skin surface structure, analyzed by microscopic evaluation of skin replicas, are shown to be highly sensitive for diagnosing skin irritation. Evaluation of skin reactions to weak irritants with no macroscopic changes is possible by these techniques (5).

The aim of the present study was to investigate the effect of glove powder on skin irritation. Skin roughness, which is one parameter of skin irritation, was measured by contact-free computer-aided laser skin profilometry, before and after wearing different types of gloves.

Materials and Methods

Subjects

After providing informed consent, 19 female volunteers from the hospital staff, of the age of 20–41 years (mean 28 years), entered the study. NRL hypersensitivity was excluded by patient history, skin prick tests using different NRL extracts and the proof of absence of latex-specific IgE antibodies by CAP-FEIA method (Pharmacia, Freiburg, Germany). None of the volunteers showed any visible sign of hand eczema.

pH measurements

pH was measured at 10 different sites on the surface of 1 glove of each glove type used in the study, electrode wet with 10 µl aqua bidestilata (Skin-pH-meter, pH 900 PC, Courage+Khazaka Electronic GmbH, Köln, Germany). The pH-variation between different gloves of the same type was investigated on 5 pairs of gloves of each brand. Changes

of pH were taken by repeated measurement at 1 point of each gloves; pH was registered every 60 s. Steady state was observed after 1–2 min during a standardized analysis for 5 min.

Replicas

Replicas were taken from defined areas on the backs of the hands, using a silicone-based skin pre-cision-moulding compound (polisiloxane condensation-linking according to DIN 13913 A2, ISO 4823, Type 1 Cat. B). After mixing hardener paste and silicone (V:V 2.5:12) for 45 s, the compound was applied with a standardized 1.5 kg tight pressure on the skin and hardened for 2.5 min. The elastic replicas were carefully removed from the skin and flatly attached onto glass plates with a layer of solvent-free adhesive.

Surface contour of the replicas was scanned using a semiconductor laser, wavelength 780 nm (Laserprofilometer UB 16, UBM Messtechnik, Ettlingen, Germany) (6, 7, 8, 9). The bundled laser beam is focused by an adjustable objective lens onto the skin surface impression and is reflected from there. A half-silvered mirror guides the reflected beam through a prism onto two photodiodes, which activate the autofocus lens until the beam is refocused on the surface. The position of the lens is measured and stored as a digital value, which is generated as a true to life, 3-dimensional monitored image of the skin. The roughness parameter, Rz, is a standardized surface parameter according to DIN 4768 (9). 3 measurement fields, each 3×3mm, were evaluated, with 200×25 points per mm². The median Rz of the 3 values was used for the statistical analysis.

Gloves

3 different types of gloves were investigated: (a) Regent Biogel (unpowdered, NRL) (Regent, Mönchengladbach, Germany); (b) Peha taft (powdered, NRL) (Paul Hartmann AG, Germany); (c) Manex neoderm (powdered, latex free) (Johnson & Johnson, Germany).

Additionally, we tested the effect of Biogel gloves on hands prepowdered with 0.5 g powder (Biosorb Hand Creme, Johnson & Johnson, Norderstedt, Germany). Overall, 136 replicas (series of 4 replicas of 34 hands) were obtained. Technical problems with single replicas occurred in 4 further series, which were completely excluded from the results.

Experimental design

Volunteers entered the study during a normal working day. On the precondition that no creams

were used on the day in question, the 1st skin replicas were taken from defined skin areas on the backs of both hands. For the next 60 min, the participants were instructed to work regularly, but to reduce hand wash procedures to the minimum necessary for hygienic standards in hospital, to avoid disinfectants and not to wear gloves; a 2nd replica was taken from the same patch. Subsequently, gloves were put on for the next 2 h. After the gloves were removed, hands were washed with water and dried without rubbing, followed by taking of the 3rd replica. For the next 60 min, the volunteers were instructed to work on as normal, but to reduce hand wash procedures, to avoid disinfectants and not to wear gloves, and finally the 4th replica was taken (Fig. 1).

Statistical analysis

Statistics were performed using SPSS for Windows software. Differences in the baseline skin roughness in volunteer groups using different types of gloves were tested by 1-way ANOVA multiple range test (modified LSD, Bonaferrony), with a significance level of 0.05. Variation of roughness after 1 h of regular work was tested by the *t*-test for paired samples. Using the Friedman test, we analysed the change in roughness after wearing gloves.

Results

pH

A steady state of pH was registered 1–2 min after placing the pH meter on the glove surface for a registration period of 5 min. The mean of the maximum pH on the surface of 5 pairs of each glove type showed little variation. The values are presented in Table 1. The pH measurement at 10 different sites of each glove was very homogeneous (Table 1). The pH was alkaline on the surface of Peha taft gloves and Manex neoderm gloves, whereas the pH on the Biogel gloves was in the range of the physiological skin pH. pH of the powder was neutral, and when added

Replica 1
↓ 60 min (reducing skin irritation)
Replica 2
↓ 120 min working with gloves
↓
Replica 3
↓ 60 min (reducing skin irritation)
Replica 4

Fig. 1. Time table of the study protocol.

Table 1. Surface pH of the gloves used

	1 glove of each type			10 gloves of the same type
	pH minimum 10 values	pH maximum 10 values	pH mean 10 values	pH maximum after 5 min 5 pairs of gloves
Biogel	5.1	5.6	5.5	6.0
Biogel+powder	6.2	7.1	6.6	7.1
Manex neoderm	8.1	8.6	8.5	10.2
Peha taft	8.3	9.1	9.0	9.3

On 1 glove of each type, the homogeneity of the pH surface was analysed by measurement on 10 different sites of the glove. Variation of pH between gloves of 1 type was investigated by analysis on 10 gloves of each type; a steady state of the pH was observed after 1–2 min during a standardized analysis for 5 min.

to the Biogel glove came up to 7.1. Skin pH values, after wearing gloves, were not investigated in the present study.

Skin-roughness

Series of 4 replicas of 34 hands were evaluated. Basal roughness of the skin was in the range of 128–192 (mean 159.6 SD 18.3), after 60 min in the range of 119–197 (mean 158.4, SD 18.8). The mean skin roughness in the volunteer groups using different types of gloves, was not significantly different at the baseline level (replica no.1), as well as the change of skin roughness at the baseline within 1 group, 1 h after taking the 1st replica and without any glove wearing (comparison of the 1st and 2nd replica ($p=0.59$)).

Decrease in roughness after wearing Biogel gloves ($p=0.057$) was not significant and no change was registered using Manex neoderm gloves for 2 h ($p=0.46$). A significant increase of roughness was observed after wearing Peha taft gloves ($p=0.007$),

and also after wearing Biogel gloves on prepowdered hands ($p=0.0001$) (Fig. 2).

Discussion

Chronic irritant contact dermatitis is a multifactorial disease caused by chemical, mechanical, thermal and climatic effects. The clinical spectrum of the disease is highly variable and is predominantly characterized by redness, dryness, scaling and infiltration. The skin surface profile is 1 parameter to assess the severity of skin irritation (10). Skin reactions to weak irritants, not resulting in macroscopic changes, can be detected by microscopically evaluated skin replica techniques assessing the skin roughness (5, 11). In the present study, we demonstrate the effect of glove powder on skin roughness. Skin roughness significantly increased after wearing powdered Peha taft gloves or Biogel gloves on prepowdered hands for 2 h. In contrast to this, we observed a slight, not significant decrease in skin roughness by wearing powder-free Biogel gloves and no change by wearing powdered Manex neoderm gloves. Glove powder may increase roughness by mechanical rubbing of the skin surface, indicated by the results after wearing Biogel gloves on prepowdered skin.

On the other hand, the human skin surface is effected by occlusion and by irritants, both causing an increased number of mononuclear cells in the skin and the extension of intercellular space in the spinous layer of the epidermis (12–14), indicating that skin surface profiles may be influenced by oedema and infiltration of inflammatory cells. Local pH alterations caused by an acidic or basic permanent can initiate an inflammatory response in keratinocytes, fibroblasts or dermal vasculature (15).

In our study, we found extreme differences in the surface pH of the gloves tested. Peha taft gloves and, even more, Manex neoderm gloves were highly alkaline, whereas the pH of Biogel gloves was in the range of the physiological skin pH. This is concurrent with A. Heese's report, who found a higher pH on powdered gloves, compared with unpowdered

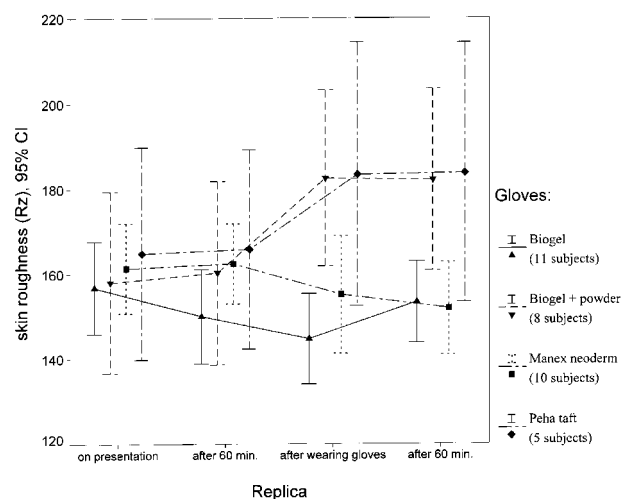


Fig. 2. Change in skin roughness during the study period, analysed by laser profilometry. Median Rz and 95% confidence interval (CI) are given for each type of glove at each of the 4 points in time when a replica was taken.

gloves. Wearing of gloves with an alkaline pH resulted in a highly alkaline skin pH for hours after taking off the gloves (16). The dissociation constant is another important feature of chemicals and is associated with the irritant capability (17). The quality and quantity of glove chemicals, liberated by the sweat of a gloved hand are not yet known. We assume high variations due to different manufacturing processes and compositions of chemicals in different glove brands. Therefore, other chemical features can probably cause an increase in skin roughness. Variation of glove pH and glove chemicals may be highly responsible factors for skin irritation due to gloves. The failure to show increase in roughness after wearing Manex neoderm gloves, in contrast to the increase after wearing Biogel gloves on prepowdered hands, may be a result of the different pH. Different skin reactions to the powdered types of gloves, Peha taft and Manex neoderm may be a result of different chemicals, although the pH is almost the same in both. In the present study, we observed changes in skin roughness, indicating skin irritation, during a short period of glove occlusion. Effects of gloves on the barrier function of the skin were investigated by other biotechnical methods. Short-term glove occlusion (6 h a day for a period of 3 days) has no significant impact on the water barrier function of normal skin, but a significant negative effect on primarily irritated skin (18). Only long-term glove wearing has a negative effect on the water barrier function of normal skin (19).

In conclusion, glove powder is 1 factor influencing skin irritation due to the wearing of gloves. Because of the high prevalence of irritant hand eczema in professions with frequent glove wearing, the prevention of skin barrier damage is important (20, 21) to prevent the development of allergic hypersensitivity, especially immediate-type allergy to NRL. Further investigation with the help of other biotechnical methods will be necessary to determine the irritant potential of gloves and rubber chemicals in more detail.

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