

# Prevention of work-related skin diseases: teledermatology as an alternative approach in occupational screenings

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*Background:* Prevention of occupational skin diseases is of high socio-economic impact. Implementing teledermatology into preventive occupational screenings holds obvious advantages; nevertheless, studies concerning this subject are scarce.

*Objectives:* The present cross-sectional study was aimed at determining if results of a teledermatological examination are equally sensitive and specific at detecting minimal skin lesions as the conventional face-to-face examination.

*Methods:* The skin condition of the hands of 100 male wet workers was assessed in a face-to-face examination and a tele-examination by means of a score for minimal skin lesions.

*Results:* The comparison of the total score values that each participant received in face-to-face examination with those obtained in tele-examination proved the skin condition to be estimated significantly worse when seen in tele-examination ( $P < 0.0001$ ). The median values of the sum totals and the median values for secondary lesions were higher in the tele-examination than in the face-to-face examination.

*Conclusions:* Our findings show a tendency in tele-examination to assess the skin condition more critically in comparison with face-to-face examination. The teledermatological examination is sufficiently sensitive in detecting early signs of hand eczema, whereas signs for chronicity may get overestimated.

*Key words:* early hand eczema; occupational screenings; teledermatology; work-related skin diseases.  
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Teledermatology is the practice of dermatology when the dermatologist and the patient are not present at the same place and/or at the same time. This method has been shown to be a feasible (1–3), cost effective (4) and for the patients beneficial method (5–10) to bring dermatological knowledge to remote (5, 11, 12) and underserved areas (4, 13–18). The main emphasis has been on the screening of pigmented, potentially malignant skin lesions (10, 19, 20), triage aspects (21–23) and chronic wound care (2). Teledermatology has been considered a mature application that yields results similar to those of conventional face-to-face

consultations (5, 10, 24). In teledermatology, the store-and-forward approach, where data are stored and sent to the physician by electronic or conventional means, has been proven as useful (5). In comparison with the real-time approach (25) where it is necessary for physician and patient to be present at the same time, it is regarded to be more effective (5), more affordable and to have a better cost-benefit ratio, while providing equivalent levels of diagnostic accuracy and concordance (11, 26). Although skin diseases still account for a large part of the total sum of occupational diseases, studies dealing with

the implementation of teledermatology into occupational medicine are scarce to non-existent.

Occupational medicine is mainly a preventive specialty, so the use of telemedical tools in occupational medical checkups, especially the screening of the skin of the hands, should be explored, because approximately 80–90% of occupational contact dermatitis is located on the hands (27).

Because surveillance is aimed at preventing the development of skin diseases, the detection of minimal skin lesions is crucial. The present cross-sectional study was aimed at determining if results of a teledermatological examination are sensitive and specific at detecting minimal skin lesions.

### Objective

The present cross-sectional study is aimed at assessing the quality of teledermatological skin examinations in 100 metal workers exposed to cutting fluids. Results of these skin examinations were compared with results of on-site findings in the same sample to determine if teledermatological examinations were a feasible alternative to face-to-face skin examinations within the framework of occupational health supervision.

### Patients and Methods

#### *Study population*

The hands of 100 randomly chosen male metal workers were examined in May 2007. All participants were employed at a German production site of a globally operating automotive supplier with a total of 2600 employees. All participants reported as having daily contact with cutting fluids. Our participants were employed as machinists (86 persons), assemblymen (10 persons), punch operators (3 persons) and handyman (1 person). The participants were aged from 22 to 57 years (median: 42.5 years, mean: 42.6 years). Ninety-two participants were right handed. Thirty-eight participants reported as having had skin-related problems of the hands at least once since having been employed in the company. Twenty-two of these participants reported to have suffered from vesicular hand eczema. The majority ( $n = 91$ ) reported as having used abrasive cleansing agents to remove work-related contamination on an average of 22 times per week, more than half ( $n = 55$ ) of our study population reported as having used skin protection creams at least once a week. The informed consent to participate in this study was given by each of the participants prior to the examination; the consent of the ethics committee of the University of Erlangen-Nuremberg was obtained.

#### *Methods*

Before the beginning of the study, the examining physicians were thoroughly trained. The training consisted of a 120-min introduction in which a scoring system for minimal skin lesions was systematically explained by a dermatologist specialized in occupational dermatology. The morphological changes characteristic of hand eczema were shown by digital photographs. Then three photographs of cases of mild to moderate hand eczema were assessed and discussed in the training session.

Each participant was examined during their working hours by one of the three specially trained physicians. In order to simulate the working conditions of a non-resident occupational physician realistically and to not unduly disturb the processes within the factory, the physician had to perform the examination as quickly as possible. The physicians first did a short interview with the participants to let any reactive reddening of their skin caused by preliminary cleansing or physical activity, such as climbing stairs, subside. For this interview, a standardized questionnaire was used. The questionnaire comprised questions related to working conditions, use of protective equipment, known dermatological disorders and medicine intake. After the interview, the skin condition of the participant was examined. The observing physician first had to classify the participant's skin subjectively into one out of the four categories, which were 'no skin changes', 'discrete skin changes', 'moderate skin changes' or 'severe skin changes'. Mild skin changes were considered to consist of rough skin, also in combination with slight erythema and mild scaling. Moderate skin changes were characterized by more widespread erythema, infiltration and scaling. Severe skin changes corresponded to florid hand eczema.

The skin was then assessed by using a quantitative scoring system related to minimal skin lesions on hands. This scoring system had to be specially developed as established dermatological scoring systems are focused on monitoring the success of therapies for patients with skin diseases such as hand eczema, for example, the hand eczema severity index (HECSI) (28) or the dyshidrotic eczema area and severity index (DASI) (29), or atopic dermatitis like the SCORAD index (scoring atopic dermatitis) (30). They were, therefore, not appropriate for participants with only minimal skin lesions on the hands.

#### *Score*

The score comprises morphological criteria and physiological abnormalities characteristic of hand eczema and the extent and intensity of the skin lesions. It distinguishes between primary changes,

such as erythema, vesicles and papules, and secondary changes, such as scaling, erosions, fissures and lichenification (meaning thickening of skin and accentuation of skin markings). For quantification, each hand was subdivided into 54 areas of almost equal size. If possible, anatomical structures were followed. Interdigital areas and knuckles, being important affected areas in hand eczema, were defined as separate areas. Morphological criteria were subdivided into primary and secondary skin lesions to differentiate acute, chronic or subchronic hand eczema. The severity of each single lesion within each area could be rated from 0 (absent) to 3 (severe), following specific criteria for each lesion. Erythema on the back of the hands was graded from 0 to 3 per defined area. Palmar erythema was also graded from 1 to 3, but the complete palmar surface was regarded as only one area. Palmar lichenification was rated from 0 to 2 with the palm considered as one single area. For grading dryness, the entire surface of one hand was regarded as one single area, too. All findings were recorded for each hand, palm and back, separately. The score values concerning primary and secondary lesions were summed up. For receiving the final total value, both results were added. The possible highest numeric value was 2260 points (range: 0–2260). Thus, a low sum total of point values indicates a good skin condition, whereas a high value signifies increasingly impaired or damaged skin.

#### *Photo-documentation and teledermatological examination*

Immediately after the examination, digital images of the participants' hands were produced in a standardized way. Photographs of the dorsal and palmar aspects of each patient were taken against a green, non-reflecting background, with a tripod-mounted, commercially available Olympus<sup>TM</sup> sp-350 camera (resolution 8.0 mega pixels; Olympus Imaging Europa GmbH, Hamburg, Germany).

The anonymized digital images were examined several weeks later by a team of two physicians in the same way as described for the face-to-face examination, but no maximum time limit was given. As in the face-to-face examination, the findings were entered into a score sheet that had been encoded previously.

In order to ensure data security, the score sheets and digital images were coded and kept separately from the decoding list.

The score sheet results from both settings (face-to-face examination versus teledermatological examination) were then compared.

#### *Statistics*

The statistic evaluation was carried out with SPSS version 16.0. To determine whether there was a significant difference between the average values of the total score sum made under two different diagnostic conditions, the paired sample *t*-test and as a non-parametric alternative the Wilcoxon signed-rank test were used. In contrast to the paired sample *t*-test, the Wilcoxon signed-rank test does not require assumptions about the form of the distributions of total score values obtained by both methods.

#### **Results**

For analysing the correspondence between both methods, the results of face-to-face and tele-examination were compared with regard to the subjective grading, in which the participants were classified into the four categories 'no', 'discrete', 'moderate' and 'severe' skin changes. Although most of our participants were right handed, there was no difference between right and left hands.

None of our participants showed 'severe skin changes' in either examination setting (i.e. face-to-face examination or tele-examination). The face-to-face examination showed in 25 cases 'no skin changes', in 71 cases 'discrete skin changes' and in 4 cases 'moderate skin changes', whereas the tele-examination showed only in 4 cases 'no skin changes', but in 95 cases 'discrete skin changes' and in 1 case 'moderate skin changes'. Hence, with regard to the subjective classification, the participant's skin condition was estimated to be worse in tele-examination compared with face-to-face examination.

Table 1 gives the correspondence between subjective categorization in face-to-face and tele-examination. Correlating the ranges of the score total and its constituent score sums with the aforementioned four subjective categories, we found extensive overlaps in the ranges of score sums between the categories 'no' and 'discrete' and between the categories 'discrete' and 'moderate' skin changes in both the face-to-face and the tele-examination. The detailed information is given in Table 2, where the results obtained from the dermatological examination of both hands either by

*Table 1.* Correspondence between the subjective categorization in live and tele-examination

| Skin lesions on examination (live:tele) (no individual showed severe skin changes) |                      |                     |
|------------------------------------------------------------------------------------|----------------------|---------------------|
| No:No 0                                                                            | No:Discrete 25       | No:Moderate 0       |
| Discrete:No 4                                                                      | Discrete:Discrete 66 | Discrete:Moderate 1 |
| Moderate:No 0                                                                      | Moderate:Discrete 2  | Moderate:Moderate 2 |

Table 2. Results of subjective and score assessment of the participants' skin condition in face-to-face (live) and tele-examination

| Skin lesions (subjective categories) | No   |      | Discrete |       | Moderate |      | Severe |      |
|--------------------------------------|------|------|----------|-------|----------|------|--------|------|
| Examination setting                  | Live | Tele | Live     | Tele  | Live     | Tele | Live   | Tele |
| <i>n</i>                             | 25   | 4    | 71       | 95    | 4        | 1    | 0      | 0    |
| Sum totals                           |      |      |          |       |          |      |        |      |
| Range                                | 0–12 | 4–9  | 2–28     | 7–63  | 15–56    | —    | —      | —    |
| Median                               | 6    | 5.5  | 15       | 15    | 32       | 9    | —      | —    |
| Mean                                 | 5.64 | 6    | 14.55    | 16.72 | 33.75    | 9    | —      | —    |

Skin lesions (subjective categories): participants got sorted into subjective categories in each examination setting; examination setting: face-to-face situation (live) and via telemedicine (tele); *n*: absolute numbers of participants who got sorted into each category; sum totals: the skin condition of each participant was assessed with a score system for minimal skin lesions.

subjective impression in one out of the four categories or by sum score value under both conditions (i.e. face-to-face examination or teledermatological examination) are compared.

On the basis of subjective categories, Fig. 1 illustrates the comparison of score values reached in face-to-face and tele-examination of both hands. Results obtained by teledermatological examinations of the hands were generally higher than those obtained by face-to-face examination.

The Wilcoxon signed-rank test showed that in 67% of all cases total score values obtained by teledermatological examination were significantly higher than those obtained by face-to-face examination in the same participant. Only in 6% of all cases, the results obtained by both examination methods were equal. Using a paired sample *t*-test to determine whether there was a significant difference between the average total score values obtained either by face-to-face examination or by teledermatological examination yielded significant higher mean values in the teledermatological examination 16.3 versus 13.1, respectively, in the face-to-face examination

( $P < 0.0001$ ). The null hypothesis of this test was that the difference in the mean values was zero.

When we differentiated the clinical findings, both face-to-face and teledermatological examination showed a predominance of secondary skin lesions, with even higher score values in the tele-examination. The median values of the sum totals (median from face-to-face examination: 12 points, range: 0–56 points; median from tele-examination: 15 points, range: 4–63 points), as well as the median values for secondary lesions (face-to-face examination: 8 points, range: 0–29; median value for tele-examination: 11 points, range: 2–37 points), were higher in the tele-examination than in the face-to-face examination, as illustrated in Fig. 2. The majority of those score points was given for lichenification. There was no difference between face-to-face and tele-examination in the median score values for primary lesions (4 points in either face-to-face or tele-examination). The primary lesion, for which the majority of the points was given, was erythema.

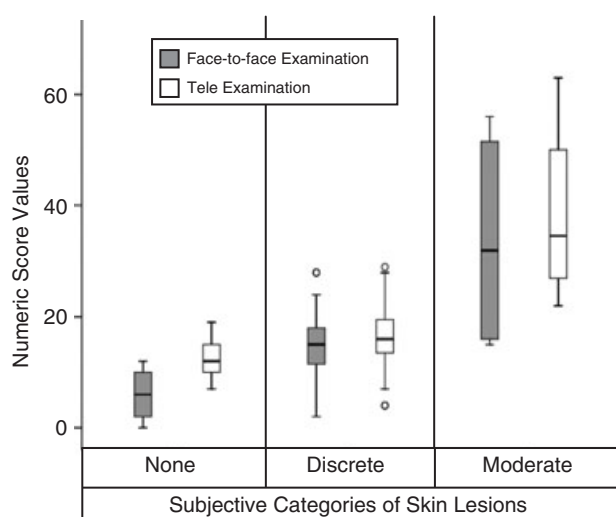


Fig. 1. Score values reached in face-to-face and tele-examination of both hands ( $n = 100$ ) in correspondence to the subjective categorization into 'no', 'discrete' and 'moderate' skin changes.

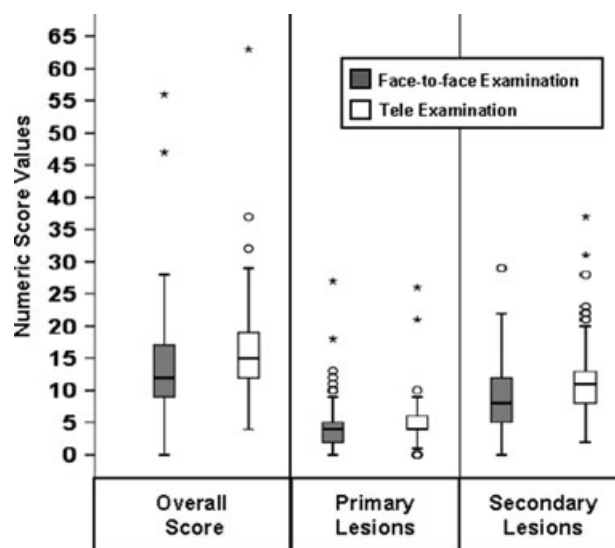


Fig. 2. Score values reached in face-to-face and tele-examination of both hands ( $n = 100$ ), shown as sum totals (overall score) and differentiated into primary and secondary changes.

## Discussion

A large number of studies have been previously performed, assessing accuracy and reliability of teledermatological diagnoses. A Medline research in August 2008 with the terms *telemedicine* yielded 7662 hits and within these, the terms *teledermatology* or *skin* yielded 274 and *teledermatology* alone yielded 230 hits. Forty-one publications were studies (sample sizes: 12–2009 cases, median: 106) concerning agreement between face-to-face examination and teledermatological examination. Apart from three randomized controlled trials (11, 31, 32), all were cross-sectional comparative studies. Many of these studies were focussed solely on malignant skin lesions (10, 20, 21, 33–37) or dealt with a range of cutaneous diseases typical of an outpatient clinic or a dermatologic ward (6, 10, 11, 18, 24–26, 38, 39). The results of most publications were favourable with regard to teledermatology.

There are few published studies to be found dealing with teledermatology in the area of occupational medicine and there is, to the best of our knowledge, no study concerned with preventive skin examinations.

The current study was, therefore, aimed at assessing the accuracy and sensitivity of a teledermatological examination of the skin concerning minimal skin lesions as they are likely to occur in occupational preventive skin examinations.

Comparing our findings with the results of these studies would be erroneous as they were all performed in clinical settings on participants with obvious skin diseases, whereas a healthy participant in a preventive skin examination shows minimal skin changes at best. The assessment of minimal skin changes cannot be differentiated dichotomously between 'diseased' and 'healthy', but has to be as thorough and as differentiated as possible. This leads to a range of possible results, thereby diminishing the possibility of a strong statistic correlation.

While comparing the score results from face-to-face and tele-examination, we consistently found higher score values in the tele-examination. The overall predominance of secondary skin lesions in both examination settings implies that the participants' skin seemed to be affected on a subclinical level without suffering from acute damage, especially because the score points for secondary lesions were mainly given for lichenification.

The higher median values for secondary skin lesions in the tele-examination suggests a higher sensitivity for secondary lesions compared with the conventional setting, probably resulting from the ability to zoom in on distinct skin changes.

There was no significant difference in the results between face-to-face and tele-examination in the detection of primary changes. The score for primary

changes consists of point values for erythema, vesicles and papules, whereby in our sample nearly all points given for primary changes were caused by erythema. Therefore, we conclude that for assessing erythema the tele-examination is sufficiently sensitive but does not lead to overestimation. Because erythema is, apart from scaling and itching, nearly always the first sign of acute occupational skin diseases, we take it as showing the suitability of tele-examination in preventive examinations of the skin.

Our findings show that in tele-examination the skin condition is assessed more critically and more closely in comparison with face-to-face examination, which can be a positive factor when quantifying minimal skin changes. However, it also shows the danger of losing the general view in the tele-examination, mainly through the ability to enlarge the photograph and, without a time limit, to put more emphasis on minute details and then to overestimate them. The subjective categorization was not completely reflected in the score values, but it is feasible that the overall total of multiple minimal skin lesions does not add up to an overall picture that can be subjectively categorized.

We found further proof for this view when we correlated the ranges of the score total and its constituent score sums with the abovementioned subjective categories and found extensive overlaps between two subjective categories ('no skin changes' and 'discrete skin changes').

There were no differences in our participants' skin condition between left and right hands, although the majority of our participants were right handed. Assuming that coarseness and reddening of our participants' hands is work related, one could suggest that they either had workplaces where the left and right hands are similarly exposed, or the coarseness and reddening does not result from work itself, but rather from mainly bimanual accompanying activities like washing of the hands. However, it is known that hand eczema is often located symmetrically on both hands while exposure to triggering agents may takes place asymmetrically.

Our findings show that it is possible to perform preventive examinations of the skin by means of teledermatology. This form of examination could be advantageous for the patient, considering the usually limited amount of dermatological knowledge among occupational physicians, the limited availability of occupational physicians, the distances that often lie between industrial sites and the nearest dermatologist's office. Teledermatology could also be useful in assessing transitory skin lesions that occur during the work shift and vanish within hours (6). Because the examination is performed by a specialist, it can be decided at once if the patient's condition is critical and needs immediate specialist intervention or

if the skin condition can be treated by the occupational physician without having to sign the patient off work. We do not suggest replacing the occupational physician in managing occupational skin diseases. The best treatment of occupational skin diseases is the amelioration of working conditions, which can be implemented only by the occupational physician. A close interaction between occupational physician and dermatologist could ensure a successful therapy and also amend the challenges that also apply to all patients in rural area, namely patient loss to follow-up and lack of information in the patient records (40).

### Conclusion

Our findings show a tendency in tele-examination to assess the skin condition more critically in comparison with face-to-face examination. The teledermatological examination is sufficiently sensitive in detecting early signs of hand eczema, whereas signs of chronicity might be overestimated. Minimal skin changes are not missed. A differentiated score-based assessment can be performed only with basic dermatological knowledge and is superior to a subjective evaluation.

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