

Occupational dermatoses in a metalworking plant

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In a plant producing advanced components for engines and drivelines we undertook a survey of occupational dermatoses, based on a questionnaire, clinical examination, and patch testing with a standard series and a series of samples from the working environment. The questionnaire was given to all 430 employees and it was answered and returned by 382 of these. 214 reported having had or having skin manifestations during the time of employment suspected of being work-related. 183 employees (164 metal workers, 19 office staff) participated in the clinical investigation, 182 (163 metal workers, 19 office staff) being patch tested. Occupational dermatoses were diagnosed in 23 of these 163 (14.1%) and in 1 of these 19 (5.3%). In all, irritant contact dermatitis was diagnosed in 12 metal workers, occupational allergic contact dermatitis in 11 (10 metal workers and 1 office clerk) and folliculitis in 1 metal worker. In the 11, neat oils were the cause in 4 workers, a water-based cutting fluid in 3 and various biocides in 4.

Key words: allergic contact dermatitis; bis ((O, O'-di-2-ethylhexyl) dithiophosphate); CAS 4259-15-8; contact allergy; epidemiology; irritant contact dermatitis; metalworking fluids; neat oils; occupational; prevention; zinc. © Blackwell Munksgaard, 2003.

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In a Swedish plant that produces advanced components for engines and drivelines for the automotive industry, a study on occupational skin disease was initiated because of a high number of suspected work-related skin diseases among the workers. The major purpose of the study was a survey of work-related skin diseases as a basis for possible preventive measures.

Materials and Methods

Plant description

Core activities in the plant, situated in the countryside in southern Sweden, include metalworking and die-casting of lightweight metals with core products being brake parts, complete cylinders, rocker-arms, king pins, shafts, and injection parts. The metals most often handled were steel, stainless steel, aluminium, and iron. The metalworking fluids (MWFs) present in the plant were neat oils (80%) and water-based fluids (20%). Anti-rust agents and degreasing solvents were also used. The individuals investigated represented employees from 3 different units with partly diverse production, but as the different MWFs were used over the whole plant, the exposure conditions were considered similar in all production workers examined.

Employees

At the time of the investigation, there were a total of 430 individuals in the plant, 366 production workers (279 men and 87 women) and 64 office clerks, cleaners and kitchen personnel (48 men and 16 women).

Investigation of occupational dermatoses

A survey of occupational dermatoses, based on a questionnaire, clinical examination, and patch test, was carried out among the workers.

Questionnaire

During the spring of 1999, a questionnaire, used earlier in several investigations (1, 2) but modified to suit the present investigation, was designed in collaboration with the Industrial Medical Service of the company. After oral information given to all employees by the authors, the questionnaire was handed out to everyone. Questions inquired about family and personal atopy, previous and present skin disease, physician consultations because of skin disease, as well as questions on the use of skin protection and type of work.

Consultation

Everyone who reported skin disease during employment, past or present, was offered a consultation consisting of an interview, clinical investigation, and patch testing. The consultation and patch testing were performed in the village near the plant from February to March 2000. If a worker had consulted a dermatologist, information from the visit was procured. Examination of the skin always included the hands, arms, face and, when indicated, other parts of the body. Histopathological examination of a skin biopsy supplemented the investigation in 1 case.

Patch testing

Patch testing was performed with a standard series and a series of samples from the working environment (Table 1). The standard series used in our department at that time comprised the European standard series supplemented with diazolidinyl urea, imidazolidinyl urea, thimerosal, methyldibromoglutaronitrile, iodopropynyl butylcarbamate, DMDM hydantoin, gold sodium thiosulphate (3), palladium chloride, a resol resin based on phenol and formaldehyde (4), ethylenediamine dihydrochloride, lichen acid mix, tixocortol pivalate, hydrocortisone-17-butyrate, budesonide, caine mix II, toluene-sulphonamide-formaldehyde resin, a textile colour mix, Amerchol L-101 and an epoxy resin based on diglycidyl ether of bisphenol F. Anticorrosion agents, emulsifiers, and biocides commonly found in MWFs, the various MWFs used in the plant (both unused and used), and acetone extracts of gloves (5) were included in the work environment series (Table 1). These products were chosen on the basis of exposure conditions observed on several workplace visits and knowledge of content of known/suspected sensitizers. When the test concentrations of the test preparations representing the work environment were determined, factors concerning active sensitization, skin irritancy, and exposure were considered (6). To substantially diminish the possibility of false-positive reactions, 20 dermatitis patients at the Department of Occupational and Environmental Dermatology, Malmö, were patch tested with each product representing the work environment in the same vehicle and at the same concentration as used later in the study. The Finn Chambers on Scanpor tape technique was used (Epitest, Tuusula, Finland). Patch tests were removed after 2 days and read after 1 or 2 additional days, according to International Contact Dermatitis Research Group criteria. A second reading was done 7 days after the initial application of patches.

Table 1. Patch test series with chemicals and products representing the work environment*

Chemical/Product	Test concentration (%)	Vehicle**
1H-benzotriazole	1.0	pet.
Dipentene (limonene)	1.0	pet.
Coconut diethanolamide	0.5	pet.
Sodium omadine	0.1	aq.
Modified dicarboxylic acid Diethanolamide	0.1	acid buff.†
Triethanolamine	2.0	pet.
Alkanolamineborate	2.0	acid buff.†
1,2-Benzisothiazolin-3-one (BIT)	0.05	pet.
Water-based coolant no. 1	4.0	pet.
Water-based coolant no. 2	4.0	pet.
Neat oil no. 1	50	pet.
Neat oil no. 2	50	pet.
Neat oil no. 3	50	pet.
Neat oil no. 4	50	pet.
Neat oil no. 5	50	pet.
Water-based coolant no. 3	4.0	pet.
Neat oil no. 3, recirculated	25	pet.
Water-based coolant no. 3, recirculated	50***	aq.
Neat oil no. 6, recirculated	30	pet.
Water-based coolant no. 1, recirculated	50***	aq.
Water-based coolant no. 1, recirculated	25***	aq.
Neat oil no. 2, recirculated	30	pet.
Water-based coolant no. 2, recirculated	50***	aq.
Neat oil no. 7, recirculated	30	pet.
Neat oil no. 1, recirculated	30	pet.
Neat oil no. 4, recirculated	25	pet.
Neat oil no. 5, recirculated	30	pet.
Extract†† of a plastic glove		acet.
Extract†† of a textile and plastic glove		acet.

* Pet., petrolatum; aq., aqueous; acid buff., acidic buffer; acet., acetone.

** w/w for pet.; w/v for liquids.

*** The concentration is based on the diluted fluid the workers are exposed to, where the concentration the workers are exposed to is designated as 100%.

†Ref. 17. ††Ref. 5.

Additional testing

In subjects with doubtful positive patch test reactions, re-patch testing with these test preparations was carried out. Clearly positive reactions to products from the workplace were followed by patch testing with ingredients. The manufacturers of the various MWFs kindly supplied components for such purposes. To confirm the allergic nature of the patch test reaction and to determine the strength of the allergy, patch testing with dilution series was performed. For each product from the work place controls were tested with the ingredi-

Table 2. Sex, age, and employment time of the metal workers and the office staff in the investigation of occupational dermatoses

Sex	Male		Female		Total	
	metal workers	office staff	metal workers	office staff	metal workers	office staff
Number	118	10	45	9	163	19
Mean age, years (range)	38 (20–64)	42 (29–59)	37 (24–56)	44 (29–55)	38	43
Mean time of employment, years (range)	11 (0.5–46)	19 (1–45)	11 (1–30)	11 (2–25)	11	15

ents not described or known to be a sensitizer in the same vehicle and at the lowest concentration that had resulted in a positive patch test reaction in the aforementioned subjects. Controls were dermatitis patients at the Department of Occupational and Environmental Dermatology, Malmö.

Results

The questionnaire was returned by 382 (88.8%), of whom 214 reported having had or having skin manifestations appearing during their time of employment. 183 (164 metal workers, 19 others) of the 214 employees (85.5%) with suspected work-related skin disease participated in the clinical investigation, 182 of whom (163 metal workers, 19 others) were patch tested (1 patient refused testing). Of the 19, 14 were office clerks (8 of these 14 had worked with MWFs earlier in the plant), 4 were cleaners (2 of these 4 had worked with MWFs earlier in the plant) and 1 was a kitchen maid. In this paper the group of 19 is designated office staff. Data on sex, age and employment time for the 182 is given in Table 2. In 65/163 metal workers and in 11/19 office staff, 120 contact allergies to preparations in the standard series were demonstrated (Table 3). Table 4 lists work-related contact allergies in 10 metal workers and in 1 office clerk, who had worked in production previously. All controls had negative patch test results.

On examination, 90 of the 164 metal workers (54.9%) and 10 of the 19 office staff (52.6%) showed current skin manifestations. Of the individuals without current skin problems, 39 of 164 metal workers (23.8%) and 3 of 19 office staff (15.8%) had had skin lesions during the past year and 35 of 164 metal workers (21.3%) and 6 of 19 office staff (31.6%) earlier.

Table 5 lists information regarding the different employees' dermatoses and whether these dermatoses were work-related. Some workers had both a non-occupational and an occupational dermatosis. Whenever applicable, only the occupational dermatosis was considered in the various compilations and tables. Occupational dermatitis

was diagnosed in 23 out of 163 metal workers (14.1%) and in 1 out of 19 office staff (5.3%). In the 24, the dermatitis was or had been localized to the hands and/or lower arms. 11 had allergic contact dermatitis (10 metal workers and 1 office clerk) and 12 metal workers irritant contact dermatitis. 1 person had folliculitis. 5 metal workers (3.1%) showed deterioration in their endogenous hand dermatitis due to work. In 66 metal workers (40.5%) and 6 office staff (31.6%) it was impossible to determine the

Table 3. Contact allergies to sensitizers in the standard test series in 65 of 163 metal workers and in 11 of 19 office staff with at least 1 contact allergy*

Substance	No. positive (163 & 19 patch tested)	%
Gold sodium thiosulphate	23/4**	14.1/21.1**
Nickel sulphate	19/2	11.7/10.5
Thimerosal	12	7.4
Palladium chloride	6/2	3.7/10.5
Myroxylon Pereirae (balsam of Peru)	7/1	4.3/5.3
Amerchol L-101	4/1	2.5/5.3
Potassium dichromate	4/1	2.5/5.3
Cobalt chloride	4	2.5
Neomycin sulphate	4	2.5
Caine mix II	3	1.8
Colophonium	3	1.8
DGEBF resin*	2	1.2
Quaternium 15	2	10.5
Fragrance mix	1/1	0.6/5.3
Formaldehyde	2	10.5
DGEBA resin*	2	1.2
4-Phenylenediamine base	2	1.2
Methylchloroisothiazolinone/methylisothiazolinone (MCI/MI)	2	1.2
Methyldibromo glutaronitrile	1	5.3
Lichen acid mix	1	0.6
Diazolidinyl urea	1	5.3
Primin	1	0.6
PPDA rubber mix	1	0.6
Benzocaine	1	0.6

*DGEBF resin, epoxy resin based on diglycidyl ether of bisphenol F; DGEBA resin, epoxy resin based on diglycidyl ether of bisphenol A (standard epoxy resin).

** Figures in bold = metal workers. Figures in italics = office staff.

Table 4. Work-related contact allergies in 10 metal workers and 1 office clerk

Employee No.	Contact allergy	Employment time	Employment
1	neat oil nos. 3 & 5, zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate)	6 months	metal worker
2	neat oil nos. 3 & 5, zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate)	1 years	metal worker
3	neat oil no. 3, zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate)	3 years	metal worker
4	neat oil no. 1	2 years	metal worker
5	coolant no. 2 fatty alcohol polyglycoether diethyleneglycol butylether	3 years	metal worker
6	coolant no. 2 fatty alcohol polyglycoether	7 years	metal worker
7	coolant no. 2	3 years	metal worker
8	modified dicarboxylic acid diethanolamide 1,2-benzisothiazolin-3-one (BIT) methylchloroisothiazolinone/methylisothiazolinone (MCI/MI)	34 years	metal worker
9	1,2-benzisothiazolin-3-one (BIT) methylchloroisothiazolinone/methylisothiazolinone (MCI/MI)	11 years	office clerk
10	1,2-benzisothiazolin-3-one (BIT)	24 years	metal worker
11	1,2-benzisothiazolin-3-one (BIT)	13 years	metal worker

Table 5. Relationship between skin disease and work in metal workers and office staff, respectively

Relationship	Male		Female		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Caused by work	16/1*	13.6/10.0	7	15.6	23/1	14.1/5.3
Allergic contact dermatitis	7/1	5.9/10.0	3	6.7	10/1	6.1/5.3
Irritant contact dermatitis	8	6.8	4	8.9	12	7.4
Folliculitis	1	0.8			1	0.6
Aggravated by work	3	2.5	2	4.4	5	3.1
Unknown relation to work	49/4	41.5/40.0	17/2	37.8/22.2	66/6	40.5/31.6
No relation to work	50/5	42.4/50.0	19/7	42.2/77.8	69/12	42.3/63.1
Total	118/10		45/9		163/19	

*Figures in bold = metal workers. Figures in italics = office staff.

relationship between skin disease and work. Non-work-related dermatoses were diagnosed in 69 metal workers (42.3%) and in 12 office staff (63.1%). Examples of non-work-related skin diagnoses were acne vulgaris, atopic eczema, psoriasis, lichen simplex chronicus, and seborrheic eczema.

Discussion

The major purpose of this study was a survey of work-related skin diseases as a basis for possible preventive measures. In this study, the assessment of relationship between a worker's dermatosis and the work he or she performed was based on traditional criteria (7, 8), i.e. identification of an occupational contact factor, demonstration of a current exposure to such a factor, and establishment of a relationship between this contact factor and the dermatosis under investigation with regard to type, localization, and course of the dermatosis. In metalworking plants, the MWFs are the major cause of occupational dermatoses (7, 9, 10), but physical factors such as minor lacerations due to metallic

or other sharp fragments may also contribute to skin lesions.

Some of the metal salts present in the standard series, i.e. chromate, cobalt chloride, nickel sulphate, and metallic aluminium (in the test chamber), represent potential contactants in production, because these metals could be released from the metal parts involved and leach into the MWFs (11, 12). Other test preparations in the standard series, such as biocides, rubber chemicals, and Amerchol L-101 also represent potential contactants in production. Although the biocides methylchloroisothiazolinone/methylisothiazolinone (MCI/MI), iodopropynyl butylcarbamate, formaldehyde and the formaldehyde releasers quaternium 15 and DMDM hydantoin are mostly found in toiletries, they can also be present in MWFs (Table 3). Rubber chemicals could reflect some components of the workers' gloves. Amerchol L-101, present in most standard series, is used to trace lanolin hypersensitivity. Though several hand creams used at the plant contained a lanolin product, the 5 individuals with hypersensitivity to

Amerchol L-101 were not diagnosed as having allergic contact dermatitis from lanolin because they did not use these products.

Several contact allergies were considered work-related. 1 individual (employee no. 8, Table 4) had a positive patch test reaction to modified dicarboxylic acid diethanolamide, an emulsifier commonly present in MWFs and a sensitizer almost exclusively seen in this type of work. Even though the substance was not present in any of the MWFs in the plant at the time of investigation, it may well have been present earlier. Furthermore, the worker, who had been at the plant for 34 years, and another 3 individuals had a contact allergy to 1,2-benzisothiazolin-3-one (BIT), a preservative present mostly in MWFs and paints. The contact allergy was considered work-related because all 4 worked or had worked in production. According to the material safety data sheets, BIT was present in a toilet cleaning powder, in a hardener for concrete plaster, and in a floor lacquer and white paint found in the plant. None of the 4 worked with any of these products but BIT had supposedly been present in MWFs in the plant earlier on. The time of employment ranged from 11 to 34 years for these 4, supporting this assumption. 2 of the 4 individuals allergic to BIT were also allergic to MCI/MI, a preservative widely used in a number of products such as shampoos, liquid soaps, etc., implying a high risk of exposure in the general population. Kathon MW, containing the active ingredients methylchloroisothiazolinone/methylisothiazolinone used to be a common biocide in MWFs. The frequency of contact allergy to MCI/MI in the present investigation, however, is no higher than what could be expected in consecutively patch-tested dermatitis patients.

3 cases of contact allergy to 1 component of neat oil no. 3 were found (13). In all cases, a positive patch test reaction was seen to an extreme pressure additive, zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate) (14). The same additive was also present in neat oil no. 5 from a different manufacturer, and 2 of the 3 workers also had contact allergic reactions to this neat oil and again to the additive. However, the same German manufacturer supplied the additive to the 2 companies that had sold the respective MWFs. Another worker was allergic to neat oil no. 1 with negative reactions to all tested components. The additive zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate) was not present in this oil. Water-based coolant no. 2 elicited allergic reactions in 3 other workers. When patch tested to the separate components only 2 showed positive patch test reactions to an additive, fatty alcohol polyglycoether. One of the 2 also reacted to another additive, diethyleneglycol butylether. The 3rd

individual had no reactions to the individual components. In the case of a positive reaction to a suspected fluid, patch tests with the individual components sometimes appear negative, probably due to the fact that several unknown reaction products can form in the fluid itself (9). This may pertain to unused fluids. Theoretically, contact allergy to a used complex product such as a MWF can be attributed not only to intentionally added components but also to new substances formed during the working process, which is why we also patch tested with recirculated MWFs. The patch test concentrations of the unused MWFs, in contrast to the recirculated MWFs, were not in accordance, though, as the control tests for irritancy made clear, lower concentrations were needed in the latter. However, no workers reacted only to recirculated MWFs and not to the unused MWFs simultaneously.

All 7 workers with contact allergy to MWFs had experienced dermatitis on exposed skin while working with the respective MWF. The range of employment time in the 7 workers varied from 0.5 to 3 years. The present investigation shows the importance of patch testing with work materials in addition to a standard series and a MWF series (15). Of the 11 workers with work-related contact allergy, only 2 would have been diagnosed with the standard series (MCI/MI). Even testing with the MWF series would have been insufficient, as only the 4 allergic to BIT would have been found. The majority needed testing with the actual MWFs.

To diagnose allergic or irritant contact dermatitis, patch testing is required. Several contact allergies that were disclosed with our standard series were of importance to the individual, even though the allergies were not work-related. Among the substances from the standard series we found the frequency of contact allergy to biocides and metals to be at the same level as in consecutively patch-tested dermatitis patients, or among workers in other areas of work without specific work-related exposure to biocides and metals. As for nickel, 33.3% of the female metal workers were hypersensitive on patch testing, in comparison to 3.4% of the male metal workers. The hypersensitivity was considered incidental and nothing in the history of these female workers spoke for a relationship with their work. This situation is in accordance with the findings of Coenraads et al. who concluded that women with metal allergy were able to carry out their jobs in metal industries without adverse effect on their hands and arms (16). 22.2% of the women in the office group were nickel allergic but none of the males. Gold allergy showed the highest frequency, but the same figure is seen in our consecutively patch-tested dermatitis patients and in other

cross-sectional studies like the present one in other areas of work (1, 2).

Some 12 metal workers were diagnosed with work-related irritant contact dermatitis localized to the hands and/or arms. Within the group that showed deterioration of skin disease during work (Table 5), no clinically relevant contact allergy was found, so the skin irritation factors were considered to be aggravating factors in a pre-existing, non-occupational hand eczema. In 66 metal workers and 6 office staff it was impossible to judge the work relation of the skin disease, because no relevant contact allergy was found and earlier or present skin manifestations and their course did not fully indicate a relationship with their work. Of these 72, 46 individuals (43 metal workers, 3 office clerks) had had skin manifestations earlier during work but not at the time of investigation, over 40% on the hands only, nearly 40% on the arms only and the rest at both sites. Furthermore, of these 72, another 26 individuals (24 metal workers, 2 office clerks) had current skin manifestations, almost 60% on the hands, around 30% on the arms and nearly 10% at both sites.

In all, 17.2% (28/163) of the metal workers and 5.3% (1/19) of the office staff were found to have a work-related contact dermatitis, 3.1% (5/163) a skin disease aggravated by work, and 14.1% (23/163) and 5.3% (1/19), respectively, a skin disease caused by work. All 24 individuals were working or had worked in production in some way. Hand eczema was seen in $\frac{1}{2}$ of the individuals but eczema on the lower arms and legs was also present. Considering the whole workforce, 6.7% (29/430) had a work-related skin disease. This figure is fairly low and for Sweden no comparable studies within the metalworking industry within the last 2 decades have been published. Internationally, frequencies from studies within the metalworking industry range from 4.5 to 14.0% (16). Any cross-sectional investigation like the present one is apt to provide minimal prevalence figures. The information can still be used in the investigation of occupational dermatoses and for preventive measures. Any findings or connections that might have been overlooked if seeing the same number of patients, but only 1 patient at a time over an extended period, may become apparent (1, 2).

To lower the incidence of work-related skin manifestations within this metalworking plant, general preventive measures should be focussed on reduction of both irritant and allergic contact dermatitis by minimizing skin contact with MWFs and degreasers, by using mild skin cleansers followed by emollients, and by putting pressure on the manufacturers to use less sensitizing component chemicals. Awareness of potential hazards

from MWFs has increased in the company in question, which has abandoned the use of MWFs containing the additive zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate) and now seeks advice from us before adding a new MWF to its arsenal.

Finally, we propose that zinc, bis ((O,O'-di-2-ethylhexyl) dithiophosphate) be included in national MWF series (13).

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