

# Non-occupational contact sensitization to epoxy resin of bisphenol A among general dermatology patients

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## Summary

**Background.** Sensitization to epoxy resins often results from occupational exposure in various fields of construction and industry. Non-occupational sensitization sources and environments have remained overlooked.

**Objectives.** To analyse non-occupational and occupational contact sensitization to epoxy resin of bisphenol A among general dermatology patients. Special attention was paid to patients sensitized from non-occupational sources.

**Patients and methods.** During a 10-year period, 6042 general dermatology patients were patch tested with epoxy resin (bisphenol A) in the Dermatology Clinic of Turku University Hospital. The clinical data and the sources of occupational and non-occupational exposure to epoxy resin were analysed in sensitized patients.

**Results.** Epoxy resin sensitization was found in 59 patients. Non-occupational sensitization was found in 21 (35%) patients, whereas the number of occupational cases was 38 (65%). The most common sources of non-occupational epoxy resin sensitization were materials used in domestic renovation and construction projects and in boat repair.

**Conclusions.** Non-occupational sensitization sources account for approximately one-third of epoxy resin sensitization cases, and therefore represent an important risk among hobbies and leisure activities.

**Key words:** atopy; epoxy resin sensitization; non-occupational; occupational.

The unique properties of epoxy resins can be exploited in many fields of construction and in various industrial applications. Occupational allergic contact dermatitis is common among patients sensitized to epoxy resins. Occupational epoxy resin sensitization is most common in construction work (1, 2), and it seems to have increased together with the increasing use of epoxy materials in construction during the last 5–10 years (3).

In this study, epoxy resin based on diglycidyl ether of bisphenol A (DGEBA-R) was tested on all patients

subjected to patch testing with the European baseline series. We analysed the occurrence of non-occupational and occupational sensitization to DGEBA-R among general dermatology patients.

## Materials and Methods

### Patients

Between September 2000 and August 2010, 6042 general dermatology patients with suspected contact allergy were patch tested with the European baseline series (Chemotechnique Diagnostics®, Vellinge, Sweden) in the dermatology clinic of Turku University Hospital. We examined those patients who had a positive reaction to DGEBA-R (1% pet.) in the baseline series. The localization of the current dermatitis, the occupation of the patient and information on the earlier occupational history

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were recorded. Concurrent patch test reactions, past or present atopic dermatitis, physician-diagnosed asthma and physician-diagnosed allergic rhinoconjunctivitis were noted.

### Prick tests

Additional test series were used according to patient's history of exposure. Thus, phenyl glycidyl ether (PGE) (0.25% pet.), cresyl glycidyl ether (CGE) (0.25% pet.), 2,2-bis (4-2-hydroxy-3-methacryloxypropoxy)phenylpropane (bis-GMA) (2% pet.), triethylenetetramine (TETA) (0.5% pet.), cycloaliphatic epoxy resin (caER) (0.5% pet.), isophorone diamine (0.1% pet.) and 4,4-diaminodiphenylmethane (MDA) (0.5% pet.) were tested in 27–34 patients. These substances tested in the additional test series were purchased from Chemotechnique Diagnostics®, except for CGE, which was from Trolab® (Almirall Hermal, Reinbek, Germany).

The test substances were applied in Finn Chambers® (Epitest Ltd, Tuusula, Finland), fastened with Scanpor® tape (Norgesplaster A/S, Vennesla, Norway), on the upper back and removed after 2 days (D2). The reactions were read 1–3 days after removal (D3, D4, or D5), according to the International Contact Dermatitis Group generally accepted criteria.

Prick tests were carried out with commercial, common environmental allergens; birch, alder, timothy, mugwort, cat, dog, horse, and house dust mite (*Dermatophagoides pteronyssinus*) (ALK-Abelló A/S, Horsholm, Denmark), using a one-peak lancet method. Histamine dihydrochloride 10 mg/ml (ALK-Abelló) was used as the positive control, and the diluent (Soluprick®; ALK-Abelló) as the negative control. The largest diameter and the diameter opposite to it were measured at 15 min. A reaction was interpreted as positive when the mean of the wheal diameter was at least 3 mm greater than that of the negative control.

### Sources of sensitization

The sources of DGEBA-R sensitization were retrospectively evaluated on the basis of available clinical data. Occupational contact sensitization sources were found in most cases, and probable sources were recorded in cases with an apparent history of occupational exposure. The patients who had no history of occupational exposure to epoxy resins were considered to be non-occupational cases. Among them, the apparent/probable or suspected sources of epoxy resin sensitization were registered.

In November 2010, a questionnaire concerning earlier exposure to the most common epoxy resin sensitizers was

mailed to 11 patients without any history of exposure. The questionnaire was returned by 8/11 patients, and more information concerning sources of non-occupational epoxy resin sensitization was obtained for 3/8 cases.

### Results

Sensitization to DGEBA-R was found in 34 (58%) males, aged 17–62 years (mean 40.7 years) and in 25 (42%) females, aged 16–78 years (mean 40.9 years). Occupational sensitization was found in 38 patients (25 males and 13 females), 11 of whom had only past exposure. No previous occupational exposure was found in 21 patients (12 females and 9 males), who were regarded as non-occupationally sensitized cases. The distribution of the skin symptoms (most often dermatitis in the face and upper extremities) was similar in both occupationally and non-occupationally sensitized patients.

#### Sources of occupational sensitization

The sources of sensitization and occupations of the patients sensitized from occupational sources are shown in Table 1. Current occupational dermatitis caused by epoxy resin was found in 27 patients, and earlier occupational exposure was found in 11. Seventeen of 38 were employed in house building, and another 12 in various fields of construction. Sensitization resulting from work in the electronics industry was found in 5 patients.

#### Sources of non-occupational sensitization

An apparent or probable source of non-occupational sensitization to epoxy resin was found in 7/21 patients (Table 2). Only 2 sensitized patients had current non-occupational dermatitis (patients 6 and 12).

Boat painting/coating (3 patients), painting of floor or roof (2 patients) and hobby glues (2 patients) were the apparent or probable sensitization sources. Sensitization resulting from previous construction or renovation projects at home or in summer houses was suspected in 7 patients. Two of them had also used two-component glues previously. Two females had used nail art with artificial materials and nail hardeners. A new ice hockey stick was suspected as a cause of contact sensitization in 1 atopic young man with hand dermatitis and multiple other contact sensitivities (patient 13 in Table 2).

No history of epoxy resin exposure could be traced in 4 patients. One of these patients was a 78-year-old female, whose extensive dermatitis totally recovered in a couple of months, after topical treatments. Two females (patients 4 and 5 in Table 2) had hand dermatitis,

**Table 1.** Occupations, apparent or probable sources of sensitization and clinical characteristics among the patients sensitized to epoxy resin (bisphenol A) from occupational sources

|                                                       |            | Patients (n)                                                                                                                                                                                                                                                               | Sources of sensitization                                               |
|-------------------------------------------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Construction                                          | Occupation | 17                                                                                                                                                                                                                                                                         | Insulation materials, coatings, varnishes, glues                       |
| Painting                                              |            | 7                                                                                                                                                                                                                                                                          | Paints outside, metal painting                                         |
| Stonework                                             |            | 3                                                                                                                                                                                                                                                                          | Injectants, glues                                                      |
| Metal industry                                        |            | 2                                                                                                                                                                                                                                                                          | Moulding                                                               |
| Boat building                                         |            | 2                                                                                                                                                                                                                                                                          | Resins and painting                                                    |
| Electronics                                           |            | 5                                                                                                                                                                                                                                                                          | Glues, moulding                                                        |
| Industry                                              |            | 1                                                                                                                                                                                                                                                                          | Ice hockey stick production                                            |
| Dental nurse                                          |            | 1                                                                                                                                                                                                                                                                          | Dental root filling/impurities in dental composite resins in the 1980s |
| Males/females                                         |            | 25/13 (males 65%)                                                                                                                                                                                                                                                          |                                                                        |
| Atopic history*                                       |            | 17/38                                                                                                                                                                                                                                                                      |                                                                        |
| Concomitant reactions to epoxy resin system allergens |            | Phenyl glycidyl ether, 15/30<br>Cresyl glycidyl ether, 8/23<br>Cycloaliphatic epoxy resin, 4/23<br>Triethylene tetramine, 1/23;<br>2,2-Bis(4-2-hydroxy-3-methacryloxypropoxy)phenylpropane (bis-GMA), 8/23<br>4,4-Diaminodiphenylmethane, 4/30<br>Isophorone diamine, 2/23 |                                                                        |
| Concomitant reactions in the baseline series          |            | Nickel sulfate, 8/38<br>Potassium dichromate, 5/3<br>Cobalt chloride, 4/38<br>Colophonium, 4/38<br>Methylchloroisothiazolinone/methylisothiazolinone, 1/38<br>Myroxylon pereirae, 4/38<br>Fragrance mix, 1/38<br>Thiuram mix, 2/38                                         |                                                                        |

\* Atopic dermatitis and/or allergic rhinoconjunctivitis with one or more positive prick test reaction(s).

an atopic background, and multiple concurrent contact sensitivities. Patient 10 was a young male suffering from atopic hand dermatitis. These 3 patients – 1 nurse, 1 pharmaceutical technician, and the male baker – were studied for suspected occupational hand dermatitis. The relevance of epoxy resin sensitization remained uncertain in these patients.

### Concomitant reactions

Positive patch test reactions to different epoxy resin system allergens were frequently seen in the occupationally sensitized group (Table 1), in which 15/30 reactions to PGE were seen, 8/23 to CGE, and 8/23 to bis-GMA. Reactions to TETA, caER, isophorone diamine and MDA were seen occasionally. Only 4 of the patients with non-occupational epoxy resin sensitization were tested with these allergens (Table 2). Among them, PGE, CGE, caER, epoxy acrylate and TETA elicited one reaction each.

Sensitization to other baseline series allergens was seen in 14/21 (67%) of patients with non-occupational sensitization to DGEBA-R and in 22/38 (57%) in the occupational group. Nickel sulfate, potassium dichromate and cobalt chloride were common sensitizers in both groups.

Potassium dichromate seemed to elicit more reactions in the occupationally sensitized patients (5/38; 13%) than in the non-occupationally sensitized patients (2/21; 9%). In the latter group, reactions to methylchloroisothiazolinone (MCI)/methylisothiazolinone (MI) (6/21) and to fragrance mix (8% pet.) (5/21) were common.

### Atopic background

An atopic background was found in 27/59 patients, 17 of whom had past or present atopic dermatitis with or without allergic rhinoconjunctivitis, and 10 of whom had allergic rhinoconjunctivitis with one or more positive prick test reactions. Among the patients with occupational sensitization to DGEBA-R, these findings were as common (17/38; 44%) as among those sensitized from non-occupational sources (10/21; 47%).

### Discussion

One-third of our patients sensitized to DGEBA-R had no occupational history of epoxy resin exposure. Although this sensitization most typically develops in those with occupational exposure, the present results emphasize that

**Table 2.** Patients with non-occupational sensitization to epoxy resin; demographic and clinical data of the patients

| Patient no.<br>DGEBA-R | Sex/age<br>(years) | Location of<br>dermatitis     | Occupation                                  | Atopic<br>history | Concomitant reactions                  | Sources of sensitization              |
|------------------------|--------------------|-------------------------------|---------------------------------------------|-------------------|----------------------------------------|---------------------------------------|
| 1<br>++                | F/51               | Hands                         | Hairdresser                                 | NA                | Ni, MCI/MI                             | Glue (making a wreath)                |
| 2<br>+++               | F/21               | Hands                         | Nurse in childcare                          | AD, ARC<br>Prick  | Ni, Co                                 | Painting (boat)                       |
| 3<br>+++               | M/29               | Groin and<br>anogenital areas | Shop assistant                              | Prick             | —                                      | Construction and painting*            |
| 4<br>++                | F/48               | Hands, arms                   | Nurse in childcare                          | AD, ARC<br>Prick  | Ni, Co, MCI/MI, TPV                    | Unknown                               |
| 5<br>++                | F/34               | Hands                         | Technician in<br>pharmaceutical<br>industry | ARC               | Ni, Co, FM, CGE, PGE,<br>caER          | Unknown                               |
| 6<br>++                | M/25               | Hands, legs                   | Student                                     | AD, ARC<br>Prick  | Epoxy acrylate                         | Glues (making model<br>planes)        |
| 7<br>++                | M/58               | Back                          | Taxi driver                                 | ARC<br>Prick      | —                                      | Floor painting*                       |
| 8<br>+                 | F/29               | Hands, arms                   | Student                                     | AD, ARC           | MCI/MI, MDBGN                          | Nail hardener*                        |
| 9<br>+                 | M/59               | Thighs                        | Retired                                     | NA                | —                                      | Coating/painting in own<br>house*     |
| 10<br>+                | M/27               | Hands, arms                   | Baker                                       | AD, ARC<br>Prick  | —                                      | Unknown                               |
| 11<br>++               | F/62               | Hands                         | Retired                                     | NA                | Cr                                     | Glues and painting*                   |
| 12<br>++               | M/51               | Face, arms                    | Computer program<br>designer                | AD, ARC           | Colophonium, MCI/MI,<br>MDBGN, FM, TET | Boat repair and painting              |
| 13<br>++               | M/18               | Hands                         | Student                                     | NA                | Ni, Co, colophonium, FM                | New ice hockey stick*                 |
| 14<br>++               | F/37               | No dermatitis                 | Cosmetician                                 | NA                | —                                      | Glues occasionally*<br>Nail hardener* |
| 15<br>+++              | F/78               | Extremities, body             | —                                           | NA                | Ni                                     | Unknown                               |
| 16<br>+                | F/52               | Face                          | Retired, office work                        | AD, ARC<br>Prick  | Formaldehyde,<br>quaternium-15, MCI/MI | Painting and construction at<br>home* |
| 17<br>++               | F/36               | Hands                         | Postman                                     | ARC<br>Prick      | Ni, Co, Cr, colophonium,<br>FM, MP     | Construction at home*                 |
| 18<br>++               | M/54               | Face, arms                    | Marketing office work                       | Prick             | MP, bacitracin, MCI/MI,<br>clioquinol  | Glues*<br>Painting*                   |
| 19<br>++               | F/58               | Face, arms                    | Masseur and<br>podiatrist                   | AD                | Ni, black rubber mix                   | Boat coating and painting             |
| 20<br>++               | F/38               | Face                          | Nurse                                       | NA                | FM, TPV                                | Floor coating in the<br>bathroom*     |
| 21<br>++               | M/78               | Gums                          | Farmer                                      | NA                | —                                      | Painting                              |

AD, atopic dermatitis; ARC, allergic rhinoconjunctivitis; caER, cycloaliphatic epoxy resin; CGE, cresyl glycidyl ether; Co, cobalt chloride; Cr, potassium dichromate; DGEBA-R, the reaction to epoxy resin (bisphenol A); F, female; FM, fragrance mix; M, male; MCI, methylchloroisothiazolinone; MDBGN, methyldibromo glutaronitrile; MI, methylisothiazolinone; MP, *Myroxylon pereirae*; NA, no atopy; Ni, nickel sulfate; PGE, phenyl glycidyl ether; Prick, one or more positive prick test reactions; TET, triethylene tetramine; TPV, tixocortol-21-pivalate.

\*Suspected, not verified.

domestic sensitization sources and circumstances are also important.

As a whole, epoxy resin sensitization was seen in 0.9% of the patients tested. In a recent report from Portugal, the frequency was similar (4). In the United States, where patient selection may be different

than in Europe, a sensitization frequency of 1.8% has been reported (5). In occupational dermatology clinics, epoxy resin sensitization from occupational sources is seen most often (6), and especially among construction workers (1, 2, 7). However, patch test reactions to DGEBA-R represent more than one half

of the cases of sensitization to epoxy resin system allergens (8). A restricted selection of reactive diluents and hardeners of epoxy resins was tested among our patients sensitized to DGEBA-R. Testing with diglycidyl ether of bisphenol F and with other reactive diluents and hardeners would probably have increased the number of patients with contact sensitization to epoxy resin system (ERS) allergens, even among these general dermatology patients (8–11).

In this study, occupational sensitization to DGEBA-R had most often developed from typical sources in the field of construction. Males accounted for 65% of those patients with occupational sensitization. In electronics industries, however, sensitization was seen in 5 females, who often had features of concomitant irritant dermatitis. Epoxy resin products are known sensitizers in electronics industries (12), where irritant contact dermatitis has also been reported to be common (13). Two females had occupational epoxy resin sensitization in particular work environments – 1 dental nurse and 1 ice hockey stick factory worker. The dental nurse with occupational allergic contact dermatitis caused by rubber chemicals in gloves was also sensitized to DGEBA-R without any reaction to bis-GMA. She had been working since the year 1978, and sensitization from impurities in dental composite resins was probable, as no past non-occupational exposure could be found. The possibility of non-occupational sensitization, however, cannot be totally excluded. One female patient had been sensitized in an ice hockey stick factory in 1990s. In contrast to the epoxy resin-sensitized ski factory workers found elsewhere in Finland (14), no cluster of occupational allergic dermatitis cases caused by epoxy resin sensitization was seen in our clinic at that time.

The source of sensitization from leisure-time activities was apparent or probable in only 7 of those 21 patients who had no history of occupational epoxy resin exposure. Suspected sources of exposure were most often recent home repair or construction projects (renovation of kitchen/bathroom), where the patient had assisted, usually without any protection. Past sensitization from nail art/hardeners was suspected for 2 females, but the exact source remained unproven. Some nail hardeners, however, have been reported to contain epoxy resins, according to information from the Helsinki Asthma and Allergy Association, which collects data concerning the sensitizing components in cosmetic products on the Finnish market.

Patient 7 (Table 2), with dermatitis on the back, had a recent history of garage floor painting and thus a probable source of recent sensitization. The dermatitis, however, was located on the back, and he was a taxi driver who had also recently bought a new car. In a recent report, epoxy

resin sensitization from a car seat was described (15). The covering of the seat in the new car was suspected, but the patient was not willing to bring a piece of the leatherette to be tested. Instead, he used an additional top on the car seat, and the dermatitis recovered.

Leisure-time activities and the environment seem to have risk factors that are poorly identified. Various types of sports equipment, and especially their maintenance, represent potential sources of epoxy resin sensitization. Golf club repair with an epoxy resin glue has caused facial and hand dermatitis (16). In our study, non-occupational sensitization from a brand-new ice hockey stick was suspected to have induced allergic hand dermatitis in a young man. He might have been sensitized from repairing his old ice hockey sticks as well.

Unfortunately, only 4 of the patients with non-occupational sensitization to DGEBA-R were tested with additional epoxy resin system allergens, and 3 of them had positive reactions. Among the occupationally sensitized patients, these reactions were seen in 9–50% of the patients tested. The most common contact allergens were PGE followed by bis-GMA, which elicited reactions in 8 patients. Concomitant reactions to bis-GMA, methacrylates and DGEBA-R have been described previously (17). Methacrylate reactions were not seen in our bis-GMA-positive patients. Cross-reactivity has been suggested to explain a number of concurrent reactions to DGEBA-R and bis-GMA (18). PGE was positive in one-half of those who had occupational epoxy resin sensitization. Among our 21 non-occupational cases, 1 female technician in the pharmaceutical industry had reactions to PGE, CGE, and caER. Occupational sensitization was suspected in this case, but the source could not be found, either in the work environment or in other activities.

PGE, even alone, has been shown to be a strong sensitizer in animal experiments (19), and corresponding clinical contact dermatitis has been described (20). In association with this study, we reviewed all positive reactions to PGE since 2007, and only 1 female patient, working in a histopathology laboratory, had a positive PGE reaction without reacting to DGEBA-R. She had occupational contact dermatitis caused by moulding specimens with a commercial epoxy resin product.

Patients with occupational sensitization to DGEBA-R seemed to have fewer (57%) concurrent reactions to other baseline allergens than the non-occupational group (67%). Only sensitization to potassium dichromate was more common in patients with occupational sensitization. This finding is in line with previous findings showing that epoxy resin sensitization seems to have a negative correlation with polysensitization (21). On the other

hand, positive reactions to fragrance mix and to MCI/MI were often seen in the non-occupational group. An association between the components of fragrance mix and epoxy resin was suggested recently (22), but, in this study, a similar association was not seen in the occupationally sensitized patient group.

In this study, as many as 46% of the sensitized patients had a history of atopic dermatitis and/or allergic rhinoconjunctivitis. Exposure to multiple skin irritants may occur in environments where epoxy resin products are handled. Skin irritability and irritant dermatitis may

increase the risk of sensitization in atopic subjects, if protection is insufficient.

As non-occupational sensitization to DGEBA-R is not infrequent, adequate and detailed product information should be available for consumers using epoxy resin containing items used in hobbies, self-performed construction, and repair projects. The development of less sensitizing epoxy resin products will hopefully decrease the risk of sensitization (23). In addition, information concerning the importance of protection when handling epoxy resin chemicals is always important.

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