

Severe occupational contact dermatitis caused by black rubber as a consequence of *p*-phenylenediamine allergy resulting from a temporary henna tattoo

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p-Phenylenediamine (PPD) is a widely used precursor in oxidative hair dye products. It is an aromatic amine and an extreme sensitizer that can lead to contact allergy and severe dermatitis. PPD may also be used in so-called 'temporary henna tattoos' as an addition to henna, where it has been reported in concentrations of up to 15% (1). Exposure to PPD in temporary henna tattoos can cause primary allergy that leads to allergic contact dermatitis if the person later becomes exposed to PPD or PPD-related substances. Antioxidant chemicals contained in black rubber products can cross-react with PPD and result in skin allergic symptoms among PPD-sensitized individuals. However, even though these cross-reactivity patterns are known, no reports exist concerning the potential practical implications for the patients.

Case Report

A 22-year-old non-atopic man was referred to our department because of eczema. Three years earlier, he had been hired as a trainee in a company selling plumbing supplies. His primary consumers were plumbers, and the daily routines included selling and handling sanitary

appliances, various metal pieces, rubber gaskets, lubricant oil, and other lubricants. However, after 3 months he developed eczema on both hands and subsequently on the feet, arms, and legs. In the following years, the hand eczema worsened, impaired his working capacity, and resulted in periods of sick leave. Consequently, after 3 years of employment, he was dismissed, and when first seen by us he had been unemployed for 7 months. On direct questioning, he recalled that, on a trip abroad at the age of 12 years, he had had a temporary tattoo that caused a severe eruption of eczema.

Patch testing was performed with an extended European baseline patch test series and an extended rubber ingredient series (all from Almirall-Hermal, Reinbek, Germany) with Finn Chambers[®] (8 mm; Epitest Ltd, Oy, Finland) applied on the back with Scanpor[®] tape (Norgesplaster A/S Alfarma, Vennesla, Norway) for 2 days. Because, a few months earlier, the patient had tested positive to nickel sulfate and PPD, these substances were omitted. Patch test readings were performed on D2, D3, and D6, and results were graded according to the criteria of the International Contact Dermatitis Research Group (2). At D2, there were strong positive reactions to several of the applied allergens (Table 1), including *N*-cyclohexyl-*N'*-phenyl-*p*-phenylenediamine (CPPD), *N*-isopropyl-*N'*-phenyl-*p*-phenylenediamine (IPPD), and 4,4'-diaminodiphenylmethane, all of which are compounds used in black rubbers. Positive reactions to the hair dye chemicals toluene-2,5-diamine sulfate, 3-aminophenol and 4-aminophenol were also identified.

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Table 1. Positive patch test results of a 22-year-old man with occupational contact dermatitis caused by black rubber

	Concentration (%) (pet.)	D2 reading	D3 reading	D6 reading
<i>p</i> -Phenylenediamine	NT			
<i>N</i> -Isopropyl- <i>N'</i> -phenyl- <i>p</i> -phenylenediamine	0.1	++*	+	++
<i>N</i> -Cyclohexyl- <i>N'</i> -phenyl- <i>p</i> -phenylenediamine	1.0	++*	++	++
4,4'-Diaminodiphenylmethane	0.5	++*	+++	++
Textile dye mix [†]	6.6	++*	+++	+++
Toluene-2,5-diamine sulfate	1.0	+++*	+++	+++
3-Aminophenol	1.0	+++*	+++	++
4-Aminophenol	1.0	+++*	+++	++
Benzocaine	5.0		++	++
Cobalt chloride	1.0		+	++
Nickel sulfate	NT			
Thiuram mix	1.0			+

+?, Doubtful positive reaction; NT, not tested owing to a previous positive patch test.

*Application of clobetasol propionate.

[†]Supplied by courtesy of Drs Bruze and Ryberg, Malmö.

A doubtful positive reaction to thiuram mix was found. Furthermore, there were positive reactions to benzocaine, cobalt chloride, and a textile dye mix (supplied by the Department of Occupational and Environmental Dermatology, Malmö University Hospital, by courtesy of Drs Bruze and Ryberg). The textile mixture consisted of eight ingredients: Disperse Blue 35, 106, and 124, Disperse Yellow 3, Disperse Orange 1 and 3, and Disperse Red 1 and 17 (3).

It was concluded that the patient had allergies to several black rubber chemicals, hair dye chemicals, benzocaine and textile dyes in terms of cross-sensitization to PPD, and that the PPD sensitization most likely originated from the previous temporary henna tattoo. Furthermore, the reactions to thiuram mix and metals (nickel sulfate and cobalt chloride) were also considered to be relevant and probably caused by exposure to the materials in the plumbing store.

Discussion

This case report shows that a temporary henna tattoo, in terms of sensitization to PPD and the derivative cross-sensitizations, may lead to occupational hand eczema among persons with contact with black rubber products. The colour of henna tattoos is based on henna, in which the active ingredient is lawsone (2-hydroxy-1,4-naphthoquinone). Henna is a natural substance that induces a light brown colour. It is only a weak sensitizer in itself. However, to create a more intense, long-lasting colour and accelerate the colouring process, PPD may be

added. This may lead to allergic sensitization to PPD and cross-reactivity to other related *para*-aromatic amines that can be found in commonly encountered products (Table 2). CPPD, IPPD and 4,4-diaminodiphenylmethane are compounds used as antioxidants in the production of black rubber. With time, vulcanized rubber will react with atmospheric oxygen and ozone, and gradually be degraded. To prevent the decomposition, antioxidants may be added prior to the vulcanization process (4). As a result of their chemical similarities, these antioxidants may cross-react with PPD and lead to occupational hand eczema among persons in industries requiring contact with black rubber products such as rubber gaskets and black tyres.

The prevalence of PPD sensitization among European dermatitis patients has been reported to be fairly steady since the 1980s, ranging between 2% and 6% (6). In a multicentre study including 10 European patch test centres, the PPD patch test results from dermatitis patients tested between 2003 and 2007 were evaluated, and showed a prevalence of 4%. The most frequent cause of PPD sensitization was consumer hair dyeing (41%). Occupational hair dye exposure (10%) was another prominent cause, and temporary tattoos were reported by 4% (7). The lifetime prevalence of temporary henna tattoos has been shown to be 6% in the Danish general population, but there is a much higher number (24%) in the age group between 18 and 24 years (8). To reduce the occurrence of PPD allergy in the EU, the Cosmetics Directive has stipulated a limit of 4% PPD (2% after mixing with the oxidative solution) in hair dye products (9), and addition of PPD to temporary henna tattoos is prohibited. However, many temporary henna tattoos are obtained during foreign holidays in countries where no legislation exists. Furthermore, the illegal importation of temporary henna tattoos that contain PPD make regulations difficult to implement.

Table 2. Compounds with chemically related structures that, owing to cross-sensitization, may cause skin allergic symptoms among *p*-phenylenediamine-sensitized individuals (4, 5)

Local anaesthetics (procaine, benzocaine)
Sulfonamides
Sulfonylureas
Dapsone
Thiazide diuretics
Mesalazine
Antihistamines
<i>p</i> -Aminobenzoic acid (e.g. PABA sunscreens)
<i>p</i> -Aminosalicylic acid
<i>p</i> -Amino hair dyes
Anthraquinone
Azo dyes/aniline dyes
Rubber antioxidants

In conclusion, the presence of PPD in temporary henna tattoos poses a health hazard, owing to a risk of allergy to PDD and the derivative cross-sensitizations. It may

have potential long-term consequences. Therefore, consumers should be warned about obtaining temporary henna tattoos.

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