

Contact dermatitis from a presumed allergy to paraphenylenediamine

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Summary

Paraphenylenediamine (PPD) is a potent skin allergen found in permanent hair dye and temporary henna tattoo ink. Several cases of adverse skin reactions to PPD have been reported in the literature. Here we present a case involving a patient who acquired a temporary tattoo while vacationing in Mexico and subsequently developed contact dermatitis at the tattoo site. He provided a history of permanent hair dye use in the past with associated cutaneous reaction. Temporary tattoos have become increasingly popular with travelers and as a result so have reports of associated allergic contact dermatitis. Of concern is cross-reaction of PPD to related compounds, severe reactions in younger populations and sequelae including increased sensitization, permanent scarring, and persistent postinflammatory hyperpigmentation.

Keywords: contact dermatitis, dermatitis, irritant contact dermatitis, tattoo

Case report

A 43-year-old white male presents 2 weeks after returning from a vacation in Mexico. A week prior to his trip he applied a black pigmented hair dye to his hair which caused a “blistering rash” that resolved a few days later. While in Mexico, he had a henna tattoo placed on his left upper arm in the shape of a bull. Within 2 days he developed a painful, vesicular rash in the exact area of the tattoo. At the time of presentation, the lesion had progressed to crusted ulcerations surrounded by a fissured and lichenified plaque (Fig. 1). He was treated with mometasone 0.1% ointment twice a day for 2 weeks. Figure 2 shows the patient’s lesion after 1 week of treatment. Figure 3 shows the lesion 8 weeks postapplication of temporary tattoo. The lesion slowly improved over time, leaving behind only an area of postinflammatory hyperpigmentation that persisted for several months.

Discussion

Paraphenylenediamine (PPD) is known to be one of the most potent contact allergens, both from experimental studies in laboratory animals and from human clinical experience.¹ It is a strong contact sensitizer commonly found in hair and textile dyes and temporary tattoos.² Of concern is an increasing number of reports of cutaneous reactions to temporary henna tattoos and black hair dyes, believed to be caused by sensitization to PPD.³ Here we present a case of presumed acquired sensitization to PPD in a temporary tattoo after exposure to hair dye. Our patient presented with contact dermatitis in the area of a temporary tattoo he acquired while vacationing in Mexico. Prior to his vacation, he died his hair black and developed a severe reaction on his scalp. He had used the same hair dye previously without subsequent reaction. Cutaneous reactions to PPD in hair dyes and temporary tattoos are well documented. After discussing the pros and cons of patch testing with the patient, it was decided to forgo the test and accept PPD as the most likely allergen. Since patch testing was not performed, it is

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Figure 1 Initial presentation of patient, approximately 2 weeks after application of temporary tattoo.



Figure 2 After 1 week of treatment with topical ointment.



Figure 3 Eight weeks postapplication of temporary tattoo.

possible that other dyes and additives of varying purity may have also played a role.

While an increasing number of patients have reported cutaneous reactions after temporary tattooing with black henna, allergic reactions to pure henna is extremely rare.^{2–6} Henna has been used as temporary tattoo paint for thousands of years in several different countries as part of social and religious customs. It comes from the plant *Lawsonia (inermis, alba)*, which grows in Asia, Eastern Mediterranean, and North Africa. The leaves are dried, powdered, and mixed with various ingredients to produce a paste that is then applied to the skin. The orange/reddish-brown pigment binds to the keratin in skin to achieve a desired stain or tattoo. As this process can take several hours, PPD is often added to henna to speed up this process, achieve a darker color and improve pattern definition.^{2–5} This type of henna is referred to as black henna.^{3–5}

A variety of serious adverse skin reactions to products containing PPD have been reported. Clinical presentations include localized dermatitis and hair loss¹ to severe angio-edema-like reactions necessitating intensive care treatment.⁷ Other reported presentations include abnormal nail pigmentation and severe toxicity with acute renal insufficiency and tubular necrosis.² These reactions are most commonly attributed to delayed-type hypersensitivity, though immediate-type hypersensitivity with subsequent anaphylactic reactions has also been reported.^{1,5} Krasteva *et al.* investigated the mechanism of T-cell activation in PPD contact sensitivity. *In vitro* results suggest PPD acts as a prohaptens which when applied to skin is metabolized and converted into products such as Bandrowski's base, which are the immunogenic haptens able to activate specific T cells.⁸

It is generally accepted that the induction of allergic contact dermatitis takes at least 7–10 days when a new antigen is introduced.³ Yet cases of cutaneous reaction to PPD within 3–4 days have been reported. There are several theories to this short sensitization period. One theory suggests that patients have already been sensitized to PPD. Another explanation is the potency of PPD as a sensitizer. Patch testing is often performed in order to confirm reaction to PPD and identify cross sensitivity with other hair and textile dyes. Patch testing has been shown to actively sensitize patients after only 2–3 days. The recommended concentration of PPD in patch testing is 1%, whereas the concentration in skin tattoos may be over five times this amount. PPD content in temporary tattoo ink has been reported to vary between 0.43% and 15.7%⁷ and is allowed in hair dye at a concentration of 6%.^{1,5,7} It is possible that irritancy of this substance may contribute to the erosive reactions and short incubation

period. Additional substances, other than PPD, that speed up the staining process may enhance the penetration of PPD and thus increase irritancy and shorten sensitization time. These include eucalyptus, clove or lavender essential oils, lemon oil, vinegar, and many other unknown additives.³

Repeated exposure to PPD over time in some contexts have been shown to be of equal or greater significance than just duration of exposure.⁷ The role of repeated exposure in eliciting a reaction to PPD was studied by White *et al.* They investigated whether individuals could better tolerate repeated short exposures compared with less frequent exposures of a greater magnitude. They found that the allergenic component of PPD accumulates in the skin, thus intermittent exposure to lower concentrations can be equivalent to a single exposure to a higher concentration.⁹

Paraphenylenediamine exposure through hair dye may be less sensitizing than temporary tattooing. Various ingredients in hair dye including hydrogen peroxide accelerate oxidation of PPD which decreases its period of contact with the skin, and thus its sensitizing potential.^{2,5} With temporary tattoo ink, contact with the skin is more prolonged.² Despite having a positive patch test reaction to PPD, some patients continue to dye their hair without a reaction. This is thought to be due to a difference in sensitization. Ho *et al.* found a strong linear relationship between strength of patch test reaction and continuation of hair dying by patients. Patients with stronger patch test reactions were more likely to have a cutaneous reaction from hair dyes than those who had a weak reaction.¹⁰

Reported sequela from reactions to hair dyes and temporary tattoos include postinflammatory pigment changes, keloid scarring, and permanent sensitization to PPD.^{4,5} Matulich and Sullivan report a case of a 17-year-old female who acquired a henna tattoo on her back while vacationing in Bali. A repeat application of the ink was performed 4 days later. Ten days after the original application, a pruritic, vesicular reaction occurred in the area of the tattoo. The reaction rapidly progressed to a vesiculo-pustular eruption disseminating to her feet, thighs, axillae, arms, trunk, face and later scalp. Symptomatic resolution took over 5 weeks with residual postinflammatory hyperpigmentation which persisted for several months.⁴

Individuals allergic to PPD may also be sensitive to other chemicals and drugs, which have similar structure such as azo dyes used in textiles.^{2,4} Saunders *et al.* reports a case of contact dermatitis to textile dye in dark colored clothing. The patient had a history of severe skin reaction following application of a permanent hair dye

as well as a reaction to a temporary tattoo obtained in Thailand.¹¹ Sensitization to azo dyes has occurred from many sources including clothing, nylon stockings, shoes, synthetic wigs and occupational exposure.¹¹ Cross reaction to sulfonamides, *p*-aminobenzoic acid sunscreens, and local anesthetics such as benzocaine and procaine has also been described.⁵

Of concern is an increased number of individuals dying hair and obtaining temporary tattoos at younger ages, as life-threatening reactions have occurred in children⁶ and future consequences of excessive exposure to these potent allergens remains unknown.⁷ Sosted *et al.* report severe allergic reactions to hair dye in multiple children. Five of the eight children were hospitalized and treated with systemic anti-histamines, corticosteroids, and antibiotics. Four of these five children had a history of temporary tattoo with subsequent skin reaction.⁷

Currently, legislation controlling the amount of PPD added to henna tattoo ink and hair dyes does not exist in many countries, especially those where tattooing is readily available. The European Union mandates an upper limit of 6% PPD in hair dyes.^{2,4,5,12} Other countries like Australia have no limits. In the US and EU it is illegal to include PPD in cosmetics other than hair dye. Importation of temporary tattoo ink without required ingredient declaration on the label or containing PPD is illegal in the US.⁴

Conclusion

Skin reactions to paraphenylenediamine can be serious with long lasting changes in the skin. As popularity of temporary tattoos and the use of permanent hair dye increases, so does the risk of skin sensitization and subsequent severe cutaneous reactions. There is a need for public education regarding the risks associated with the use of PPD containing products and its long-term consequences.

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