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RESEARCH ARTICLE

Cross-reactions among hair dye allergens

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Abstract

Background: *p*-Phenylenediamine (PPD) is an important hair dye allergen, but there remains a reasonable suspicion that other hair dye chemicals may also be responsible for a proportion of the clinical burden of hair dye allergy. **Objective:** To assess to what extent presently assessed additional patch test agents contribute to the diagnosis of non-PPD hair dye allergy. **Methods:** A retrospective analysis was conducted of patch test results with hair dye allergens, focusing on the extent to which patients who were positive for allergic reactions to other hair dye allergens also had a concomitant positive reaction to PPD. **Results:** For the hair dye allergens other than *p*-toluenediamine (PTD), reactions in the absence of a concomitant positive reaction to PPD were very rare. Positive reactors to PTD were also positive for reactions to PPD in 5 of every 6 cases. Pyrogallol positives often occurred in the absence of a PPD positive, but were never judged to be of clinical relevance. **Conclusions:** Hair dye chemicals other than PPD may be of importance, but the presently tested materials, with the possible exception of PTD, are normally positive only when a PPD-positive reaction is also present, suggesting that their use in patch testing in hair dye allergy is likely to be of limited value.

Keywords: Hair dye allergy; cross-reactions; PPD; PTD

Introduction

Although other allergens may be involved, it remains the case that the majority of hair dye allergy either is caused by *p*-phenylenediamine (PPD) or at least can be detected by diagnostic patch test with PPD (1–6). This suggests that a number of the chemicals used in hair dye that might also be responsible for allergic reactions in practice cross-react with PPD. Some investigation of this matter has already been reported and indicates that cross-reactions do indeed occur (5–8). For example, the ability of *p*-toluenediamine (PTD), sometimes used in hair dye products in preference to PPD, to cross-react with PPD has been documented in an experimental model (9). In addition, the possibility that an oxidative trimer of PPD known as Bandrowski's base is actually responsible for its sensitizing action has been demonstrated to be incorrect (10). Attempts to understand the

chemistry of PPD hair dye cross-reactions also have been undertaken and have demonstrated, in guinea pig models at least, that cross-reactions do occur, although not necessarily via the commonly supposed common oxidation product 1,4-benzoquinone (8–12).

In the present work, we report experience from a single regional UK patch test clinic, analyzing the data particularly in terms of potential cross-reactivities to generate insights into whether currently used potential hair dye allergens other than PPD contribute value in terms of diagnosis of hair dye allergy.

Patients and methods

Data on patients routinely attending the patch test clinic and with a suspect diagnosis of hair dye allergy (based on history and clinical picture) have been harvested

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Table 1. Results of testing with other hair dye-related allergens.

	Number (%) positive ^a	Number (%) negative to PPD ^b	Number tested
PTD	48 (27)	8 (4.5)	175
Resorcinol	10 (5.7)	1 (0.6)	175
NPPD	14 (18)	0 (0)	80
3-Aminophenol	9 (11)	0 (0)	80
4-Aminophenol	13 (16)	1 (1.3)	80
Hydroquinone	1 (1.3)	0 (0)	80
Pyrogallol	13 (7.4)	8 (4.6)	175

^aWithin the selected patient group, this is the proportion who reacted to the allergen.

^bThis figure is the number who reacted to the selected allergen but who were negative to a concurrent test with PPD.

PPD = *p*-phenylenediamine; PTD = *p*-toluenediamine; NPPD = 2-nitro-PPD.

from the period 1997 to 2007. One hundred seventy-five patients were tested with PPD, resorcinol, and PTD, but only about half (80 patients) in this group were also tested with 2-nitro-PPD (NPPD), 3-aminophenol, 4-aminophenol, 1,4-hydroquinone, and pyrogallol. Patch tests were applied in Finn chambers for 48 hours (Epitest Ltd Oy, Tuusula, Finland) and test materials at 1% in petrolatum were standard products supplied by Chemotechnique Diagnostics (Vellinge, Sweden) and were read at 48 hours and 96 hours according to the standard International Contact Dermatitis Research Group (ICDRG) criteria (13).

Results and discussion

The experience from the UK patch test clinic over the period 1997 to 2007 is that the rate of positivity to PPD was 3.9% among all those who were patch tested, and clinical relevance was typically very high (perhaps as high as 70%). However, within the subset of patients with suspect hair dye allergy, a little under half were positive for allergic reactions to PPD: 68 (39%) of the group of 175 patients and 35 (44%) of the group of 80 patients. In total, 108 additional reactions were seen to hair dye allergens other than PPD, nearly half (48) of which were due to PTD. The reactions to other hair dye allergens are summarised in Table 1. Notably, only 18 (16.7%) of these occurred in the absence of a reaction to PPD. Eight of 13 reactions that were seen to pyrogallol occurred in the absence of a PPD response. Pyrogallol is reputedly a weak sensitizer only historically associated with hair dye allergy, so it is unclear what contributed to the response to this material in the current series (5,14). No clinical relevance for the pyrogallol-positive reactions could be discerned. Consequently, if these data are removed from the series, then only a single positive patch test each to 4-aminophenol and to resorcinol would have been missed if they had been omitted from the series of testing. For PTD, the situation is somewhat

different, but even here 83% of those responding to PTD were also detected as potential hair dye allergy sufferers via a positive patch test reaction to PPD.

Cross-reactions between hair dye allergens can only really be studied in experimental models. Results of investigations in the guinea pig have shown that the aminophenols assessed here and PTD do indeed cross-react well with PPD (9,11). The authors are aware that substantive efforts are under way to identify other important hair dye allergens that should be added to the patch test series (1,2; Johansen JD, personal communication, 2008). This is important, as the conclusion from the present data is that a number of the current additional hair dye materials appear almost exclusively as positives only when there is also allergy to PPD. Whether these are cross-reactions, multiple concomitant sensitization, or a combination of these factors remains to be determined, but what is clear is that the clinical utility of patch testing with resorcinol, NPPD, 3-aminophenol, 4-aminophenol, and hydroquinone is open to question and tends toward the conclusion that there is limited utility in having them in the hair dye series.

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Declaration of interest: The authors report no conflicts of interest.

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