

## Correlation of patch test with repeated open application test in patients with suspected hair-dye dermatitis

Sir,

Repeated open application test (ROAT) is an alternative method to patch test for detection of allergic contact dermatitis. It simulates the exposure pattern to allergen as in daily life, is cheaper, easier to perform and products can be tested as a whole. Hence, we proposed to compare ROAT with patch test as a tool to detect allergic contact dermatitis to hair dye in the Department of Dermatology and STD, Safdarjung Hospital and Vardhaman Mahavir Medical College, New Delhi. The study was approved by the ethical committee of the hospital. After informed consent, 50 patients (>12 years) having dermatitis over head and neck, trunk or upper limbs and temporal correlation with hair dye use were included in the study. Patients on oral corticosteroids or immunosuppressants and pregnant/lactating women were excluded. All patients were subjected to patch test and ROAT.

Patch test was done following standard guidelines as per International Contact Dermatitis Research Group (ICDRG)

using Indian standard series (Systopic Laboratories, New Delhi). Reading taken on day 4 was considered as final.<sup>1</sup>

To perform ROAT, patients were asked to apply a one-fourth fingertip unit of all brands of hair dye used by them and vaseline (negative control) on a marked area of 3 × 3 cm on the volar aspect of the forearm for one week, as standardized by Hannuksela and Salo.<sup>2</sup> Readings were recorded as per Johansen's modified scale.<sup>1</sup> Ten healthy controls with no history of contact dermatitis or atopy were also asked to perform ROAT with two different commonly used brands of hair dye (Garnier and Godrej) and vaseline as control. The data was analyzed with Statistical Package for Social Sciences (SPSS) version 21.0.

Sixty-two patients presented with suspected hair-dye dermatitis, of which 50 completed the study. The clinical characteristics and hair dye used by the patients are given in Table 1. On patch test, 36/50 (72%) showed positive reaction

to paraphenylenediamine (PPD) [Figure 1] along with other allergens [Table 2]. In those who had positive reaction to PPD and other allergens such as parthenium, nickel sulphate, nitrofurazone, thiuram mix, fragrance mix, colophony and mercaptobenzothiazole, only PPD was found clinically relevant [Table 2]. The diagnosis in 14 patients who tested negative on patch test and ROAT as well was revised based on repeat history and patch test results [Table 2] to parthenium in 5, nickel dermatitis in 3, nitrofurazone in 3, colophony in 1 and fragrance mix in 1 and endogenous dermatitis in 1.

Thirty (60%) patients showed positive reaction on ROAT [Table 2 and Figure 2] and all were patch test positive too. In the 30 ROAT-positive patients, there were 60 positive reactions to different dyes of which 49 occurred on day 2, and the remaining 11 occurred on day 4. No new positive reaction appeared on day 7. On comparing ROAT with patch test, correlation coefficient was 0.846 and *P* value was < 0.0001. Taking patch test as the standard, sensitivity of ROAT was 83.33% (95% CI: 67.19- 93.63%), specificity was 100% ( 95% CI: 76.84-100.00%), positive predictive value was 100% and negative predictive value was 70%. ROAT was negative in all controls. On comparison with 50 cases, *P* value was highly significant (<0.001). No adverse effects to patch test or ROAT were noted.

PPD is the most common contact sensitizer in hair-dye dermatitis, others being resorcinol, henna, lead acetate, *m*-aminophenol, *o*-aminophenol, *p*-aminophenol and toluene-2,5-diamine sulfate. The permissible limit of PPD in hair dyes is 6% and estimated PPD sensitivity in general population is around 1%.<sup>3</sup> Even in low concentration, PPD is a potent contact sensitizer as seen on EC3 value (effective concentration of the test substance required to produce a three-fold increase in the stimulation index) for PPD on local lymph node assay.<sup>4</sup> The reported prevalence of positive patch test reactions to PPD among dermatitis patients is 4.4% in Asia, 4.1% in Europe, 6.0% in North America, and 11.5% in India.<sup>5,6</sup>

In India, patch test positivity in hair-dye dermatitis is 67.5% similar to our study (72%)<sup>7</sup> while in Korea and Japan, it is lower (25% and 35.1%, respectively), which could be because of other allergens such as toluene-2,5-diamine, *p*-aminophenol, *m*-aminophenol, cysteamine HCl and *o*-aminophenol, causing hair dye dermatitis in their population.<sup>8,9</sup>

ROAT is used to determine the relevance of doubtful positive patch test reactions to preparations in which the suspected allergen is present in a low concentration. ROAT is as good as patch test in determining allergy to oxidized limonene<sup>10</sup> in high concentration, methyl dibromoglutaronitrile<sup>11</sup> and nickel,<sup>3</sup> but is inferior to patch test for hydroxycitronellal, formaldehyde and chromium.<sup>12</sup>

The correlation coefficient between patch test and ROAT in our study was 0.84, suggesting significant correlation. Even

**Table 1: Clinical features**

Clinical features	Number of patients (%)
Presenting complaints	
Itching	50 (100)
Burning	25 (50)
Photosensitivity	5 (10)
Atopy	9 (18)
Hair dye brand used	
Garnier	34 (68)
Godrej	20 (40)
Neha mehendi	16 (32)
Colormate	12 (24)
L'oreal	10 (20)
Vasmol	2 (40)
Pure henna	26 (52)
Examination findings	
Lesional erythema	50 (100)
Lesional edema	44 (88)
Hyperpigmentation	24 (48)
Lichenification	22 (44)
Scaling	20 (40)
Hyperkeratosis	20 (40)
Tenderness	16 (32)
Oozing	12 (24)
Sites involved	
Face	49 (98)
Scalp	31 (62)
Neck	30 (60)
Upper limb	18 (36)
Back	10 (20)
Chest	5 (10)

though ROAT is inferior to patch testing in confirming contact dermatitis to hair dye, it can be considered as an alternative tool in situations where patch test cannot be conducted due to reasons such as remote area, non-availability of patch test kit, expertise to read the test, unavailability of PPD antigen or non-compliance by patient.

ROAT has a theoretical risk of sensitization to PPD in patients who are not allergic to it as the concentration of PPD in dyes is high but there are no guidelines for not performing or discouraging ROAT in already sensitized patients. Since ROAT is not performed under occlusion, the risk of sensitization maybe not as high as suspected. The disadvantage of using hair dye 'as is' for ROAT is that it does not give information on which antigen/constituent caused the allergy. Unavailability of hair dye allergens other than PPD and the small number of patients were the limitations of this study.

ROAT is less sensitive than patch test, but highly specific with a positive predictive value of 100% and negative predictive value of 70%. ROAT correlates well with patch test and can

**Table 2: Number of patients positive on patch test and repeated open application test**

Allergen	Patch test with ISS		ROAT	
	Number of patients (%)	Dye (number of patients using it)	Number of patients positive on ROAT (%)	
PPD + other allergens	36 (72)	Vasmol (2)	2 (100)	
PPD	32 (64)			
PPD + nickel sulfate 5%	3 (6)			
PPD + Nitrofurazone 1% + Colophony 10% + Parthenium hysterothorus 15% + fragrance mix 5%	1 (2)			
Nickel sulfate 5%	3 (6)	Godrej (20)	16 (80)	
Nitrofurazone 1%	3 (6)	Garnier (34)	24 (71)	
Colophony 10%	1 (2)	Colormate (12)	8 (67)	
Parthenium hysterothorus 15%	5 (10)	L'Oreal (10)	4 (40)	
Fragrance mix 5%	1 (2)	Neha mehndi (16)	6 (32)	

ROAT: Repeated open application test, PPD: Paraphenylenediamine, ISS: Indian standard series



**Figure 1:** Patch test showing bullous reaction to paraphenylenediamine on day 4



**Figure 2:** Repeated open application test showing positive reaction and kissing lesions on day 2

be used as an alternative tool for diagnosis only in situations where patch test cannot be performed.

#### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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#### Conflicts of interest

There are no conflicts of interest.

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