

Frequency of PPD (Para-Phenylenediamine) Allergy in Hair Dye Users in Faisalabad

SHAKEEL AHMED¹, MEHWISH KHAN ABDALI², FILZA HAFEEZ³, HAAFIZA HINA IMTIAZ⁴, RABIA ASHFAQ⁵, AISHA MALIK⁶

¹Consultant Dermatologist, DHQ Hospital, Faisalabad

²Consultant Dermatologist, Lahore General Hospital, Lahore

³Consultant Dermatologist, Social Security Hospital, Faisalabad

⁴Senior Registrar of Dermatology, Aziz Fatima Hospital, Faisalabad

⁵Senior Registrar of Dermatology, PESSI/University of Lahore Teaching Hospital, Lahore

⁶Associate Professor of Dermatology, University of Lahore Teaching Hospital, Lahore

Correspondence to: Dr. Shakeel Ahmed, Email: shakeel1787@gmail.com, Cell: 0334-1464077

ABSTRACT

Objective: To evaluate the frequency of PPD allergic contact dermatitis in hair dye users in Faisalabad district.

Study Design: Cross Sectional study.

Place and Duration of Study: Dermatology Outpatient Department of District Headquarter Hospital, Faisalabad from 01-07-2018 to 31-12-2018.

Methodology: A cross sectional study was carried out in Dermatology Outpatient Department and 135 patients were included. Male and female patients were included in this study with the age between

Results: A total number of 135 patients were included in this study. Gender distribution showed that there were 110 (81.5%) males and 25 (18.5%) females. The mean age of the patients was 38.04±4.96 years. The mean duration of hair dye use of the patients was 4±1.5 years. There were 92 (68.1%) patients between 30-40 years of age and 43 (31.9%) patients between 41-50 years of age. There were 80 (59.3%) patients between 3-4 years of duration of hair dye and 55 (40.7%) patients between 4-5 years of duration of hair dye. PPD allergic dermatitis was observed in 13 (9.6) patients. There was no association between gender ($p=0.232$), age ($p=0.591$) and duration of hair dye use ($p=0.676$) with respect to PPD allergic dermatitis.

Conclusion: Para-phenylenediamine is the commonest cause of hair dye contact dermatitis. Patients can present with a variety of clinical manifestations, including severe reactions. Patch testing remains the gold standard method for confirming PPD allergy. Avoiding future contact with permanent and semi-permanent hair dyes is the standard preventative measure.

Keywords: Allergy, Hair, Phenylenediamine, Para-Phenylenediamine.

INTRODUCTION

The great demand for hair dyes can be seen by the proliferation of hair salons. Their ability to impart temporary or permanent color change to the hair satisfies the desire of consumers for beauty, fashion, and a look-younger image. Para-Phenylenediamine is found in more than 1000 hair dye formulations and is the most frequently used permanent hair dye component in Europe, North America, and East Asia.¹ The diagnosis of contact allergy is based on patch testing. A positive patch test reaction indicates that an individual is sensitized. Allergic contact dermatitis occurs when exposure to an allergen exceeds the individual's threshold for elicitation. Most studies on contact allergy are based on patch testing of consecutive eczema patients. Para-Phenylenediamine used as an indicator of allergy to hair coloring products, has been present in the baseline series for many years.² The rates reported in those studies vary from 0% to 1.5% in Europe the clinical relevance of PPD allergy to hair coloring products or black henna tattoos was not investigated in any of those studies. Itchy skin rash on face/ears only was reported by 4.3% of hair dye users and by 2.7% of non-users during the last month. Confirmed contact dermatitis was reported by 9.5% in hair dye users and 4.1% in non- hair dye users during their life time.^{2,3}

Different studies involving the dermatitis patients have shown the median prevalence of positive PPD patch test to be 6.2% in North America, 4% in Europe, and 4.3% in Asia, although there may be broad variations within the country and between different countries.^{4,5} Hair dyes contain over 5000 chemical substances, in particular the aromatic amines. Hair dyes can be divided into four categories based on its chemical composition and mechanism of action; (1) permanent (oxidative) dyes, (2) temporary or semi permanent (direct) dyes, (3) metal salts and (4) natural dyes. It consists of primary intermediates (e.g., para-phenylenediamine, para-toluenediamine, orthoaminophenol, and para-aminophenol) that are mixed with couplers (e.g., m-aminophenols, m-hydroxyphenols, resorcinol and others) and oxidizing agent to generate coloured oxidation product through chemical reaction that binds irreversibly within the hair shaft. Hydrogen peroxide causes swelling of the hair cuticle which allows the diffusion of precursors into hair cortex and catalyzes the

oxidation of the precursors to large coloured molecules that are infused within the hair shaft. Temporary and semi-permanent hair dyes coat on the outer cuticle or surface of hair and are removed after one to several washings. It is estimated that in one hair dyeing process with about 4g of amines, 40mg or 1% of hair dye chemicals (precursors, products and side products) are absorbed through the scalp.⁶

Given its widespread use in the United States, Europe, and East Asia, safety assessment of hair dye ingredients remains a growing concern.⁷ The possible association between permanent hair dye use and cancer risk has been examined in several cohort studies. In a population based control study in Italy, the use of permanent hair dyes was associated with leukemia and follicular non-Hodgkin's lymphoma. Gago-Dominguez and co-workers reported that the risk of bladder cancer among women who used permanent hair dyes at least once a month and barbers with more than 10 years of working experience increases by 2.1 fold and 5 fold respectively compared to the non-users. Besides, bacterial test using *Salmonella typhimurium* tester strain showed 89% of commercial permanent hair dye ingredients such as 2,4-diaminoanisole, 4-nitro-o-phenylenediamine, 2-nitro-phenylenediamine, PPD, and others showed various degrees of mutagenicity. Although numerous studies have been done, the question on whether hair dyes possess significant risk to carcinogenesis is still an issue of debate.⁸

Permanent hair dyes are widely used with over 80% of market share in the United States. In 1980's, some hair dye chemicals were banned from use due to their mutagenic and carcinogenic effects as evidenced by laboratory animal studies. However, hair dye ingredients such as para-phenylenediamine and para-toluenediamine are still being used to date.⁹ For the past 50 years, PPD has been used commonly as a primary intermediate in the formulation of permanent hair dyes and still remains unchanged. According to a previous study, 76 out of 115 commercial oxidative hair dyes showed PPD concentrations ranging from 2.2 to 3.4%. Today, the European Union cosmetic directive regulation allows maximum PPD concentration of up to 6% in hair dyes. PPD is an aromatic amine with a chemical formula $C_6H_8N_2$.¹⁰ Present in the form of white crystals, PPD oxidizes in the

air turning from red to brown and finally black. PPD has the ability to penetrate hair shaft and follicle and has a strong protein binding capacity thereby making it an effective hair dye chemical.^{11,12}

MATERIALS AND METHODS

A total of 135 patients were included in this study after scrutinized by inclusion criteria and exclusion criteria. Informed consent will be taken from the patient. The history was taken and examination was done of each case to get required data. Then patch testing was performed by placing standardized concentrations of contact allergens (which are present in European standard series) on plastic (IQ) chambers and attaching the set of these to skin of the back with hypoallergenic paper tape. Patches were left in place for 48 hours and then removed. Patch test reading was taken at 120 hours after application of allergens. Patch reactions were graded 1 (erythema), 2 (papules or edema), or 3 (confluent vesiculobullous reaction). Reading as grade 1 or above was considered positive. Patients were labeled as having PPD allergy contact dermatitis if patch test for PPD was positive.

RESULTS

A total number of 135 patients were included in this study, both genders. Gender distribution showed that there were 110 (81.5%) males and 25 (18.5%) females (Table 1). The mean age of the patients was 38.04±4.96 years. The mean duration of hair dye use of the patients was 4± 1.5 years (Table 2). There were 92 (68.1%) patients between 30-40 years of age and 43 (31.9%) patients between 41-50 years of age (Table 3). There were 80 (59.3%) patients between 3-4 years of duration of hair dye and 55 (40.7%) patients between 4-5 years of duration of hair dye (Table 4). PPD allergic dermatitis was observed in 13 (9.6) patients (Table 5). There was no association between gender (p=0.232), age (p=0.591) and duration of hair dye use (p=0.676), with respect to PPD allergic dermatitis (Table 6-8).

Table 1: Gender distribution(n=135)

Gender	No	%
Male	110	81.5
Female	25	18.5

Table 2: Age distribution(n = 135)

Variable	Mean	S.D
Age (Years)	38.04	4.96
Duration of hair dye (years)	4	1.5

Table 3: Stratified age (years)(n=135)

Stratification	No	%
30-40 years	92	68.1
41-50 years	43	31.9

Table 4: Stratified duration of hair dye (years)(n=135)

Stratification	No.	%
3-4 years	80	59.3
4-5 years	55	40.7

Table 5: PPD Allergic Dermatitis (n = 135)

Presence	No.	%
Yes	13	9.6
No	122	90.4

Table 6: Association PPD Allergic Dermatitis with gender

Gender	PPD Allergic Dermatitis		Total	P-value
	Yes	No		
Male	9	101	110	0.232
Female	4	21	25	
Total	13	122	135	

Table 7: Association PPD Allergic Dermatitis with Stratified age

Stratified age	PPD Allergic Dermatitis		Total	P-value
	Yes	No		
30-40 years	8	84	92	0.591
41-50 years	5	38	43	

Table 8: Association PPD Allergic Dermatitis with Stratified duration of hair dye

Duration of hair dye	PPD Allergic Dermatitis		Total	P value
	Yes	No		
3-4 years	7	73	80	0.676
4-5 years	6	49	55	
Total	13	122	135	

DISCUSSION

The patch test system used, TRUE Test (Mekos, Hillerod, Denmark), has been well standardized for many years. In a comparative study of TRUE Test versus a chamber system, the PPD TRUE test performed equally well compared to the chamber system, eliciting a slightly higher number of positive patch tests.¹³The clinical relevance of positive patch tests to PPD has not been studied in population-based studies. PPD allergy is generally attributed to hair coloring products through consumer use or occupational exposure of hairdressers to cross-reacting chemicals and to black henna tattoos. In clinical studies, PPD positivity is associated with hair dyeing to various degrees.^{14,15}

An estimation extrapolating clinical data to a population level on PPD that elicited allergic contact dermatitis was performed using Information Network of Departments of Dermatology (IVDK) data on 83,030 patch tested consecutive eczema patients. According to this estimation, 0.11% of patients had PPD allergy related to use of hair coloring products by consumers; 0.11% had PPD allergy related to occupational exposure associated with hair coloring products, paints, or rubber; 0.06% had allergy related to exposure to clothing and shoes; and 0.21% had allergy related to unspecified exposures.¹⁶ Our study confirms the estimation of the rate of PPD allergy related to consumer use of hair coloring products (0.1% of the general population according to our results). Evaluation of the clinical relevance to hair coloring products was performed using an algorithm devised for population-based studies.¹⁷

Our study found no additional risk for PPD contact allergy from the use of hair coloring products on the population level. No difference was found in prevalence rates between lifetime users of hair coloring products and nonusers, and no difference was found between males and females despite more frequent use of hair coloring products among females. No association was found with lifetime use of hair coloring products.

Nevertheless, there is a clear relationship between reactions to hair coloring products and positive patch test results to PPD. Thus, the prevalence of PPD allergy was significantly higher in subjects who had a reaction to hair coloring products during their lifetime (2.8% vs. 0.5%), particularly among those whose eyelids and face had swelled after a reaction (14.3% vs. 1.2%)¹⁸ reported that sensitization to PPD was found to be significantly increased in patients with scalp dermatitis. Use of black henna tattoos appeared to be a significant risk factor for PPD contact allergy. Black henna tattoos may contain even higher concentrations (reaching 64%).¹⁹ A consumer presensitized by a black henna tattoo will be at higher risk for elicitation of a serious reaction when using a hair coloring product containing PPD²⁰ and potentially cross-reacting colorants. There are more than 100 reports in the literature on sensitization to PPD by black henna tattoos. Severe edematous reactions to hair coloring products leading to hospitalization of or emergency department visits by adolescents sensitized by black henna tattoos have been described.²¹

Thus, compared to hair dyeing, black henna tattoos appear to be a significant risk factor for PPD allergy and for severe skin reactions to PPD.²² This finding is in line with quantitative assessment of the allergy induction threshold for PPD indicating that the high-exposure conditions for black henna tattooing clearly led to values exceeding the induction threshold, whereas maximal hair colorant use exposure to PPD was found to be close to the induction threshold. Consequently, a single application of a black henna tattoo is more likely sufficient to induce contact allergy than hair coloring. An estimated mean of 2.5% of individuals using black

henna tattoos become sensitized to PPD. Improved education of the public, and especially of younger people, about the risks of black henna tattoos is needed. The relationship between induction and elicitation dose follows general rules of contact sensitization and is not confined to PPD.²³

CONCLUSION

PPD is the commonest cause of hair dye contact dermatitis. Patients can present with a variety of clinical manifestations, including severe reactions. Patch testing remains the gold standard method for confirming PPD allergy. Avoiding future contact with permanent and semi-permanent hair dyes is the standard preventative measure.

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