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Contact dermatitis to hair cosmetics: Current diagnostic recommendations

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Summary

Hair cosmetics such as shampoos, hair dyes, bleaching agents or hair straightening creams contain frequent contact allergens. These can lead to allergic contact dermatitis especially in hairdressers, but also in their customers and in others who use hair products at home. While hairdressers suffer mainly from hand dermatitis, in customers and home-users, dermatitis primarily affects the head, neck and face. In this mini-review, we propose a diagnostic algorithm in two steps, based on patch testing, that can be used for the assessment of suspected hair product-induced contact dermatitis. In a first step, we recommend testing the German Contact Allergy Group (DKG) standard series, DKG ointment series, DKG preservative series, DKG hairdresser series, DKG fragrance series as well as (especially in hairdressers) the DKG rubber series. In a second step, if the culprit allergen cannot be identified with the help of the standardized test series and there is a well-founded suspicion, testing the patient's own products, such as shampoos, hair sprays and hair dyes, is recommended.

Introduction

Hair cosmetics, such as hair dyes, bleaching agents or hair straightening creams, contain various known contact allergens [1]. These may cause allergic contact dermatitis especially in hairdressers, but also in their customers and in others using hair products at home. While studies with female patients dominate in the literature [1–3], male patients may of course also be affected.

In hairdressers, contact dermatitis occurs predominantly on the hands [1]. Two forms can be distinguished: irritant and allergic contact dermatitis. Irritant contact dermatitis develops as cumulative effect from wet work (intensive repeated contact with water and permanent perspiration-related humid climate when wearing rubber gloves) and contact with irritants included in hair care products [4]. The resulting irritant contact dermatitis is associated with a disruption of the skin barrier, which, in turn, may result in penetration of allergens into the epidermis causing sensitization. In this manner, irritant contact dermatitis may promote the secondary development of allergic contact dermatitis over time [5]. While in hairdressers both irritant and allergic contact dermatitis develop in most cases on the hands (81.2 % compared to 7.8 % in customers), allergic contact dermatitis predominates

in customers and affects primarily the head, neck and face (72 % in customers compared to 7.6 % in hairdressers) [1].

In cases of suspected hair product-related allergic contact dermatitis, we recommend a diagnostic two-step approach. In a first step, patch tests based on the test series of the German Contact Allergy Group (DKG) (standard series, ointment series, preservative series, hairdresser series, fragrance series; in addition, rubber series in hairdressers) should be performed (Figure 1, Table 1). In a second step, if the causative allergen cannot be identified in the first step, testing of the patient's own substances is recommended (Figure 1).

Standard series

The DKG standard series already includes some indicator substances relevant to this issue. Sensitization to vulcanization accelerators can, for example, be determined with thiuram mix and mercapto mix. These are used in rubber production during the process of vulcanization to accelerate the reaction speed. Given that hairdressers, in particular, often wear disposable gloves when they are exposed to hair products, especially hair dyes, vulcanization accelerators are potential triggers of allergic contact dermatitis. Thiuram mix and mercapto mix are indicator mixes for identifying sensitization

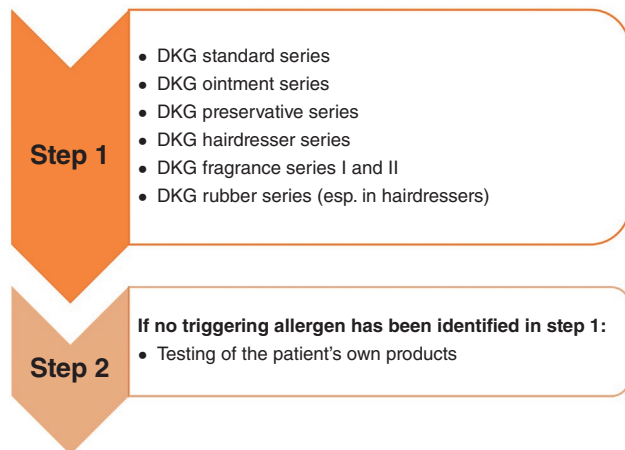


Figure 1 Structured work-up for the assessment of allergic contact dermatitis in hairdressers and their customers.

to vulcanization accelerators. The vulcanization accelerator mercaptobenzothiazole, a component of the rubber series, is also listed separately in the standard. Accelerator-free gloves are available, if sensitization to vulcanization accelerators is identified during assessment.

The group of so-called “para-group substances” is discussed in detail in the section on hairdresser substances.

The fragrance mixes I and II are also tested in the standard series. These contain nine and five individual, declarable fragrance allergens, respectively, that must be assessed separately if a positive test result is obtained. Based on the most recent analysis of the Information Network of Departments of Dermatology (IVDK) on contact allergies to hair cosmetics, fragrance mixes are slightly more often positive in hairdressers than in customers (11.1 % and 7 %, respectively, for fragrance mix I & II in tested hairdressers with contact dermatitis vs. 6.9 % and 4.4 %, respectively, in customers) [1].

Other relevant substances in the standard series are propolis (bee resin) found in hair wax and the group of preservatives. Here, chloromethylisothiazolinone (MCI) und methylisothiazolinone (MI) are of particular interest; these are frequently used in fixed combination (MCI/MI, Kathon CG) and are, therefore, listed combined (methylisothiazolinone also individually) in the standard series. Similar to all isothiazolinone derivatives they exert their antimicrobial activity by binding proteins to their nitrogen and sulfur-containing aromatic ring. This chemical process is thought to be the starting point for sensitization. Since 2014, combinations of MCI//MI are prohibited in *leave-on* cosmetics, such as creams and wet wipes; only in the USA are they still permitted with a concentration of up to 7.5 ppm (*parts per million*). In *rinse-off* products such

as shampoos, MCI/MI mixtures at low concentrations are still permitted in Europe. At higher concentrations, MI alone also poses a high risk of sensitization and has therefore been prohibited in *leave-on* products since 2017. Since 2018, only MI concentrations below 15 ppm are approved in *rinse-off* products; below this concentration, sensitization is not expected. However, this legislation applies only to Europe; in Canada, the USA, and Japan, MI is still permitted at higher concentrations [6]. In Europe, the continued presence of MI in industrial products, including wall paints, should be considered.

Hairdresser series

In the hairdresser series, the so-called para group substances, or p-substances, are particularly relevant for the development of contact dermatitis. The p-substances are compounds containing a benzene ring with two amino groups in para position, where the prefix “para” indicates the relative position of the amino substituents on the ring. As a group, p-substances carry a high risk of sensitization and are highly cross-reactive with each other.

An important p-substance is p-phenylenediamine (PPD). In order to prevent iatrogenic sensitization, PPD was removed from the standard series several years ago. N-Isopropyl-N'-phenyl-p-phenylenediamine (IPPD), which is partially cross-reactive with PPD, remained in the standard series [7, 8]. p-Phenylenediamine not only plays an essential role in hair dyes, but is also a component of many black products, such as car tires, rubber boats, bicycle handlebars, and leather. Data from the IVDK suggest that contact dermatitis is attributable to previous sensitization to PPD in 20 % of affected hairdressers [1]. In customers and home-users, allergic reactions to PPD-containing hair dyes are even more common [1]. In recent years, initial sensitizations have frequently been attributed to black henna tattoos. Here, PPD is added to the plant-derived red henna powder to obtain more intense, darker, and faster dyeing. Due to the long skin contact, black henna tattoos are a particularly important source of sensitization [9].

p-Phenylenediamine also cross-reacts with other p-substances included in the hairdresser series, such as p-toluenediamine (PTD) and p-aminophenol, but also with other substances such as m-aminophenol, Disperse Orange (compare textile dye series), or benzocaine (compare tattoo product series, local anesthetics series). Moreover, the possibility that PPD may cause immediate-type allergic reactions should be considered; in such cases, the underlying sensitization can sometimes only be identified by testing the original product and not by standardized test series optimized for type IV reactions [10]. Although hair dyes declared as “gentle” or “sensitive” often advertise as being free of PPD, they frequently

Table 1 Recommendations for patch testing in cases of suspected allergic contact dermatitis to hair cosmetics.

Test series		Important test substances in case of suspected sensitization to hair cosmetics				
DKG standard series	Indicator mixes catalyzers Thiuram mix (2) Mercapto mix (8)	N-Isopropyl-N'-phenyl-p-phenylenediamine (6)	Fragrance mix I & II (13 & 23)	Propolis (15)	Preservatives (Chloro) methylisothiazolinone (17)	
DKG hairdresser series	Para substances p-Phenylenediamine (10) p-Toluenediamine (2) p-Aminophenol (4) Hydroxyethyl-p-phenylenediamine sulfate (15)	Resorcin (5)	Monoethanolamine (1)	Ammonium persulfate (8)	Thioglycolates Ammonium thioglycolate (9) Glyceryl mono-thioglycolate (6)	Sugar-based surfactants Decyl glucoside (16) Lauryl polyglucose (17)
DKG ointment series	Cocamidopropyl betaine (6)	Hydroquinone (12)				
DKG rubber series (especially in hairdressers)	Thiurams Tetramethylthiuram disulfide (1) Tetramethylthiuram monosulfide (2) Tetraethylthiuram disulfide (3) Dipentamethylenethiuram disulfide (4)	Dithiocarbamates Zinc dibutyldithiocarbamate (9) Zinc dibenzylthiocarbamate (18)	Mercaptobenzothiazole N-Cyclohexyl-2-benzothiazolesulfenamide (5) Morpholinyl mercaptobenzothiazole (7)	1,3-Diphenylguanidine (10)		

The numbers in parentheses indicate the position of the respective substance in the corresponding DKG series of 07/2020.

contain substances such as p-toluenediamine (PTD) that cross-react with PPD, and may therefore also cause allergic reactions in subjects allergic to PPD [11, 12]. Given that hydroxyethyl p-phenylenediamine sulfate has been shown to be less cross-reactive than the other p-substances, it may present a suitable alternative for allergic subjects in the future [13]. Whether it truly represents a tolerated alternative in the next hair dyeing should be tested in advance by repeated open application test (ROAT).

Finally, resorcin should be mentioned in connection with p-substances. As a so-called coupling agent it provides various colors from red to brown to black by polymerization with p-substances and it also has allergenic potential [14].

Another substance in the hairdresser series to be considered is monoethanolamine, which is used as additive in cleaning agents and cosmetics. In addition, ammonium persulfate should be mentioned, which is used in bleaching agents. Ammonium persulfate may cause both a type I sensitization with bronchial symptoms and a type IV sensitization with allergic contact dermatitis [15]; the type of diagnostic workup is, therefore, dependent on the symptoms. According to an IVDK analysis, hairdressers are particularly often affected by sensitization to ammonium persulfate (18.7 % of hairdressers compared to 2.1 % of customers) [1].

Thioglycolates are an important component of two-component perming products. Apart from the most frequently used ammonium thioglycolate (ATG), glyceryl monothioglycolate (GMTG) is relevant. The latter has been prohibited since 1997 and is no longer commercially available; however, as shown in the current IVDK report, sensitizations continue to be detected, although they were most likely acquired before prohibition of the ingredients [1].

Finally, 4-amino-2-hydroxytoluene and the sugar-based surfactants decylglucoside and lauryl polyglucose should be mentioned. 4-Amino-2-hydroxytoluene is an aromatic compound from the group of cresols used in hair care products and hair dyes. Decylglucoside is a common component of shampoos and shower gels, while lauryl polyglucose may also be included, in other cosmetics, such as skin cleansers or shaving creams.

Ointment series

The allergen cocamidopropyl betaine (CAPB) is, for example, an ingredient of shampoos and shower gels. CAPB has frequently tested positive in the past, and the putative allergenic effect of the substance is currently predominantly attributed to the two substances amidoamine and dimethylaminopropylamine. These substances are formed as contaminants during the production process of CAPB and have strong sensitizing effects. In contrast, most subjects who previously tested positive for CAPB show negative test results with highly purified

CAPB. The purified products currently in use contain only very small amounts of amidoamine and dimethylaminopropylamine. Given that CAPB may trigger irritant reactions, sensitization should only be assumed in case of a dual positive reaction [16].

Hydroquinone in the ointment series is another p-substance of the phenol group used in hair dyes and is cross-reactive with other p-substances.

Rubber series

Increased awareness among hairdressers of the risk of developing contact dermatitis has led to an increased use of disposable gloves [17]. This has resulted in an increased incidence of sensitizations to rubber ingredients [18]. In case of suspected sensitization, testing of the rubber series is therefore recommended, in addition to the accelerator mixes in the standard series mentioned above. Of particular relevance are the thiurams (tetramethylthiuram disulfide, tetramethylthiuram monosulfide, tetraethylthiuram disulfide, and dipentamethylthiuram disulfide), dithiocarbamates (zinc dibenzylthiocarbamate and zinc diethylthiocarbamate), mercaptobenzothiazoles (N-cyclohexyl-2-benzothiazolesulfenamide and morpholinyl mercaptobenzothiazole), and 1,3-diphenylguanidine. These allergens are used as catalysts in rubber production, and residues of these substances may be present in rubber gloves. In this context, knowledge of the frequent cross-reactions between thiurams and carbamates, and between allergens of the individual rubber groups is also important.

Testing the patient's own products

If, in case of suspected allergic contact dermatitis, the culprit allergen is not identified by standardized patch test series, the various hair cosmetics used by the patient should be tested in a second step (patient's own products; see Figure 1). Here, however, it is important to consider the possible toxicity and irritant potential of the hair cosmetic products. If the medical history provides clear indications for a specific trigger, testing the patient's own products may already be considered in the first step.

Pursuant to § 67 of the German Medicinal Products Act (AMG), patch testing with the patient's own substances must be reported to the corresponding federal state authority (GCP Inspectorate); usually this is required only once. The cover letter required for this purpose can be requested from the DKG (see DKG website: dkg.ivdk.org) [9].

If the patient's own substances pose a risk of severe irritation, an open or semi-open patch test is recommended instead of the occlusive variant (Table 2). For the open test, the test substance applied to the skin is covered by gauze

Table 2 Recommendations for the testing of the patient's own products.

Oxidative hair dyes	Test in two steps: 1. semi-open test, 2. occlusive patch test
Perming agents	Dilute 100 times
Shampoos	Dilute 10–100 times
Hair gel	May be tested undiluted
Hairsprays	Spray undiluted onto filter paper, then apply filter paper
Disposable gloves	Test interior and exterior; test different layers individually

bandage, for the semi-open test by plaster. The results are evaluated after 24 to 48 hours [19].

Oxidative hair dyes should be tested with a two-step approach; first, using a semi-open test, and then, if negative, with an occlusive patch test. Perming agents should be diluted 100 times in buffer solution, and shampoos should also be diluted 10–100 times. Hair gel may be tested undiluted. For testing of hairsprays, these should be sprayed undiluted onto filter paper which is then applied to the skin [19].

Disposable gloves can be tested by moistening a fragment of the glove (approx. 2 cm²) with distilled water and attaching it subsequently under occlusive conditions in a large chamber to the skin. It is advisable to test both the inside and the outside of the glove by affixing both sides of the glove. For gloves with several layers, it is recommended to test both sides of each layer [19].

Prevention

The risk of developing contact dermatitis can be significantly reduced by consistently implementing a number of precautionary measures [20, 21]. Before using disposable gloves, for example, it should be ensured that these are new, dry, clean, and optimally, free of accelerators (applicable, for example, for vinyl or certain nitrile gloves). They should be worn for as short a time as possible, while taking into account the permeation times and degradation of the gloves. Hair preparations should be readied in a separate and ventilated mixing room. The hair should be cut before dyeing to avoid unnecessary contact with the allergen. In addition, the wearing of rings should be avoided. The use of water-repellent skin protection creams to protect the skin barrier before and during work and of ointments with skin-caring properties afterwards is recommended, although the possible inclusion of fragrances should be viewed critically.

Conclusions

In hairdressers, contact dermatitis occurs mainly on the hands, in their customers predominantly on the head, neck, and face [1]. The most important allergens among hairdressers and their customers are PPD and PTD, and among hairdressers also the bleaching agent ammonium persulfate, which may also cause bronchial symptoms. Other important substances are MI, thioglycolates in perming agents, preservatives (one of the most common causes of contact dermatitis especially in hairdressers, in 39 % of tested hairdressers compared to 2 % of tested clients [1]), as well as rubber additives, in particular the most frequently positive thiuram mix that may indicate sensitization to accelerators, and thus a “glove problem”. Preventive measures to avoid contact with allergens on the one hand and to maintain the barrier function of the skin on the other hand are useful for avoiding occupational-specific sensitizations in hairdressers.

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