

Allergic contact dermatitis



Patient management and education

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Learning objectives

After completing this learning activity, participants should be able to counsel and educate patients with allergic contact dermatitis by utilizing tools available to dermatologists and identify emergent allergens not available on standard testing series.

Disclosures

Editors

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Allergic contact dermatitis is a common diagnosis resulting from exposure to a chemical or chemicals in a patient's personal care products, home, or work environment. Once patch testing has been performed, the education and management process begins. After the causative allergens have been identified, patient education is critical to the proper treatment and management of the patient. This must occur if the dermatitis is to resolve. Detailed education is imperative, and several resources are highlighted. Photoallergic contact dermatitis and occupational contact dermatitis are other considerations a clinician must keep in mind. (J Am Acad Dermatol 2016;74:1043-54.)

Key words: allergen; allergic contact dermatitis; eczema; occupational contact dermatitis; patch testing; photoallergic contact dermatitis; systemic contact dermatitis.

The identification of allergens in a patient diagnosed with allergic contact dermatitis (ACD) is the first step in patient management. Patient education follows, and is vital to the successful treatment and management of the patient. Part II of this continuing medical education article reviews education of the patient, including important resources, the management of complications, a discussion of photoallergic contact dermatitis (PACD), and an introduction to the complex and

Abbreviations used:

ACD:	allergic contact dermatitis
ACDS:	American Contact Dermatitis Society
BRM:	black rubber mix
NACDG:	North American Contact Dermatitis Group
OCD:	occupational contact dermatitis
PACD:	photoallergic contact dermatitis
PCP:	personal care product
PPD:	para-phenylenediamine
SCD:	systemic contact dermatitis
ROAT:	repeat open application test

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challenging subject of occupational contact dermatitis (OCD).

PATIENT EDUCATION

With regard to successful patient management, patient education regarding the allergens identified through patch testing is as important as identifying the allergens themselves. It is imperative that patients be educated about all allergens identified during the patch test procedure. This information should be both oral and written and include instruction on label reading, written materials discussing where the allergens can be found, relevant synonyms that might be used, and how to avoid the allergens. Simply supplying a patient with the names of any identified allergens is not adequate. Time must be taken for detailed patient education or it is unlikely that the patient's dermatitis will improve even after discovering the causative allergens. Educating patients about the allergens identified and their potential current, past, and future relevance is important for patients to clear current dermatitis and avoid future problems with the allergens.

Written materials sent before patch testing can be helpful in preparing the patient for the patch testing procedure. Information describing the procedure, including patch testing basics, can lay the foundation for the education process even before patch testing begins. Many patients are misinformed and believe that patch testing and skin scratch/intradermal testing are identical. Patients need to be educated that patch testing is a delayed-type hypersensitivity reaction that differs from skin prick testing, which tests for an immediate hypersensitivity reaction.¹⁻³ The former typically leads to skin rashes; the latter leads to rhinorrhea, eye tearing, and shortness of breath.⁴

Patch testing identifies allergens that come into direct contact with the skin (ie, those found in personal care products [PCPs], such as fragrances, preservatives in soaps, lotions, and shampoos) and items worn on the skin (ie, metals [jewelry, belt buckles, zippers, snaps, and cell phones], rubber additives [gloves, shoes, and elastic in clothing], or textiles [dyes/formaldehyde resins]). In addition, topical drugs—both over the counter and prescription varieties—can contain allergens in the inactive or active ingredients of the products.

Grouping allergens can make it easier for patients to understand what they are and where they are found (Table I). Carba, thiuram, and black rubber mixes (BRMs) are rubber allergens. Disperse blue 106 and melamine formaldehyde are clothing allergens. Tixocortol pivalate and budesonide are cortisone allergens. Quaternium-15, fragrance, and

Table I. American Contact Dermatitis Society core allergens grouped into main categories*

Allergen	Allergen type
Core allergen panel I	
Nickel sulfate	M, S
<i>Myroxylon pereirae</i>	f, P, S
Fragrance mix I	f, P, S
Quaternium 15	P
Neomycin	m
Budesonide	m, c
Formaldehyde	P, S, T
Cobalt chloride	M, S
p-tert-Butylphenol formaldehyde resin	A
p-Phenylenediamine	P
Core allergen panel II	
Potassium dichromate	M, P, S
Carba mix	R, T
Thiuram mix	R, T
Diazolidinyl urea	P
Paraben mix	P, S
Black rubber mix	R, T
Imidazolidinyl urea	P
Mercapto mix	R, T
Methylchlorisothiazolinone/ methylisothiazolinone	P, R
Tixocortol-21-pivalate	m, c
Core allergen panel III	
Mercaptobenzothiazole	R, T
Colophony	A, P
Epoxy resin	A
Ethylenediamine	R, S, T
Wool alcohol	P
Benzocaine	m
Bacitracin	m
Mixed dialkyl thioureas	A, R, T
Fragrance mix II	f, P, S
Benzophenone-3	P, Su
Core allergen panel IV	
Disperse blue 106	T
Disperse blue 124	T
Gold sodium thiosulfate	M
Ethyl acrylate	A, P
Compositae mix	P, pl, S
Sesquiterpene lactone mix	P, pl, S
DMDM hydantoin	P
Tosylamide formaldehyde resin	P
Methyl methacrylate	A, P
Cinnamic aldehyde	f, P, S
Core allergen panel V	
Propylene glycol	P, S
Cetyl steryl alcohol	P
2-Bromo-2-nitropropane-1,3-diol	P
Sorbitan sesquileate	P, S
Cocamidopropylbetaine	P
Glyceryl thioglycolate	P
Ethyleneurea melamine-formaldehyde	T
Iodopropynyl butylcarbamate	P

Continued

Table I. Cont'd

Allergen	Allergen type
Chloroxylenol (PCMX)	P
Glutaraldehyde	d, P
Core allergen panel VI	
Ethyl cyanoacrylate	A, P
Benzyl alcohol	f, P, S
Benzalkonium chloride	d, P
Methyldibromoglutaronitrile	P
Propolis	P
n,n-Diphenylguanidine	R, T
Lanolin alcohol (Amerchol 101)	P
Triethanolamine	P
Amidoamine	P
Desoximethasone	m, c
Core allergen panel VII	
Triamcinolone	m, c
Clobetasol-17- propionate	m, c
Hydrocortisone-17-butyrate	m, c
4-Chloro-3-cresol (PCMC)	P
Benzophenone-4	P, su
Chlorhexidine digluconate	d, P
Ylang ylang	f, P
Phenoxyethanol	P
Sorbic acid	P, S
2, 6-Ditert-butyl-4-cresol (BHT)	P, S
Core allergen panel VIII	
Disperse orange 3	T
3-(Dimethylamino)propylamine (DMAPA)	P
Oleamidopropyl dimethylamine	P
DI alfa tocopherol	P, S
Cocamide DEA	P
Lidocaine	m
Dibucaine	m
Jasmine absolute	f, P
Tea tree oil	f, P
Triclosan	P

A, Adhesive; c, corticosteroid; d, disinfectant; f, fragrance; m, medication; M, metal; P, personal care product; pl, plant; R, rubber; S, systemic (ingested) allergen; su, sunscreen; T, textile.

*This table is not meant to be an exhaustive grouping of allergens into various categories, but rather to give examples of some ways to consider allergen function for patient education.

methylisothiazolinone (MI) are all PCP allergens. The PCP allergens can be further divided into categories, such as preservatives (eg, methyldibromoglutaronitrile, MI, iodopropynyl butylcarbamate, and paraben mix), fragrance screening chemicals (eg, fragrance mixes I and II and *Myroxylon pereirae*), surfactants (eg, cocamidopropyl betaine), and emulsifiers (eg, sorbitan sesquioleate).

Many allergens have >1 function. For example, ethylenediamine is a stabilizer used in cosmetics but also in latex emulsion.⁵ Colophony, a pine tree derivative, is used in adhesives, cooling fluids, hair removal wax, and can be a screening chemical for

fragrance allergy.⁵ Formaldehyde can be used as a preservative, in synthetic rubber production, textiles, leather tanning, and dental plastics.^{5,6} Patients who are allergic to formaldehyde also need to be educated about formaldehyde-releasing preservatives (FRPs) found in shampoos, body washes, lotions, and some corticosteroids, such as Quaternium-15, 2-bromo-2-nitropropane-1,3-diol (bronopol), imidazolidinyl urea (imid urea), diazolidinyl urea, and 1,3-bis(hydroxymethyl)-5,5-dimethylimidazolidine-2,4-dione (DMDM hydantoin).

It is important for patients to understand the functions of their allergens so they can better assess where they are found and how to comply with avoidance. To show the importance of this, one should consider the formaldehyde-sensitive patient who has a diffuse truncal rash but is not using any PCPs with FRPs. This patient should be informed that permanent press/wrinkle-resistant fabrics can release formaldehyde, and formaldehyde in clothing could therefore be contributing to the dermatitis.

Patch testing investigates allergy to many chemicals. Some chemicals can indicate allergy to other structurally related chemicals. For example, the hair dye chemical p-phenylenediamine (PPD) and BRM are often used to test for textile dye allergens because of structural similarities between these and certain disperse dyes. In 1 study, PPD and BRM detected approximately 50% of patients allergic to ≥ 1 ingredient of a textile dye mix.⁷ Similarly, a patient who is allergic to neomycin could also react to gentamycin and tobramycin given their structural similarities to neomycin.⁵

Chemicals that can be used to help detect fragrance allergy include cinnamic aldehyde (on the North American Contact Dermatitis Group [NACDG] standard but not on the Thin-layer Rapid Use Epicutaneous [T.R.U.E.] Test [SmartPractice, Phoenix, AZ]), fragrance mix I (a NACDG standard and T.R.U.E. Test allergen), fragrance mix II (on the NACDG standard but not on the T.R.U.E. Test), and *Myroxylon pereirae* (a NACDG standard and T.R.U.E. Test allergen). One study found that patients who were allergic to fragrance mix I had coreactions to various other fragrance chemicals not present in the mix.⁸

Allergy to fragrance mix I was detected in 8.5% of the approximately 4300 patients with dermatitis who were tested by the NACDG.⁹ Allergy to *Myroxylon pereirae* was detected in 7%, and allergy to fragrance mix II in 5% of the NACDG patients with dermatitis.⁹ This indicates that fragrance allergy represents a significant allergen. Patients are frequently reacting to fragrances within PCPs.¹⁰ Unfortunately for consumers, even items labeled as “fragrance-free,” “sensitive skin,” “dermatologist-tested,” and “for

baby” are often not truly fragrance-free.¹¹ It is essential to have patients bring in all of their PCPs to help them with the label-reading process. Patients need to be educated that even products labeled “fragrance-free” can contain fragrance chemicals, such as farnesol, benzyl alcohol, benzaldehyde (the latter 2 are components of *M pereirae*), and various essential oils of flowers.¹² Maltol, an ingredient in some soaps, occurs in pine needles and the bark of larch trees and is a fragrance/flavoring.¹³ If ingredients are not used “solely to impart an odor to a product” but are instead used as emollients or have other functions, it is legal for a “fragrance-free” product to contain fragrance.¹¹ There are 2 helpful databases that simplify this process as cross-reactors are removed from the list of safe products, making avoidance easier for patients: the Contact Allergen Management Program (CAMP) and the Contact Allergen Replacement Database (CARD).

In the United States, fragrances are listed generically on product labels as “fragrance,” making avoidance difficult. As a result of this labeling process, if patients test positive to fragrances they must, at least initially, avoid all fragrances until clearing of the dermatitis occurs and then add 1 product back every 1 to 2 weeks, if so desired. The European Union has identified 26 fragrance chemicals that, since 2005, must be labeled on cosmetic products.¹⁴ Studies have shown that testing to this list helps identify relevant fragrance allergens.^{15,16} This also assists patients in identifying products containing known allergens and may make fragrance avoidance to these 26 chemicals easier to follow. This labeling practice is not yet standard in the United States.

RESOURCES

Given the complexity of information a patch test patient may receive, it is helpful to provide them with written information for future reference. *Contact and Occupational Dermatology*⁵ contains handouts specifically created for teaching purposes, and these sheets can be distributed to patients. Some manufacturers and organizations include allergen information on their websites, such as Chemotechnique (www.chemotechnique.se), T.R.U.E. Test (www.truetest.com), Smart Practice (www.allergeaze.com), the American Contact Dermatitis Society (ACDS) (www.contactderm.org) and Preventice (www.allergyfreeskin.com).

A given patient’s educational level and literacy need to be considered.¹⁷ Patients with lower literacy levels are less likely to understand printed material and more likely to have difficulty controlling chronic illnesses.^{17,18} Tests are available to help determine a patient’s literacy level, and these can be easily

administered in the office.¹⁷ Patient information should be written at a sixth grade or lower reading level.¹⁷ In addition to providing easily understandable materials, health care providers must also provide concrete ways to put clinical recommendations into practice, otherwise known as “actionability.”^{19,20} Demonstrating label reading can be useful. Studies have shown that recall of easily understandable material is poor, even in individuals with high literacy levels and even after repetition.^{21,22}

Cognitive theory recommends minimizing extraneous information to improve memory and prevent memory overload.²³ This means that printed patch test materials should be concise, written in simple language, and use lists or pictures when possible.²³ Patients should be instructed to keep the handouts and review them periodically. Free videos describing specific allergens can be accessed at www.mypatchlink.com.

There are benefits and disadvantages to both print- and video-based health materials.²³ For procedural content (ie, the patch test procedure), a video may be the most effective tool. However, for actions that need to be practiced on a long-term basis to control a chronic disease (ie, ongoing avoidance of identified allergens), print information may be preferable for longer recall so that patients can refer to the information. If patients are not improving within 4 to 6 weeks after patch testing, it is worthwhile to review allergens and avoidance strategies to make sure they are in compliance with allergen avoidance and understand the process.

Two large databases provide lists of “safe” products that are free of allergens identified during patch testing (CAMP and CARD). These can be printed or emailed for patient use.

CAMP is a member benefit of the ACDS and contains approximately 5000 products. Most CAMP products are found in major American drug stores. CAMP product ingredients are checked by hand before being entered into the database and are updated every 1 to 1.5 years. A quality assurance committee of the ACDS reviews approximately 1% of CAMP products annually for accuracy. Products are grouped into categories, such as antiaging creams, hair dyes, moisturizers, shampoos, soaps, sunscreens, and prescription medications, to name a few. This provides patients with an easily accessible list of products that are safe to use. Reading the labels of all PCPs to confirm that a product is free of a known allergen is still encouraged, but this list makes product selection easier for the patient. Patients can also be given a unique access code that allows them to update their CAMP lists directly at www.acdscamp.org and via the ACDS CAMP app,

free of charge. An in-depth, step by step guide to using CAMP can be found on the ACDS website.

Physicians can pay for a yearly subscription to CARD, and patients can get access to their CARD listing for a monthly fee after a 6-month free trial. CARD is maintained by the for-profit group Preventice and contains approximately 5500 products.

ACD can occur 24 to 48 hours after exposure; patients are therefore often unaware that a favorite PCP is causing their rash.²⁴ Even products that have been used for years can result in dermatitis either because of a change in the product formulation or as a result of sensitization to the product over time.²⁵ An important contributing factor in the development of ACD is decreased skin barrier function.²⁶ Decreased environmental humidity, sweating, friction, heat, and exposure to skin irritants can all enhance ACD in a sensitized individual. Patients with disrupted barrier function (eg, poorly controlled patients with atopic dermatitis or patients with leg ulcers and chronic dermatitis) are at risk of sensitization to even weak allergens.²⁷⁻³⁴

The labels on all of a given patient's PCPs should be read to determine if an identified allergen is present. In addition, it is important for patients to bring in their PCPs for testing. Failure to test with a patient's PCP can miss a causative allergen. A repeat open application test (ROAT) or use test can be performed with leave-on products to verify that a product is safe to use. A ROAT involves twice daily application of a leave-on product to see if a rash develops.^{35,36} If no dermatitis occurs, one can assume that the product is safe to use. However, there can be false-negative results with a ROAT, especially if the product in question has been applied to nondiseased skin.³⁵ For topical corticosteroids, a ROAT may need to be performed for ≤ 2 weeks because the corticosteroid can suppress reactions to itself. Wash-off products cannot be tested "as is" because they are not meant to be left on the skin. These products need to be diluted, and there are excellent resources for diluting them.³⁷ Provocative use testing is another way to determine relevance: this involves applying a small amount of the product in question to the area of typical use and observing for a reaction.

The relevance of any reaction needs to be determined and discussed with the patient. There are times that clinical relevance can only be ascertained weeks after testing.³⁸ For example, a patient with hand dermatitis who is found to be allergic to carba mix and who has a history of wearing rubber gloves to wash dishes needs to know that carba mix can be present in natural and synthetic rubbers, such as the gloves being worn to wash dishes. If the

patient's hand dermatitis resolves with avoidance of these rubber gloves, it provides empiric evidence of clinical relevance of the positive patch test reaction. However, positive reactions may simply represent past sensitization and may not be clinically relevant. For example, a patient with scalp dermatitis and a positive reaction to gold on patch testing but no history of gold exposure does not have clinical relevance of the gold patch test reaction to the scalp dermatitis. Gold and thimerosal are frequently positive, but not always relevant, and as a result, the NACDG no longer includes either of these T.R.U.E. Test allergens in their standard series, citing infrequent relevance with the exception of eyelid dermatitis and gold allergy.^{9,39,40} Some allergens, such as parabens and lanolin, are paradoxical—they may be allergenic on dermatitic skin but tolerated on intact skin.⁴⁰⁻⁴² Gold, a common allergen in patients with eyelid dermatitis, is often tolerated under jewelry, but can cause eyelid dermatitis when transferred from the fingers to the eyelids.^{43,44}

SYSTEMIC CONTACT DERMATITIS

A patient sensitized to a "topical" allergen can develop systemic contact dermatitis (SCD) if exposed to that allergen via a non-skin surface route (ie, ingestion, parenteral, suppository, implanted, and inhaled).⁴⁵ Dermatitis can manifest as oral, anogenital, flexural, fixed, reactivation of a previous positive patch test site or flare of previous dermatitis, vasculitic lesions, vesicular hand dermatitis, or a widespread dermatitis.⁴⁵⁻⁵⁶ Patients with proven contact allergens who are exposed to their allergen systemically can develop noncutaneous symptoms, such as fever and sepsis-like manifestations, chest pain, or urticaria.⁵⁷⁻⁵⁹

Medications, including antibiotics, corticosteroids, antifungals, and antiepileptics, can cause SCD, as can implants and metals (eg, mercury, gold, nickel, chrome, cobalt, and titanium), plants (eg, chamomile, chrysanthemum, and other members of the Compositae family), mango, garlic, and shiitake mushrooms.⁴⁵ Additional allergens that have both topical and potential ingested exposure sources include propylene glycol, parabens, butylated hydroxyanisole and cross-reacting butylated hydroxytoluene, sorbic acid, benzoic acid, sodium benzoate, formaldehyde, sorbitan sesquioleate (sorbitol), gallates, and fragrance/flavoring.⁴⁵ The interested reader is referred to an excellent review article by Veien⁴⁵ for more in-depth reading on this subject.

In patients who are not improving with the cutaneous avoidance of allergens, dietary avoidance may help.^{60,61} Approximately 50% of fragrance-allergic patients, in 1 study, improved while adhering

Table II. Potential side effects of patch testing

Occurrence	Side effect
Common	Itching at site of patch testing Pruritus Tape irritation
Rare	Anaphylaxis Angry back syndrome Infection Koebnerization Persistent patch test reaction Scarring Sensitization

to a diet that was low in balsam.⁶² Nickel, chromium, and cobalt are present in many foods.⁶³⁻⁶⁶ Reviewing various oral challenge studies, Jensen et al⁶⁶ found that patients with SCD to nickel can react to ingested nickel in a dose-dependent fashion. The most sensitive of nickel-allergic patients can react to normal amounts of nickel in water and diet (0.22-0.35 mg).⁶⁶ A point-based system of foods that may be eaten in the setting of SCD to metals has been suggested for nickel-, cobalt-, and chromium-allergic patients.^{67,68} Sharma⁶⁹ delineates food avoidance strategies for chromium-allergic patients.

PATCH TEST SIDE EFFECTS

Serious side effects from patch testing are infrequent. Side effects fall into 2 major groups. The first type of side effect is common and expected, such as pruritus at the site of a positive reaction. The second type of side effect is rare but serious, including sensitization to the patch test allergen, infection, and anaphylaxis (Table II). Extensive research has been conducted to determine that the correct concentrations of allergens are applied. Most side effects from patch testing are anecdotal.

In rare cases, a patient may develop widespread, multiple, positive patch test reactions. This phenomenon has been termed angry back syndrome (ABS)⁷⁰ and is also known as excited skin syndrome. Excited skin syndrome may be the preferred term because the entire skin is hyperexcitable.^{71,72} This reaction must be distinguished from individuals that have multiple positive patch tests (ie, multiple reactors). Multiple reactor patients have allergen reactions that appear to be clinically relevant and related; most reactions in patients with ABS are eventually deemed clinically irrelevant.

Angry back syndrome

ABS is uncommon, poorly understood, and poorly studied. It appears that the reactions are not reproducible within any given patient.⁷³ This

hyperirritability may more likely be caused by allergens that act as both irritants and allergens, and in a small subset of patients ABS occurs.⁷⁴ Perhaps irritants can cause secondary weak to moderate positive patch test reactions in the correct individual and under the correct physiological conditions.⁷⁴

A combination of a fluctuation in cellular and humoral immunity, irritancy, nonimmunologic factors, and other unknown factors play a role in its development.⁷³ Some authors indicate that ABS is caused by a severe allergic relevant reaction at 1 site with spreading (spillover) to other patch test sites. The typical presentation is seen after the patch tests are removed for the first reading. Widespread positive reactions will be seen. There is often 1 severe patch test reaction and multiple positive reactions in close proximity to the most severe reaction. Characteristically, the reactions are across many classifications of allergens; multiple reactors are more likely to have multiple reactions within a class of allergens (eg, the formaldehyde class).

In 1 study of 5 patients, ABS was not reproducible.⁷³ Clinicians need to be aware of this potential reaction and differentiate it from the patient with multiple relevant reactions. In patients with ABS, patch testing again in 2 to 3 months seems a reasonable approach if clinically warranted.⁷⁵ In exceedingly rare situations, patients will have near universal positivity to all patch test sites. In these cases, one must consider an allergy to the vehicle or the Finn chamber, which is composed of aluminum.⁷⁶

Persistent patch test reactions

Another rare potential side effect of patch testing is the persistent patch test reaction. These reactions typically occur during the first week of application and can persist for ≥ 30 days. These reactions are most likely underreported by patients, and the true incidence is unknown. The mechanism of how these persistent reactions occur is unknown. An interaction with antigen-presenting skin cells is likely to play a role. One theory is that the antigen-presenting cells may act by sequestering the antigen within the skin, allowing a persistent reaction to occur.⁷⁷

One of the most commonly reported allergens to cause persistent patch test reactions is gold, in the form of gold chloride or sodium gold thiosulfate.⁷⁷⁻⁷⁹ Other reported causes of persistent patch tests include phenylephrine, methyl methacrylate, and textile dyes. Other than with gold salts, this is an exceedingly uncommon event.⁸⁰⁻⁸²

Sensitization

Active sensitization of a patient directly caused by the application of allergens during patch testing is,

for the most part, an exceptionally uncommon reaction, and almost never occurs at the standardized patch test concentrations that have been established over many decades. There are many sources to obtain standardized patch test concentrations to minimize and remove this potential side effect.^{5,83,84} The exact rate of active sensitization induced by patch testing is unknown, but it is felt to be rare and estimated to occur in 0.1% of patients tested.^{85,86} It may be underreported because patients may not be aware of a late reaction, or they may attribute it erroneously to a known reaction that occurred during their patch test readings. Although rare, this is one of the most concerning of the potential side effects of patch testing, because clinicians are trying to help their patients avoid allergens. Active sensitization results in another allergen that must be avoided.^{86,87}

Clinicians should consider the induction of sensitization when a patient calls 10 to 21 days after patch test application and states that they have a new reaction at a patch test site. One exception is with gold salts; these late reactions are nearly always felt to be persistent patch test reactions and not active sensitization. These late reactions can be caused by individuals that have delayed reactions (ie, slow responders and late reactors) to the allergen, or because of active sensitization, and the differentiation of these 2 possibilities is difficult.^{88,89} If the allergen that has caused this late reaction is identified, one can test for sensitization by using a $\times 10$ to $\times 100$ dilution of the allergen. This diluted allergen can then be re-patch tested, and if a positive reaction occurs within 6 days, active sensitization has most likely occurred.⁹⁰ In 1 study, PPD was felt to cause sensitization in 1.5% of those tested and epoxy resin caused sensitization in 0.3% of those individuals tested, with a 1% concentration in petrolatum for each.⁹¹ In this same study, no sensitization was found with the use of nickel sulfate. The authors of this study recommended decreasing the test concentration or time of patch test application of PPD so as to avoid sensitization. When the time of patch test application of PPD was decreased from 48 to 24 hours, the sensitization rate decreased from 1.5% to 0.3%.⁹¹ When decreasing the patch test concentration to 0.35%, a decrease in the sensitization rate of PPD was also seen.⁹²

PPD has been the most reported allergen to cause sensitization. Other allergens have also been reported, including epoxy resins, isothiazolinones, primula, acrylates, balsam of Peru, fragrance mix I, para-tertiary-butylcatechol, and Compositae mix.^{86,93-97}

Other complications and side effects

Other complications and side effects⁹⁸ of patch testing are listed below.

Pruritus. Pruritus is the most common effect of a positive patch test, and its presence is a normal reaction to a positive test reaction. It technically should not be considered a side effect, but patients should be informed of this common reaction. Pruritus is self-limited and is often easily treated with a topical corticosteroid for a few days.

Postinflammatory hyper- or hypopigmentation. As with any eczematous reaction, post-inflammatory hyper- or hypopigmentation may occur, typically in patients with darker skin. These reactions are typically mild and self-resolve.

Infections. Infections, particularly a mild impetiginization with *Staphylococcus aureus* or another bacterial agent, may cause a superinfection of the patch test site. Viral reaction of herpes simplex virus within the patch testing sites is possible but unlikely. A single case report of a deep fungal infection occurring after patch testing part of a plant has been reported.^{99,100}

Scarring. Any disruption of the dermoepidermal junction may lead to scarring. This is a highly unlikely side effect to patch testing, and is most often seen in patients with severe bullous reactions. Keloids and hypertrophic scarring have both been reported to occur, typically in individuals with an underlying predisposition or a history of previous abnormal scarring.^{99,100} Bullous patch test reactions have led to the development of milia.

Anaphylaxis. Another exceedingly rare potential side effect of patch testing is an immediate reaction leading to anaphylaxis. These reactions, if they occur, typically do so within 30 minutes of application of the patch test agents. The hair bleach ammonium persulfate is the most often reported agent; however, latex, formaldehyde, penicillin, and others have been reported.¹⁰¹⁻¹⁰⁷

Irritant tape reaction. The most common adverse effect of patch testing is irritation from the tape used to occlude the patches to the skin. This reaction is nearly always self-limited and resolves spontaneously. It may cause itching and slight discomfort. On occasion, the reaction may continue to worsen in a crescendo pattern after the adhesive tape has been removed. In these cases, clinicians should be suspicious of an allergy to a component of the adhesive tape product used in the patch testing process.

Koebnerization. In patients who undergo patch testing and who have underlying skin disorders, such as psoriasis, lichen planus, and Jessner lymphocytic infiltrate, koebnerization of their underlying dermatoses may be seen at the site of a positive patch test.^{108,109}

PHOTOALLERGIC CONTACT DERMATITIS

PACD is a rare dermatologic condition that can cause photosensitivity. PACD is a type IV hypersensitivity reaction requiring sensitization and elicitation, and it differs from ACD in that this reaction requires a chemical that is exposed to ultraviolet radiation.^{110,111} Upon exposure, there is a chemical reaction that forms a photoallergen. The active wavelength of light involved in PACD is primarily ultraviolet A. Photopatch testing is recommended as part of the workup for photosensitive patients; however, because of overlapping clinical patterns of other photodermatoses, PACD is found in 10% to 20% of patients who are tested.⁵

PACD was first described after factory workers used tetrachlorosalicylanilide antibacterial agent in soaps in the 1960s in England.¹¹² These products were removed from the market, and tetrachlorosalicylanilide is no longer a significant cause of PACD.

Patients suspected of having PACD and candidates for photopatch testing often present with an eczematous rash in sun-exposed areas with sparing behind the ear, under the chin, and under clothing. These rashes tend to last for weeks. Some individuals complain predominately of photosensitivity. In all cases, a thorough history and physical examination is warranted, focusing on both occupational and recreational photoallergic contact allergens.¹¹³

The incidence of PACD cannot be accurately determined; however, one can deduce that its incidence is low. There are many reasons for the inaccuracy in determining the incidence of PACD. There is a lack of standardized testing, testing is typically only done at highly specialized centers, and some allergens can cause PACD, ACD, and photoirritant contact dermatitis, which can make interpretation difficult, even for the most experienced clinicians.

There is no universally accepted standardized protocol for PACD testing. An international agreement on standardization of PACD would be helpful and allow for better data collection, which could be used to assess patient safety and quality care initiatives. The European Taskforce for Photopatch Testing has advocated for standardization and has done considerable work in this regard.¹¹⁴ Required equipment for PACD testing includes a standard broad-spectrum ultraviolet A light (320-400 nm)

Table III. Photopatch test procedure

Day	Procedure
1	MED testing 2 Sets of identical allergens applied
2	MED determined
3	Reading 1: preirradiation (48 hours postapplication) UVA treated to 1 set of allergens
5	Reading 2: Immediately postirradiation; cover all sites with opaque material Reading 3: 48 hrs after UVA irradiation, 96 hrs reading of nonirradiated side
7/9 (optional)	Reading 4: 96- to 128-hr reading for final UVA-irradiated side

MED, Minimal erythema dose; UVA, ultraviolet A light.

Table IV. Patch test interpretations

Irradiated side	Nonirradiated side	ACD	PACD
—	—	No	No
—	+	Yes	No
+	—	No	Yes
++	+	Yes	Yes*

ACD, Allergic contact dermatitis; PACD, photoallergic contact dermatitis.

*ACD and possibly PACD. This is controversial, and PACD should be interpreted with caution in this setting. Clinical correlation is necessary, and retesting may be required.

source that minimizes ultraviolet B light irradiation and a standalone ultraviolet B light source. Finn chambers and an allergen set (PACD standard tray) are the backbone of the testing. Various centers across the globe test different allergens, which leads to a nonstandard approach.

If the patient is being photopatch tested because of widespread dermatitis involving all photoexposed skin, phototesting is needed before the ultraviolet light exposure is performed as part of photopatch testing.¹¹⁵ This is to ascertain that the tests will be interpretable and not become diffusely red because of a lower than normal minimal erythema dose. However, PACD does not always involve all photoexposed skin. For example, if photoallergy to a sunscreen in a lip balm or hair product is causing the dermatitis, the rash may be limited to the lips or face and neck, respectively. The photopatch test procedure and interpretation is shown in [Tables III and IV](#).

Multiple agents have been reported to cause PACD. The majority of agents fall into a few primary categories, including sunscreens (the most frequent cause of PACD), antimicrobials, fragrances, and other medications.¹¹⁶⁻¹²¹

One side effect unique to PACD is the potential for a ultraviolet light–induced burn at the site of exposure (ie, minimal erythema dose sites and or the test sites on the back). Other sources offer a more complete discussion of PACD and photopatch testing, which is beyond the scope of this review.^{110,111,113,117}

OCCUPATIONAL CONTACT DERMATITIS

Allergic or irritant contact dermatitis resulting from workplace exposures is another interesting and challenging facet of contact dermatitis. It is critical that the physician evaluating these workplace injuries be well-versed in contact dermatitis but also workers' compensation protocols. Effects of personal protective equipment, vacation, and details of the job description and exposures are critical pieces of the history. The steps of the patient's job from start to finish—including all allergen exposures as part of the job function or job site—is essential information that must be obtained and sometimes requires a site visit. Material safety data sheets can be helpful in identifying the ingredients of workplace chemicals and also provide the phone number for companies when additional information is needed. The ingredient listing often omits chemicals that are present in small percentages, such as preservatives that are felt to not be toxic. Contacting the company can help identify full ingredient listings but can also be difficult to obtain because it can be considered proprietary information.

OCD is a significant cause of occupationally related disease second only to musculoskeletal work-related injury.¹²² As in non-OCD, in the occupational setting, irritant contact dermatitis is more common than ACD. Significant cost and lost work days occur because of skin disease in the workplace.¹²² However, many cases are not reported because of a lack of identification of the workplace as the problem, the lack of established reporting, and the fact that many physicians diagnose and treat these patients. OCD costs are estimated to be up to \$1 billion annually in lost wages, lost productivity, medicolegal costs, and disability payments, etc. A significant burden of disease occurs in patients suffering from OCD because of job interruption, job transfers, lost wages, economic disadvantage, and decreased quality of life.¹²²

Some of the more common occupations that have high rates of OCD include hairdressing, health care workers, construction workers, agriculture workers, and the food industry. The most common site for OCD is the hands.¹²²⁻¹²⁴

Patch testing to appropriate allergen series specific to the patient's employment can often identify the

causative allergen. With education of the patient and employer and avoidance of any identified allergens, clearance can occur. However, even with appropriate identification of allergens, many patients with OCD will not clear completely.¹¹³ In addition to understanding the specific allergens associated with particular occupations, the patch test clinician must be well-versed in issues of worker's compensation and disability. Identifying the causative allergen is the first part in the process; helping establish a workplace environment free of identified allergens and successfully processing these claims through the system can be challenging. A thorough and complete discussion of all components of OCD is important and is beyond the scope of this article. The reader is referred to other sources^{5,83,84,122-124} for a more detailed discussion of this important and broad subject.

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