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COMMENTARY

Dermatotoxicologic clinical solutions: textile dye dermatitis patch testing

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Abstract

The authors provide a framework for working up and counseling a patient with suspected textile dermatitis, focusing on identifying which textile materials are most likely to be the cause of the eczematous lesions, the current clinical guidelines, the utility and appropriateness of patch testing, the limitations of these guidelines, and our pro tempore recommendations. While there are many challenges to correctly identify and counsel patients on how to avoid the offending textile products in a patient with suspected textile dye dermatitis, there is value in following the guidelines set forth to help identify the causative textile(s). Although patch tests can be useful, dermatologists should understand the limitations of standardized patch testing for patients with suspected textile dye-induced dermatitis. These guidelines are expected to increase the likelihood of identifying the causative textile(s), so that patch testing can be supplemented with swatch testing and chemical dye extraction to help discover the allergenic dye.

Keywords

Allergic contact dermatitis, disperse dyes, dye fastness, fibers, guidelines, patch test, textiles, textile dye dermatitis

History

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Introduction

The human eye is able to identify 10 million distinct colors, and as a result, color has been interwoven into the history of our civilization. Colored fibers found in caves in the Republic of Georgia date back over 30 000 years¹. History suggests that from early time, humans were interested in clothing's ability to do more than offer protection from the elements and for modesty. Dyes allow clothing to represent social, cultural and religious values.

Dyes used in the coloring of fabrics have evolved from simple vegetable or animal-based ingredients found in nature to increasingly complex chemicals manufactured on a large scale in factories. Today, dyes used in the manufacturing of textiles represent a multi-billion dollar market².

Here, we provide a framework for working up and counseling a patient with suspected textile dermatitis. This overview focuses on identifying which textile materials are most likely to be the cause of the eczematous lesions, the current clinical guidelines, the utility and appropriateness of patch testing, the limitations of these guidelines, and our pro tempore recommendations.

With limitations in current and past publications³, we are uncertain of the magnitude of the clinical problem;

however, to a given textile dye allergic patient, it is of practical importance, both clinically and in lifestyle.

Background

Dermatitis is an umbrella term for several inflammatory skin conditions of varying etiology. Textile contact dermatitis results when a patient develops skin manifestations due to clothing or other fabrics that contact the skin, commonly from the chemical additives used in processing the fabric, such as textile dyes, tanning agents and finishing resins. Predominant clinical manifestations include erythema, vesicles, scaling, itching, and lichenification where there is chronic inflammation⁴. Eruption tends to localize to areas of tight-fitting clothing, such as the axillae, hips, groin area, and buttocks, often clearly delineated with sharp borders.

Disperse dyes (DDs) are a leading cause of textile-related allergic patch test positivity, comprising two-thirds of approximately 50 dyes shown to be contact allergens in an industry with over 800 commercially used dyes today³. They are thought to be more allergenic partially due to their lipophilicity, which allows increased dye migration from the fabric to the epidermal lipids⁵. Due to their higher prevalence, much textile allergy research has been focused on DDs.

Many materials are used in textile production. Fibers are the basic unit of these materials, and determine which dyes can be used for coloring. Two main fiber types have been associated with DDs and textile dye dermatitis: cellulose acetate (CA) and polyester (PES), utilized in materials such as

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PES, nylon, and acetate fibers⁶. Knowing fiber composition gives clues as to which dyes were used and enables one to deduce which textiles are more likely to have caused the dermatitis

Summary of clinical guidelines to identify textile dye dermatitis source:

1. Categorize and list all colored-fabric textile products that contacted the affected skin areas
2. Inspect fiber composition and corresponding colorant class
3. Examine the dye fastness of each item
4. Prioritize fabrics based on color darkness

Patient Instructions:

1. Make an inclusive list of all fabrics that come in contact with the affected skin, from clothing to furniture
2. Prioritize fabrics based on darkness of color
3. Notice if the fabric color bleeds when being washed
4. Does the skin improve with abstinence from suspected fabric after 4–6 weeks?

Other causes of dermatitis must be considered and excluded, such as atopic dermatitis, psoriasis, eczema (not otherwise specified), and fungal infection.

Detailed discussion of chemistry, procedures and shortcomings related to textile allergic contact dermatitis (ACD) is found in “Contact allergy to textile dyes”⁷.

Clinical guidelines

When a patient is suspected of having a textile-related dermatitis, it is important for the dermatologist to have a reliable set of guidelines for clinical direction; the following are adapted from Hatch⁸.

First, assist the patient by listing all categories of textile products that could have come into contact with the skin lesion(s) including: bed linens, household textile products, furniture, transportation, and all garments broken down by affected anatomic location. While these lists should be all-inclusive, clothing is most likely to be clinically relevant.

Next, refine the search by studying the textile fiber composition. As previously stated, fiber composition determines what dyes were most likely used in coloring that fiber. For example, PES fabrics can be colored with dyes from the disperse and pigmented classes but not with dyes from other classes. We focus on DDs and the following fibers capable of containing them: PES fibers, CA fibers, triacetate fiber, nylon fiber or any of these in combination. Textiles from any other materials can be ruled out as the causative textile.

After narrowing the list of possible offenders, next assess the garment's ability to hold onto dye molecules. This is referred to as a garment's color fastness. Generally speaking, products with poor color fastness are more likely associated with textile dermatitis. As more dye is able to escape from the fabric and onto the skin, the likelihood of dermatitis increases. Color fastness diminishes with perspiration and improves with garment age as the washing process removes excess dye. A simple method for patients to measure color fastness is to notice if the laundry water becomes colored or if other clothing is stained after washing, as these indicate poor color fastness⁸. This step can facilitate in the process of ranking possible offending textiles.

Another useful tool is to place a priority on fabrics of darker color. Textile dye allergens are more likely to be darker colors – particularly blue and black⁹. Regardless of the color, darker or more intense colors have a higher concentration of dye, making more dye available for transfer to the skin.

At this point, the list of possible allergens should be more condensed. Current thinking in dermatology is that patch testing is indicated when an allergic component of dermatitis is suspected, such as textile dye-induced dermatitis. While there is merit to this practice, current evidence shows there are limitations to a standardized patch test series in these patients.

Limitations

Patients presenting to the clinician with suspected textile dye-induced dermatitis pose a challenge. It is difficult to identify the offending textile product, and to properly counsel the patient on how to avoid using textile products that will contribute to the recurrence of ACD skin lesions. Here, we review the current limitations to the standard work up that have been uncovered in recent research.

Patch testing is the standard utilized by dermatologists to identify the product(s) responsible for causing the patient's contact dermatitis. In theory, the perfect patch testing series would be a broad, high yield sampling of known allergenic dyes that are heavily used in the current textile industry. These patch tests would have similar concentrations of dyes eluted from clothing, the samples would be pure without any contaminants, would contain the correct dye, and would have low enough concentration to not cause sensitization.

However, recent investigations into textile dye patch testing practices have proven that these conditions infrequently exist. Since there are approximately 50 known textile contact allergens, and the standard patch test series only accounts for 8 allergenic dyes, it is clear that these tests are not comprehensive. So relevant allergies to these dyes can be missed⁵.

Complicating matters further, routine patch test readings at 48 and 72–96 h may miss positive reactions for DDs. Several studies show that positive patch tests may occur after this time, so it is recommended that clinicians perform a late patch test reading⁵ on day 7.

In the event of a positive patch test, the dermatologist must correlate the patch test dye with the fabric in question. The only way to verify this is to send the clothing sample for chemical analysis; however, this is not commonly done. Even if chemical analysis is pursued, it is far from routine that clinical correlations will be identified, as research shows that dyes to which patients are frequently patch positive are infrequently identifiable in their clothes¹⁰. Analysis of 121 consumer textiles from 13 countries demonstrated that only 3 of the 121 garments had known allergenic DDs⁹. Unfortunately, this means that the DDs which we currently test may not be commonly used in today's textiles.

When performing a patch test it is impossible to get accurate data if the dye is not correctly labeled, the appropriate concentration, or free of impurities. Ryberg et al. demonstrated that Direct Orange #3 (DO3) could not be found in 4 of 15 preparations labeled DO3. Additionally,

the DD patch test preparations examined contained only 20–50% of the labeled concentration. Although 7/8 of the investigated DDs were chemically defined, impurities were demonstrated in all preparations¹¹. Furthermore, thin layer chromatography (TLC) and high performance liquid chromatography analysis of test preparations labeled DO3 actually contained DO31 instead¹². Due to the inconsistencies observed with patch test preparations, researchers have drawn into question the accuracy of commercial patch test samples.

Outdated dye allergens offer another methodological limitation. Hopefully, suppliers will verify defects of stability, at room temperature and refrigeration.

Another challenge facing dermatologists who patch test is to avoid exposing patients to sufficient concentrations of an allergen that has the potential to induce sensitization or elicit allergies in recurrent patients¹³. This is further complicated by the fact that concentrations of these dyes in patch tests are highly variable from their labeled concentration and usually contain impurities. One study showed that 25% of patients were non-reactive to the main DD, but did react to impurities therein⁹.

Care must also be taken when advising the patient on how to avoid coming into contact with textiles containing dyes of concern. Since most of the offending dyes are blues and blacks, advising patients to avoid dark colors is encouraged. This is not straightforward, however, as many garments have a combination of colors making it difficult to predict which dyes have been used in a textile based on color⁹. Many patients and physicians have relied on governmental agencies. The United States abides by the Global Organic Textile Standard (GOTS), which prohibits the use of DDs classified as allergenic and azo dyes that can be metabolized into carcinogenic amines. Similarly, the European Union (EU) and Japan abide by the Oeko-Tex Association which has a list of allergenic dyes forbidden in clothes certified with the Oeko-Tex label. The EU also mandates that all garments produced in or imported to EU countries come with a statement indicating non-use of certain DDs and a proven report of color fastness¹⁴. Despite these attempts to closely regulate the textile industry, a high percentage of clothing is manufactured outside the aforementioned countries, allowing for travelers to be exposed to garments dyed with allergenic DDs. Additionally, all of the potential allergens have yet to be identified. For this reason, the prevalence of DD contact allergy varies within populations and dyes that are tested⁵.

Conclusion

There are many challenges to correctly identify the offending textile products in a patient with suspected textile dye dermatitis. This is further complicated when counseling the patient on how to avoid the textile products most likely to cause a recurrence of ACD skin lesions. Nevertheless, there is value in following the guidelines set forth here to help identify the causative textile(s).

Clinical guidelines to identify the textile dermatitis source:

- (1) Categorize and list all colored-fabric textile products that contacted the affected skin areas

- (2) Inspect fiber composition and corresponding colorant class
- (3) Examine the dye fastness of each item
- (4) Prioritize fabrics based on color darkness

While patch tests can be useful, dermatologists should understand the limitations of standardized patch testing for patients with suspected textile dye-induced dermatitis. These guidelines are expected to increase the likelihood of identifying the causative textile(s), so that patch testing can be supplemented with swatch testing and chemical dye extraction to help discover the allergenic dye.

Advising patients to look for the OEKO-TEX label and generally avoid synthetic fabrics close to the skin are suggested precautionary measures for patients with possible textile dye contact dermatitis.

Further research into which dyes are actually being used in present day textiles is necessary so that these potentially allergenic dyes can be included in patch test preparations. Forming a more standardized procedure for swatch testing and chemical dye extraction would also be helpful in identifying allergenic dyes.

Patch testing with fabric itself may produce positive results – strong *prima facie* evidence of causation. Unfortunately, this is often negative. Literature documentation of frequency of positive and negative patch test results remains incomplete.

Several laboratories document feasibility of extraction and patch testing with TLC samples^{11,15}. When positive, this too is strong evidence of causation.

Should a clinician seek clinical identification of leechable dye in suspected allergic contact dermatitis, ETAD (The Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers) has kindly provided such assistance¹⁰.

Declaration of interest

The authors declare no conflicts of interests. The authors alone are responsible for the content and writing of this article.

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