

Dermatitis of the Foot: Epidemiologic and Clinical Features in 389 Children

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Abstract

Background/Objectives: Footwear dermatitis is a form of contact dermatitis resulting from exposure to shoes. There have been only small studies regarding foot contact dermatitis in children. The present study was undertaken to define the prevalence and epidemiologic and clinical features of shoe dermatitis in children.

Methods: A retrospective study was undertaken of all children referred for patch testing between 1996 and 2015. Children with dermatitis limited to the feet were selected.

Results: We collected data from 389 children younger than 16 years, 52 of whom (13.4%) were referred with dermatitis exclusively on the feet. Diagnosis after patch testing was allergic contact dermatitis in 23 children (44.2%), atopic eczema in 12 (23.1%), juvenile plantar dermatosis in 8 (15.4%), dyshidrotic eczema in 6 (11.5%), irritant contact dermatitis in 2 (3.8%), and tinea pedis in 1 (1.9%). The most frequent allergens were potassium dichromate, thimerosal, cobalt chloride, mercapto mix, colophonium, mercury, and nickel(II) sulfate.

Conclusion: Allergic contact dermatitis caused by footwear is a common cause of foot dermatitis in children. Children with foot dermatitis should be referred for patch testing when an allergic origin is suspected.

Footwear dermatitis is a form of contact dermatitis resulting from exposure to shoes. Multiple chemicals in footwear and a hot and humid environment within the shoe predispose the foot to develop allergic or irritant contact dermatitis (1). Not all cases of foot dermatitis are of allergic origin or related to foot wear. Other diseases causing dermatitis of the

foot are psoriasis, atopic dermatitis (AD), and juvenile plantar dermatitis (2). Diagnosis and treatment of footwear dermatitis can be challenging because of the large number of potential allergens in shoes (1).

Shoe dermatitis can affect any age group and both sexes. It accounts generally for 10% of cases referred for patch testing (3). Allergic contact dermatitis

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(ACD) in children was considered to occur infrequently, but over the past 30 years there appears to have been an increase in the frequency of contact allergies in children (4,5). Diagnosing ACD in children is more difficult than in adults because patch testing is technically more difficult and related allergens may not be the same as in adults (6). Studies of footwear dermatitis have been focused on adults, with only small series of children with foot dermatitis studied (2,7,8).

Rubber, leather, and adhesives in shoes commonly cause allergic shoe dermatitis (3,9,10). Linings and dyes cause it less frequently (11). Not only shoes but also socks can cause footwear dermatitis, as well as preservatives, fungicides, nail polish, and cosmetics. Footwear differs in various regions of the world, so different allergens are involved in shoe dermatitis in different countries.

The present study was undertaken to further define the prevalence, epidemiology, and clinical features of foot dermatitis in children.

MATERIALS AND METHODS

A retrospective study was conducted of all children referred for patch testing at University General Hospital of Valencia between 1996 and 2015. Children with dermatitis limited to the feet were selected, with patients with dermatitis on the feet plus other locations excluded.

Children (<16 yrs of age) were patch tested with the standard and shoe series proposed by the Spanish Group for the Study of Contact Dermatitis and Cutaneous Allergy, with additional series and the child's daily footwear being added where indicated.

Allergens were applied over healthy skin in Finn chambers on the patient's back. Readings were performed at 2 and 4 days and reactions were scored according to International Contact Dermatitis Research Group criteria. All patient information and patch test results were prospectively recorded on a departmental database.

Positive skin reactions were categorized as present, past, or unknown according to the presence of the allergen in the patients' daily footwear, determined according to the manufacturer's ingredient list and, when this was not available, response to withdrawal of the footwear.

Analyses were conducted using SPSS version 22.0 for MAC-OS (IBM, Armonk, NY). The chi-square test was used to compare categorical variables (sex, atopic background, odds of a positive patch test). The

Mann–Whitney *U* test was used to compare children with and without foot dermatitis.

RESULTS

A total of 389 children ages 0 to 16 years were referred to our center for patch testing between 1995 and 2015; 52 who had foot dermatitis exclusively were selected and compared with all other children who were patch tested (excluding the feet) ($n = 337$).

Twenty-eight patients (53.8%) were tested with specific shoe series and seven (13.5%) were tested with customized allergens from their own shoes; 29 (55.8%) had one or more positive patch test reactions (57 positive reactions total). Current definite relevance was considered to be present in 31 reactions (54%).

Of the 52 children with foot dermatitis, 30 (57.7%) were male and 22 (42.3%) were female. The mean age of children referred with foot dermatitis was 10.6 ± 3.5 years. Patients with foot dermatitis were more likely to be male than the other 337 children referred for patch testing (57.7% vs 40.1%; $p = 0.02$) (Table 1). They were of the same age (mean age 10.6 years; $p = 0.91$) and similar atopic background (1.9% vs 4.5%; $p = 0.39$). The odds of finding a positive patch test in children with foot dermatitis were similar to those in the general population (55.7% vs 49.3%; $p = 0.38$).

Final diagnosis after patch testing was ACD in 23 children (44.2%), atopic eczema in 12 (23.1%), juvenile plantar dermatosis in 8 (15.4%), dyshidrotic eczema in 6 (11.5%), irritant contact dermatitis in 2 (3.8%), and tinea pedis in 1 (1.9%).

The most frequent allergens were potassium dichromate (13 patients), thimerosal (11 patients), cobalt(II) chloride (8 patients), mercapto mix (7 patients), colophonium (5 patients), mercury (4 patients), and nickel(II) sulfate (3 patients). A full list of allergens is shown in Table 2.

TABLE 1. *Epidemiologic Data of Patients with and without Foot Dermatoses*

Characteristic	Children with only foot dermatosis ($n = 52$)	Children with no foot-limited dermatosis, ($n = 337$)
Age, mean $\pm$ standard deviation	10.6 ± 3.5	10.6 ± 4
Male, n (%)	30 (57.7)	133 (49.3)
Atopic dermatitis, n (%)	1 (1.9)	15 (4.5)
Positive patch test, n (%)	23 (44.2)	166 (49.3)

TABLE 2. Location of Lesions in Children with and without Atopic Contact Dermatitis (ACD) Diagnosis After Patch Testing

Location	ACD (n = 23)	Non-ACD diagnosis (n = 29)
Dorsum of feet	13 (56.5)	14 (48.3)
Dorsum of toes	2 (8.7)	4 (13.8)
Interdigital	3 (13)	2 (6.9)
Base of toes	1 (4.3)	5 (17.2)
Soles	6 (26)	14 (48.3)
Lateral aspect of feet	0 (0)	3 (10.3)

All data given as n (%).

Allergen origin was footwear in 16 patients (with the shoe being responsible in all cases) and iatrogenic in 7. Iatrogenic allergens were adhesives in wound dressings in six patients and merbromin, a mercurial topical antiseptic, in one patient.

The most frequently affected location (Table 3) was the dorsum (13 patients [56.5%]). In children without ACD, the most frequently affected locations were the dorsum and the soles (14 patients [48.3%] each). Five of six patients (83.3%) with involvement of the plantar toes were finally diagnosed as juvenile plantar dermatosis. Multiple affected locations were a frequent finding, with in six patients with ACD (26.1%) and 12 without ACD (41.4%) having two or more locations involved. One patient with ACD (4.3%) and two without (6.7%) had three affected locations.

DISCUSSION

Of all children patch tested, 3.4% were referred with suspected foot dermatitis. This prevalence is in agreement with the prevalence of foot dermatitis in adults, which has been reported to be between 1.5% and 24% of referred populations (3,9,10). Different inclusion approaches may explain this variability.

A higher prevalence of boys with dermatitis of the foot was found than in children with dermatitis of other sites. This can be attributed to the more occlusive nature of boys footwear compared with that of girls (sneakers versus sandals) (11). Other studies in adults have found a higher prevalence in women, possibly because women wear shoes without socks, which results in closer contact with potential allergens (3). The use of shoes without socks is probably more frequent in adult woman than in girls (9).

Despite some studies showing an association between foot dermatitis and AD (10,12), our study found a low prevalence of AD in patients with dermatitis of the foot. Our findings confirm additional

TABLE 3. Allergens Found in Our Series and Their Relevance

Allergen	Total, n	Relevant, n (%)	Source (if relevant)
Potassium dichromate 0.5%	12	12 (100)	Shoes, leather
Thimerosal 0.1%	11	1 (9.1)	Mercurial antiseptic
Cobalt chloride 1%	8	6 (75)	Shoes, leather
Mercapto mix (N-cyclohexyl-2-benzothiazylsulfenamide, dibenzothiazyl disulfide, 2-(4-morpholinylmercapto)-benzothiazol) 1%	3	3 (100)	Shoes, rubber sole
Colophonium 20%	5	5 (100)	Wound dressing
Mercury 1%	4	1 (25)	Mercurial antiseptic
Nickel(II) sulfate 5%	2	0 (0)	Unknown (not relevant)
Lanolin (wool alcohols) 30%	1	1 (100)	Topical medication
P-tert-butylphenol-formaldehyde resin 1%	1	1 (100)	Shoes, adhesive
Fragrance mix I 8%	1	1 (100)	Wound dressing
N-diphenylguanidine 3%	1	0 (0)	Unknown (not relevant)
Abietic acid 10%	1	1 (100)	Wound dressing
Disperse red 1 1%	1	1 (100)	Shoes, dye
P-phenylenediamine 1%	1	0 (0)	Unknown (not relevant)
Disperse red 17 1%	1	1 (100)	Shoes, dye
Gold sodium thiosulphate 0.25%	1	0 (0)	Unknown (not relevant)
P-tert-butylcatechol 1%	1	1 (100)	Wound dressing

studies that did not find a significant risk of foot dermatitis in individuals with AD (11). This is in contrast to hand dermatitis, a common manifestation of AD.

Metals, as a group, were the most common allergen involved in foot dermatitis, with potassium dichromate leading the list. This is in agreement with other European series, where chromium is the most common allergen in foot dermatitis (3,8,11,12). Chromium salts are used in tanning leather to provide flexibility, durability, and softness to the product (13). It has been estimated that more than half of leather products release dangerous amounts of free chromium (14). Since May 2015, the European Union has strictly limited the amount of chromium allowed in leather to less than 3 mg/kg of product (13). Therefore, ACD due to chromium should drastically decrease over the coming years. Cobalt sensitization is usually found in patients who are also allergic to chromium (13). This has been attributed to the

presence of cobalt in leather products (15–17). Cobalt can also be present in shoe eyelets and buckles and in some dyes used in footwear (3,18).

In our series, only 1 of 11 cases of sensitization to thimerosal was relevant due to the use of an antiseptic containing this allergen. Thimerosal is a combination of thiosalicylic acid and ethylmercuric chloride and is used as a preservative in a few products, mostly vaccines. Despite being one of the most common allergens found globally, positive reactions are usually deemed not relevant (11), because of the low frequency of relevant positive reactions to thimerosal. Thus it has been proposed that it be withdrawn from standard patch series.

Nickel is one of the most common allergens found globally in patch tested children (19,20). Therefore, relevance of a positive nickel patch test in a patient with footwear dermatitis is often doubtful (21). Nevertheless, nickel can be present in metal components of footwear (11). In cases in which there is a positive nickel test in the absence of obvious metal in the shoe, the presence of dyes with nickel salts has been suggested (18), but this remains speculative.

Colophonium, abietic acid, para-tertiary butylphenol formaldehyde resin, and 4-tert butylcatechol are used as adhesives in many products (12). Colophonium is also a marker of fragrance allergy (22). Adhesives as a group were the second most common cause of ACD in our series; six of seven cases of allergy to adhesives were due to medical wound dressings and only one to footwear adhesives.

Merapto mix is a mixture of rubber accelerators used during the manufacture of shoe soles. They were the most common allergens causing shoe dermatitis in North American and South American series (10,23) but merapto mix is a less frequent cause of ACD in Europe and other Eastern countries (8–12). In our series, rubbers were a relatively infrequent cause of ACD, after metals and adhesives. All cases of rubber allergy were found in the soles, thus the differential diagnosis should include other non-ACD causes of foot dermatitis.

A thorough clinical history is crucial to determine the causative allergen (11). All of the cases of ACD found in our series could have been detected using a standard battery of allergens. Nevertheless, there are multiple potential allergens in shoes and there have been many reports of allergens causing footwear ACD that are absent even in specific shoe series. This highlights the importance of performing customized patch testing with the patients' daily footwear. When all the patch tested series are negative, advanced techniques such as ultrasound bath allergen

extraction, liquid chromatography, and mass spectrometry can help in the diagnosis of ACD due to less-frequently found allergens (24).

Although the involvement of the dorsum of the foot has been classically attributed to ACD, this association is not completely reliable (3,25). In our study, 43.5% of children with ACD had no involvement of the dorsum, and 51.9% with involvement of the dorsum had a non-ACD diagnosis. Therefore eczema on the dorsum of the feet is neither sensitive nor specific for ACD. On the other hand, almost all cases with involvement of the plantar toes were diagnosed as juvenile plantar dermatosis. Therefore involvement of the toe footpads is highly suggestive of this disease (25).

The majority of our patients with foot dermatitis were diagnosed with ACD, highlighting the importance of patch testing any child with foot dermatitis when an allergic cause is suspected (4). Signs suggestive of ACD include but are not limited to symmetric involvement of both feet, involvement of maximum footwear contact locations, and chronic dermatitis with acute flares of vesiculation (1). Signs suggestive of a non-ACD cause are involvement of the plantar flexure creases and the lateral aspect of the feet. Involvement of the footpads is highly suggestive of a non-ACD cause of foot dermatitis.

ACD caused by footwear is a common cause of foot dermatitis in children. Pediatricians and pediatric dermatologists should refer children for patch testing when an allergic origin is suspected.

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