

Sole Dermatitis in Children: Patch Testing Revisited

Mark I. Darling, M.B.Ch.B, M.R.C.P., Helen M. Horn, M.D., F.R.C.P., Sally K.A. McCormack, M.B.Ch.B, M.R.C.P., and Olivia M.V. Schofield, M.B.B.S., F.R.C.P.

Department of Dermatology, Royal Infirmary of Edinburgh, Edinburgh, UK

Abstract: Although dermatoses affecting the soles of the feet in children are regularly encountered in dermatology clinics, the relationship with allergic contact dermatitis affecting this part of the foot is not well established. The aim of this study was to evaluate the relevance of patch testing children with sole dermatoses. We reviewed the results of all patch tests performed in children (<18 years) presenting with dermatoses involving the soles between 1997 and 2009 from our departmental patch test database. Forty-one children were identified: 27 children with an inflammatory dermatitis affecting the sole and 14 children with juvenile plantar dermatosis (JPD). Seventeen (41%) children had at least one clinically relevant positive patch test reaction. Rubber additives and potassium dichromate were the most frequent allergens identified. Forty-eight percent of children with inflammatory dermatitis affecting the sole and 29% of children with JPD had at least one relevant reaction. Of the children with relevant reactions, 76% had a personal or family history of atopy. Our results demonstrate the importance of patch testing children with dermatoses affecting the soles and indicate that a history of atopy or a diagnosis of JPD should not deter investigation.

Dermatoses affecting the soles of the feet in children are regularly encountered in pediatric dermatology clinics. They are most commonly attributed to atopic eczema, juvenile plantar dermatoses (JPD), and rarely to allergic contact dermatitis (ACD). Identification of an underlying cause can be challenging, and symptoms, often chronic in nature, have a variable response to intervention.

Allergic contact dermatitis of the soles of the feet is often attributed to allergy to components of footwear or to hosiery. The hot and humid environment within shoes,

in addition to the numerous constituents used in their manufacture, makes the feet at particular risk of developing dermatitis. Allergy to rubber, adhesives, or leather components of insoles, in addition to dyes and textile finishing agents in shoes and hosiery, may cause sole ACD (1). The differential diagnosis of ACD of the soles includes atopic dermatitis, irritant dermatitis, JPD, psoriasis, and tinea pedis.

The role of patch testing in children with all types of dermatitis suspected of being ACD has been reported (2). An apparent increase in the prevalence of ACD in

Address correspondence to Mark I. Darling, M.B.Ch.B, M.R.C.P., Department of Dermatology, Royal Infirmary of Edinburgh, Lauriston Building, Lauriston Place, Edinburgh EH3 9HA, UK, or e-mail: Mark.darling@nhs.net.

children has been attributed to increased exposure to environmental allergens influenced by social and regional demographics and to increases in the numbers of children undergoing patch testing (3,4).

After an observation in our department that at least two children with JPD had positive patch tests to potentially relevant allergens, we retrospectively reviewed all patch test results of children with sole dermatoses who had been investigated for ACD.

MATERIALS AND METHODS

All children younger than 18 at the time of patch testing were identified from our departmental patch test database, which includes details of adults and children patch tested between 1997 and 2009. A dermatologist reviewed all children referred for patch testing. Results relating to children with dermatoses affecting the soles were subject to analysis.

Children were patch tested using Finn chambers (Smartpractice, Phoenix, AZ) on Scanpor tape (Actavis, Vennessla, Norway) or IQ chambers™ (Chemotechnique Diagnostics, Vellinge, Sweden). Chemotechnique Diagnostics and TROLAB (Reinbek, Germany) supplied allergens. Patch tests were removed on day 2, and readings were undertaken on days 2 and 4. All 41 children with sole dermatoses were tested to the British Society for Contact Allergy (BSCA) standard series, modified if a child's small size constrained available space. Thirty-nine were additionally tested to a shoe series; 19 to textiles, colors and finishes; seven to a corticosteroid series, six to a cosmetics series, six to glues and plastics, three to rubber additives, and 15 to other miscellaneous allergens, including pieces of the patient's own hosiery or footwear. The concentrations of allergens were not modified for age.

Results were compared for primary diagnosis, frequency of contact sensitivity, and relevance of reactions. Diagnoses were classified into inflammatory dermatitis affecting the soles (pompholyx, forefoot eczema, and hyperkeratotic eczema) and JPD.

The Pearson chi-square test was performed to test for differences in sex ratio between all children patch tested and children patch tested with sole involvement.

RESULTS

Of 483 children younger than 18 patch tested in our department between 1997 and 2009, 41 had documented skin problems involving the soles of the feet (Table 1). In addition to the soles of the feet in those 41 children, other areas of involvement on the feet were recorded. Fifteen (37%) had involvement of the

TABLE 1. Results of Retrospective Review of Total Cohort of Children Younger than 18 Patch Tested: 1997–2009

	n (%)	Male: Female	Age mean (range)	Personal or family history of atopy, %
Total	483	2:3	13 (2–18)	68
With history of involvement of the soles	41 (8%)	3:1	10 (5–16)	78

TABLE 2. Results of Retrospective Review of Patch Testing in Children Younger than 18 with Involvement of the Soles of the Feet: 1997–2009

Clinical diagnosis	Total, n (%)	Personal or family history of atopy, n (%)	≥1 relevant patch test reaction, n (%)	Personal or family history of atopy in those with a relevant patch test reaction, n (%)
Inflammatory dermatitis	27 (66)	21 (78)	13 (48)	9 (69)
Juvenile plantar dermatosis	14 (34)	11 (78)	4 (29)	4 (100)
Total children with sole involvement	41 (100)	32 (78)	17 (41)	13 (76)

toes, 11 (27%) the dorsal feet, five (12%) the instep, and five (12%) the heel. A statistically significant difference in sex ratio was observed between all children patch tested (male:female ratio 2:3) and those patch tested with sole involvement (male:female ratio 3:1) ($p < 0.001$).

The children with sole involvement were clinically divided into two groups (Table 2): those with inflammatory dermatitis, including 10 (24%) with eczema affecting the feet alone, 13 (32%) with eczema of the hands and feet, and four (10%) with generalized eczema including the feet. The remainder had a clinical diagnosis of JPD.

A total of 66 positive patch test reactions were recorded in 29 (71%) children. In 17 (41%), at least one reaction was interpreted as relevant to the sole dermatosis. Relevant positive reactions are listed in Table 3. Positive reactions to mercaptobenzothiazole (MBT), mercapto mix, and potassium dichromate were observed most frequently. One child with suspected JPD had seven relevant positive reactions to textile dyes. The most common nonrelevant positive reaction was to nickel (six male and three female). Two reactions to cobalt were observed, both of uncertain relevance.

TABLE 3. *Allergens Identified as Relevant to Sole Dermatitis and Number of Positive Reactions in Children Younger than 18 Years, 1997–2009*

Allergen	Positive reactions, n
Mercaptobenzothiazole 2%	5
Mercapto mix	4
Potassium dichromate 0.5%	4
Disperse blue106	2
Ethylene urea, melamineformaldehyde (Fixapret Ac) 5%	2
Formaldehyde 1%	2
Glutaraldehyde	2
Fragrance mix 8%	2
2-bromo-2-nitropropane-1-3-diol	1
Acid red 118 5%	1
Balsam of Peru 25%	1
Cocamidopropyl betaine 1%	1
Colophony 20%	1
Diphenylguanidine	1
Reactive blue 238 1%	1
Reactive black 5 1%	1
Reactive red 123 1%	1
Reactive red 228 1%	1
Reactive red 238 1%	1
Reactive violet 5 1%	1
Tixocortol pivalate	1

DISCUSSION

This study shows a high prevalence of contact allergy in children with sole dermatoses in our pediatric patch test population. Compared with all children undergoing patch tests in our department, those with sole dermatoses were significantly more likely to be boys, and the average age was younger (10 vs 13). Seventeen (41%) of 41 patch-tested children with sole involvement had at least one relevant patch test reaction. An increasing incidence of ACD in children has been reported (2,3), and high rates (up to 53%) of positive patch tests have been observed in children with dermatitis affecting the feet (3,5). Our study, examining specifically children with involvement of the sole, appears in keeping with this high prevalence of contact sensitivity. We also demonstrate a greater prevalence of contact sensitivity than one other similar study that specifically identified children with sole involvement (29%) (6). The small numbers in our cohort and referral bias may partially explain this, but this strikingly high proportion of positive results adds further support to the use of patch tests as an appropriate investigation in this group of children.

Our results also revealed that the majority of children with relevant positive patch test reactions had a personal or family history of atopy. Small numbers and selection bias may again be a factor, but this observation is consistent with a number of other studies that have identified a similar relationship (2,4,7,8). Although

atopic individuals may be more likely to develop irritant contact dermatitis, the disrupted epidermal barrier and increased penetration of allergens that may be encountered in these individuals is a plausible concept that may account for the higher incidence of ACD in this group. The relationship between contact allergy and atopy is clearly complex, and many other studies support the more traditional view that atopic individuals have less capacity to develop contact sensitivity because of altered cell-mediated immunity (9,10).

The largest studies to review the association between JPD and ACD were conducted more than 25 years ago and did not identify any significant correlation between contact sensitivity and JPD (11,12). Fewer than 10% of children were found to have relevant positive patch test results. In our comparatively smaller study, we have identified relevant positive patch test reactions in 29% of children with JPD. These children may represent cases of ACD that are clinically indistinguishable from JPD or a subgroup with greater contact allergy secondary to an impaired epidermal barrier from JPD. It is interesting to speculate that changing footwear fashions seen over the past 30 years might alter the relationship between JPD and ACD.

The most common relevant allergen in our series was the rubber accelerator MBT, (five potentially relevant reactions). MBT is the most common allergen found in rubber and the most frequent shoe allergen found in a number of other studies (1,2,13). A strong positive correlation between sensitization to mercapto-rubber chemicals and plantar dermatitis has been demonstrated in children, with improvement in symptoms after avoidance (6). Although our data were retrospective, and the relevance of patch testing was based on clinical assessment, our findings would be consistent with these allergens being causes of ACD of the soles. Rubber can be found in almost all parts of shoes, including insoles, midsoles, tongues, and uppers. There is potential for any of the chemicals within the shoe to migrate to distant parts of the shoe when damp during wear, which can account for the variability in clinical presentation and poor correlation between the anatomy of the shoe and the site of symptoms (1,5). Potassium dichromate and glutaraldehyde are often used during the tanning process of leather. In keeping with many studies of foot dermatitis, our patch test results confirm that allergy to potassium dichromate is an important cause of footwear-related eczema (5,6,8). Although testing to the BSCA standard series revealed the majority of allergies, extended testing to the shoe and textile series revealed additional allergies (glutaraldehyde and textile dyes, respectively). The small size of young children may dictate modification of patch test series and omission of

some allergens, with a risk that less-common allergies will be missed.

Identifying the presence of allergens in footwear remains challenging. There are no legislative measures to force manufacturers to disclose constituents of footwear, and the final assembler of the footwear may not have information regarding specific ingredients. A significant proportion of footwear is manufactured internationally, and constituents often come from numerous suppliers, making attempts to establish the presence of allergens difficult. There are a small number of specialist retailers who can supply shoes free of rubber and leather. Before assembly of hand-made shoes, there is the option of patch testing to individual materials.

If the reported increase of ACD in children continues, investigation with patch testing in this population should become more common and accessible. This study demonstrates the importance of patch testing children with dermatoses affecting the soles and highlights that a history of atopy or a diagnosis of JPD should not be a deterrent to investigation.

REFERENCES

1. Rietschel RL, Fowler JF. Textiles and shoes. In: Rietschel RL, Fowler JF, eds. *Fisher's Contact Dermatitis*, 6th edn. Hamilton, Ontario: BC Decker Inc, 2008:339–369.
2. Shah M, Lewis FM, Gawkrödger DJ. Patch testing in children and adolescents: 5 years experience and follow up. *J Am Acad Dermatol* 1997;37:964–968.
3. Beattie PE, Green C, Lowe G et al. Which children should we patch test? *Clin Exp Dermatol* 2006;32:6–11.
4. Milingou M, Tagka A, Armenaka M et al. Patch tests in children: a review of 13 years of experience in comparison with previous data. *Pediatr Dermatol* 2010;27:255–259.
5. Cockayne SE, Shah M, Messenger AG et al. Foot dermatitis in children: causative allergens and follow up. *Contact Dermatitis* 1998;38:203–206.
6. Clayton TH, Wilkinson SM, Rawcliffe C et al. Allergic contact dermatitis in children: should pattern of dermatitis determine referral? A retrospective study of 500 children tested between 1995 and 2004 in one U.K. centre. *Br J Dermatol* 2006;154:114–117.
7. Seidenari S, Giusti F, Pepe P et al. Contact sensitization in 1094 children undergoing patch testing over a 7-year period. *Pediatr Dermatol* 2005;1:1–5.
8. de Waard-van der Spek FB, Oranje A. Patch tests in children with suspected allergic contact dermatitis: a prospective study and review of the literature. *Dermatology* 2009;218:119–125.
9. Jones HE, Lewis CW, McMarlin SL. Allergic contact sensitivity in atopic dermatitis. *Arch Dermatol* 1973;107:217–222.
10. Lammintausta K, Kalimo K, Fagerlund V-L. Patch test reactions in atopic patients. *Contact Dermatitis* 1992;26:234–240.
11. Mackie RM, Husain SL. Juvenile plantar dermatosis: a new entity? *Clin Exp Dermatol* 1976;1:253–260.
12. Ashton RE, Griffiths WAD. Juvenile plantar dermatosis – atopy or footwear? *Clin Exp Dermatol* 1986;11:529–534.
13. Roul S, Ducombs G, Leaute-Labreze C et al. Footwear contact dermatitis in children. *Contact Dermatitis* 1996;35:334–336.