

Safety and Efficacy Evaluation of TRUE TEST Panels 1.1, 2.1, and 3.1 in Children and Adolescents

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Background: The Thin-layer Rapid Use Epicutaneous (TRUE) Test has approval for adults.

Objective: To evaluate the efficacy and safety of TRUE Test panels 1.1, 2.1, and 3.1 in children and adolescents suspected of having allergic contact dermatitis (ACD).

Methods: An open-label prospective study was performed, analyzing 102 consecutive patients aged 6 to 18 years referred for suspected ACD, between December 2008 and October 2009. Patch tests were applied for 48 hours, and evaluations of skin reactions were conducted at days 3 and 7, with a follow-up visit 3 weeks after the initial applications.

Results: The mean age of all enrolled subjects was 11.6 years, and subjects included 52% females and 48% males. Positive reactions noted in more than 10% of the children were to nickel sulfate (29.7%), p-tert-butylphenol formaldehyde resin (16.8%), wool alcohols (15.8%), fragrance mix (12.9%), and cobalt dichloride (12.9%). Of the 101 subjects, 77 (76.2%) tested positive to one or more of the 28 allergens. No meaningful differences were observed in the frequency or severity of adverse events; reports of burning and stinging following patch removal; or the frequency, intensity, or symptoms of persistent reactions when evaluated by age, sex, or race.

Conclusion: Patch testing is efficacious and safe in the pediatric population.

PATCH TESTING is considered the “gold standard” for diagnosis of allergic contact dermatitis (ACD).^{1–3} The Thin-layer Rapid Use Epicutaneous (TRUE) Test (Mekos Laboratories A/S, Hillerød, Denmark) is a commercially available patch test kit that received its initial biologics license from the Food and Drug Administration (FDA) in 1994. The TRUE Test product consists of three panels (1.1, 2.1, and 3.1) containing 28 allergens and allergen mixes and one negative control as uniform dried gel coatings on polyester sheeting. Hypoallergenic adhesive surgical tape secures the patches to the skin.

The frequency of ACD reactions in children referred to tertiary care centers for patch testing has been reported to be 25 to 60%, depending on the study.⁴ As early as 1984, Weston and colleagues reported that 20% of all pediatric dermatitis was due to ACD⁵; in a follow-up study, they determined that aluminum-chamber patch testing was safe in pediatrics as a diagnostic tool.⁶ In 2000, Bruckner and colleagues published the results of the first US-based

pediatric study using the TRUE Test. These authors tested 85 asymptomatic children, aged 6 months to 5.5 years, and found that 24.5% had at least one positive patch-test (PPT) reaction.⁷ Given that these were asymptomatic patients, clinical relevance (and therefore the utility of the TRUE Test) could not be adequately determined.

The first US-based pediatric studies testing affected patients were reported in 2008. These retrospective studies confirmed that comprehensive patch testing was safe and efficacious in pediatric patients referred to tertiary care centers for patch testing and that ACD was equally prevalent in pediatric and adult populations.^{8,9} In response to the FDA's requirements of compliance with the Pediatric Research Equity Act (PREA), a safety and efficacy study of the TRUE Test in children aged 6 to 18 years was performed.

Objective

The objective (in compliance with the FDA PREA requirement) was to evaluate the diagnostic performance and safety of TRUE Test Panels 1.1, 2.1, and 3.1 in children and adolescent subjects (6–18 years of age) with suspected ACD based on symptoms and clinical history.

Design and Methodology

This was an open-label prospective single-center study approved by the institutional review board (University of

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California, San Diego, IRB No. CHHC#12087) and was designed to evaluate the diagnostic performance and safety of the 28 allergens and negative control on TRUE Test Panels 1.1, 2.1, and 3.1 in 100 pediatric subjects (6–18 years of age, inclusively) with suspected ACD and referred to Rady Children's Hospital between December 2008 and October 2009.

The goal was to enroll approximately 25 subjects aged 6 to 8 years, 25 subjects aged 9 to 12 years, and 50 subjects aged 13 to 18 years, with females constituting at least 50 to 65% of enrollees. Approximately 6 to 12% of study participants were to be Hispanic, 5 to 10% African American, and 2 to 4% Asian. Inclusion criteria specified that adolescent females 15 years of age or older (or with menarche) had to consent to a urine pregnancy test and that urine test results had to be negative.

Subjects were excluded from the study if they reported a history of topical corticosteroid treatment on or near the test area during the 7 days prior to the first visit. Systemic treatment with corticosteroids or other immunosuppressant medication during the 7 days prior to the first visit was also not permitted. In addition, subjects who were receiving or had received other investigational drugs, treatments (including ultraviolet light or tanning), or devices in the 21 days prior to the first visit were excluded, along with subjects who were participating in other clinical studies.

Moreover, subjects were excluded if they had had an acute dermatitis outbreak or dermatitis on or near the test area on the back or were unable to comply with activity restrictions (eg, protecting test panels from excess moisture due to showering or vigorous activity). Subjects who were unable or unwilling to comply with multiple return visits were excluded as well.

Prior to the first study visit, written informed consent or assent was obtained. The presence and location of any dermatitis sites were recorded on day 0 (visit 1). TRUE Test panels 1.1, 2.1, and 3.1 were applied to each subject's back. The TRUE Test patches were removed 2 days later (at the second visit), and an assessment of the integrity of the test panels as well as potential reactions was performed. Photographs of all patch-test reactions were taken with each subject's individual disposable camera at each visit, and the removed panels were disposed of in accordance with the protocol. Subjects' reports of itching and/or burning at the test-site locations were also recorded during the visit.

Evaluations of test-site skin reactions were conducted at 3 days (visit 3) and 7 days (visit 4); a follow-up visit (visit 5) took place at 3 weeks after the initial patch

applications. All skin reactions were evaluated according to standard patch testing guidelines established by the International Contact Dermatitis Research Group. These evaluations took into consideration the presence of erythema, induration, papules, discrete vesicles, and bullous reactions. Adverse events (AEs) and serious adverse events (SAEs) were documented at visits 2 through 5. At visits 4 and 5, late and/or persistent skin reactions were also recorded.

Primary Outcome Measures

The diagnostic performance of each of the allergens on TRUE Test panels 1.1, 2.1, and 3.1 was evaluated using the frequency and characterization of the reactions to each allergen.

Secondary Outcome Measures

The safety of the allergens on TRUE Test panels 1.1, 2.1, and 3.1 was evaluated using the frequency and characterization of late or persistent reactions, AEs and SAEs, tape-induced irritation at each test site, incomplete panel adhesion, and subject-reported sensations of itching or burning during the test period. A late or persistent reaction was defined as a positive response at visit 5.

Statistical Methods

All statistical processing was performed with SAS software version 9.1 (SAS Institute Inc., Cary, NC). Computations and tabulations used the entire study population; no imputations for missing data were performed. The frequency and 95% confidence intervals for positive, negative, irritant, and doubtful reactions were tabulated for all subjects as well as by age category (children [6–12 years of age] and adolescents [13–18 years of age]), sex, and race (Caucasian and non-Caucasian).

Results

Demographics

As two patients did not complete the study (one was lost to follow-up; the other withdrew consent), 102 patients were enrolled. The mean age of all enrolled subjects was 11.6 years, and the proportions of females and males were comparable (52.0% and 48.0%, respectively). The study population included 28 subjects (27.5%) who were 6 to

8 years of age, 29 subjects (28.4%) who were 9 to 12 years of age, and 45 subjects (44.1%) who were 13 to 18 years of age. Although participants were predominantly Caucasian or Hispanic (39.2% and 31.4%, respectively), Asian and African American patients made up 12.7% and 6.9% of the population, respectively (Table 1). The demographics for the subjects in each age category were similar to one another and to the population of all enrolled subjects with respect to race and gender (ie, at least 50% of the subjects within each of these age categories were female, and a majority were Caucasian or Hispanic).

Baseline Characteristics

Participants had histories of allergic dermatitis (97.1%), atopic dermatitis (53.9%), and irritant dermatitis (25.5%); no other types of dermatitis were reported. Overall, 99% of subjects presented with dermatitis symptoms at the time of entry into the study (Table 2).

Baseline characteristics in each of the age, sex, and race categories were similar to one another and to the population of all enrolled subjects with respect to the type of dermatitis and the proportion of subjects who presented with dermatitis symptoms at screening (ie, at least 95% of the subjects within each of the subgroups had allergic dermatitis, and 97.5–100% presented with dermatitis symptoms).

Table 1. Subject Demographic Characteristics (N = 102)

Characteristic	Age	Gender	Race
Mean age	11.6 yr	—	—
SD	3.61 yr	—	—
Median age	11.0 yr	—	—
Minimum to maximum age	6–17 yr	—	—
Aged 6–8 yr	28 (27.5%)	—	—
Aged 9–12 yr	29 (28.4%)	—	—
Aged 13–18 yr	45 (44.1%)	—	—
Male	—	49 (48.0%)	—
Female	—	53 (52.0%)	—
Caucasian	—	—	40 (39.2%)
Hispanic	—	—	32 (31.4%)
Asian	—	—	13 (12.7%)
African American	—	—	7 (6.9%)
Other ethnicity*	—	—	10 (9.8%)

SD = standard deviation.

*Subject 001, Caucasian Asian; subject 005, Caucasian Hispanic; subject 030, Native American; subject 033, Afghan; subject 051, Hispanic/African American; subject 056, South Asian (Indian); subject 070, Middle Eastern/Kurdish; subject 079, Iranian/Asian/Hispanic; subjects 084 and 085: Caucasian Hispanic.

Frequency of Positive Reactions to Allergens

The frequency of a diagnosis of one or more contact allergies in our patients was 76.2% (77 of 101). The top 10 PPT reactions observed in all patients on visits 3 and 4 were associated with the following allergens: nickel sulfate (30 subjects [29.7%]), p-tert-butylphenol formaldehyde resin (17 subjects [16.8%]), wool alcohols (16 subjects [15.8%]), fragrance mix and cobalt dichloride (each with 13 subjects [12.9%]), balsam of Peru (10 subjects [9.9%]), potassium dichromate and colophony (each with 9 subjects [8.9%]), and neomycin sulfate and tixocortol-21-pivalate (each with 8 subjects [7.9%]). Table 3 shows the specific frequencies for all the allergens tested.

No subject experienced a PPT reaction to caine mix or to the negative control. No more than two subjects had irritant reactions associated with any single allergen at visit 3, and no subject had irritant reactions to any of the allergens at visit 4. In addition, PPT reactions associated with paraben mix, p-phenylenediamine, mercapto mix, thimerosal, diazolidinylurea, and imidazolidinylurea occurred only in adolescents (2–5 subjects [4.4–11.1%] for each allergen) whereas reactions associated with black rubber mix, budesonide, and quinoline mix occurred only in children 6 to 12 years of age (1–2 subjects [1.8–3.6%] for each allergen).

Safety

Overall, AEs were consistent with expectations: 35 subjects (34.7%) reported 52 AEs, all of which were nonserious and the majority (96.1%) of which were mild to moderate in severity (defined as either a slight worsening of the dermatitis or worsening of a specific body site, occasionally with superinfection). Two AEs were categorized as severe, referring to extensive worsening of the dermatitis with superinfection. There were no deaths and no events that led to a participant's discontinuation. The majority (approximately 80%) of participants experienced no tape-induced irritation associated with any of the TRUE Test panels.

All reported patch-test reactions were mild to moderate in severity, and no subject experienced a severe skin reaction of any type to any of the allergens. Overall, four subjects experienced seven persistent reactions, including four PPT reactions associated with nickel sulfate (one instance each of mild infiltration and mild pruritus and two instances of mild hyperpigmentation) and one reaction each associated with methylchloroisothiazolinone/methylisothiazolinone (Cl+Me-isothiazolinone) (moderate hyperpigmentation),

Table 2. Subject Baseline Characteristics (N = 102)

	Type of Dermatitis* [†]	Current Dermatitis Symptoms*
Allergic	99 (97.1%)	—
Irritant	26 (25.5%)	—
Atopic	55 (53.9%)	—
Occupational	0 (0.0%)	—
Other	0 (0.0%)	—
Yes	—	101 (99.0%)
No	—	1 (1.0%)

*Proportion based on the number of subjects.

[†]Some subjects presented with more than one type of dermatitis.

quaternium-15 (mild hyperpigmentation), and diazolidinylurea (mild hyperpigmentation).

Discussion

We present the first prospective pediatric study evaluating the safety and efficacy of the TRUE Test as a diagnostic tool. Owing to the low rate of AEs and both the observed and self-reported improvement of the patients at visit 5 following avoidance, we found the test to be both safe and efficacious. Because of the constraints of the study, designating definite relevance to the contact allergens was not possible as the patients' products were not tested, nor were the patients followed prospectively with observation and the reintroduction of their positive allergens. We were able to identify the likely, possible, and (at times) probable sources of the allergens from the products the patients brought to the final evaluation session, and the patients were counseled to avoid these sources (Table 4).

As mentioned above, the frequency of a diagnosis of one or more contact allergies in our patients was 76.2%. This was not significantly different from the reported rates in prior pediatric patch-test studies, which ranged from 51 to 77%.^{8–11}

Nickel was the most frequent contact allergen; 29.7% of the study population were sensitized, and the most relevant sources were clothing snaps and jewelry. We found that children aged 6 to 12 years were more affected than adolescents, and that reactions were nearly equally distributed between genders. The high rate of sensitization parallels what is reported in the literature from comprehensive patch-test studies.^{8,10–12} Similarly, we found a significant number of children who were allergic to both nickel and cobalt (which ranked fourth, with 12.9% sensitized).

The second most common allergen was p-tert-butylphenol formaldehyde resin, a liquid glue or adhesive used in

the manufacture of neoprene. In 2009, dialkyl thiourea (the other “neoprene cement allergen”) was named Allergen of the Year for its growing prevalence. We are seeing an increase in the number of children and adolescents with athletic gear–associated dermatitis correlating with wrist supports or shin guards, items that contain both dialkyl thioureas and p-tert-butylphenol formaldehyde resin.¹³ Of note, reactions to sports equipment may be exacerbated by sweat and moisture, especially when these occur under occlusion. In addition, both allergic and irritant contact reactions have been described in the literature.^{14,15}

In reports of prior pediatric studies, wool alcohols (lanolin) have been among the top 10 allergens.⁸ Our study found wool alcohols to be the third most common allergen, having a prevalence rate of 15.8%. Relevant exposure sources included the patients' emollients and ointments, especially in the case of patients with atopic dermatitis.

Fragrance mix I (FM I) and *Myroxylon pereirae* (balsam of Peru) were the fourth and sixth most frequent allergens; their prevalence rates were 12.9% and 9.9%, respectively. We found that reactions to FM I were more common in males than females and more common in adolescents than children aged 6–12. Both FM I and *M. pereirae* are expected to be common in the pediatric group because of their significant use in a number of personal hygiene products marketed for children and the use of these or similar chemicals as flavorants. PPT reactions to FM I, *M. pereirae*, and colophony (ranked seventh) were noted simultaneously in several patients, indicating the potential for cross-reactivity between these fragrance-based allergens.¹⁶ In addition, colophony is widely used as an adhesive, and a correlation between a self-reported reactivity to first-aid bandages and a PPT reaction was noted.¹⁷

Neomycin sulfate, second only to nickel in prevalence in adult populations for the last three decades, recently began to decline in prevalence.^{1,18} Notably, neomycin placed ninth in our study, with a prevalence of 7.9%. This lower ranking (compared to rankings of third to fifth in other studies)^{8,9,10,11} may be due to the use of other topical antibiotics (such as bacitracin and mupirocin) instead by our population. Neomycin was the only antibiotic tested in this study.

One significant finding in our study was the reactivity (7.9%) to the group A corticosteroid tixocortol pivalate (ranked ninth). Many of the patients who reacted to this allergen had reported the use of class A topical corticosteroids as both over-the-counter and prescription medicaments, especially the atopics. Notably, only one child was found to be allergic to the class B corticosteroid budesonide.

Table 3. Frequency of Cumulative Positive Reactions* at Visit 3 or Visit 4

TRUE Test Allergen (mg/cm ²)	Subjects Aged 6–12 yr (n = 56)		Subjects Aged 13–18 yr (n = 45)		Total Subjects (N = 101)	
	No. (%)	95% CI [†] (%)	No. (%)	95% CI [†] (%)	No. (%)	95% CI [†] (%)
Panel 1.1						
Nickel sulfate (0.2)	18 (32.1)	20.3–46.0	12 (26.7)	14.6–41.9	30 (29.7)	21.0–39.6
Wool alcohols (1.0)	10 (17.9)	8.9–30.4	6 (13.3)	5.1–26.8	16 (15.8)	9.3–24.4
Neomycin sulfate (0.23)	4 (7.1)	2.0–17.3	4 (8.9)	2.5–21.2	8 (7.9)	3.5–15.0
Potassium dichromate (0.023)	6 (10.7)	4.0–21.9	3 (6.7)	1.4–18.3	9 (8.9)	4.2–16.2
Caine mix (0.63)	0 (0.0)	0.0–6.4	0 (0.0)	0.0–7.9	0 (0.0)	0.0–3.6
Fragrance mix (0.43)	5 (8.9)	3.0–19.6	8 (17.8)	8.0–32.1	13 (12.9)	7.0–21.0
Colophony (1.2)	3 (5.4)	1.1–14.9	6 (13.3)	5.1–26.8	9 (8.9)	4.2–16.2
Paraben mix (1.0)	0 (0.0)	0.0–6.4	2 (4.4)	0.5–15.1	2 (2.0)	0.2–7.0
Negative control	0 (0.0)	0.0–6.4	0 (0.0)	0.0–7.9	0 (0.0)	0.0–3.6
Balsam of Peru (0.8)	4 (7.1)	2.0–17.3	6 (13.3)	5.1–26.8	10 (9.9)	4.9–17.5
Ethylenediamine dihydrochloride (0.05)	4 (7.1)	2.0–17.3	2 (4.4)	0.5–15.1	6 (5.9)	2.2–12.5
Cobalt dichloride (0.02)	4 (7.1)	2.0–17.3	9 (20.0)	9.6–34.6	13 (12.9)	7.0–21.0
Panel 2.1						
p-tert-Butylphenol formaldehyde resin (0.045)	10 (17.9)	8.9–30.4	7 (15.6)	6.5–29.5	17 (16.8)	10.1–25.6
Epoxy resin (0.05)	2 (3.6)	0.4–12.3	2 (4.4)	0.5–15.1	4 (4.0)	1.1–9.8
Carba mix (0.25)	4 (7.1)	2.0–17.3	3 (6.7)	1.4–18.3	7 (6.9)	2.8–13.8
Black rubber mix (0.075)	2 (3.6)	0.4–12.3	0 (0.0)	0.0–7.9	2 (2.0)	0.2–7.0
Cl+Me-isothiazolinone (0.004)	1 (1.8)	0.0–9.6	3 (6.7)	1.4–18.3	4 (4.0)	1.1–9.8
Quaternium-15 (0.1)	2 (3.6)	0.4–12.3	2 (4.4)	0.5–15.1	4 (4.0)	1.1–9.8
Mercaptobenzothiazole (0.0075)	1 (1.8)	0.0–9.6	1 (2.2)	0.1–11.8	2 (2.0)	0.2–7.0
p-Phenylenediamine (0.09)	0 (0.0)	0.0–6.4	2 (4.4)	0.5–15.1	2 (2.0)	0.2–7.0
Formaldehyde (0.18)	6 (10.7)	4.0–21.9	1 (2.2)	0.1–11.8	7 (6.9)	2.8–13.8
Mercapto mix (0.075)	0 (0.0)	0.0–6.4	2 (4.4)	0.5–15.1	2 (2.0)	0.2–7.0
Thimerosal (0.008)	0 (0.0)	0.0–6.4	4 (8.9)	2.5–21.2	4 (4.0)	1.1–9.8
Thiuram mix (0.025)	1 (1.8)	0.0–9.6	6 (13.3)	5.1–26.8	7 (6.9)	2.8–13.8
Panel 3.1						
Diazolidinylurea (0.55)	0 (0.0)	0.0–6.4	5 (11.1)	3.7–24.1	5 (5.0)	1.6–11.2
Imidazolidinylurea (0.6)	0 (0.0)	0.0–6.4	2 (4.4)	0.5–15.1	2 (2.0)	0.2–7.0
Budesonide (0.001)	1 (1.8)	0.0–9.6	0 (0.0)	0.0–7.9	1 (1.0)	0.0–5.4
Tixocortol-21-pivalate (0.003)	5 (8.9)	3.0–19.6	3 (6.7)	1.4–18.3	8 (7.9)	3.5–15.0
Quinoline mix (0.19)	1 (1.8)	0.0–9.6	0 (0.0)	0.0–7.9	1 (1.0)	0.0–5.4

Cl+Me-isothiazolinone = methylchloroisothiazolinone/methylisothiazolinone.

*+, ++, or +++.

[†]Calculated using SAS PROC FREQ with the exact binomial option.

Finally, we noted that only children aged 13 years and older had reactions to thimerosal, which had a prevalence rate of 8.9% in the adolescent group. This may correlate with vaccination sensitization and the greater exposure of adolescents compared with that of the younger population, as thimerosal has recently been removed from most

pediatric vaccinations. We did not find this allergen to be clinically relevant in our population.

As previously mentioned, this study's ability to assign definite relevance was limited, because the study was designed to evaluate the safety and efficacy of a commercial product, without follow-up over time. The

Table 4. Top Allergens and Relevant Sources

<i>University of California, San Diego, 2008–2009 Pediatric Contact Dermatitis Data</i>	<i>Relevant Sources for Study Patients</i>
1. Nickel sulfate (29.7%)	Clothing fasteners, belt buckles, jewelry (piercings), toys
2. p-tert-Butylphenol formaldehyde resin (16.8%)	Sneakers, athletic gear
3. Wool alcohols (15.8%)	Emollients, ointments
4. Fragrance mix* (12.9%)	Perfumes, personal care products, household products, soaps and detergents, cleaners
4. Cobalt dichloride* (12.9%)	Buckles, vitamin B ₁₂
6. Balsam of Peru (9.9%)	Fragrances, flavorants (artificial in foods and liquid medications), ketchup, soda, chocolate
7. Potassium dichromate [†] (8.9%)	Leather, shoe eyelets
7. Colophony [†] (8.9%)	Fragrance, adhesive bandages
9. Neomycin sulfate [‡] (7.9%)	Topical antibiotic ointment
9. Tixocortol-21-pivalate [‡] (7.9%)	OTC and prescription steroid creams and ointments

OTC = over-the-counter.

*Allergen shares the rank of 4.

[†]Allergen shares the rank of 7.

[‡]Allergen shares the rank of 9.

patients' products and other potentially clinically relevant allergens, therefore, could not be adjunctively tested, which then affected the ability to assign clinical relevance. We acknowledge that a PPT reaction does not necessarily correlate with the clinical expression of ACD. Even given these limitations, however, we found that more than 65% of our patients improved by following an avoidance regimen directed at the allergens we deemed of possible relevance.

Conclusions

The results of the study indicate that the allergens in Test panels 1.1, 2.1, and 3.1 are safe and effective when used for the diagnosis of allergic contact dermatitis in persons aged 6 to 18 years.

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References

1. Nijhawen RI, Matiz C, Jacob SE. Contact dermatitis: from basics to allergodromes. *Pediatr Ann* 2009;38:99–108, doi:[10.3928/00904481-20090201-07](https://doi.org/10.3928/00904481-20090201-07).
2. Militello G, Jacob SE, Crawford GH. Allergic contact dermatitis in children. *Curr Opin Pediatr* 2006;18:385–90, doi:[10.1097/01.mop.0000236387.56709.6d](https://doi.org/10.1097/01.mop.0000236387.56709.6d).
3. Jacob SE, Steele T, Brod B, Crawford GH. Dispelling the myths behind pediatric patch testing—experience from our tertiary care patch testing centers. *Pediatr Dermatol* 2008;25:296–300, doi:[10.1111/j.1525-1470.2008.00670.x](https://doi.org/10.1111/j.1525-1470.2008.00670.x).
4. Jacob SE, Yang A, Herro EM, Zhang C. Contact allergens in a pediatric population: association with atopic dermatitis and comparison with other North American referral centers. *J Clin Aesthetic Dermatol* 2010;3:29–35.
5. Weston WL, Weston JA. Allergic contact dermatitis in children. *Am J Dis Child* 1984;138:932–6.
6. Weston WL, Weston JA, Kinoshita J, et al. Prevalence of positive epicutaneous tests among infants, children, and adolescents. *Pediatrics* 1986;78:1070–4.

7. Bruckner AL, Weston WL, Morelli JG. Does sensitization to contact allergens begin in infancy? *Pediatrics* 2000;105:e3, doi:[10.1542/peds.105.1.e3](https://doi.org/10.1542/peds.105.1.e3).
8. Jacob SE, Brod B, Crawford GH. Clinically relevant patch test reactions in children—a United States based study. *Pediatr Dermatol* 2008;25:520–7, doi:[10.1111/j.1525-1470.2008.00769.x](https://doi.org/10.1111/j.1525-1470.2008.00769.x).
9. Zug KA, McGinley-Smith D, Warshaw EM, et al. Contact allergy in children referred for patch testing: North American Contact Dermatitis Group Data, 2001-2004. *Arch Dermatol* 2008;144:1329–36, doi:[10.1001/archderm.144.10.1329](https://doi.org/10.1001/archderm.144.10.1329).
10. Hogeling M, Pratt M. Allergic contact dermatitis in children: the Ottawa hospital patch-testing clinic experience, 1996 to 2006. *Dermatitis* 2008;19:86–9.
11. Hammonds LM, Hall VC, Yiannias JA. Allergic contact dermatitis in 136 children patch tested between 2000 and 2006. *Int J Dermatol* 2009;48:271–4, doi:[10.1111/j.1365-4632.2009.03890.x](https://doi.org/10.1111/j.1365-4632.2009.03890.x).
12. Zug KA, Warshaw EM, Fowler JF Jr, et al. Patch-test results of the North American Contact Dermatitis Group 2005-2006. *Dermatitis* 2009;20:149–60.
13. Hsu J, Jacob SE. The other side of athletic safety gear in adolescents. *J Dermatol Nurses' Assoc* 2009;1(3):198–200.
14. Powell D, Ahmed S. Soccer shin guard reactions: allergic and irritant reactions. *Dermatitis* 2010;21:162–6.
15. Weston WL, Morelli JG. Dermatitis under soccer shin guards: allergy or contact irritant reaction? *Pediatr Dermatol* 2006;23:19–20, doi:[10.1111/j.1525-1470.2006.00162.x](https://doi.org/10.1111/j.1525-1470.2006.00162.x).
16. Wöhrl S, Hemmer W, Focke M, et al. The significance of fragrance mix, balsam of Peru, colophony and propolis as screening tools in the detection of fragrance allergy. *Br J Dermatol* 2001;145:268–73, doi:[10.1046/j.1365-2133.2001.04345.x](https://doi.org/10.1046/j.1365-2133.2001.04345.x).
17. Matiz C, Bush RA, Maldonado E, et al. Can a pre-patch test allergen exposure questionnaire predict positive patch test reactions in children with suspected contact dermatitis? Poster presented at the Society for Pediatric Dermatology (SPD); Portland, OR 2010. 36th Annual Meeting, July 15–18, 2010.
18. Jacob SE, Breithaupt A. Environmental exposures—a pediatric perspective on allergic contact dermatitis. *Skin Aging* 2009. 28–36.