

An 8-Year Retrospective Review of Patch Testing with Rubber Allergens: The Mayo Clinic Experience

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Background: Allergic contact dermatitis from rubber chemicals is increasingly recognized.

Objective: To review the results of patch testing with rubber allergens from January 1, 2000, through December 31, 2007.

Methods: Patients who underwent patch testing with a specialized series of rubber allergens were identified.

Results: In total, 773 patients (64.2% female; mean age, 48.6 years) were patch-tested with a rubber series (27 allergens), and 739 (95.6%) were concomitantly patch-tested with a standard allergen series. Commonly affected sites of dermatitis were the hand (49.7%), foot (15.9%), leg (12.0%), and arm (10.9%). The most common occupations were health care worker (16.3%) and homemaker (6.5%); 11.3% were retired. The rate of allergic reaction to at least one rubber allergen was 245 of 773 (31.7%). The allergens that most commonly yielded positive reactions were 4,4-dithiodimorpholine 1% (28/286 [9.8%]), thiuram mix (56/739 [7.6%]), and diphenylguanidine 1% (57/759 [7.5%]).

Conclusion: Rubber is a frequent cause of allergic contact dermatitis. Patch testing with a rubber series improved the ability to diagnose allergic contact dermatitis caused by rubber.

RUBBERS are often defined as latex products with additives. Rubbers also include synthetic (nonlatex) rubbers such as neoprene. Most of the clinically significant thiourea allergies come from synthetic rubbers. Frequently found in household and medical products, rubber allergens are now recognized as important occupational and environmental causes of allergic contact dermatitis.

The aim of our study was to report our experience of patch testing with rubber allergens from a specialized rubber series and a standard allergen series and to determine the rate of allergic patch-test reactions to rubber. We also sought to establish the overall usefulness of patch testing with a special series of rubber allergens in identifying patients with type IV hypersensitivity to rubber.

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Methods and Materials

Patient Population

This study was approved by the Mayo Clinic Institutional Review Board. Patients with suspected allergic contact dermatitis from rubber underwent patch testing with both a specialized rubber allergen series and the standard allergen series at Mayo Clinic (Rochester, MN; Jacksonville, FL; or Scottsdale, AZ) from January 1, 2000, through December 31, 2007. Patients were identified with the Mayo Clinic patch-testing database (Sybase Inc, Dublin, CA), which combined data from all Mayo Clinic sites. Those who withheld research authorization were excluded from this study. Typically, patients were not patch-tested if they applied topical corticosteroids to patch-test sites, took immunosuppressive medications, or had preexisting medical conditions that could compromise the reading of results.

Patch Testing

Patch testing was conducted in a standardized fashion according to the North American Contact Dermatitis Group¹ and Mayo Clinic protocols, as reported previously.¹⁻³ Generally, patch testing with the rubber allergen series (27 allergens) was performed concurrently with

Table 1. Results of Patch Testing with Rubber Allergens

Allergen	No. of Patients Tested	No. of Irritant Reactions*	Positive Reactions (%)	Total Relevant Reactions		Strength of Reaction [†]												
				Reactions		1			2 or 3						4			
				No. [‡]	% [§]	P	Q	R	U	N	P	Q	R	U	N	P	Q	R
4,4-Dithiodimorpholine 1%	286	5	9.8	27	96.4	0	10	8	0	1	0	2	6	0	0	0	1	0
Thiuram mix	739	6	7.6	55	98.2	0	1	8	1	0	0	2	39	0	0	0	0	5
Diphenylguanidine 1%	759	28	7.5	55	96.5	0	11	17	0	2	1	8	17	0	0	0	0	1
Carba mix	739	22	7.4	54	98.2	0	4	8	1	0	0	4	37	0	0	0	0	1
Tetramethylthiuram monosulfide 1%	771	8	5.4	40	95.2	0	2	14	1	1	0	2	17	0	0	0	0	5
N-(Cyclohexylthio)phthalimide 1%	769	13	5.2	39	97.5	0	6	15	1	0	0	7	11	0	0	0	0	0
Tetraethylthiuram disulfide 1%	772	4	4.5	35	100	0	0	9	0	0	0	2	22	0	0	0	0	2
Hexamethylenetetramine (methenamine 2%)	773	7	3.9	30	100	0	6	3	0	0	0	9	10	0	0	0	0	2
Tetramethylthiuram disulfide 1%	772	5	3.1	24	100	0	1	7	0	0	0	1	12	0	0	0	1	2
Diaminodiphenylmethane 0.5%	773	9	2.7	21	100	0	0	3	0	0	1	7	10	0	0	0	0	0
Dipentamethylenethiuram disulfide 1%	772	0	2.7	21	100	0	1	10	0	0	0	1	8	0	0	0	0	1
Mercaptobenzothiazole 2%	376	8	2.7	9	90	0	1	2	1	0	0	1	4	0	0	0	0	1
Morpholinyl mercaptobenzothiazole	771	12	2.7	21	100	0	1	8	0	0	0	2	9	0	0	0	0	1
Diethylthiourea 1%	770	6	2.2	17	100	0	1	5	0	0	0	0	7	0	0	0	0	4
N-Cyclohexylbenzothiazyl sulfenamide 1%	770	14	2.2	16	94.1	0	5	2	0	1	0	0	8	0	0	0	0	1
Mercaptobenzothiazole 1%	753	5	2.0	15	100	0	1	2	0	0	0	0	11	0	0	0	0	1
Zinc dimethyldithiocarbamate 1%	772	4	1.6	12	100	0	0	4	0	0	0	2	5	0	0	0	1	0
Black rubber mix	737	5	1.5	11	100	0	1	3	0	0	0	3	3	0	0	0	1	0

Table 1. Continued.

Allergen	No. of Patients Tested	No. of Irritant Reactions*	Positive Reactions (%)	Total Relevant Reactions		Strength of Reaction†													
				No.‡	%§	1			2 or 3						4			R	Q
						P	Q	R	U	N	P	Q	R	U	N	P	Q		
Mixed dialkyl thioureas 1%	738	2	1.5	11	100	0	0	3	0	0	0	0	4	0	0	0	0	4	4
N-Cyclohexyl-N-phenyl phenylenediamine 1%	771	4	1.3	9	90	0	1	0	1	0	0	3	5	0	0	0	0	0	0
2,2,4-Trimethyl-1,2-dihydroquinoline 1%	772	4	1.3	10	100	0	2	6	0	0	0	0	2	0	0	0	0	0	0
Dibenzothiazyl disulfide 1%	771	4	1.2	9	100	0	0	4	0	0	0	0	4	0	0	0	0	1	1
Zinc diethyldithiocarbamate 1%	762	5	1.2	9	100	0	1	4	0	0	0	0	4	0	0	0	0	0	0
Mercapto mix 1%	738	2	1.2	9	100	0	1	0	0	0	1	0	7	0	0	0	0	0	0
Zinc dibenzylthiocarbamate 1%	97	0	1.0	1	100	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Dibutylthiourea 1%	770	5	0.9	7	100	0	0	4	0	0	0	2	0	0	0	0	0	1	1
N-Isopropyl-N-phenyl phenylenediamine 0.1%	772	4	0.8	5	83.3	0	1	0	1	0	0	1	3	0	0	0	0	0	0
N,N-Diphenyl-4-phenylenediamine 1%	771	2	0.8	5	83.3	0	1	3	1	0	0	0	1	0	0	0	0	0	0
Zinc dibutylthiocarbamate 1%	760	3	0.5	4	100	0	0	4	0	0	0	0	0	0	0	0	0	0	0
N-Phenyl-2-naphthylamine 1%	772	6	0.5	4	100	0	1	3	0	0	0	0	0	0	0	0	0	0	0
Diphenylthiourea 1%	771	1	0.4	3	100	0	1	1	0	0	0	1	0	0	0	0	0	0	0
Dodecyl mercaptan 0.1%	771	6	0.4	3	100	0	0	2	0	0	1	0	0	0	0	0	0	0	0
N,N-Di-β-naphthyl-p-phenylenediamine 1%	771	5	0.3	2	100	0	0	1	0	0	0	0	1	0	0	0	0	0	0

N = not relevant (positive) reaction; P = past relevant (positive) reaction; Q = questionable relevant (positive) reaction; R = relevant (positive) reaction; U = relevance unknown.

*Irritant reactions were present at the initial reading but were diminished or negative at the second reading (not a true allergic reaction).

†Strength of reaction: 1 = macular erythema; 2 or 3 = mild or moderate; 4 = severe.

‡Calculated by summing the number of reactions with past, questionable, or current relevance.

§Percent of all positive reactions (irritant reactions were not considered positive reactions).

^{||}Included in the standard series of patch-test allergens.

patch testing with the standard series, which includes six rubber allergens. Table 1 lists the rubber allergens used in the study; note that mercaptobenzothiazole is used in both the rubber series and the standard series but in different concentrations. The number of patients tested with each allergen was not constant in our study because of variations in the allergens in both the standard and rubber series during the study period. Furthermore, physician discretion in ordering patch tests also affected the number of patients tested.

Test allergens were obtained from Chemotechnique Diagnostics AB (Vellinge, Sweden). Testing was performed with Finn Chambers (Epitest Ltd Oy, Tuusula, Finland) on Scanpor tape (Norgesplaster Aksjeselskap, Vennesla, Norway). Patches were typically applied to clean dry skin on the upper back and were removed after 48 hours. Reactions were evaluated 48 to 72 hours and 96 to 168 hours after application. Patches were applied by nurses trained and experienced in patch testing. Final patch-test reading, interpretation, and determination of the relevancy of the results were performed by the ordering physician. As previously described,³ all Mayo Clinic Department of Dermatology physicians, including residents, take part in the ordering of patch testing and final interpretation of results. Tests are performed under the supervision of the Mayo Clinic Contact Dermatitis Group.

Interpretation of Patch-Test Results

Patch-test results were determined as reported in previous articles.⁴⁻⁶ Reactions were rated as negative, macular erythema, weak, strong, or extreme. A weak reaction consisted of nonvesicular erythema, infiltration, or occasionally papules. A strong reaction was indicated by edematous or vesicular lesions. An extreme reaction was indicated by bullous or spreading reactions.

Results were assessed for relevancy as determined by the likelihood of exposure to the chemical in the work or home environment. Relevancy was characterized by the following scale: I (irritant, not necessarily allergic); N (allergic, not relevant); Q (allergic, questionable relevance); P (allergic, formerly relevant); R (allergic, currently relevant); and U (unknown relevance). Reactions present at the initial reading but diminished or absent at the second reading were generally characterized as irritant reactions. For the purposes of this study, a patch-test reaction was considered positive if it was a weak, strong, or extreme reaction at the last

reading. A macular erythema reaction was also considered positive if the result was relevant.

Statistical Analysis

All statistical analyses were performed with *Statistical Analysis System* (version 8.2) software (SAS Institute Inc., Cary, NC).

Results

Patient Characteristics

We identified 773 patients who underwent patch testing with rubber allergens in both the rubber series and the standard allergen series during the study period; 496 (64.2%) were female, and 571 (73.9%) were white. The mean age of the patients was 48.6 years (range, 3–89 years). The most common final diagnoses after patch testing were allergic contact dermatitis ($n = 286$ [37.0%]), dermatitis not otherwise specified ($n = 167$ [21.6%]), and irritant contact dermatitis ($n = 67$ [8.7%]). The most common sites of dermatitis were the hand ($n = 384$ [49.7%]), foot ($n = 123$ [15.9%]), leg ($n = 93$ [12.0%]), and arm ($n = 84$ [10.9%]). One hundred twenty-six patients (16.3%) were health care workers. “Nurse” was the most commonly listed career (84 patients [10.9%]); the second most commonly listed was “homemaker” (50 patients [6.5%]). Eighty-seven patients (11.3%) were retired.

Patch-Test Results

Patients were patch-tested with both the rubber series and the standard series ($n = 739$) or with the rubber series alone ($n = 34$). Table 1 lists our results of patch tests with rubber allergens. Table 2 shows the number of patients who had positive reactions. (The results of patch testing with latex will be reported in a separate article.)

The median number of rubber allergens tested per patient was 31. Of the 773 patients, 245 (31.7%) were allergic to at least one rubber allergen. The rubber series allergens that yielded the greatest percentage of positive reactions were 4,4-dithiodimorpholine 1% ($n = 28$ [9.8%]), diphenylguanidine 1% ($n = 57$ [7.5%]), tetramethylthiuram monosulfide 1% ($n = 42$ [5.4%]), and N-(cyclohexylthio)phthalimide 1% ($n = 40$ [5.2%]). Standard series rubber allergens yielding the greatest percentage of positive reactions were thiuram mix ($n = 56$ [7.6%]), carba mix ($n = 55$ [7.4%]), and mercapto-

Table 2. Frequency of Positive Reactions to Rubber Allergens

Positive Reactions per Patient	Patients Reacting (N = 773)	
	No.	%
0	528	68.3
1	119	15.4
2	47	6.1
3	30	3.9
4	17	2.2
5	11	1.4
6	8	1.0
≥ 7	13	1.7

Table 3. Comparison of Positive Reaction Rates for Carba Mix and Diphenylguanidine*

Carba Mix 3%	Diphenylguanidine 1% (n = 727)	
	Negative Reactions	Positive Reactions
Negative	634 (87.2%)	39 (5.4%)
Positive	39 (5.4%)	15 (2.1%)

*Diphenylguanidine is a component of carba mix.

benzothiazole 1% ($n = 15$ [2.0%]). Irritant reactions to rubber allergens were noted in 99 patients (12.8%).

Patch-Test Reactions to the Special Rubber Series versus the Standard Series

Of the 739 patients who underwent patch testing with both standard and rubber series, 239 patients (32.3%) had a positive reaction to at least one rubber allergen in either series. Of those 239 patients, only 120 (50.2%) had a positive reaction to a rubber allergen in the standard series. Therefore, using the rubber series roughly doubled the diagnoses of rubber allergy for patients in this study. We also compared the results of tests with standard series mixes (carba mix and thiuram mix) with the results of

tests using the individual components of these mixes (Table 3 and Table 4).

Discussion

We present the results of patch testing with a rubber allergen series and a standard allergen series for 773 patients with suspected allergic contact dermatitis from rubber. For this population, use of the rubber allergen series increased the diagnoses of rubber allergies by approximately 100% when compared to the use of the standard allergen series alone.

Comparison with Previously Published Rubber Series Results

Table 5 and Table 6 compare our results with those of other reports of patch testing with a special rubber allergen series.^{2,3,7-9} As listed in Table 6, other patch test series with rubber allergens yielded overall positive reaction rates to at least one allergen ranging from 3.8 to 14.7%. Of the 773 patients tested in our study, 245 (31.7%) were allergic to at least one rubber allergen; this allergenicity rate is roughly twice that of previously published studies. There are several possible explanations for our higher rate of allergic patch-test reactions. First, we tested patients with a large number of rubber allergens, thereby increasing the potential for more positive reactions. Second, Mayo Clinic is a large referral center, and many patients in our study were specifically referred for patch testing with rubber allergens; this referral bias may have contributed to the higher rate of rubber allergy. Third, the patients in this study were strongly suspected of having allergic contact dermatitis from rubber (ie, this was not a random population). Fourth, our patients may have truly had a higher rate of allergic patch-test reactions when compared with the rates of previously reported studies. Fifth, we included relevant macular erythema reactions when we were calculating the allergic patch-test reaction rate. Other patch-test reports have excluded macular erythema reac-

Table 4. Comparison of Positive Reaction Rates for Thiuram Mix and Thiuram Mix Components

Thiuram Mix 3%	Tetramethylthiuram Monosulfide 1% (n = 737)		Tetramethylthiuram Disulfide 1% (n = 738)		Dipentamethylenethiuram Disulfide 1% (n = 738)		Tetraethylthiuram Disulfide 1% (n = 738)	
	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive
Negative	672 (91.2%)	9 (1.2%)	680 (92.1%)	2 (0.3%)	673 (91.2%)	9 (1.2%)	677 (91.7%)	5 (0.7%)
Positive	24 (3.3%)	32 (4.3%)	34 (4.6%)	22 (3.0%)	45 (6.1%)	11 (1.5%)	27 (3.7%)	29 (3.9%)

Table 5. Comparison with Results of Other Studies

Allergen	Positive Reactions (%)			
	<i>This Study</i>	<i>Nettis et al</i> ²	<i>Holness and Nethercott</i> ³	<i>Conde-Salazar et al</i> ⁷
4,4-Dithiodimorpholine 1%	9.8	0.3	0	ND
Thiuram mix	7.6	4.0	8.8	83.0
Diphenylguanidine 1%	7.5	1.0	4.4	2.3
Carba mix	7.4	3.0	4.8	22.3
Tetramethylthiuram monosulfide 1%	5.4	2.7 (0.25% conc)	6.0	62.2
N-(Cyclohexylthio)phthalimide 1%	5.2	ND	3.2	ND
Tetraethylthiuram disulfide 1%	4.5	1.0 (0.25% conc)	2.8	54.0
Hexamethylenetetramine (methenamine 2%)	3.9	1.3 (1% conc)	1.9	ND
Tetramethylthiuram disulfide 1%	3.1	1.3 (0.25% conc)	3.8	50.1
Diaminodiphenylmethane 0.5%	2.7	ND	ND	ND
Dipentamethylenethiuram disulfide 1%	2.7	0.7 (0.25% conc)	1.9	21.2
Mercaptobenzothiazole 2%	2.7	1.3	3.5	ND
Morpholinyl mercaptobenzothiazole	2.7	0.3	2.8	5.9
Diethylthiourea 1%	2.2	0	1.1	ND
N-Cyclohexylbenzothiazyl sulfenamide 1%	2.2	1.3 (0.5% conc)	1.6	4.9
Mercaptobenzothiazole 1%	2.0	0.3 (0.5% conc)	3.5	12.0
Zinc dimethyldithiocarbamate 1%	1.6	0	ND	ND
Black rubber mix	1.5	1.0	2.0	17.8
Mixed dialkyl thioureas 1%	1.5	ND	ND	ND
N-Cyclohexyl-N-phenyl phenylenediamine 1%	1.3	0.3 (0.25% conc)	2.5	14.2
2,2,4-Trimethyl-1,2-dihydroquinoline 1%	1.3	0	ND	ND
Dibenzothiazyl disulfide 1%	1.2	0.3 (0.5% conc)	1.9	4.2
Zinc diethyldithiocarbamate 1%	1.2	0.7	2.2	11.3
Mercapto mix 1%	1.2	1.3 (2% conc)	2.8	16.0
Zinc dibenzylthiocarbamate 1%	1.0	ND	ND	ND
Dibutylthiourea 1%	0.9	0.3	1.1	ND
N-Isopropyl-N-phenyl phenylenediamine 0.1%	0.8	1.0	4.4	14.1
N,N-Diphenyl-4-phenylenediamine 1%	0.8	0 (0.25% conc)	1.6	6.1
Zinc dibutylthiocarbamate 1%	0.5	0	1.3	3.7
N-Phenyl-2-naphthylamine 1%	0.5	0	0	2.4
Diphenylthiourea 1%	0.4	0.7	0	ND
Dodecyl mercaptan 0.1%	0.4	0	ND	ND
N,N-Di- β -naphthyl-p-phenylenediamine 1%	0.3	ND	1.4	ND

conc = concentration; ND = no data.

tions from the calculations of allergic patch-test reaction rates.

Table 5 shows positive reaction rates to individual rubber allergens and compares our findings with those of other studies. The 1993 article by Conde-Salazar and colleagues reported higher allergic reaction rates per individual allergen than those we observed.⁷ In that study, patients were first screened by being patch-tested with rubber allergens from a standard series before undergoing testing with the rubber series; only those patients who had positive reactions to rubber allergens in the standard series underwent additional patch testing with the special rubber

series. Because of this screening step, the positive reaction rates to rubber allergens from that study are notably higher when compared with our results.

Although our overall allergenicity rate was higher than rates previously reported (see Table 5 and Table 6), many of our results for individual allergens were similar to those previously reported by Nettis and colleagues² and by Holness and Nethercott.³ Because there are discrepancies between our study and others in regard to the concentration of chemicals used for patch testing, we decided to present numbers for comparison, but we have not performed a formal analysis.

Table 6. Rates of Allergic Patch-Test Reaction to a Special Rubber Allergen Series

<i>Study</i>	<i>No. of Patients</i>	<i>% of Patients Allergic to ≥ 1 Rubber Allergen</i>
Nettis et al ^{2*}	295	10.5
Holness and Nethercott ³	1,670	8.9
Conde-Salazar et al ⁷	4,680	14.7
Miri et al ^{8*}	48	14.6
von Hintzenstern et al ⁹	3,851	3.8
This study	773	31.7

*Study population consisted entirely of health care workers.

Specific Allergens

4,4-Dithiodimorpholine is a vulcanizing agent used in the synthesis of rubber. We were surprised that, in this study, 4,4-dithiodimorpholine 1% was the allergen that yielded the highest proportion of positive reactions (9.8%). This allergen was added to the rubber series during the study period; therefore, only 286 patients underwent patch testing with this substance. 4,4-Dithiodimorpholine is a commonly positive allergen in the shoe allergen series. Of interest, of the 28 patients who tested positive for this allergen, only 3 patients (10.7%) reported dermatitis on the foot. The most common sites of dermatitis in those patients who had a positive reaction to 4,4-dithiodimorpholine was the hand (13 [46.4%]); others reported generalized dermatitis (7 [25.0%]).

Patch testing with 4,4-dithiodimorpholine is reported infrequently.¹⁰ These studies generally have reported lower reaction rates than ours. Nettis and colleagues reported only a 0.3% rate of positive reactions,² and Holness and Nethercott reported no positive reactions.³ 4,4-Dithiodimorpholine was studied by the North American Contact Dermatitis Group for 2 years and was found to have both high irritancy and low relevance rates; therefore, it was subsequently dropped as a screening allergen. How can we explain the inconsistency between studies? Perhaps our rates were higher because we included macular erythema reactions in the calculation of our patch-test reaction rates. Alternatively, 4,4-dithiodimorpholine may truly be an irritant, even though its reaction patterns misleadingly fit those of an allergic patch-test reaction (nonirritant morphology). Indeed, of the 27 positive reactions to this allergen, 18 (66.7%) were macular erythema reactions, and 10 (55.6%) of these were of questionable relevance.

The allergen causing the second highest percentage of allergic reactions was thiuram mix, a blend of four thiuram rubber accelerants. This mix is part of the standard

allergen series. Our positive reaction rate of 7.6% was similar to the rates reported by Holness and Nethercott³ and by Conde-Salazar and colleagues.⁷ Thiuram mix was the allergen that yielded the most positive reactions in the comparison studies (see Table 5).

Diphenylguanidine 1%, one of three components of the carba mix, was the third most common positive allergen in our series. The rate of allergenicity that we observed for diphenylguanidine 1% was roughly twice that of the comparison studies. Carba mix was the fourth most common allergen in the standard series. Carba mix positive reaction rates were comparable with those of the other studies.

Rubber Mixes Compared with Mix Components

It is interesting to compare the reactions to mixes with reactions to components of the mixes (see Table 3 and Table 4). Of the 54 patients (7.4% of 727 patients) who had positive reactions to diphenylguanidine, 39 (72.2%) had negative results with carba mix. Although diphenylguanidine is a component of carba mix, carba mix has low sensitivity for detecting diphenylguanidine allergy. Patch testing patients with both carba mix and diphenylguanidine is critical for detecting rubber allergy.

For each of the four components of thiuram mix, less than 1.2% of patients reacted positively to an individual component of the mix while reacting negatively to thiuram mix. This indicates that patch testing with thiuram mix is adequate screening for thiuram allergy.

Limitations

Our study has a number of limitations that may affect the conclusions. First, this is a retrospective review of patch-test data. Second, our population is not unbiased; patients were suspected of having allergic contact dermatitis from rubber and were referred for patch testing. Third, the assessment of the relevance of allergic patch-test reactions was subjective. Generally, patients were not subsequently patch-tested with the actual item suspected to be the culprit, and use tests were not performed. Most patients were lost to follow-up (often because of long travel distances), and we could not assess whether avoidance of the identified allergen was helpful. Furthermore, follow-up data were not available in our database; therefore, data showing whether patients actually improved with allergen avoidance were not available. Fourth, more specific information on rubber relevance, such as data on the use of gloves, shoes, or neoprene braces and information about nonrubber sources of rubber chemicals (eg, cutting fluids, fungicides), was not widely

available, and occupational relationship was not documented for most cases. Last, all the physicians in our dermatology department participated in the ordering and reading of patch tests and in the final assessment of relevancy. Because of the relatively subjective assessment of patch-test results, the large number of physicians involved in patch testing was a limitation of the study.

Conclusions

Although several rubber allergens are included in the standard series used for patch testing, consideration should be given to additional patch tests with a special series of rubber allergens for patients with suspected allergic contact dermatitis from rubber. In our experience, the number of patients with positive patch-test reactions doubled when a special rubber allergen series was used to diagnose rubber allergy.

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