

**DOI:10.2478/jbcr-2023-0025**
**Original Article**

## ALLERGIC CONTACT DERMATITIS TO ACRYLATES: A STUDY AMONG MANICURISTS AND CLIENTS

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### Summary

The study aimed to investigate the association between the professional environment and hypersensitivity reactions to various contact allergens, features of the clinical course, and types of allergic contact dermatitis (ACD) in 34 manicurists and ten service users. The analysis was based on the data on length of professional experience, localisation of rashes, clinical diagnoses and allergens, and the cause of positive reactions in epicutaneous testing. Pathological skin changes most often affected the upper limbs (hands, palms, fingers). As a diagnosis, the frequency of ACD was the highest – 79.4%, followed by that of dyshidrotic eczema (DE) – 17.6%, which also determines the highest percentage of dermatitis on the upper limbs (97%). Of the patients, 47.1% had a history of the disease for up to one year. For manicurists, the results of patch tests with the specialised MH-1000 series showed the highest frequency of positive reactions to 2-Hydroxyethyl methacrylate (2-HEMA) and 2-Hydroxypropyl methacrylate (2-HPMA) – 88.88% each, Ethylene glycol dimethacrylate (EGDMA) – 83.33% and 2-Hydroxyethyl acrylate (2-HEA) – 61.11%. After combining data for manicurists and clients, correlation analysis found a significant effect on the development of ACD to 2-HPMA ( $p=0.003$ ) and EGDMA ( $p=0.005$ ), as well as for hand dermatitis to 2-HEMA ( $p=0.05$ ) and 2-HEA ( $p=0.044$ ).

**Keywords:** allergic contact dermatitis, manicurists, (meth)acrylates, acrylic nails, gel polish

### Introduction

(Meth)acrylates are chemical substances that can cause contact hypersensitivity, both in the professional sphere and in the domestic environment. As salts, esters and conjugates of acrylic and methacrylic acid, these substances are widely used in various production fields - bone cement, dental and medical products, consumables, adhesives, sealing materials and artificial nails. They are formed by the polymerisation of small monomers that are chemically linked and form polymer molecular chains. It is a known fact that monomers are strong irritants and sensitisers, while polymers are significantly less active or safe[1, 2].

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**Received:** June 15, 2023

**Revision received:** July 26, 2023

**Accepted:** November 09, 2023

In the last 20 years, the increase in the incidence of contact allergy to (meth)acrylates worldwide is an indisputable fact and is defined as an epidemic of contact allergy. It is mainly due to the increasing use of various nail cosmetic products – gel/shellac, nail sculpturing, artificial nails and other procedures related to UV irradiation to stimulate acrylic polymerisation to ensure a long-lasting effect [3, 4]. In aesthetic practice, the most affected contingent are manicurists. At the same time, due to the high allergenic potential of (meth)acrylic monomers and polymers, the risk of ACD is also high enough for customers applying the modern range of nail cosmetics [5]. Clinically, (meth)acrylic ACD from nail polish occurs predominantly on the fingers and on the face due to the auto transfer of the acrylate allergens [6, 7].

We aimed to study the characteristics of the clinical course of ACD from (meth)acrylates in nail artists and their clients and determine the allergens which cause contact allergy in the professional group, comparing the results with the data published in the scientific literature.

The following tasks were completed:

1. To analyse the contact allergy in the epicutaneously tested persons dividing them by gender, age, professional occupation, and diagnostic groups and determine the type of contact dermatitis based on the localisation of the pathological skin changes.

2. To analyse the frequency of allergens, the cause of allergic contact dermatitis, and to determine occupationally-related sensitisers among manicurists.

3. To characterise the features of the clinical course of ACD in nail technicians and to establish the cross-linked reactions of allergens from the applied series for epicutaneous testing.

4. To look for correlations between positive allergens with the type of dermatitis and the diagnosis of ACD.

## **Material and Methods**

The study included 34 manicurists - women aged 22 and 48 (average age  $32.97 \pm 7.45$ ) and ten service users – women between 21 and 71 (average age  $39.20 \pm 15.67$ ). All have actively sought a consultation with a dermatologist regarding a skin rash with different localisation

on the body. The two groups were selected for five years (2016-2020) in three dermatology centres in Pleven, Sofia and Ruse.

A registration form valid for the country was used for the epidemiological analysis. Based on the data, the patients were divided by gender, age, professional experience, diagnostic group and location of the rash. The persons examined are divided into two age ranges – up to 40 and 40 and over.

The clinical-morphological characteristics of allergic contact dermatitis (acute, subacute and chronic ACD/eczema) were studied using a clinical method (data from the history and dermatological status). The results are interpreted depending on the clinical picture, and the patients are grouped into different diagnoses: allergic contact dermatitis/eczema (ACD), atopic dermatitis (AD), dyshidrotic eczema (DE), and other types of eczema. Based on the topographical characteristics of the exanthema in the positive individuals, ACD is classified as healthy (without dermatitis clinic), ACD of the hands, the face and the hands, and the face.

Allergy method (epicutaneous testing, patch tests). Epicutaneous testing for the diagnosis of contact allergy was performed using patch tests according to the testing guidelines of ESCD (European Society of Contact Dermatitis) and ICDRG (International Contact Dermatitis Research Group). The European baseline series S-1000 with 30 allergens and the Nail MN-1000 acrylate series specialised for manicurists with 13 allergens were applied. For application on the skin (for 48 hours on the back of the subject), aluminium disc 8 mm chambers (Thalioderma, Varna, Bulgaria) attached to a hypoallergenic adhesive material (Micropore, 3M) were used. The results were reported on the 48th, 72nd hour and the 7th day (with an intensely positive reaction) and were interpreted according to the ICDRG criteria [8,9]. Individuals with irritative or doubtful reactions were excluded from the study.

The collected information was entered and processed with the IBM SPSS Statistics 23.0.0 statistical package, and some of the data was processed with EXCEL as well. The Chi-square ( $\chi^2$ ) statistics and correlation analysis were applied. We present the results in tables, graphs and numerical values (percentages, coefficients,

average values, standard deviation, etc.). A p-value  $\leq 0.05$  was chosen as the significance level for rejecting the null hypothesis.

**Ethical aspects**

The study was carried out following the national and international requirements for conducting clinical studies. Each participant signed an informed consent form. It was explained to the volunteers that they could withdraw from the study at any time without giving reasons.

**Results**

The group of manicurists includes 34 positive women aged  $32.97 \pm 7.45$  on average, tested with the S-1000 (used 18 times) and MN-1000 (used 19 times) series. In four patients, both series were administered. Based on the topographical location of the rash, the highest frequency is the involvement of the palms (79.4%) and fingers (60%), followed by the face (17.6%) and neck (17.6%) (Table 1).

The distribution by age groups, professional experience, type of dermatitis, diagnosis and duration of the disease is presented in a crosstabulation. Twenty-seven (76.5%) manicurists were at a young age (under 40 years of age), and 22 of them (64.7%) had up to 5 years of work experience. The most frequently recorded diagnoses were ACD (79.4%) and DE (17.6%). The disease had a history of up to 1 year in 47.1% and from 1 to 3 years in 26% of the sample. Twenty-three patients (67%) with dermatitis of the hands had a history of the disease for up to 3 years, and 12% had a history of 3 to 6 years. Four patients (11.7%) had dermatitis of the face and hands. Three of them had a history of up to 3 years and two of them - with facial dermatitis. One had no clinical manifestation

of the disease despite a positive skin patch test. The dermatological status showed that the facial involvement in the manicurists included complaints of mild to moderate pruritus and moderately marked erythema on the cheeks with pityriasis desquamation. In manicurists, hand eczema was localised on the volar surface of the palms and fingers, in the acute phase in the form of bullous pulpitis and perionixis, and in the chronic phase - with xerosis, moderately expressed palmar hyperkeratosis with pityriasis desquamation, compaction and desquamation of the skin on the distal phalanges with single rhagades, perionixis and onychodystrophic changes (Figure 1).

We did not find a significant relationship between the length of professional experience and the onset of the clinical manifestation of ACD. We found a statistically significant difference in the distribution of diagnoses by age of clinical presentation, with 54% of hand eczema of a duration of up to one year and dermatitis of the face and hands in 50% having a history of one to three years ( $\chi^2=21.24$ ,  $df=8$ ,  $p=0.007$ ).

Ten women with an average age of  $39.20 \pm 15.67$  years applied nail cosmetics: 60% were under 40; 60% had dermatitis of the upper limbs; 90% were diagnosed with ACD, the history of which in 80% of cases was up to three years – 50% in the period 0-1 years, and 30% in the period 1-3 years.

Epicutaneous testing with the European baseline series S-1000 (with 30 allergens) and the professional MN-1000 (with 13 allergens) was applied to study contact allergy among nail technicians and clients.

Among the nail technicians tested with the S-1000, 41 positive tests were reported with the highest frequency to Cobalt (6 times, 32.5%), five

**Table 1.** Localisation of pathological skin changes in 34 manicurists

Zones	Patients (n)	Percent
Face	6	17.6%
Scalp	2	5.9%
Neck	6	17.6%
Palms	27	79.4%
Fingers, nails	21	60.0%
Hands	16	47.1%
Torso	3	8.8%
Feet	1	3.0%

times (31.25%) to 2-Hydroxyethyl methacrylate (2-HEMA) and four times (21.05%) to Nickel. In those 18 tested with MN-1000, 113 positive tests were reported with the highest frequency for 2-Hydroxyethyl methacrylate (2-HEMA) and 2-Hydroxypropyl methacrylate (2-HPMA) – 16 times each (88.88%), 15 times (83.33%) to Ethyleneglycol dimethacrylate (EGDMA) and 11 times (61.11%) to 2-Hydroxyethyl acrylate (2-HEA) (Table 2).

Five of the manicurists were tested with both series. All five had ACD of the upper extremities with involvement of the palms and fingers. Four of them had a positive patch test to 2-HEMA by S-1000 and confirmed by epicutaneous testing

with MN-1000.

A 36-year-old woman, in the profession for two years, with a history of ACD of the hands and pathological changes on the palms, fingers, and dorsal surface of the palms and thighs, had a history of complaints up to 1 year. At the time of clinical examination, she was free of signs of the disease, with negative epicutaneous reactions to S-1000 and MN-1000 allergens.

The results with  $\chi^2$ -statistics showed a statistically significant difference in the distribution by diagnosis of the patients with positive and negative tests for 2-HEMA, with the positives in 100% having ACD of the upper limbs and the negatives having ACD in 67% and



**Figure 1.** Clinical signs of hand eczema in manicurists (*own photo archive*) 1 – acute bullous pulpitis of a thumb; 2 – chronic pulpitis of the fingers; 3 – periungual chronic dermatitis; 4 – nail dystrophy of the third finger

**Table 2.** Frequency of top 5 sensitizers, cause of contact allergy in 34 manicurists

Series	Allergens	Number	Percent
S-1000 applied 19 times	Cobalt	6	31.5%
	Nickel	4	21.1%
	2-Hydroxyethyl methacrylate	5	26.3%
	Colophonium	3	15.8%
	IPPD*	3	15.8%
	Balsam Peru	3	15.8%
MN-1000 applied 18 times	ETHYL METHACRYLATE	9	50.0%
	2-Hydroxyethyl methacrylate	16	88.9%
	2-Hydroxypropyl methacrylate	16	88.9%
	Ethylene glycol dimethacrylate	15	83.3%
	Ethyl acrylate	9	50.0%
	2-Hydroxyethyl acrylate	11	61.1%
	Triethylene glycol diacrylate	9	50.0%

\*IPPD - *N-Isopropyl-N-phenyl-4-phenylenediamine*

31% having DE ( $\chi^2=6.206$ ,  $df=2$ ,  $p=0.045$ ). For 2-HPMA with hand eczema, 94% of manicurists had a positive and 67% had a negative patch test to the allergen, the difference in distribution being statistically significant ( $\chi^2=3.85$ ,  $df=1$ ,  $p=0.05$ ).

The cross-reactivity of the 13 sensitisers was extremely rich. It proved the high allergenic potential of (meth)acrylates, the most common being 2-HEMA\*2-HRMA\*EGDMA – in 78% of the manicurists, followed by 2-HEMA\*2-HRMA\*EGDMA\*2-HEA – in 56% of them.

Ten positive tests were reported in the clients tested with S-1000 with the highest frequency for Nickel – 3 times. In those tested with MN-1000, 52 positive results were registered with the highest frequency for 2-HPMA and EGDMA (8 times each), Butyl acrylate (BA) and Triethyleneglycol diacrylate (TEGDA) – 7 times each. A 21-year-old woman with acute bullous pulpitis was positive for 11 allergens.

Considering that the clinical picture of dermatitis in both subgroups is the same in terms of morphology and body area involvement, as well as to study the correlations of dermatitis with positive allergens, we united allergic manicurists and clients. We determined the top 5 allergens in the general group of 44 individuals. The most common was allergy to 2-HPMA (86%) and EGDMA (82%). The cross-reactivity in 63% of them had the affinity to 2-HEMA\*2-HPMA\*EGDMA of the specified allergens. With the bivariate correlation method, we established the following regularities:

- from the point of view of the involvement of the different anatomical areas of the body, it was established that when the palms and fingers are involved, a statistical relationship existed with 2-HEMA ( $p=0.041$ );
- 2-HPMA ( $p=0.05$ ) and 2-HEA ( $p=0.044$ ) had a significant effect on the development of the «hand dermatitis» type;
- Positive tests for 2-HPMA ( $p=0.003$ ) and EGDMA ( $p=0.005$ ) had a statistically significant impact on the development of the diagnosis of ACD (different from atopic dermatitis and dyshidrotic eczema).

## Discussion

Acrylates were synthesised in the early 19<sup>th</sup>

century. Furthermore, there are salts and esters of acrylic and methacrylic acids. Due to their qualities (stability, hardness, durability, and resistance to external influences), they are widely used in industry and medical devices and consumables. Stevenson described the first case of ACD from acrylates in 1941 [10]. For nail sculpting gel, acrylates began to be applied in the 1970s. Currently, they are increasingly used as part of the composition of varnishes and nail polish hardeners when modelling the nail plate when glueing artificial nails [11.] The sensitisation mechanism is related to the processing and preparation of the photo-acrylic gels and adhesives used in sculpting artificial nails. The material used to shape the nails contains a mix of acrylate monomers and polymers. The most practised method is mixing the powdered and liquid acrylic polymer and subsequent application on the nail, after which the manicure is hardened with UV light [12]. Sensitisation occurs gradually with each successive application and UVB exposure (over two weeks) to ensure manicure maintenance. This fact explains why sensitisation to acrylates takes longer, as ACD can develop for several months to several years, with methyl methacrylate (MMA), 2-HEMA, and triethylene glycol dimethacrylate (TEGDM) being considered the strongest sensitisers [13-16].

In recent years, reported cases of acrylate-associated ACD among manicurists and clients have been steadily increasing. The problem with manicurists is aggravated by the fact that they use the new techniques on their own nails [3, 17, 18]. Cutaneous manifestations are characterised by erythema and oedema of the perynichium, periungual acute (with vesicles and bullae) and chronic eczema (with hyperkeratosis and desquamation), fissures and ridges on the tips of the fingers, paronychia, nail dystrophy, onycholysis, subacute and chronic eczema of the hands and face, periorbital dermatitis, symptoms that we also observed in our patients [5, 19].

Montgomery (2016) studied 4710 patients selected from 2008 to 2014, and 44 individuals were tested with (meth)acrylates, with ACD predominantly affecting the hands or face and hands. The highest frequency was positive reactions to 2-HEMA - 81% of the whole group and 93% of the professionals. In this

author's opinion, contact sensitisation to acrylic ingredients was more common among clients than among manicurists [20]. A similar statement was made by Aneta Lazarov as early as 2007 after a retrospective analysis for four years (2001-2004). Of 55 patients with ACD of the hands, 21 (38.2%) had positive reactions to the (met)acrylate series - most commonly to 2-HEMA, 2-HPMA, and EGDMA. Of these 21 persons, 11 were licensed manicurists, and 10 were clients [14]. When comparing our results with those of Lazarov (Table 3), we did not find more frequent contact (meth)acrylate allergy among our clients. Still, we found an equivalent frequency of sensitisation to the same top allergens, including Nickel sulfate (41.7%). The higher number of positive reactions in our study is striking – 113 compared to 47 in the Israeli one (6.3:4.3 reactions per person). On the one hand, there is a significant difference in the years between the two studies (15 years). On the other hand, the question could be asked to what extent the consumables for nail cosmetics currently used in Bulgaria are licensed, with proven safety and permitted on our market.

In a study by Raposo et al. (2017), the cross-linking reactions of different acrylate allergens are reported. In 93.4% of the 230 acrylate-allergic subjects studied, 2-HEMA\*2-HPMA\*EGDMA were associated. In our study of 44 individuals allergic to acrylates, we found the same cross-reactivity in 63% of cases [21]. Studying the patterns of association between different allergens in occupational contact dermatitis, Aalto-Korte et al. (2010) reported the most frequent positive tests to EGDMA, followed by those to 2-HEMA and 2-HPMA and suggested that association with reactions to Triethylene glycol diacrylate (TREGDA) is common in occupational ACD [22]. In our study, we found cross-reactivity between (meth) acrylates and TREGDA among manicurists in 50% of cases, i.e., in 17 of them. However, we would not associate this fact with a statement that these persons have an occupational disease. Acrylate-associated occupational ACD in a manicurist was described in our country in 2015. Zheleva and Durlenski published a case report on occupation-associated contact dermatitis to acrylates in a woman with the same profession,

**Table 3.** Comparison of data in the two studies

The studies	Lazarov (2007)		Our study (2021)					
	manicurists		clients		manicurists		clients	
Number of participants	n = 11		n = 10		n = 18		n = 10	
Allergens (MN-1000)	number	percent	number	percent	number	percent	number	percent
Butyl acrylate	0	0%	1	10%	7	38.9%	7	70%
ETHYL METHACRYLATE	3	27.3%	6	60%	9	50%	1	10%
BUTYL METHACRYLATE	3	27.3%	0	0%	5	27.8%	2	20%
2-Hydroxyethyl methacrylate	8	72.7%	9	90%	16	88.9%	5	50%
2-Hydroxypropyl methacrylate	9	81.8%	8	80%	16	88.9%	8	80%
Ethylene glycol dimethacrylate	7	63.6%	6	60%	15	83.3%	8	80%
Triethylene glycol dimethacrylate	4	36.6%	4	40%	3	27.3%	5	50%
1,6-Hexanediol diacrylate	1	9.09%	1	10%	4	36.4%	2	20%
Trimethylpropane triacrylate	1	9.09%	2	20%	1	5.55%	0	0%
Tetrahydrofurfuryl methacrylate	3	27.3%	3	30%	8	72.3%	1	10%
Ethyl acrylate	4	36.6%	4	40%	9	50%	3	30%
2-Hydroxyethyl acrylate	4	36.6%	4	40%	11	61.1%	2	20%
Triethylene glycol diacrylate	0	0%	2	20%	9	50%	7	70%
Number of positive reactions	47		50		113		51	

and the results of epicutaneous testing showed hypersensitivity to Nickel, Methylmethacrylate (MMA) and materials used by the patient herself [23].

It should not be forgotten that facial dermatitis can also be a form of allergy to (meth)acrylates due to the auto transfer of allergens by touching and scratching the face with an acrylic manicure. In our study, we found ten patients with facial involvement (22.7%) – in 6 manicurists (of which 4 with dermatitis on the face and hands) and four clients (of which 2 with dermatitis on the hands and face). The clinical manifestation of this type of ACD can lead to a wrong diagnosis. McCarthy et al. (2018) described a case of a 22-year-old Irish woman seen by a dermatologist because of erythematous plaques on the face and neck in sun-exposed areas. A family history of systemic lupus erythematosus suggested the same diagnosis. A biopsy showed no evidence of lupus or psoriasis. Serology for connective tissue diseases was negative. Patch-testing with the European baseline series showed a positive result for 2-HEMA, and the application of artificial nails points to ACD to (meth)acrylates by auto transfer of the allergen [24].

At the same time, from a professional point of view, it should be considered that within less than 30 minutes, 2-HEMA can penetrate through protective nitrile gloves, which a positive patch test has proved through a layer of the glove material [25].

## Conclusion

The present study examined the clinical-epidemiological and allergy spectrum of (meth)acrylate-related ACD in the aesthetic practice of manicurists and consumers of the service. Acrylic and (meth)acrylic monomers have a very high allergic potential. The frequency of allergic reactions to them has grown significantly in recent years, mainly associated with applying gel-lack and nail sculpting in aesthetic practice.

Our results will help assess risk factors and allergic predisposition in beautician procedures and stimulate new social and therapeutic methods for treating and preventing contact allergy. We recommend that the conduct of dermatologists be consistent with international and national consensus on the diagnosis and treatment of

contact dermatitis and hand eczema, as well as with country-specific occupational pathology regulations and standards.

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