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ORIGINAL ARTICLE

Sensitization to Acrylates Caused by Artificial Acrylic Nails: Review of 15 Cases

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Abstract. *Background.* Allergic contact dermatitis due to acrylates present in the workplace is a disease frequently reported among dentists, printers, and fiberglass workers. Recently, the number of cases of contact allergic dermatitis among beauticians specialized in sculpting artificial nails has increased.

Objective. Our objective was to study the clinical characteristics and allergens implicated in allergic contact dermatitis due to acrylates in beauticians and users of sculpted nails.

Material and methods. This was an observational, retrospective study of patients diagnosed with allergic contact dermatitis due to acrylates used in sculpting artificial nails over the last 26 years in the Hospital General Universitario, Valencia, Spain.

Results. In total, 15 patients were diagnosed: 14 beauticians and 1 client. Most cases were diagnosed in the past 2 years. All were women, their mean age was 32.2 years, and 26.7% had a personal or family history of atopy. The sensitization time varied between 1 month and 15 years. The most frequently affected areas were the fleshy parts of the fingers and hands. Three patients —2 beauticians and 1 client— presented allergic asthma due to acrylates. All patients underwent patch testing with a standard battery of allergens and a battery of acrylates. The most frequent allergens were ethylene glycol dimethacrylate (13/15, 86.7%), hydroxyethyl methacrylate (13/15, 86.7%), triethylene glycol dimethacrylate (7/15, 46.7%), 2-hydroxypropyl methacrylate (5/15, 33.3%), and methyl methacrylate (5/15, 33.3%).

Conclusions. Acrylate monomers used for sculpting artificial nails are important sensitizers for contact and occupational dermatitis. The most important consideration is primary and secondary prevention.

Key words: acrylates, methacrylates, artificial nails, allergic contact dermatitis.

SENSIBILIZACIÓN A ACRILATOS POR UÑAS ARTIFICIALES ACRÍLICAS. REVISIÓN DE 15 CASOS

Resumen. *Introducción.* La dermatitis alérgica de contacto (DAC) ocupacional a acrilatos es una patología frecuente en dentistas, la industria de la imprenta o la fibra de vidrio. Recientemente el número de casos publicados de DAC a acrilatos en esteticistas especializadas en esculpir uñas artificiales ha ido en aumento.

Objetivo. Estudiar las características clínicas y los alergenos implicados en la DAC a acrilatos en esteticistas y usuarias de uñas esculpidas.

Material y métodos. Se trata de un estudio observacional y retrospectivo de todos los pacientes diagnosticados de DAC a acrilatos debido a las uñas artificiales esculpidas en los últimos 26 años en el Hospital General Universitario de Valencia.

Resultados. Un total de 15 pacientes fueron diagnosticadas: 14 esteticistas y una usuaria. La mayoría de los casos fueron diagnosticados en los últimos dos años. Todos eran mujeres, con una edad media de 32,2 años. El 26,7% tenían historia personal o familiar de atopia. El tiempo de sensibilización fue variable, entre un mes y 15 años. Las áreas más frecuentemente afectadas fueron los pulpejos de los dedos y las manos. Tres pacientes, dos ocupacionales y otra no ocupacional, presentaron asma alérgica debido a los acrilatos. Todas las pacientes fueron estudiadas mediante pruebas epicutáneas con la batería estándar y la batería de acrilatos. Los alergenos más frecuentes fueron etilenoglicol dimetacrilato (13/15, 86,7%), hidroxietilmetacrilato (13/15, 86,7%), trietilenglicol dimetacrilato (7/15, 46,7%), 2-hidroxipropil metacrilato (5/15, 33,3%) y metil metacrilato (5/15, 33,3%).

Conclusiones. Los monómeros acrílicos utilizados en esculpir uñas artificiales son importantes sensibilizadores de contacto y ocupacionales. El aspecto más importante es la prevención primaria y secundaria.

Palabras clave: acrilatos, metacrilatos, uñas artificiales, dermatitis alérgica de contacto.

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Introduction

The use of sculptured nails (also called acrylic or porcelain nails) is becoming increasingly popular in beauty treatment centers, and they are also available in kits for do-it-yourself applications at home. In recent years we have witnessed an increase in the incidence of allergic contact dermatitis (ACD) caused by the acrylic products used in artificial nails. ACD mostly affects the professional beauticians who handle the product, but can also be observed in end users.

Materials and Methods

The dermatology department of the Hospital General Universitario de Valencia, Valencia, Spain, has a section specializing in contact dermatitis, with a database holding information on 8400 patients evaluated between June 1981 and January 2008.

Using the data stored in this database we conducted an observational retrospective study of all patients who had developed ACD as a consequence of contact with acrylates, whether as professionals who work with artificial nails or as end users of such products.

All the patients had undergone the standard panel of patch tests of the Spanish Contact Dermatitis Research Group (GEIDC) (supplied by J Martí Tor, Barcelona, Spain), the acrylates series (Chemotechnique Diagnostics AB, Vellinge, Sweden) (Table 1), and other tests in accordance with the medical background of each patient. Throughout the study period, the acrylates series remained unchanged. Test patches were applied to the patient's back using Finn-Chamber test strips (Epitest Ltd Oy, Tuusula, Finland), and were left in place for 48 hours. Results were read at 48 and 96 hours, and positive reactions were scored, according to the International Contact Dermatitis Research Group, as weak (+), strong (++), and extreme (+++). Patch test results were considered relevant for our study if the clinical symptoms could be attributed to the handling of, or contact with, acrylate-based sculptured nail kit products.

The following data were studied: year of diagnosis; age and sex; whether contact occurred as a professional user or end user; medical history or family members with atopy; time since onset or latency period; lesion sites; skin symptoms; respiratory symptoms; patch test results; and evaluation of whether positive tests were of present, past, or unknown relevance.

Table 1. Acrylates Series Used in the Hospital General Universitario de Valencia, Spain

Order	*Allergen*
1	Ethyl cyanoacrylate 10% pet.
2	n-Butyl methacrylate 2% pet.
3	2-Hydroxypropyl methacrylate 2% pet.
4	1,6-Butanediol dimethacrylate 2% pet.
5	Ethylene glycol dimethacrylate 2% pet.
6	2,5-bis (4-Methacryloxy) phenyl propane (BIS-MA) 2% pet.
7	Hydroxyethyl methacrylate 2% pet.
8	Methyl methacrylate 2% pet.
9	Tetrahydrofurfuryl methacrylate 2% pet.
10	Triethylene glycol dimethacrylate 2% pet.
11	2,2-bis (4-(2-Hydroxy-3-methacryloxypropoxy) phenyl propane (BIS-GMA) 2% pet.
12	Tetraethylene glycol dimethacrylate 2% pet.
13	Urethane dimethacrylate 2% pet.
14	N,N-Dimethylaminoethyl methacrylate 0.2 % pet.
15	1,6-Hexandiol diacrylate (HDDA) 0.1 % pet.

Abbreviation: pet, petrolatum.

Results

A total of 15 patients—all women—were diagnosed with ACD resulting from acrylates used in artificial nails (Table 2); 14 were professional beauticians and 1 was an end user of artificial nails. Ages ranged between 18 and 58 years (mean, 32.2 years). Although the earliest case was diagnosed in 1997, most cases were diagnosed in the 2 years prior to January 2008.

Three patients (20%) had a personal and family history of atopy, and 1 patient had a personal history of atopy. Sensitization periods ranged from 1 month to 15 years. Skin lesions were evident on the pads of the fingers (excluding the thumb) in 12 patients, on the back of the hands in 8 patients, and on the forearms in 2 cases. Six of the patients (40%)—5 beauticians and the only end user—developed secondary facial lesions as a result of particle transport by the hands or in the air. Initial symptoms were acute eczema (Figure 1), rendered chronic by continuous contact with the product; eventually, painful fissures developed in the pads of the fingers (Figure 2), aggravated further by eczema flare-ups. In the only patient who was an end user, the acute eczematous lesions developed away from the site of contact. Three of the patients (cases 3 and 5, referring to beauticians, and 8, the end user) had respiratory symptoms accompanied by bronchospasm.

In addition to chronic eczematous lesions on the hands, facial edema was reported for case 3, and generalized indurated lesions on parts of the body with no direct contact with the allergenic material were reported for case 5; these conditions appeared at the same time as the respiratory symptoms, and so may be the result of a type 1 (IgE-

Table 2. Summary Details of 15 Cases of Allergic Contact Dermatitis Due to Acrylates in Artificial Nail Products

Case	*Diagnosis, y*	*Age, y*	*Sex*	*Atopy*	*Source of Sensitization*	*Latency, y/mo*	*Lesion Site*
1	2008	58	Female	No	Professional use	–	Pads, fingers 1-3, both hands Back of hands Arms
2	2007	22	Female	No	Professional use	18 mo	Pads, fingers 1-3, both hands Back of hands
3	2007	30	Female	No	Professional use	3 y	Pads, fingers 1-3, both hands Back of hands Face
4	2007	34	Female	No	Professional use	6 mo	Pads, fingers 1-3, both hands Back of nondominant hand
5	2007	34	Female	Personal and family IgE 154 kU/L IgE Anisakis Type 1	Professional use	–	Face Forearms Generalized
6	2007	34	Female	No	Professional use	6 mo	Pads, fingers 1-3, both hands Back of hands
7	2007	33	Female	No	Professional use	–	Pads, fingers 1-4, both hands Back of hands
8	2006	18	Female	No	End use	1 y	Face Neck Neckline
9	2006	41	Female	No	Professional use	1 mo	Pads, fingers 1-3, nondominant hand
10	2005	46	Female	No	Professional use	9 y	Pads, fingers 1- 4, both hands
11	2005	19	Female	No	Professional use	7 mo	Pads and sides, fingers 1-3, dominant hand
12	2003	39	Female	Personal and family Asthma and allergic rhinitis	Professional use	15 y	Interdigital and periungual folds, both hands Ungual dystrophy
13	2001	28	Female	Personal and family Allergic rhinitis	Professional use	–	Pads, fingers 1-3, nondominant hand Back of hands Face
14	1999	28	Female	No	Professional use	–	Pads, fingers 1-3, both hands Back of hands Face
15	1997	19	Female	Family	Professional use	–	Pads, fingers 1-2, dominant hand Face

Skin Symptoms	*Respiratory Symptoms*	*Acrylates Series*	*Other Series*
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 10.Triethylene glycol dimethacrylate	
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate	
Eczema Pruritus Facial edema	Yes	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 10. Triethylene glycol dimethacrylate 12. Tetraethylene glycol dimethacrylate 15. 1,6-Hexandiol diacrylate	Standard 4. Paraphenylenediamine 5. Nickel sulfate
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate	Standard 5. Nickel sulfate 18. Cobalt chloride
Eczema Indurations Pruritus	Yes	3. 2-Hydroxypropyl methacrylate 4. 1,6-Butanediol dimethacrylate 5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 8. Methyl methacrylate 10. Triethylene glycol dimethacrylate	
Eczema Pruritus	No	3. 2-Hydroxypropyl methacrylate 5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 8. Methyl methacrylate 9. Tetrahydrofurfuryl methacrylate 10. Triethylene glycol dimethacrylate 12. Tetraethylene glycol dimethacrylate 14. N,N-Dimethylaminoethyl methacrylate	Standard 5. Nickel sulfate 18. Cobalt chloride
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 10. Triethylene glycol dimethacrylate 13. Urethane dimethacrylate	Standard 5. Nickel sulfate 10. Thimerosal 20. Ethylenediamine
Acute eczema Pruritus	Yes	1. Ethyl cyanoacrylate 8. Methyl methacrylate	Standard 4. Paraphenylenediamine 5. Nickel sulfate 17. Paraphenylenediamine mix 28. Fragrance mix Perfumes 20. Musk
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate	
Dysesthesia Edema Pruritus	No	3. 2-Hydroxypropyl methacrylate 5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 8. Methyl methacrylate 10.Triethylene glycol dimethacrylate 12.Tetraethylene glycol dimethacrylate	
Eczema Pruritus	No	3. 2-Hydroxypropyl methacrylate 7. Hydroxyethyl methacrylate	Standard 10. Thimerosal Glues 6. Butyl acrylate
Eczema Pruritus	No	3. 2-Hydroxypropyl methacrylate 5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate	Standard 5. Nickel sulfate 20. Ethylenediamine
Eczema Pruritus	No	1. Ethyl cyanoacrylate 5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate 8. Methyl methacrylate 10. Triethylene glycol dimethacrylate	Standard 10. Thimerosal
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 7. Hydroxyethyl methacrylate	Standard 10. Thimerosal
Eczema Pruritus	No	5. Ethylene glycol dimethacrylate 15. 1,6-Hexandiol diacrylate	

Figure 1. Acute inflammation of the finger pads.

Figure 2. Chronic inflammation of the finger pads.

Figure 3. Patch test for the acrylates series showing positive for several allergens.

mediated) allergic mechanism. Patch tests using the acrylate series (Figure 3) revealed the following sensitizations: ethylene glycol dimethacrylate (13 cases, 86.7%), hydroxyethyl methacrylate (13 cases, 86.7%), triethylene glycol dimethacrylate (7 cases, 46.7%), 2-hydroxypropyl methacrylate (5 cases, 33.3%), methyl methacrylate (5 cases, 33.3%), tetraethylene glycol dimethacrylate (3 cases, 20%), ethyl cyanoacrylate (2 cases, 13.3%), 1,6-hexandiol diacrylate (2 cases, 13.3%), 1,6-butanediol dimethacrylate (1 case, 6.7%), tetrahydrofurfuryl methacrylate (1 case, 6.7 %), urethane dimethacrylate (1 case, 6.7%), and N,N-dimethylaminoethyl methacrylate (1 case, 6.7%). Nine patients (60%) were sensitized to allergens in other test panels. The most frequent positive reactions for the standard tests were to 5% nickel sulfate in petrolatum (6 cases, 40%) and to 0.1% thimerosal in petrolatum (4 cases, 26.7%).

We are of the opinion that all our cases have present relevance, given the timing of the onset of symptoms relative to use of the product, and the relationship between the presence of acrylates in the products and the absence of relapses once use was discontinued. Multiple positive reactions to different acrylates in the administered tests were probably due to cross-reactivity. Sensitization to nickel sulfate and cobalt chloride was of past relevance and the remaining sensitizations were of unknown relevance.

Discussion

The number of dermatology consultations for contact dermatitis caused by acrylate sensitization is increasing and this has important repercussions for both treatment and work. Dentists and dental technicians are the professionals most affected by ACD, followed by workers in the paints and coatings, printing, and fiberglass industries, and then by professional beauticians.[1-3] The prevalence of sensitization to acrylates among dentists and dental technicians ranges from 5% to 10%; prevalence is unknown for the other occupational groups mentioned and for end users of artificial nails.[1,4]

The only article published in Spanish on the subject of occupational sensitization to acrylates is that by Conde-Salazar et al,[5] which refers to ACD in dentists and dental technicians.

Sculptured nail kits typically contain the following items (Figure 4):

1. Metallized paper nail forms that are placed on the nail surface to shape the nail
2. A glue based on an acrylic monomer such as ethyl methacrylate or isobutyl methacrylate, and which also might contain hydroquinone
3. A powdered polymethylmethacrylate or polyethyl methacrylate polymer (or a copolymer composed of both), containing, as an initiator, benzoyl peroxide, and, as a stabilizer, resorcinol, eugenol, thymol, or, more commonly, hydroquinone or methyl ethyl hydroquinone. The polymer may also contain monomers such as methyl methacrylate and ethyl methacrylate.
4. A catalyst, typically N,N-dimethyl-*p*-toluidine (DMPT), to trigger the production of free radicals of benzoyl peroxide in the polymer powder
5. Plasticizers, such as tricresyl or phthalate phosphate
6. Solvents
7. Dyes.

The typical application procedure is as follows.[6,7]

The nail is soaped, brushed, cleaned with antiseptic and antifungal agents, and dried with a nail dehydrator based on diethyl ether. A metallized paper form is then applied to the nail, which is primed with a methacrylic acid solvent acting as a double-sided bond that adheres to both the natural nail and the acrylate. The DMPT catalyst is mixed with the acrylic polymer in powder form and this product is molded to the nail.

Allergic reactions to sculptured nails can appear within months or years after use by both professional users and end users. Symptoms of sensitization to acrylates in professional beauticians—generally women—consist of subacute or chronic eczema located on the pads of the fingers that come into direct contact with the acrylic resin.[8] Typically the finger pads of the first, second, and third finger of both hands are affected—the nondominant hand from holding the client's nail, and the dominant hand from holding the brush. Lesions also frequently occur on the sides of the hands where these rest on work surfaces is likely to carry monomer residues (Figure 5). Typical symptoms are pruritus, paresthesia, and pain once fissures develop.[9] Eczematous lesions frequently occur away from the site of contact as the result of transportation of residues of either the glue monomer or the powder polymer (which can also contain the monomer) by the hands to more distant areas of skin. The powder polymer can also be transported in the air, and nail filings frequently retain particles of the monomer, which does not react fully until after 48 hours.[10] Airborne particles deposited on the skin lead some patients to develop angioedema, rhinoconjunctivitis, and asthma symptoms. In our series, 3 patients (cases 3, 5 and 8) had allergic asthma symptoms and facial lesions that were likely to have developed—like the respiratory symptoms—as a consequence of particles transported in the air or on the hands.

The development of photoallergic contact dermatitis, contact urticaria, palmoplantar psoriasiform eruption, or lichenoid dermatitis of the hands is rarer.[8]

Symptoms in end users differ from those in professional users. The first sign is itchiness at the nail base, with paronychia, painful nails, and, occasionally, paresthesia subsequently developing. The nail base often becomes dry and thickened, and onycholysis is frequent.[11] The nail plate may show evidence of thinning, splitting, and discoloration. Once the cause has been eliminated, the nail takes months to recover, although permanent nail loss and intractable prolonged paresthesia are exceptional.[9] Distant ACD affecting the face and eyelids is probably caused by contact with hands or fingers carrying traces of the monomer.

Sculptured nails can cause other types of dermatitis apart from ACD. The initiator (methacrylic acid) is a powerful irritant capable of causing third-degree burns. If a nail becomes too thin, the initiator can penetrate the nail plate and be absorbed by the nail bed. In such cases, lye (sodium hydroxide) soap mixed with water is an excellent neutralizer. Irritant reactions to the monomer may also occur, presenting—with or without onycholysis—as a thickening of the keratin layer of the nail bed. Mechanical or traumatic dermatitis can also develop. Sculptured nails, with time, tend to become unattached at the sides, and so have to be reattached and reconstructed, as otherwise bacterial and fungal infections may develop. Artificial nails have to be filed around every 15 days; the leverage exerted by long nails may damage the natural nail and cause onycholysis, given that the bond between the natural and artificial nail is stronger than the adhesion of the nail plate to the nail bed. End users should not wear sculptured nails for more than 3 months at a time and should allow rest intervals of at least 1 month, as damage to the natural nail (typically, thinning and discoloration) frequently occurs—the result of poor maintenance and excessive filing using powerful abrasives.[6]

Other less complex nail enhancement methods include the use of preformed nails, nail wraps, and gel nails.[6]

Figure 4. Sculptured nail kit.

Figure 5. Lesions on the hand at the point of contact with the work surface.

Figure 6. Protective finger cut from a 4H glove.

Preformed nails are applied as entire nails or nail tips glued directly to the natural nail.

Nail wraps are used to repair nail plates that are split or cracked along their entire length. The wrap, which is made of paper, silk, linen, plastic, or fiberglass, is cut and shaped to fit the natural nail, and is then glued to the nail surface. Several layers of a transparent-fiber varnish with a high solid content are then applied. The glue used for preformed nails and the wrap is cyanoacrylate-based, and so may cause local and distant allergic reactions.

The liquid gel used for gel nails may include an acrylic or cyanoacrylate base. The gel is applied using a brush and is hardened (polymerized) using ultraviolet or visible light. Gel that is not polymerized in the powder or in filings may cause allergic reactions in body parts other than the fingers. As the gel hardens it shrinks by 20% and this may cause split nails, onycholysis, sharp pain, a feeling of tightness around the nail, or a sensation of heat in the nail plate.

Patients allergic to liquid acrylic monomer react strongly to patch tests for 1% to 5% monomer in petrolatum or olive oil. Koppula et al proposed the following 5 products as screens: ethyl acrylate, 2-hydroxy ethyl acrylate, ethylene glycol dimethacrylate, ethyl cyanoacrylate, and triethylene glycol diacrylate. The most frequently positive cross-reactivity pattern for the acrylates suggests that the carboxy ethyl functional group may be a requirement for ACD to develop.

Sensitization to cyanoacrylate does not prevent a person from wearing or working with sculptured nails containing other types of acrylates, as cross-reactivity does not occur.[11] The cyanoacrylate glue and the powder polymer may contain hydroquinone, benzoyl peroxide, eugenol, resorcinol, etc, and so it is advisable to conduct patch tests for these compounds.

Protection at work using face masks, suitable clothing, and 4H gloves (Safety 4 A/S, Lyngby, Denmark) are the most important measures for preventing primary and secondary contact. Note that latex, vinyl, polyethylene, and nitryl gloves afford no protection against these agents. The rigidity of 4H gloves hinders the performance of tasks that require dexterity (for example, nail shaping), and so these gloves are not widely used by beauticians. However, a suggested solution to this problem, and one we have found to be effective, is to wear fingers cut from the 4H gloves under more flexible gloves (Figure 6). Primary prevention is recommended as the best approach for this group of professionals.

Conflicts of Interest

The authors declare no conflicts of interest.

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