



The Present and Future Burden of Contact Dermatitis from Acrylates in Manicure

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Abstract

Purpose of Review (Meth)acrylates are chemical compounds used in a wide variety of settings such as nail esthetics and the medical field. A progressive increase in the frequency of acrylate-induced sensitization likely caused by the popularity and widespread use of semi-permanent polishes has been described.

Recent Findings Several factors contribute to such scenario including the insufficient training of beauticians regarding the risks posed by the manipulation of acrylate-based manicure materials, the fact that some consumers end up self-applying these products at home, and the poor training of the general dermatologist on the specific clinical features of contact allergy to acrylates in manicure products (often misdiagnosed as psoriasis and unnecessarily treated with immunosuppressants). Knowledge of the different techniques and materials used allows the clinician to understand the characteristics and distribution of the lesions. In some cases, sensitization to acrylates from manicure, a merely esthetic procedure, has been described to cause contact dermatitis to medical devices containing acrylates.

Summary Information regarding the risks, preventive measures, protection equipment, and training should be delivered to consumers and professionals respectively; the commercialization of these materials for the general public should be regulated and general dermatology practitioners trained to diagnose and manage these patients more efficiently.

Introduction

Acrylates and methacrylates, hereby referred to as (meth)acrylates, are formed by the spontaneous or ultraviolet (UV)-induced polymerization of monomers containing an acrylic acid-derived or methacrylic acid-derived acryl group (acrylates or methacrylates respectively) [1••]. Polymers result from the combination of monomers. (Meth)acrylic polymers are extremely versatile. Their presence is ubiquitous, being widely spread substances contained in an extensive scope of applications (Table 1).

(Meth)acrylic monomers are responsible for most of the allergic reactions due to (meth)acrylates. Their low molecular weight allows them to penetrate the skin, thus causing the sensitization and the allergic elicitation in already sensitized individuals. On the other hand, polymers are relatively inert high molecular weight compounds. However, residual traces of free monomers are always present in polymerized acrylates in the final products [2]. These free monomers are able to sensitize and to elicit allergic contact dermatitis reactions in previously sensitized patients [2].

Allergic contact dermatitis (ACD) from (meth)acrylates occurs classically at the occupational settings. Dental personnel (dentists and technicians), employees working in fiberglass, printing, glue [3•], or paint industries are perfect examples of professionals at risk of developing ACD due to acrylates.

Currently, the main sources of (meth)acrylate exposure are the products intended for manicure procedures both in professional and non-professional settings. Other sources described as well are feminine hygiene and incontinency pads [4, 5], dressings and

wound care products [6], dental materials, and medical devices among others [7•]. Unfortunately, the frequency of ACD from acrylates in all of these settings, and particularly, in manicure as well as in medical devices, has quickly increased in the last few years.

ACD from (meth)acrylates in nail cosmetics was originally reported in 1956. Initially, it was an uncommon but well-recognized condition involving the professionals building porcelain nails as well as their clients [8•]. In 2014, contact allergy to artificial nails was still infrequent [9], yet there were several cases of occupational contact dermatitis from acrylic nails in beauticians [10–12] and one case in a flamenco guitar player being reported [13]. More recently, the so-called semi-permanent or long-lasting nail polish became widespread and rapidly caused a fast increase in the number of allergies related to the nail beauty industry [14••]. Most of these cases are occupational but an increasing number of consumers have regrettably also been affected, therefore calling for stricter regulation and preventive measures. As isolated facial lesions may be overlooked, inclusion of acrylates in the baseline patch tests series may be warranted [15, 16].

We will review the most popular types of manicure techniques (Table 2) involving contact with acrylates as well as their adverse impact on both professionals and consumers, particularly stressing the topic of ACD and its potential long-term dramatic consequences. Recommendations regarding preventive methods are also reviewed.

Manicure techniques classification

In recent years, the different manicure techniques have been developed as an art and both nail technicians and consumers self-applying manicure products on themselves incorporate their personal touch in practices and styles. It is very frequent to combine different techniques and to use a diversity of materials and adornments (such as strass stones, purpurin, ribbons). To have in mind the variety of products and methods is key since the mechanism of the sensitization and the topographical distribution of the ACD lesions will depend on it.

Table 1. Acrylates sources

Medical sources	Dental sources	Esthetic and cosmetic sources	Household or personal items	Industrial sources
Surgical glues	Dentures	Acrylic manicure techniques (Table 2)	Glues	Adhesives
Wound dressings	Dental prostheses		Disposable diapers	Sealants
Adhesive tape	Restorations		Sanitary pads	Paints
Glucose sensors and insulin pumps	Fillings	False eyelash glues	Incontinence pads	Inks
Bone cement for arthroplasty	Crowns	Eyelash extension	Fitness devices	Printing plates
Orthopedic prostheses	Veneers	glue	Do-it-yourself water-based	Coatings for several items (paper, glass, rubber, leather, textiles, wood, etc.)
Intraocular contact lenses, contact lenses, and acrylic ocular prostheses.	Desensitizing dental swabs	Hair extension glue	decorative paints and corks	Fiberglass/insulators/lacquers/plastics
Disposable blue diathermy pads (conducting gel)	Orthodontic adhesive	Hair fixative of capillary prosthesis	Cleaning products (polishes, waxes, etc.)	Printing inks
Hearing aids	Occlusal splint			To repair windshields glass/window panes
Spectacle frames				Graphic industry
Transcutaneous electrical nerve stimulator (TENS) (conductive "hydro-pad" covering the electrodes)				Computer hard disks
Electrocardiogram electrodes (conductive gel)				Components of wood lacquers
Microporous biomaterials				
<i>N</i> -butyl-2-cyanoacrylate-base material for endovascular embolization of arteriovenous malformation				
Medical tissue adhesive for varicose veins and venous incompetence				
Polymethyl-methacrylate-based material for cranioplasty				

Nail polish (non-reconstructive techniques)

1. "Clasic varnish," "polish," or "lacquer" is a colored mixture of agents suspended in volatile solvents that is applied immediately on the nail plate with a brush. It dries on the nail plate by evaporation not requiring ultra-violet (UV) light. Three or four layers are usually applied (first and last coats are usually colorless and the coats in between are colored) [17]. Historically, the most frequent allergen in classical or traditional nail polish was tosylamide formaldehyde resin (TSFR). Its replacement by newer compounds caused new allergens such as phthalic anhydride glycol copolymers or adipic acid to emerge [18]. Regular lacquers do not usually contain (meth)acrylates. However, we found that some classical nail varnishes are

Table 2. Classification of acrylic manicure techniques and synonyms (syn)

Non-reconstructive (polish)	Classic nail varnish (syn.: nail polish, nail lacquer)
	Semi-permanent nail polish (syn.: long-lasting nail polish, curable nail lacquers, gel nail polish)
	Magnetic nail polish (syn.: effect 3D)
	Nail digital printing
	Powder nails (syn.: dipped nails)
Reconstructive (sculpture of the nail)	Acrylic nails (syn.: porcelain nails, sculptured nail)
	Gel nails (syn.: photobonded nails)
	Nail wrapping (syn.: silk nails)
Preformed nail	Preformed nail (syn.: press-on nail, fake nails, false nails, stick-on nails)

actually labeled to contain some (meth)acrylates. In 1995, Kanerva et al. described a consumer sensitized to methyl methacrylate contained in a traditional nail polish that was not labeled on the product but confirmed to be contained in it by chromatographical analysis [19].

2. "Semi-permanent" or "long-lasting" or "gel nail polish" is directly applied with a brush to the consumer's nail plate or as a finish on top of acrylic or gel nails like a traditional nail lacquer. At least, three layers are usually applied. The first and final layers ("base coat" and "top coat" respectively) are transparent while intermediate layers contain pigments responsible for the final color [14••]. All layers contain acrylates and, after application of each layer, exposure to a UV or LED source is required for polymerization. Each hardening step takes 2 min with UV lamps and only 30 s with an LED source. When the polish is applied to natural nails, it can be removed by soaking the nails (fingertips) in acetone for ~ 20 min. On the other hand, when the polish is applied on top of either "acrylic" or "gel" nails, it should be removed mechanically with a milling machine [20••]. A trained beautician is able to apply long-lasting nail polish in only 15–30 min. It is usually an inexpensive technique [14, 20].
3. "Magnetic nail polish" or "3D effect" is a type of varnish that actually contains metals and are sold along with a magnet reproducing a specific pattern. The magnet is used for a few seconds right after the polish is applied on top the nail, so the metal particles are attracted by it reproducing the same specific design. The light effect is "degraded" with unique three-dimensional visual effects. The metals contained in most magnetic varnishes are ferric ferrous oxide (Fe₃O₄) and other alloys, presenting excellent magnetic and cosmetic properties as well as low sensitizing potential. However, other metals with a higher risk for sensitization may be contained by this type of products without being declared and be able to induce a contact dermatitis reaction in sensitized individuals [20, 21]. The magnetic effect can be added to both the classical and the semi-permanent nail polish.
4. Digital nail printing requires a printer specifically designed to print images on either natural or fake nails. When it is applied on the natural nail, a

polish base coat is applied prior to printing the images. Then a white layer is applied acting as an ink absorber. The next step consists of printing the desired image with a printer, either a pre-design pattern or a photograph. Finally, a varnish top coat is applied. When the procedure is performed on natural nails, the image is printed on one nail at a time. Conversely, images can be printed simultaneously on several fake nails (even on 20 at a time). The printer has a tactile screen that allows the image to be adjusted to the size of each nail. The printer also includes a photo camera and a USB port. It can be used in combination with either classical or semi-permanent varnishes [20••].

5. "Powder nails" or "dipped nails" are another acrylate-based nail treatment. After the nail is prepared, a base polish coat is applied to the distal three-quarters of the nail plate and immediately the fingertip is dipped into a recipient with natural color powder. This type of polish is supposed to contain ethyl cyanoacrylate. The base polish is then applied to the entire nail, followed by a dip into the polish color of choice. This process is completed twice, followed by shaping and application of a top coat [22].

Reconstructive techniques (nail sculpture)

1. "Acrylic nails," "porcelain nails," or "sculptured nail" is built by mixing powder polymer and liquid monomer materials which are applied to the nail plate. The polymerization occurs in the presence of catalyst molecules and UV light is not required. The liquid monomer contain acrylates (such as ethyl methacrylate, isobutyl methacrylate), inhibitors to prevent spontaneous polymerization (hydroquinone), and accelerators (*N,N*-dimethyl-*p*-toluidine). The powder polymer contains acrylate polymers and an initiator (benzoyl peroxide) to start off polymerization when the two components are mixed [1, 12]. The basic steps to build acrylic nails are (1) a paper metallic form is applied under the hyponychium, (2) a primer that facilitates the adhesion is applied to the nail plate, and (3) a brush is submerged into the liquid monomer and then dipped into the powder polymer forming a "pearl"-like material that can be spread throughout the nail plate and the form. This way, an artificial nail is built at the desired length. At the end, it is milled and filed into any planned shape. The color may be in the powder and be steady or a colorless nail can be built and then varnished [23, 24]. In the latter, color can be changed often. As long as the nail grows, the space remaining between the cuticle and the acrylic nail is usually filled in on a regular basis [23].
2. "Gel nails" or "photo bonded" nails consist of a thick acrylic material that are applied to the nail plate needing UV light and photo-initiator (such as benzophenone) to polymerize. Each nail is made one at a time and exposed to the UV lamp and polymerized before making the next nail. Both acrylic and gel nails are designed to rebuild a damaged nail or to be made into a nail extension past the edge of the natural nail [23]. They are usually applied to create sculpted nails on a "form," which is removed at the end of the procedure, or on a plastic "tip" glued onto the nail plate with a cyanoacrylate-based glue. "Forms" and "tips" are clipped and filed into

shape before applying the acrylic material. It takes a trained professional 1–2 h to apply acrylic or gel nail manicures which is why the price is higher than semi-permanent nail polish [10•].

3. “Nail wrapping” or “silk nails” nails are built with a piece of silk which is applied to the nail plate requiring a lacquer to toughen it. Beauticians require significant experience to accomplish this technique making it less popular than others. Silk nails are excellent alternatives for the patients who become allergic to acrylic compounds [10•].

Preformed nails

“Preformed nails,” also called “Press-on,” “Fake,” “False,” or “Stick-on” nails, are pieces of plastic containing tricresyl ethyl phthalate that can be fixed to the natural nail with a cyanoacrylate-based glue. Some include an adhesive. It is a very easy technique to perform and is used by many consumers including teenagers who buy the “do-it-yourself” kits. They are inexpensive but only last for 2 or 3 days [23].

Prevalence

According to our experience, the prevalence of allergic contact dermatitis to acrylates in general and in nail esthetic materials in particular has increased progressively in the last few years. In a retrospective study performed in 4 hospitals across Spain, in a 3-year period (2013–2016), we found that 1.82% of our general patch tested population corresponded to patients sensitized to acrylates in manicure (mostly beauticians) [14••]. In a more recent research by 15 centers across Spain, the population sensitized to acrylates in 1-year period (2017–2018) was found to be 2.35% [25]. In this latter research, we performed patch tests on consecutive patients with HEMA as part of our screening series finding frequencies of sensitization to it in 3% [26]. Our results were higher than the figures shown by three other recent European independent researches in the UK, Italy, and Denmark detecting sensitization rates of 1.7%, 1.5%, and 2.4% (total tested population of 5920, 4025, and 1293) respectively [27–29]. Ten years before, 2790 Swedish and Singaporean patients were consecutively patch tested with 2-HEMA showing a 0.6% of sensitization [30]. These differences may reflect either an actual gradual increase in the sensitization rates or regional variations.

Clinical features

Allergic contact dermatitis

Nail polish (non-reconstructive technique)

Classic nail polish

Kanerva et al. identified the presence of methyl acrylate in a traditional nail polish (by means of chromatography) used by a patient who became

sensitize to it. Unfortunately, the clinical features of this interesting case were not described [19]. Traditional regular lacquers do not usually contain (meth)acrylates. However, we have evaluated the labels of several nail polishes (non-published observations), observing meth(acrylates), or photo-initiators disclosed in the labels of several varnishes of well-known brands. These photo-initiators would be of no purpose if polishes did not contain any (meth)acrylates. So, although it is not the most common scenario, we have to keep in mind that classical polishes may also contain (meth)acrylates. Additionally, since the application of a lamp is supposedly not required in the case of the classical polishes, the polymerization would likely not be completed thus likely leading to a higher risk of sensitization.

Semi-permanent nail polish

The clinical picture is variable and mainly depends on the subject involved. Thereby, nail technicians and consumers will exhibit different manifestations. Occasionally, nail technicians use the products on themselves and some consumers also apply the products on themselves and/or others at home [31]. In these common scenarios, a mixed clinical picture is expected. In the nail technician, the topographical distribution of the lesions is very characteristic and is justified by the way the product is applied. Lesions usually involve the fingertips (especially the first three or four fingers) with a more severe involvement of the dominant hand [14••]. In the acute phase, the lesions are very exudative and itchy, eventually evolving to a more chronic phase where the picture is dominated by a dry and fissured fingertip dermatitis with hyperkeratosis of the hyponychium [20••]. At this later stage, pain is the prevailing symptom. The lesions involving the hands are produced by a direct contact with the acrylic based polish (Fig. 1). Many technicians remove any excess of the product with the dominant hand while holding the brush. At this point in time, the product is fresh and fluid and acrylates are at a non-polymerized state and hence highly sensitizing [20••]. Half of the cases can develop lesions involving other locations within the hands (other than the fingers), such as the dorsal aspect of the non-dominant hand and particularly on the first knuckle (areas used by the professionals to rub the excess of the product off their fingertip) (Fig. 2). Other locations often involved are the face, eyelids, cheeks, and mandibular area. The distribution of the lesions on these areas may be explained by a passive transfer through the fingers or contaminated objects (cell phone) and, to a lesser degree, by airborne means. The neck may also be affected through the same mechanisms causing the facial lesions. The forearms are also very often involved due to the habit of leaning on contaminated work surfaces. Lesions on the thighs and abdomen can also be observed and are related to accidental spillages of the polish [20••]. Additionally, many patients occasionally refer to mild paresthesia or diminution of the finger's sensitivity. In almost all technicians, a certain degree of nail dystrophy is observed including onycholysis, subungual hyperkeratosis, and/or splinter hemorrhages [14, 20]. Less often, allergic contact dermatitis from acrylates in semi-permanent nail polish can be associated with eyelid or lip edema and/or upper respiratory tract symptomatology [14••].



Fig. 1. Characteristic lesions of the chronic phase of ACD to acrylates in semi-permanent nail polish. They consist of a dry fissured fingertip dermatitis involving the first fingers of the dominant hand. These most affected areas are due to the way the professional holds the brush and are circumscribed to the areas the skin contacts with the brush and gets stained by the fresh polish.



Fig. 2. Dermatitis involving the dorsal aspect of the hand and first finger of the non-dominant hand where the patient rubbed off the excess of the fresh polish. She used her naked fingertips instead of using the orange wood stick, thus directly contacting the fresh monomers-full polish.

Regarding the consumers, there are two situations: the person attending a salon and having the product applied by professionals and the person who self-applies the product at home. In those who attend the beauty salon, the most frequent involved locations are the periungual area and the fingertips and to a lesser extent, the face (eyelids and lips) and neck. Occasionally, an ectopic contact cheilitis with labial edema predominates being the periungual lesions so subtle that the diagnosis may be very difficult [32]. The users who self-apply the products at home (thus becoming “domestic” nail technicians) develop much more intense and spread lesions, involving not only the hands but many other locations. These patients sometimes buy kits marketed for domestic use and on other occasions, products intended to be used by professionals only, but are available to purchase online without any restrictions [33••].

Regarding nail technicians, the diagnosis usually does not pose many difficulties since, very often, the patients attribute their symptoms to the manipulation of the manicure products. Concerning the consumers, very frequently, the diagnosis is more challenging, since they do not suspect the manicure products and even express an attitude of denial [33••]. If the suspicion is low or the physician is not too knowledgeable on the topic, mistaken diagnosis can likely be made.

In 2012, severe pseudo-leukonychia, *onychoschizia lamellina* (lamellar splitting) and thinning of the nail plate from gel nail polish, was first described. In this research, measurements of the nail plate prior to and after the application of the gel were performed by means of ultrasound and reflectance confocal microscopy [34]. These alterations can easily be misdiagnosed and treated as nail psoriasis for months. We have recently dealt with two cases involving users of long-lasting nail polish previously diagnosed mistakenly as ungual psoriasis and treated with systemic drugs for more than 1 year. After the diagnosis of ACD was made and avoidance measures taken, both cases slowly resolved. The resolution of the nail alterations may take many months in some cases. Clinical presentation with multiple splinter hemorrhages without dermatitis suggesting a systematic illness and making the patient undergo several unnecessary tests has also been published [35]. On the other hand, true psoriasis has been described to be also induced by allergic contact dermatitis in artificial nails [36].

Pterygium inversum unguis has also been published as a secondary complication of acrylates allergy from acrylic nails during the past 10 years [37]. A woman who never complained of dermatitis presented with a painful vascular-appearing lesion suggestive of pyogenic granuloma involving the subungual area. The patient did not relate their symptoms to the use of the long-lasting nail polish-kits-for-home use. Eventually, patch tests confirmed sensitization from acrylates causing the clinical features that were so difficult to diagnose initially [33••].

Regarding the cutaneous lesions, a wrong diagnosis of lupus has been made on a patient with allergic contact dermatitis from acrylates in different manicure products who received immunosuppressants for a long period of time [38].

Airborne allergic contact dermatitis without hand involvement was described in a beautician. Periorbital, facial dermatitis, and asthma occurred

whenever she used the nail drill machine to remove the preexisting nail manicure [39].

Lately, some cases involving children have been reported. A 11-year-old girl developed hand eczema from “playing” with acrylic manicure materials belonging to her mother who was herself a professional beautician [40]. Another case involving a 10-year-old girl who presented with vesicular and bullous lesions on her fingertips after applying her mother’s long-lasting nail polish over a 4-month period was also published [41].

Digital nail printing

To the best of our knowledge, we are not aware of any ACD cases due to digital nail printing. The procedure can be performed on both classical and semi-permanent polish. The reason why there are not reported cases in relation to this technique is probably due to the fact that it is not very widespread and possibly there is a lower sensitization risk linked to the mechanized application process (less manual).

Magnetic nails

One case of ACD to metals in magnetic polishes has been described [21]. We are not aware of any cases of sensitization to acrylates in this particular source.

Reconstructive techniques

Acrylic nails

The first case of ACD to methacrylates in manicure procedures was described in the 1950s in relation to this technique [8•]. Lesions are very similar to the lesions caused by semi-permanent nail polish. Ectopic lesions have also been described. A severe nail dystrophy, with onycholysis, and permanent loss of fingernails have also been described from acrylic nails [42, 43]. Another side effect of sculptured nails is severe and prolonged paresthesia first described by Fisher. His paper was followed by many others describing different degrees of paresthesia and ungual alterations [44]. A specific trait of acrylic nails is that the airborne mechanism seems to be more prominent due to the powder component. Besides, drills are used in the modeling of the nails increasing the spreading of the particles into the air. Semi-permanent nail polish is normally used in combination with acrylic nails (on top of them) and a lathe is used to remove them (instead of acetone which would damage the reconstruction of the acrylic nail) further contributing to the airborne extension.

Gel nails, nail wrapping, and preformed nails

Clinical features of allergic contact dermatitis from these other techniques are similar to the ones described for acrylic nails and semi-permanent polish. It has been described that gel nails and preformed nails induce

dermatitis causing lichen planus-like changes of the nail plate [45]. Contact dermatitis from gel nails can impact fitness for work and lead to sick leave. An office worker suffering from severe fingertip dermatitis and onychodystrophy from preformed nails went on sick leave for many months before the cause could be uncovered [46].

Urticarial lesions

We dealt with a case involving a nail beautician who, after a long workday applying acrylic nails to several clients, developed generalized lesions compatible with acute urticaria and requiring assistance in the emergency room. The lesions were successfully treated with corticosteroids and antihistamines. Another nail beautician with a personal history of angioedema lasting 6 months developed hand eczema that eventually was diagnosed as ACD from acrylates in manicure products [14••]. A gel nails user who suffered from spontaneous chronic urticaria lasting 18 months developed ACD from acrylates. After avoiding contact with acrylates in manicures, the resolution of both processes (urticaria and ACD) was observed. The lesions of urticaria have been previously treated with conventional therapy without success [47].

Lymphomatoid papulosis-like contact reactions

A case of ACD induced by acrylates in a gel nails user mimicking lymphomatoid papulosis clinically (asymptomatic papular lesions in the upper eyelid) and histologically was published. Lesions cleared completely after avoiding contact with acrylate-containing substances [48].

Leukoderma

Acquired leukoderma involving the fingers has been described in a patient sensitized to acrylates after repeated episodes of acute dermatitis on the fingertips [49, 50].

Lichen planus

A patient who developed dermatitis upon the use of acrylate fingernails and exposure to paint dust, followed by oral painful lesions of erosive lichen planus caused by acrylate-based dental fillings, was reported [51].

Asthma

Some cases of rhino-conjunctivitis and asthma challenge have been reported from various acrylate compounds cyanoacrylates and (meth)acrylates [52–54].

Recently, in a wide multicenter research, it was concluded that acrylate-induced occupational asthma shows specific characteristics and is usually concomitant with work-related rhinitis symptoms, suggesting that acrylates may induce asthma through different immunologic mechanisms [55].

Diagnostic procedures

Regarding the diagnosis, patch tests with a specific artificial nail series must be performed. HPMA (hydroxypropyl methacrylate), HEMA (hydroxyethyl methacrylate), and THFMA (tetrahydrofurfuryl methacrylate) have been found to be

responsible for most cases of sensitization to acrylates in this context. In some countries, HEMA has been included in the national baseline series after the epidemic of contact dermatitis to semi-permanent nail polish was revealed. HEMA seems to be a good screening acrylate allergy marker.

It is very important to remember that acrylates must be loaded immediately before the patch tests application to avoid a loss of volume due to evaporation. If they are loaded too long ahead of time or if they are left unrefrigerated, false negative results of the patch tests can be obtained [56].

In sensitized patients, multiple and intense positive patch tests reactions are usually observed. Intensity usually varies from intense (2+) to strong (3+). *Angry back* type reactions and acquired leukoderma have been described as adverse reactions of the tests [14••] (Fig. 3).

Multiple positive reactions may likely be due to several reasons including a high degree of cross-reactivity for (meth)acrylates [6, 57], possible contamination of the manicure materials with other acrylates during the manufacturing process [1••], or the presence of multiple (meth)acrylates in the final products [14••]. Acquired leukoderma after patch testing with commercially available acrylates has been described as well [14, 58–61].

It is not advisable to apply the original manicure undiluted products *as is* due to their high potential for active sensitization and toxicity. According to the literature, it is recommended that late patch tests readings (on day 7, D7) are performed. However, in our experience, reactions are noticeable and intense on the first readings performed at D2 in almost all cases.

Regarding the consumers, the symptoms are not always recalled by the patients. Some of them do not relate the lesions to the exposure to the semi-permanent nail polish materials. It is very important that the dermatologist takes the diagnosis of acrylates contact dermatitis into consideration whenever dealing with female patients having eczemas on their fingertips, periungual skin, and face with or without other locations involved. The interrogatory must include questions regarding the possibility of a temporal relationship to exposure to manicure products with acrylates. The clinical suspicion must be confirmed with patch tests in the same way as in the nail technicians. Acrylate allergy may present with unusual symptoms, and adequate patient evaluation is crucial.

Therapy

Allergic contact dermatitis to acrylates in acrylic manicure products generally respond to topical and/or oral corticosteroid treatment. However, the definitive treatment for ACD consists of the strict avoidance of culprit allergens. Therefore, the instructions on the avoidance of the allergen are vital in order to achieve a complete and lasting recovery (Tables 3 and 4).

Prevention

Primary prevention

Most nail technicians lack an adequate training on the risks that acrylates in nail esthetic procedures pose. Many do not know about the risk for sensitization of semi-permanent polishes and manage the products as if they were the same as

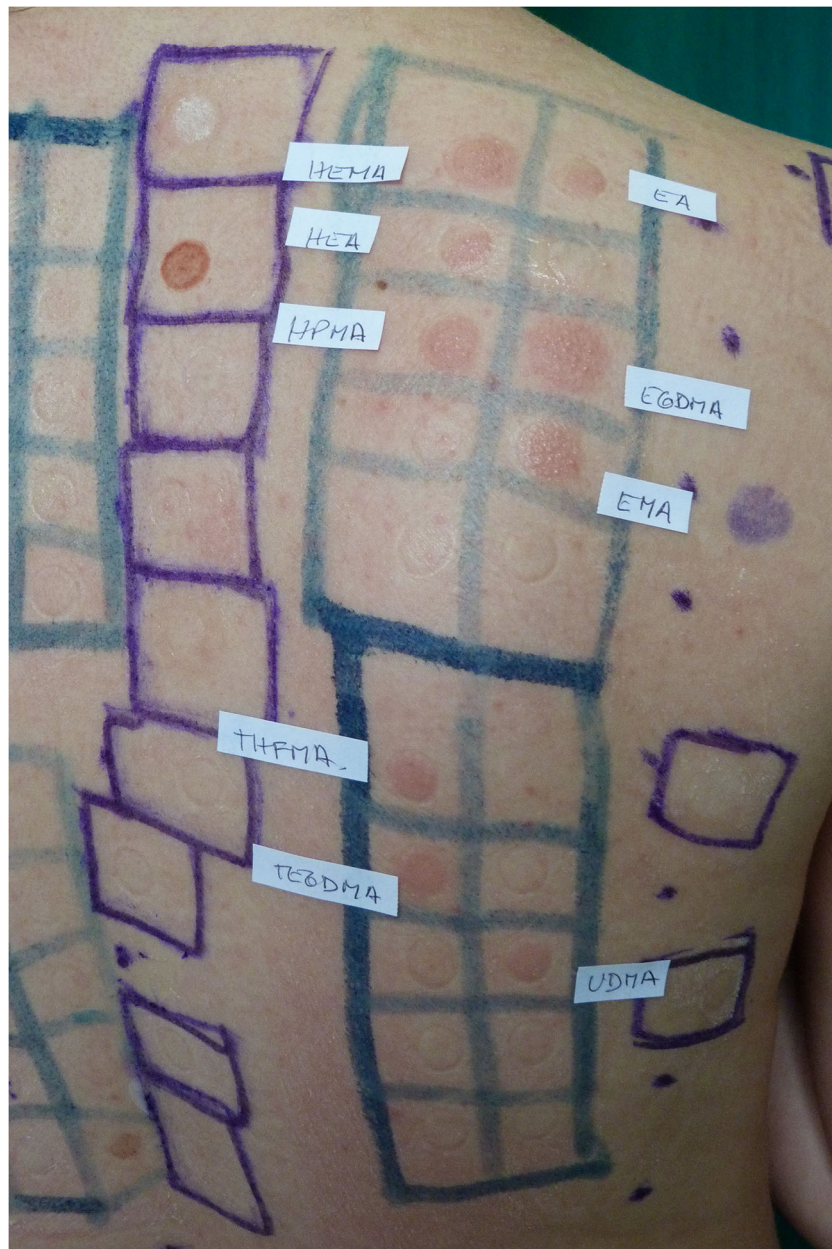


Fig. 3. Multiple and strong reactions to the (meth)acrylates series patch tests.

traditional varnishes without wearing any type of gloves and without using appropriate materials such as the orange wood stick. Primary prevention should be addressed by professional nail technicians. As in any other business or industries where acrylates are manipulated by the workers, nail technicians should be appropriately trained in the risks these materials pose [20••]. If this can be done, the consumers will indirectly also be protected. Consumers should be able to be familiar with the risks of the exposure as well as the potential

repercussions so they are free to choose. Unfortunately, sometimes in the manicure salons, the protection measures are purposely avoided so the client does not have the impression that the manicure is a hazardous procedure. The need for use of gloves, masks, and other protection equipment should be mandatory and responsibility of the companies. Workers should be provided with this equipment by their employers. The consumer should understand that by using this equipment the professional beauticians are not only protecting themselves but also their customers.

These measures could be implemented in different ways such as labor risk training courses aimed at beauticians, inspections of the salons to monitor the compliance with the protection measures as well as the hygiene, and the technical maintenance of the lamps. A document on informed consent to be signed by the consumers (in a similar way to when consumers are subjected to laser hair removal procedures) so they are well informed of the side effects and potential future repercussions could also be helpful.

It is well known that latex and vinyl gloves are rapidly permeated by MMA. It is recommended that professionals wear a double layer of nitrile gloves for tasks lasting 15 to 30 min [1••]. The use of polyethylene/ethylene vinyl alcohol Silver Shield/4H™ gloves fingerstalls and nitrile gloves on top to keep them in place is recommended [12, 14] (Fig. 4).

Secondary prevention

Allergic beauticians who want to continue their job as before should be advised to comply with *non-touch* techniques and to wear 4H gloves or fingerstalls.

Table 3. Preventive recommendations for both non-sensitized and sensitized beauticians (primary and secondary prevention respectively)

1. Not to touch the polish when it is fresh ("non-touch" technique).
2. To avoid contact with workplace products containing it or are contaminated by it. To work "as in a surgery room" keeping the "contaminated" products in the workplace.
3. To avoid the contamination by keeping out of the workplace all the objects that will be touch later such as the cell phone, drinks, and door knobs.
4. To change the cloth covering the worksurfaces with every client.
5. The lathes, drills, orange wood stick, and all the tools used to perform the manicure should not be used later to perform a classical manicure since they may remain contaminated by acrylates and expose both the manicurist and the next clients.
6. To make sure the acrylate polymerization is correct. The client's hands must be exposed the appropriate time to the UV-light and all the fingernails should be exposed. The whole hand should be placed under the lamp and then the first finger by itself. Otherwise, the external aspect of the first finger will be left outside and polymerization may be partial exposing the consumer to the sensitizing monomer particles. The technical maintenance of the lamp should be updated. The lamps should be periodically renovated.
7. The hands should be protected with gloves type Silver Shield 4H® (Honeywell Safety Products EMEA, Roissy, France). Fingerstalls can be cut off the gloves to cover the most exposed fingers. These gloves are purchased in stores specialized on workers individual protection equipment. Nitrile gloves can be used on top to keep the fingerstalls on place. Nitrile gloves should be changed with every client and 4H fingerstalls can be reused.
8. Alternatively, a double layer of nitrile gloves for tasks lasting 15 to 30 min can be considered.
9. It is also recommendable that the beautician uses protection masks and glasses.
10. To remind the beautician that the compliance with adequate hygiene and protection measures will positively impact the image of the beauty salon and will build customer's trust and not the opposite.

Table 4. Preventive recommendations for both sensitized beauticians and customers

1. To avoid manicure procedures involving contact with the acrylate molecules the patient is sensitized to. All techniques (except for “nail wrapping” and “preformed nails”) contain the same type of acrylates or acrylates that cross-react with the others. “Nail wrapping” and “preformed nail” contain cyanoacrylates which do not show cross-reactions with acrylates used in other techniques.
2. Classical polishes are usually safe although reading the labels is recommendable.
3. To avoid other esthetic procedures involving exposure to acrylates such as eyelash extensions or fake eyelashes, hair extensions, or wigs.
4. To have in mind other sources of acrylates, especially in the medical field such as white dental fillings. It is recommendable to advice the dentist so the operations are as clean as possible preventing the material to contact with the oral mucosa, adequately polymerizing the materials with the lamp and profusely rinsing them off with water [62]. If materials such as dental sleeves, prosthesis or splints are necessary, the polymerization processes should be completed before their use or application [63]
 - a. To remind the doctors of the acrylate’s allergy in case a medical device or prosthesis are needed. Occasionally, acrylates-free alternatives or methods to guarantee a correct polymerization are available [63, 64].
5. To consider other acrylate sources in the occupational setting. If the individual plans on changing jobs, it is recommendable to contact the risk prevention personnel of the company to evaluate the risks related to the new position as well as to consult the technical and safety files of all the materials that will be manipulated.

Alternatively, they could wear nitrile gloves that have to be changed at least every 30 min.

Most sensitized beauticians could go on working without developing symptoms as long as they adequately protect themselves as described in Table 3.

However, some of them have to give up their jobs. Spending time to inform the sensitized beauticians about the presence of these hazardous chemicals in other workplaces should be considered. A beautician gave up her job on account of suffering from ACD so she started to work as a dental nurse. Soon after re-exposure to acrylates in dental materials, she experienced recurrence of the skin symptoms [65].

Both beauticians and consumers should be advised against the exposure to acrylates in manicure procedures with the exception of fake or wrapping nails [10•]. The latter techniques involve contact with cyanoacrylate-based adhesives which do not show cross reactions with other acrylates. Alternatively, they can use classical polishes. Information on other sources and uses of acrylates should also be provided especially in a medical setting (dental fillings, prosthesis, endovascular procedure materials, adhesives, etc.).

Potential problems with other sources of acrylates

The main concern related to becoming allergic to (meth)acrylates is that any object containing these materials poses a potential risk to trigger reactions in sensitized individuals and acrylates are widespread in many sectors including the medical field.

The frequency of ACD to acrylates in the medical devices is increasing, in parallel with the growing use of acrylate-based medical materials. A few years ago, most contact allergies from acrylates in medical devices were due to surgical glues involving mild to severe reactions affecting patients of all ages, many of



Fig. 4. The image shows how to prepare and wear the Shield 4H® (Honeywell Safety Products EMEA, Roissy, Francia) gloves fingerstalls and how to keep them in place by wearing a nitrile glove on top. The 4H® fingerstalls could be reused but the nitrile gloves should be changed with every client.

them following orthopedic surgeries [66, 67]. However, recently, glucose sensors and insulin pumps have emerged as frequent and significant sources of sensitization. First cases related to glucose sensors were published in 2016 and thus far, more than 20 publications showing more than 150 cases have been described. Some of them had personal histories of periungual eczemas secondary to gel and artificial nails [7•].

Reactions from acrylic dental materials and severe complaints from them have also been described involving both beauticians and consumers previously sensitized to acrylates in nail esthetic procedures [68].

ACD due to 2-HEMA present in dental swabs for professional use in a patient previously sensitized to acrylates in acrylic nails has been described [69].

Patients previously sensitized to acrylates from the exposure to semi-permanent polish have been described to eventually show a variety of oral symptoms triggered by dental procedures [14••]. Acrylates have also been implicated in oral lichen planus [70].

The sensitization to acrylates in nail esthetic procedures has also been published to jeopardize traumatological operations with time. The acrylic bone cement contains the same materials as acrylic nails. A female patient with a personal history of acrylate ACD due to manicure materials occurring 4 years prior to a left knee replacement operation, developed aseptic loosening of the prosthesis likely related to her previous sensitization. A cement-less prosthesis without acrylates needed to be inserted [71].

In theory, the sensitization to acrylates in a merely esthetic procedure such as manicure could jeopardize any future medical intervention involving materials with acrylates. The presence of acrylates has been described in a large variety of sources in the medical field and sensitized patients should be appropriately trained to avoid them whenever possible and report any possible reactions to any of them.

These sources include among others: wound dressings (causing ACD to (meth)acrylates enhanced by local inflammation, reduced skin barrier function and occlusive bandages) [6, 72]; oral splints (causing oral lesions from insufficiently polymerized splints) [63]; ECG electrodes (causing contact dermatitis likely due to acrylate compounds such as acrylic acid, isobornyl acrylate, 2-HEMA, EA, etc.) [73]; transdermal therapeutic systems used to administer different drugs (causing ACD to (meth)acrylates such as 2-ethylhexyl acrylate) [74]; transcutaneous electrical nervous stimulation used to treat lumbago (causing ACD to acrylic acid in the electrodes) [75]; medical adhesives with n-butyl-2-cyanoacrylate used to treat chronic venous insufficiency through endovascular embolization (such as VenaSeal) (reported to cause ACD along the treated veins [76] as well as systemic contact dermatitis) [77]; materials used for adjuvant embolization of arteriovenous malformations with *N*-butyl cyanoacrylate (causing urticarial reactions) [78]; hearing aids (causing ACD to different (meth)acrylates) [79–81]; cranioplasty material with polymethylmethacrylate (causing extreme headache and eosinophilia) [82]; acrylic ocular prosthesis [64]; among many other.

Unfortunately, the cases of ACD continue increasing and it is very difficult to determine the etiology since manufacturers of medical devices often do not cooperate by providing information regarding the composition. It is likely that an allergy acquired from the manicure acrylic products may jeopardize the future use of any of these products.

Other causes of acrylate allergy in the esthetic and cosmetic fields include hair fixative of capillary prosthesis [83] and false eyelash glue (containing cyanoacrylates) [84].

Cosmetics contain polymeric acrylates which are very unlikely to cause allergies, due to their high molecular weight. However, residual monomers may still be present in creams in concentrations sufficient to cause sensitization and elicitation of contact allergic reactions in sensitized patients. There is one reported case regarding “anti-cellulite”/“intense firming” creams containing a copolymer with HEA and probably causing sensitization from HEA monomer in a patient [85]. Additionally, a cream type moisturizing pack applied at a beauty salon containing HEA triggered a facial dermatitis on the first treatment in a patient previously sensitized to it from her hobby consisting of making earrings and necklaces [86].

In the industrial setting, the variety of sources of acrylates able to induce contact dermatitis are wide and would exceed the purpose of this chapter. However, we should always try to advise our beautician-sensitized patients against choosing work activities requiring contact with acrylates whenever they are planning changing jobs.

Conclusion

Sensitization to acrylates is increasing due to the popularity and widespread use of semi-permanent polishes. Allergic contact dermatitis to these products as well as to other acrylate-based manicure materials is frequent and fairly specific. The involvement of the fingertips and hyponychium is characteristic and usually lesions are dry, hyperkeratotic, and reminiscent of psoriasis. This is the norm and not the exception. Unfortunately, many general dermatologists who are not familiar with this process often misdiagnose it as psoriasis and puts the patient under unnecessary immunosuppressive treatment. It is worrisome that

the use of acrylate-based manicure materials by young consumers may eventually jeopardize the use of medical devices containing acrylates. We hereby show some published articles regarding cases who, after been sensitized to acrylates from manicure, developed reactions to different medical devices.

In our opinion, only beauticians adequately trained and provided with individual protection equipment should be able to apply these products, the consumer should be informed on the risks posed by these materials before the procedure, and dermatology practitioners should be trained to recognize the typical clinical picture.

Compliance with Ethical Standards

Conflict of Interest

María-Elena Gatica-Ortega declares that she has no conflict of interest and María-Antonia Pastor-Nieto declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

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