

# Contact Sensitization to Allergens in Nail Cosmetics

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**Ingredients found in the nail cosmetic industry, including but not limited to methacrylate and acrylate monomers, formaldehyde, and toluene sulfonamide-formaldehyde resin, can incite allergic contact dermatitis. An eczematous outbreak presents on areas surrounding the nail plate and may spread through contact transfer of the allergen, commonly to the face and neck. Even components that were originally deemed nonsensitizing, such as the ubiquitous cyanoacrylate adhesive family, have been found to be allergenic. They do not, however, cross-react with methacrylates and acrylates. Alternative options for individuals with allergic contact dermatitis reactions to these ingredients can be avoidance of these procedures or use of products that are “3, 4, 5 free” in which the common allergens dibutyl phthalate, toluene, and formaldehyde are absent. In cases where strengthening of the nail is the sole purpose, nail wraps or preformed nails can be applied for non-cyanoacrylate-sensitive individuals.**

Contact dermatitis, characterized by acute erythema, pruritus, and vesiculation, can occur because of interactions with external compounds.<sup>1,2</sup> There are 2 subcategories of contact dermatitis: allergic contact dermatitis (ACD), which accounts for approximately 20% of cases, and irritant contact dermatitis (ICD), which makes up the remaining 80%.

The relationship between cosmetics exposure and onset of ACD has been well documented for more than 50 years.<sup>3–5</sup> Sensitization to nail cosmetics leads to ACD on areas such as the proximal nail fold, eponychium (cuticle), paronychia (lateral nail folds), and hyponychium, along with the neck and face (Fig. 1).<sup>6,7</sup> A 1987 study demonstrated that 4.2% of patients with contact dermatitis experienced an allergic reaction to cosmetic products, with approximately 8% of those cases attributed to nail cosmetics.<sup>8</sup> With the nail service industry expanding from \$7.30 billion in 2011 to \$8.54 billion in 2015, the burden of nail cosmetic-related ACD has grown.<sup>9,10</sup> Two retrospective studies, one from 2008 to 2014 and another between 2004 and 2013, revealed a significant increase in consumer and occupational cases of ACD due to nail cosmetics.<sup>11,12</sup>

## CLINICAL PRESENTATION AND SEVERE REACTIONS

Patients with nail cosmetic-related ACD present with proximal nail fold, hyponychial or paronychia tenderness, edema, erythema, and paresthesia. Severe nail abnormalities associated with the use of acrylic and gel manicures include paronychia, thickened and dry nail plates, onycholysis, and, in extreme cases, nail loss (Fig. 2). Lip edema, cheilitis, and other ectopic dermatitis of the mouth, chin, neck, and eyelids occur in 80% of cases.<sup>6,13,14</sup> Additional characteristics include discoloration of the nail plate.<sup>15</sup>

Nail technicians, who experience occupational contact dermatitis due to chronic nail cosmetic exposure, often present with subacute or chronic eczema on the pads of the pollex and second and third digits of the nondominant hand, where the client's nail is held. The sides of the hand may be afflicted because of contact with work surfaces that carry residues of allergenic compounds.<sup>15,16</sup> Airborne particles from nail filings can deposit on various areas of the skin and the respiratory system leading to asthma symptoms and facial lesions.<sup>17</sup>

## DIAGNOSIS

A contact dermatitis diagnosis is synthesized through patient history and physical examination and confirmed by patch testing (Fig. 3).<sup>18</sup> With a sensitivity and specificity of approximately 70% to 80%, patch testing is the standard for determining causative allergens in ACD.<sup>19</sup> A prevalent commercial patch-test kit is the 3-panel, 36-antigen T.R.U.E. (Thin-Layer Rapid Use Epicutaneous) Test.<sup>20</sup> However, the T.R.U.E. Test does not include many of the antigens found in personal cosmetic products and should be supplemented with diluted allergens for customized patch testing.<sup>21</sup> Up to 10% of patients with ACD have a positive patch test for

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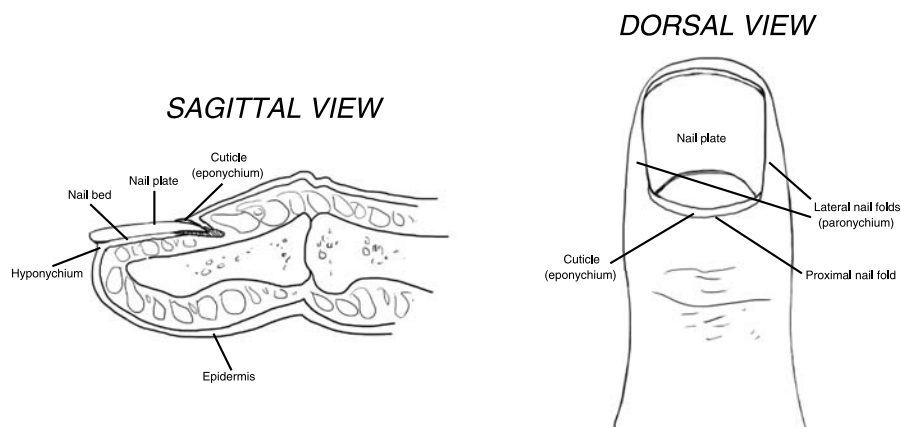


**Figure 1.** Anatomy of the nail.

cosmetic products or their ingredients, justifying the inclusion of nail cosmetic allergens in testing (Table 1).<sup>28</sup>

## EPIDEMIOLOGY

It is projected that 1% to 3% of the population is sensitized to ingredients found within nail polish.<sup>3</sup> Contact dermatitis is seen twice as often in women as men, and most individuals who frequent nail salons are women between the ages of 26 and 46 years.<sup>29,30</sup>

Occupational contact dermatitis is also prevalent and often underreported, with an annual incidence of 0.5% to 1.9%.<sup>31,32</sup> Sixty-four percent of occupational ACD and 80% of occupational ICD cases presented on the hands.<sup>33</sup> With 404,154 active nail technician licenses in the United States, ACD due to nail salon procedures in professional beauticians is not unusual.<sup>30</sup>

## COMMON SALON PROCEDURES AND RELATED ALLERGENS

The 2 most common manicure services provided in nail salons across the United States are gel and regular manicures.<sup>34</sup> Although regular manicures are purely aesthetic, gel or acrylic procedures may additionally strengthen the nail (Table 2).



**Figure 2.** Nail onycholysis due to acrylate allergy.

## Regular Manicure

Main steps in a regular manicure involve layering base, color, and top nail polish coats on the surface of the nail. This process requires compounds for film formation, resins, plasticizers, and solvents, comprising many known allergenic chemicals (Table 3). Allergic contact dermatitis is primarily associated with exposure to liquid nail polish; however, a minority of patients react to toluene sulfonamide-formaldehyde resin (TSFR) and residual, unpolymerized methacrylate and acrylate monomers ([meth]acrylate) found in dried enamel.<sup>35</sup> Key ACD-associated ingredients are discussed hereinafter.

Benzophenone, an additive to regular and gel nail polish, protects cosmetic products by absorbing UV light. It is linked to cases of ectopic allergic contact and photocontact dermatitis, often presenting on the eyelid and neck.<sup>36,37</sup>

Dibutyl phthalate (DBP), a plasticizer that increases nail polish flexibility, has also been linked to ACD.<sup>38</sup> Furthermore, it is an environmental endocrine disruptor known to interfere with male reproductive development in animal models if present in utero.<sup>39,40</sup>



**Figure 3.** Acrylate patch test with 2-HEMA 2.0% pet, EA 0.1% pet, TSFR 10.0% pet, and MMA 2.0% pet. At 72 hours, the reading identified a positive reaction to 2-HEMA, EA, and MMA. The patch test for TSFR was negative (pet, petrolatum). Courtesy of Drs Vincent DeLeo and Anthoni Rossi.

**TABLE 1. Probable Allergens Found in Nail Cosmetics and Their Patch-Testing Protocol**

| Nail Cosmetic           | Probable Allergen                                                  | Patch Test                                       | Patch Test Series          |
|-------------------------|--------------------------------------------------------------------|--------------------------------------------------|----------------------------|
| Cuticle softener        | Potassium or sodium hydroxide                                      | 0.5% in aqueous solution <sup>22</sup>           | None                       |
| Nail polish             | Benzophenone                                                       | 10% in petrolatum <sup>23</sup>                  | ACDS, NACDG                |
|                         | DBP                                                                | 5% in petrolatum <sup>24</sup>                   | None                       |
|                         | Formaldehyde                                                       | 1% in aqueous solution <sup>25</sup>             | T.R.U.E. Test, ACDS, NACDG |
|                         | TSFR                                                               | 10% in petrolatum <sup>3</sup>                   | ACDS, NACDG                |
|                         | Tosylamide epoxy resin*                                            | 1% petrolatum                                    | T.R.U.E. Test, ACDS, NACDG |
|                         | Ethyl and butyl acetate                                            | 10% in petrolatum <sup>25</sup>                  | None                       |
| Nail polish remover     | Acetone                                                            | 10% in olive oil <sup>25</sup>                   | None                       |
| Glue                    | ECA                                                                | 10% in petrolatum <sup>26</sup>                  | ACDS                       |
| Acrylic and gel systems | Methacrylate monomers (2-HEMA, 2-HPMA, EGDMA, EMA, MMA, and THFMA) | 1%–5% in petrolatum or olive oil <sup>26</sup>   | ACDS, NACDG                |
|                         | Acrylate monomers (2-HEA, 2-EHA, 2-HPA, EA, and TREGDA)            | 0.1%–5% in petrolatum or olive oil <sup>26</sup> | ACDS, NACDG                |
|                         | HQ                                                                 | 2% in petrolatum <sup>27</sup>                   | None                       |
|                         | Benzoyl peroxide                                                   | 10% in petrolatum <sup>27</sup>                  | None                       |
|                         |                                                                    |                                                  |                            |

The T.R.U.E. Test contains 36 allergens. The NACDG core series contains 70 allergens. The ACDS (American Contact Dermatitis Society) core series contains 80 allergens.

\*Tested as epoxy resin.

Free formaldehyde is a common nail hardener and associated with ACD.<sup>41,42</sup> It is the main active ingredient in nail-strengthening products, found as formalin or its hydration product, methylene glycol.

Tosylamide/formaldehyde resin, also known as TSFR, accounts for most ACD cases related to nail polish and is the seventh most common ACD-associated cosmetic allergen overall.<sup>43,44</sup> Data compiled by the North American Contact Dermatitis Group (NACDG) revealed that 4% of all positive patch tests resulted from TSFR sensitivity. Toluene sulfonamide-formaldehyde resin may be a particularly potent allergen because its chemical structure does not change between the liquid and dried states. Toluene sulfonamide-formaldehyde resin in dry polish may continue to sensitize locally, as well as produce ectopic ACD.<sup>41</sup> Many nail polish brands now use tosylamide epoxy resin in place of TSFR; however, this substitute is also a sensitizing agent.<sup>45</sup>

Reactions to solvents such as ethyl acetate and isopropyl alcohol, although rare, have also been reported.<sup>46,47</sup> A recent 2011 study revealed that isopropyl alcohol allergies may be more pervasive than expected.<sup>48</sup>

Finally, (meth)acrylates can be found in nail polishes at low concentrations (Table 4).<sup>41</sup> Allergic contact dermatitis induction

by (meth)acrylates will be explored in the following section on acrylic and gel manicures.

### Acrylic Manicures and Preformed Nails

Although they are gradually being replaced by gel manicure systems, acrylic manicures remain a significant source of ACD.<sup>11</sup> A diagram of the acrylic manicure procedure, the ingredients used at each stage, and probable adverse reactions from those materials are shown in Figure 4 and listed in Table 5.

Acrylic manicures may include an optional dehydrator step not performed in regular manicures to remove excess oils after nail plate cleansing. The dehydrator procedure introduces additional exposures and uses both ethyl acetate and isopropyl alcohol.

After these steps, a plastic nail tip can be applied to extend the natural nail using cyanoacrylate glue (ethyl cyanoacrylate [ECA]). Although ECA was originally deemed nonsensitizing, it has since been associated with ACD, paronychia, and nail dystrophy.<sup>13,49,50</sup> Of note, allergies to cyanoacrylate and (meth)acrylates are mutually exclusive and do not cross-react.<sup>13</sup>

Next, a primer is applied to the surface of the nail to provide adhesion between the acrylic and the nail. Nail primers are

**TABLE 2. A Comparison of Gel Versus Acrylic Manicures**

| Benefits of Acrylics                      | Benefits of Gel                | Drawbacks of Acrylics     | Drawbacks of Gel                                                                |
|-------------------------------------------|--------------------------------|---------------------------|---------------------------------------------------------------------------------|
| Creates a hard, durable surface           | Creates a natural, glossy look | Looks unnatural and dense | Does not strengthen the nails                                                   |
| Lasts very long                           | Fast curing time               | Is more tedious to apply  | Does not last as long as acrylic nails, although longer than a regular manicure |
| Ease of removal                           | More flexible nails            | Damaging to the nail bed  | More expensive than acrylics                                                    |
| Ability to self-fix a broken acrylic nail | Lack of fumes                  | Heavy odors and fumes     | Self-fix of a broken gel nail is not possible                                   |

**TABLE 3. Allergens Present in Regular Manicures**

| Step in Regular Manicure   | Purpose                                                                                                                                                                   | Main Ingredients                                                                                                                                                                                       | Adverse Reactions                                                                                                                                                                                 |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Base, color, top coat      | Base: to create an even surface for the color coat and to facilitate adhesion<br>Color: to add pigment to the nail<br>Top: to give a glossy finish and protect the enamel | Film former: nitrocellulose<br>Plasticizers: camphor, DBP<br>Resins: (meth)acrylates, formaldehyde, tosylamide epoxy resin, TSFR<br>Solvents: acetates, alcohols, toluene<br>UV absorber: benzophenone | ACD to (meth)acrylates, benzophenone, camphor, DBP, formaldehyde, tosylamide epoxy resin, and TSFR<br>Rare ACD to ethyl acetate and isopropyl alcohol, ICD to acetone, ethyl acetate, and toluene |
| Nail hardener/strengthener | Optional, to reinforce weak, natural nails                                                                                                                                | Formaldehyde                                                                                                                                                                                           | ACD to formaldehyde                                                                                                                                                                               |
| Nail polish remover        | To dissolve nitrocellulose and remove nail polish                                                                                                                         | Acetone and/or ethyl acetate                                                                                                                                                                           | Rare ACD to acetone and ethyl acetate, ICD to acetone and ethyl acetate                                                                                                                           |

The steps in the regular manicure procedure, their purpose, and their main, constitutive ingredients are detailed. Possible contact dermatitis reactions to certain ingredients are listed for each corresponding step.

categorized into acid and non-acid containing. Acid primers use methacrylic acid (MAA), a corrosive chemical that can cause an ACD reaction if unintentionally applied onto the cuticle or skin.<sup>51</sup> Nonacid primers do not contain MAA but may contain other allergenic compounds such as acetates and acrylates (Table 4).<sup>15,52,53</sup>

After priming, acrylic is applied by coating a brush in powdered polymeric methacrylate and then liquid monomeric methacrylate, generating a flexible polymer that can be applied to the nail. The liquid acrylic end product contains a mixture of methacrylate monomers that function as adhesives and cross-linkers. Allergic contact dermatitis allergen screens should include 2-hydroxyethyl methacrylate (2-HEMA), 2-hydroxypropyl methacrylate (2-HPMA), ethylene glycol dimethacrylate (EGDMA), ethyl methacrylate (EMA), methyl methacrylate (MMA), and tetrahydrofurfuryl methacrylate (THFMA) (Table 4), with particular attention paid to the most common culprits 2-HPMA, EGDMA, and, especially, 2-HEMA. Most cases of ACD are caused by exposure to 2-HEMA, 2-HPMA, and EGDMA.<sup>15,16,54–58</sup> Patients are often allergic to multiple (meth)acrylates because of cross-reactivity between (meth)acrylic monomers.<sup>45,59</sup>

The main active ingredient in liquid acrylics originally consisted of MMA monomers. However, in 1974, after reports of allergic sensitization to MMA, the US Food and Drug Administration banned its use in cosmetics.<sup>60</sup> Now, most products contain ethyl, isobutyl, and THFMA, which are likewise implicated in ACD.<sup>61,62</sup> Hydroquinone (HQ), an inhibitor that prevents polymerization from happening too readily, is an uncommon allergen as well.<sup>63</sup>

Powder acrylic products contain polymers of methacrylates such as EMAs and MMAs or a combination of the two: polymethylmethacrylate (PMMA). Although reactions to the polymeric forms are rare, residual monomers of MMA and EMA can remain and evoke a response.<sup>41,64</sup> Benzoyl peroxide, an initiator of polymerization, is also an occasional allergen.<sup>65</sup>

The remaining steps in an acrylic manicure involve applying regular nail polish on top of the polymerized (meth)acrylates and involving the same ACD agents previously described for regular manicure. It is important to note that only liquid (meth)acrylate

monomers are sensitizing, and completely cured polymers rarely cause reactions. However, there can be instances where unhardened (meth)acrylate monomers can remain on the surface of a nail after application and cause cases of ectopic ACD on areas such as the face, eyelids, and neck.<sup>64</sup>

## Gel Manicures

A popular, newer manicure procedure, gel manicures require the use of a UV or LED light to create a durable, glossy polish over natural nails (Fig. 5). They are quicker, odorless, and more natural compared with acrylic manicures, leading to their rising popularity in salons.

**TABLE 4. Common (Meth)acrylates Used in the Nail Polish and Service Industry Ordered Alphabetically**

### Common Forms of (Meth)acrylates Used in the Nail Industry

2-EHA  
2-HEMA  
2-HPMA  
2-HEA  
2-HPA  
Bisphenol A glycerolate dimethacrylate  
Diethylene glycol diacrylate  
Di-HEMA trimethylhexyl dicarbamate  
EA  
ECA  
EMA  
Ethylene dimethacrylate  
EGDMA  
HEMA  
Isobutyl methacrylate  
MMA  
PMMA  
PPG-5 methacrylate  
THFMA  
TREGDA  
Triethylene glycol dimethacrylate



**Figure 4.** Acrylic manicure process. A, The nail is cut, shaped, and buffed. B, A preformed nail tip is glued onto the natural nail using cyanoacrylate. C, The preformed nail is trimmed. D, The extended nail is filed. E, A nail primer is applied onto the nail. F, A brush is dipped into liquid methacrylate monomers and then placed into the powder methacrylate polymer, creating a flexible acrylic material. G, The flexible acrylate is placed onto the nail. H, The mixture is molded on the nail using the brush. I, The acrylic manicure is complete. J, To remove the acrylic manicure, a cotton ball is soaked in acetone. K, The cotton ball is placed on top of the acrylic manicure. L, A piece of aluminum foil is used to wrap the nail and the acetone together.

A detailed chart of gel manicure procedures, the corresponding ingredients used in each step, and possible adverse reactions from those substances are listed in Table 6. Many steps within the gel manicure coincide with those found in acrylic and regular manicures, with a few differences.

Whereas acrylic manicures contain mainly methacrylates, gel systems use both acrylates and methacrylates. Methacrylate allergies have been described in the previous section on acrylic manicures and likewise persist in sensitization from gel manicures.<sup>56</sup> Again, most cases of ACD are caused by exposure to 2-HEMA, 2-HPMA, and EDGMA.<sup>15,16,54,55</sup> As for acrylates, additional patch testing should be performed on 2-hydroxyethyl acrylate (2-HEA), 2-ethylhexyl acrylate (2-EHA), 2-hydroxypropyl acrylate (2-HPA), ethyl acrylate (EA), and triethylene glycol diacrylate (TREGDA) (Table 1).<sup>6</sup>

Gel manicures use photoinitiators to start polymerization. Photoinitiators, such as hydroxycyclohexyl phenyl ketone, generate free radicals and can result in allergic sensitization.<sup>57,58</sup>

## DIFFERENTIAL DIAGNOSES

### Irritant Contact Dermatitis

Irritant contact dermatitis results from direct cytotoxic effects of the irritant on the epidermis and dermis, skin injuries, or cutaneous inflammation after contact with an agent. Observable alterations in the skin include dryness, cracking, and inflammation. Symptoms of ICD can occur immediately after exposure and persist if the irritant is not removed.<sup>18,66</sup> Although ICD and ACD share many presenting features, ICD tends to occur on the dorsal

plane of the hands rather than the palmar, with an absence of vesicles and presence of pain.<sup>2</sup>

### Atopic Dermatitis

A common inflammatory condition, atopic dermatitis usually begins in childhood and presents chronically.<sup>67</sup> Patients have a higher risk of developing both ACD and ICD, along with a 13.5-times greater risk of experiencing occupational dermatitis than nonatopic patients.<sup>68</sup> History taking should focus on inquiring about previous dermatitis outbreaks, as well as symptoms such as dry and pruritic skin.

### Dyshidrotic Eczema/Pompholyx

Dyshidrotic eczema, also known as pompholyx, may be related to sweating dysfunction and initially presents with pruritus.<sup>69</sup> The development of small vesicles and bullae on the palmar surface of the hand, as well as the lateral aspects of the fingers, then occurs. The vesicles last approximately 2 to 4 weeks, recur sporadically, and can appear on other regions such as the feet and toes.<sup>68</sup> Symptoms can lead to nail dystrophy.

## TREATMENTS

In cases of contact dermatitis, the contributing substance should first be identified, then removed, and avoided.

### Steroids

Potent and midpotent topical steroids (classes I–V) can be used in cases of acute ACD lesions on the hand. On areas with delicate skin, such as the face, lower-potency steroids can be used to prevent striae, skin atrophy, and dyspigmentation.<sup>70</sup> Steroid

**TABLE 5. Allergens Present in Acrylic Manicures**

| Step in Acrylic Manicure               | Purpose                                                                                                                                                    | Common Ingredients                                                                                                                                                                                                  | Adverse Reactions                                                                                                                                                                                   |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nail cleanser                          | Solvent used to remove any impurities on the nail                                                                                                          | Isopropyl alcohol                                                                                                                                                                                                   | Rare ACD to isopropyl alcohol                                                                                                                                                                       |
| Nail dehydrator/<br>pH-balancing agent | Optional: solvent used to remove oils on the nail and increase adhesion                                                                                    | Ethyl acetate, isobutyl acetate, isopropyl alcohol                                                                                                                                                                  | Rare ACD to ethyl acetate and isopropyl alcohol<br>Rare ICD to ethyl acetate                                                                                                                        |
| Apply plastic nail tips                | To extend the nails                                                                                                                                        | Resin/glue: cyanoacrylate                                                                                                                                                                                           | Not as sensitizing, although ACD to cyanoacrylate has been reported                                                                                                                                 |
| Nail primer                            | There are 2 types: acid and nonacid; to help the acrylic mixture adhere to the natural nail and nail tip extension                                         | Acid: MAA, (meth)acrylates<br>Nonacid: carboxyethyl acrylate, ethyl acetate                                                                                                                                         | Acid: ACD to (meth)acrylates and MAA<br>Nonacid: rare ACD and ICD to ethyl acetate                                                                                                                  |
| Liquid acrylic preparation             | Place liquid acrylic methacrylate monomers into a dish to prepare for mixing with powder polymers                                                          | Adhesives: 2-HEMA, 2-HPMA<br>Cross-linker: EGDMA<br>Inhibitors: HQ<br>Monomer: EMA, isobutyl methacrylate, MMA,* and other methacrylate monomers                                                                    | ACD to (meth)acrylates<br>Occasional ACD to HQ                                                                                                                                                      |
| Powder acrylic preparation             | Place powder acrylic methacrylate polymers into a dish to prepare for mixing with liquid monomers                                                          | Initiators: benzoyl peroxide (BP)<br>Polymer: poly(EMA), poly(MMA), or a combination of the 2 into PMMA                                                                                                             | ACD to (meth)acrylates<br>Occasional ACD to BP                                                                                                                                                      |
| Acrylic mixing and application         | Dip brush into liquid acrylic before placing into powder acrylic. Place mixture on top of the natural nail and nail tips to form a desired, hardened layer | Ingredients from previous steps                                                                                                                                                                                     | ACD to (meth)acrylates<br>Occasional ACD to HQ, Monomethyl Ether of hydroquinone, and BP                                                                                                            |
| Color coat and top coat                | Color: to add pigment to the nail plate<br>Top: to give a glossy finish and protect the enamel                                                             | Film former: nitrocellulose<br>Plasticizers: camphor, DBP<br>Resins: (meth)acrylates, formaldehyde, tosylamide epoxy resin, TSFR<br>Solvents: acetates, alcohols, dimethicone, toluene<br>UV absorber: benzophenone | ACD to (meth)acrylates, benzophenone, camphor, DBP, formaldehyde, tosylamide epoxy resin, and TSFR<br>Rare ACD to ethyl acetate and isopropyl alcohol<br>ICD to acetone, ethyl acetate, and toluene |

The steps in the acrylic manicure procedure, their purpose, and their main ingredients are detailed. Possible contact dermatitis reactions to certain ingredients are listed for each corresponding step.

\*Banned by the US Food and Drug Administration in 1974.

ointments, in place of creams that may contain allergenic preservatives, allow for extensive contact between the medication and the skin.<sup>18</sup> In addition, soaking the skin before applying the topical steroid may increase effectiveness by promoting absorption.<sup>71</sup>

### Antihistamines

Antihistamines do not effectively alleviate ACD-related pruritus. However, patients may desire the sedative properties of soporific antihistamines.<sup>72</sup>

### Barrier Creams and Moisturizers

Barrier creams, such as petrolatum, dimethicone, and paraffin, can prevent reexposure to allergens by providing another protective layer above the stratum corneum.<sup>73</sup> These creams can also contain

additional ingredients that reduce inflammation and restore the intracellular lipids of the stratum corneum.<sup>70</sup> Colloidal oatmeal, which contains anti-inflammatory compounds such as polyphenol, may appease acute, oozing lesions.<sup>74</sup> Ceramide can reduce transepidermal water loss, whereas linoleic and hyaluronic acids enhance intracellular lipid production.<sup>26</sup>

A shortcoming of barrier creams involves its practical use because the effectiveness of the cream depends on its adherence to the skin. Frequent use of certain areas, such as the hands, can lead to gradual dissipation of the cream.

### Psoralen Plus UV-A and UV-B TL01 Phototherapy

Psoralen plus UV-A (PUVA) therapy combines 2 ubiquitously traditional therapeutic agents, psoralen and UV light, to create a



**Figure 5.** Gel manicure process. A, The cuticle is pushed back. B, The nail is buffed to remove its smooth surface and shaped. C, Excess skin and cuticle are removed. D, Nail cleanser is used to remove impurities. E, A nail primer is applied to enhance gel adhesion. Note that the primer is applied only to the nail and does not touch the skin. F, A gel base coat is added to create a smooth surface. After application, the polish is cured using a UV or LED light. G, A gel color coat is applied for cosmetic purposes. The polish is cured using a UV or LED light. H, A second gel color coat is applied. I, A gel top coat is used to create a glossy finish and to protect the nail enamel. It is then cured a last time with a UV/LED light.

**TABLE 6. Allergens Present in Gel Manicures**

| Step in Gel Manicure               | Purpose                                                                                                                                                          | Common Ingredients                                                                                                                                                                                                                                                                                                                                                        | Adverse Reactions                                                                                                          |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Nail cleanser                      | Solvent used to remove any impurities on the nail                                                                                                                | Isopropyl alcohol                                                                                                                                                                                                                                                                                                                                                         | ACD to isopropyl alcohol                                                                                                   |
| Nail dehydrator/pH-balancing agent | Optional: solvent used to remove oils on the nail and increase adhesion                                                                                          | Acetates, isopropyl alcohol                                                                                                                                                                                                                                                                                                                                               | Rare ACD to ethyl acetate and isopropyl alcohol<br>Rare ICD to ethyl acetate                                               |
| Nail primer                        | Sometimes optional. There are 2 types: acid and nonacid<br>To help the gel adhere to the nail                                                                    | Acid: MAA, (meth)acrylates<br>Nonacid: carboxyethyl acrylate, ethyl acetate                                                                                                                                                                                                                                                                                               | Acid: ACD to (meth)acrylates and methacrylate acid<br>Nonacid: rare ACD and ICD to ethyl acetate                           |
| Base coat, color coat, top coat    | Base: to create an even surface for the color coat<br>Color: to add pigment and strengthen the nail plate<br>Top: to give a glossy finish and protect the enamel | Film former: nitrocellulose<br>Photoinitiators: 1-hydroxycyclohexyl phenyl ketone, benzoyl isopropanol, trimethylbenzoyl diphenylphosphine oxide<br>Plasticizers: camphor, DBP<br>Solvents: butyl acetate, isopropyl alcohol<br>UV curable monomers: 2-HEMA, 2-HPMA, diurethane dimethacrylate and other urethane methacrylates, EGDMA, triethylene glycol dimethacrylate | ACD to (meth)acrylates, camphor, DBP, and photoinitiators<br>Rare ACD to acetates and isopropyl alcohol<br>ICD to acetates |

The steps in the gel manicure procedure, their purpose, and their main, constitutive ingredients are detailed. Possible contact dermatitis reactions to certain ingredients are listed for each corresponding step.

**TABLE 7. Commercial Nail Polish Companies and Their 3-, 4-, or 5-Free Status**

| "3-Free" Brands     | "4-Free" Brands Without TSFR | "5-Free" Brands                |
|---------------------|------------------------------|--------------------------------|
| American Apparel    | Estée Lauder                 | AILA                           |
| CND                 | Lancôme                      | Bliss                          |
| Essie               | M.A.C. Nars                  | Butter London                  |
| Hard Candy          | Spa Ritual                   | Chanel                         |
| Le Métier de Beauté |                              | Côte                           |
| Nicole              |                              | Deborah Lippmann               |
| OPI                 |                              | Dior                           |
| Sally Hansen        |                              | Ella + Mila                    |
| Wet 'n' Wild        |                              | Givenchy                       |
|                     |                              | Jamberry                       |
|                     |                              | JIN Soon                       |
|                     |                              | Julep                          |
|                     |                              | L'Oreal                        |
|                     |                              | NCLA                           |
|                     |                              | Nubar                          |
|                     |                              | Obsessive Compulsive Cosmetics |
|                     |                              | Priti                          |
|                     |                              | RGB                            |
|                     |                              | Smith & Cult                   |
|                     |                              | Tenover                        |
|                     |                              | Zoya                           |

cutaneous photosensitivity reaction. This is achieved by exposing the skin to UV-A light after topical or oral administration of psoralens.<sup>22</sup> Although PUVA therapy is highly effective as mainly a psoriasis treatment because of its inhibition of epidermal DNA synthesis and possible toxic effects on activated lymphocytes, it has also been suggested as an effective ACD treatment, along with UV-B TL01 phototherapy.<sup>23–25</sup>

The short-term adverse effects of PUVA therapy include painful erythema with possible bullous lesion development, along with pruritus and nausea. Potential chronic sequelae of PUVA therapy may include skin cancer and cataracts.<sup>22</sup>

### Calcineurin Inhibitors

Calcineurin inhibitors, such as pimecrolimus, tacrolimus, and cyclosporine, generally function by impeding the calcium and calmodulin-dependent serine/threonine protein phosphatase. As a treatment, tacrolimus inhibits the activation of T lymphocytes and Langerhans cells, as well as prevents cytokine production. Topical tacrolimus ointment 0.1% has been shown to be a promising treatment for patients with ACD of the eyelids, a common site of presentation for nail cosmetic-induced ACD.<sup>27</sup>

### Other Topical Agents and Methods

Cool compresses and calamine lotion can also soothe the symptoms of acute contact dermatitis. Thin saline or Burow solution dressings can dry up acute, oozy lesions before the application of a potent topical corticosteroid.<sup>66</sup>

## INTERVENTIONS

### "3-, 4-, 5-Free" Nail Polish

For those allergic to DBP, formaldehyde and its iterations, and toluene, many brands now produce "3-free" nail polish that does not contain those 3 ingredients. Patients with TSFR or camphor sensitivity will need to find "4-free" or "5-free" nail polish, with "5-free" nail polish excluding both substances and "4-free" nail polish excluding 1 of the 2 (Table 7).

### Nail Wraps

In cases where patients do not have sensitivity to cyanoacrylates and seek to have their nails strengthened or repaired, a nail wrap can be performed (Fig. 6). The wrap, which can be silk, paper, linen, plastic, or fiberglass, is manipulated into the shape of a natural nail before being glued to the nail surface with cyanoacrylate.<sup>75</sup> Transparent fiber varnish is then applied over the wrap and the nail.

## CONCLUSIONS

Sensitizing agents such as (meth)acrylates, TSFR, and formaldehyde exist within almost all nail salon procedures. Although ACD should present in areas proximal to allergen exposure, ectopic

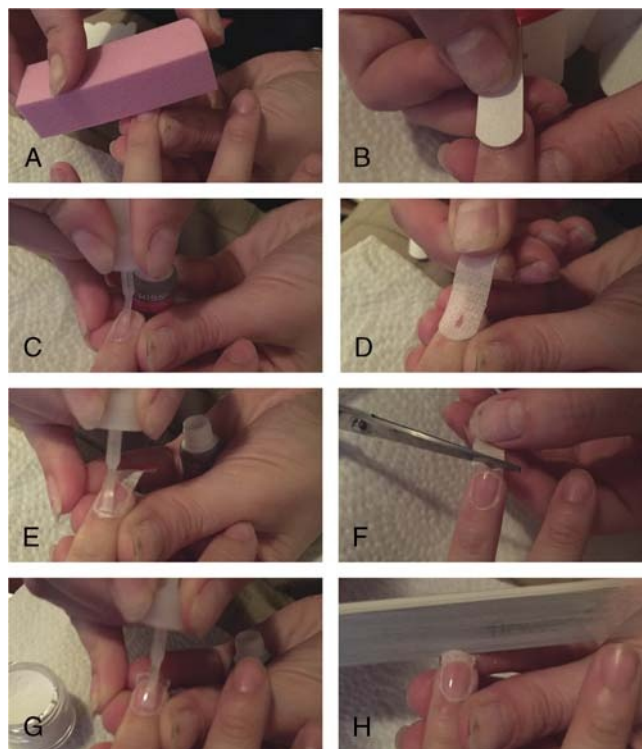


**Figure 6.** Silk wrap process. A, The nail is cut, filed, and buffed. B, A silk mesh wrap is placed onto the nail and measured for fit. C, Cyanoacrylate glue is applied onto the nail. D, The silk wrap is glued onto the nail. E, Another layer of cyanoacrylate glue is applied on top of the silk wrap. F, The silk wrap is trimmed to a desired length. G, Another layer of glue is placed on top of the nail. H, The silk wrap is filed to the desired shape.

ACD can occur because of transfer of an allergen from the nail. Nail cosmetic-related ACD represents a significant burden to patients deserving of recognition and careful management.

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