

# Cosmetic Aspects of Nail Products and Services

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Nail appearance has been an important aspect of overall beauty for centuries. Numerous products that improve nail quality are sold daily as a form of adornment and self-expression or to hide nail dystrophy; however, some nail products and services may lead to complications such as allergic contact dermatitis, irritant dermatitis, paronychia, onycholysis, onychomycosis, and brittle nails. We review the potential benefits and adverse effects of various nail products and services.

*Cosmet Dermatol.* 2012;25:357-363.

**N**ail cosmetics are a multibillion dollar industry that includes various products and salon services, such as manicures, pedicures, artificial nails, nail growth and strengthening agents, nail art, and other products that result in smooth glossy nails.<sup>1</sup> In 2004, Americans spent \$6.8 billion on nail products.<sup>2</sup> Nail salons alone earned \$1.7 billion in 2005 according to the US Census Bureau.<sup>3</sup> Products and practices that are used to beautify the nails, particularly the nail plate, offer great solutions for common nail dystrophies, as they protect against further damage to the nail while also improving the patient's self-esteem; however, the use of nail cosmetics also may lead to severe complications, such as allergic contact dermatitis, irritant dermatitis, paronychia, onycholysis, onychomycosis, and brittle nails. We review various nail products and services and highlight their potential benefits and adverse effects.

## NAIL POLISH REMOVERS

Most nail polish removers contain harsh chemicals such as acetone, ethyl acetate, butyl acetate, or methyl ethyl

ketone. Acetone-based nail polish removers commonly dry out nails, which can predispose to brittle nails. Nail polish removers also may contribute to paronychia, as they can irritate the nail folds (Figure 1).<sup>4</sup> These effects can be minimized by limiting the use of nail polish removers to less than once per week<sup>5</sup> and using acetone-free products that contain less aggressive solvents such as ethyl acetate. No known clinical studies exist on the efficacy of acetone-free nail polish removers, and some case reports show life-threatening toxicity with



**Figure 1.** Paronychia and onychoschizia with nail splitting and inflammation of the nail folds.

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*The authors report no conflicts of interest in relation to this article.*

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accidental ingestion of acetone-free products containing  $\gamma$ -butyrolactone.<sup>6</sup>

### CUTICLE REMOVERS

The eponychium, also known as the cuticle, often is considered unattractive, and its removal allows for even application of nail polish and artificial nails; however, it is important to note that overly aggressive manipulation of the cuticles may lead to infections such as paronychia or onychomycosis (Figures 1 and 2).<sup>2</sup> The cuticle seals the space between the proximal nail fold and the nail plate. When this connection is interrupted, the area under the nail fold becomes predisposed to penetration by irritants, allergens, bacteria, fungi, and other foreign materials.<sup>7</sup> Chemical cuticle removers contain harsh compounds such as sodium and potassium hydroxide, which can cause nail fold irritation when frequently or incorrectly applied.<sup>2</sup> Overmanipulation of the cuticle can harm the nail matrix and can cause transverse leukonychia.<sup>8</sup> It is best to avoid manipulation of the cuticle completely; however, to reduce nail fold trauma, many nail technicians use an orangewood stick rather than a metallic one to push the cuticle closer to the proximal nail fold.<sup>9</sup>



**Figure 2.** Onychomycosis with distal onycholysis.

### NAIL TRIMMING

When nails are trimmed in an oval shape to form an arc, they are predisposed to ingrown nails and chipping; therefore, nails should be trimmed straight across with a minimal arc. Filing the nails in one direction rather than using clippers or scissors reduces shear forces. Softening the nails by soaking them in water prior to trimming also helps minimize cracking that may occur during clipping.<sup>9</sup> Using blades with blunt ends also minimizes trauma to surrounding soft tissue.<sup>10</sup>

### NAIL STRENGTHENING AGENTS

Nail strengthening agents offer a temporary solution to brittle nails, a condition that affects approximately 20% of the US population. These products function by either mechanically protecting the nail plate or chemically altering its structure by cross-linking keratin.<sup>11,12</sup> Nail strengthening agents generally are applied as a base coat and help reduce nail plate contact with detergents and solutions, thereby decreasing water vapor loss in the nails.<sup>13</sup> They also are available in cream formulations (eg, aluminum chloride, tannin, tazarotene cream 0.1%) that can be directly applied to the nails.<sup>14</sup>

Most nail strengthening products are modified nail enamels that contain various concentrations of solvents and resins, with the optional addition of nylon, silk, acrylic, minerals, or proteins to enhance the product's adhesion to the nail plate. Nail strengtheners that contain formaldehyde actually can negatively alter the nail's keratin structure, as the cross-link density increases with continued use, resulting in reduced flexibility of the nail plate despite enhanced nail strength, which paradoxically leads to brittle nails. In high concentrations, formaldehyde also has been shown to cause blue to red nail discoloration, onycholysis (Figure 3), paronychia (Figure 1), subungual hyperkeratosis, ectopic contact dermatitis (Figure 4), and in some cases pterygium inversum unguis with severe pain.<sup>11,15</sup> Formaldehyde content has been decreased to 1% to 2% but still continues to show adverse effects such as contact dermatitis and onycholysis.<sup>16</sup>

Dimethylurea is a nail strengthener that also chemically alters keratin, though to a lesser degree than formaldehyde, and also is available as a base coat. It does not penetrate as deeply as formaldehyde, which decreases the risk for embrittlement and sensitization.<sup>15</sup> Other nonformaldehyde nail strengthening agents include Teflon, silk, nylon, acrylic resins, keratin, and vitamins.<sup>17</sup>

### NAIL MOISTURIZERS

The nail's ability to maintain a hydrated state is lower than the skin because of the constant flux of water across the nail plate.<sup>18</sup> Repetitive hand washing causes contraction



**Figure 3.** Distal onycholysis with separation of the distal nail plate from the nail bed.



**Figure 4.** Dermatitis surrounding the eye secondary to nail polish use.

moisturizers should be prescribed. This study questioned the current practice of moisturizing brittle nails by showing that there is no relationship between nail plate water content and nail brittleness.<sup>18</sup>

### NAIL POLISH

The application of nail polish is the final step of any manicure or pedicure and is a popular means of nail adornment. Nail polish provides mechanical strength and can act as a waterproof agent to minimize evaporation in the nails and improve nail moisturization.<sup>1</sup> It also offers some defense against detergents.

Nail polish is a mixture of film-forming agents, thermoplastic resin, plasticizer, a solvent extender, and pigment. The thermoplastic resin is toluene sulfonamide formaldehyde resin, which is a common allergen in most cases of nail dermatitis. It is estimated that 1% to 3% of the US population has an underrecognized allergy to nail polish,<sup>21</sup> which can clinically present as nail dystrophy, onycholysis, paronychia, and dermatitis on contact sites or elsewhere.<sup>22</sup> When allergic reactions to nail polish present as ectopic dermatitis, the usual distribution involves the face (Figure 4), ears, neck, and lower eyelids.<sup>8</sup> Contact dermatitis in the periungual area can predispose one to onychomycosis and paronychia. Patch testing is useful in the case of allergic contact dermatitis (Table). Hypoallergenic nail polish formulations contain phthalic polyester resin instead of toluene sulfonamide formaldehyde resin but still may cause ectopic dermatitis.<sup>30</sup>

Prolonged nail polish use sometimes can result in nail discoloration as well as keratin granulations (Figure 5), which are white scaly spots on the nail plate.<sup>1</sup> After wearing pigmented nail polish for more than 7 days, especially deeper shades of red and brown,<sup>10</sup> patients can develop yellow staining of the keratin at the distal nail plate, which usually fades within 2 weeks without treatment.<sup>31</sup> Dyes that cause yellow staining of the nails include D&C red 6, 7, and 34, and FD&C yellow 5 aluminum lake.<sup>32</sup> Nail plate granulations usually occur when nail polish is reapplied without removing old polish.<sup>1</sup>

### ARTIFICIAL NAILS

Artificial nails, which are made of preformed plastic that is glued onto the original nail, offer a temporary cosmetic solution to slow-growing nails or nail dystrophies. Ethyl cyanoacrylate is a common allergen present in most of the glues used and can cause periungual dermatitis. Some patients develop erythematous pruritic papules in the paronychial area only a few hours after application.<sup>33</sup> To prevent allergic contact dermatitis, it is recommended that artificial nails be worn for less than 48 hours per application.<sup>34</sup>

and expansion of the nails, leading to fractures between nail corneocytes.<sup>19</sup> Nail moisturizers function as either occlusives or humectants. They usually are applied under occlusion of white cotton gloves.<sup>1</sup> Mineral oils or lubricants that prolong moisturization can enhance flexibility while sealing the upper surface of the nail plate, thereby delaying the evaporation of the water.<sup>20</sup>

However, a study by Stern et al<sup>18</sup> showed that there was no significant difference between water content of brittle nails versus normal nails, which contrasts with claims that brittle nails have less water content and nail



## Allergens Recommended for Patch Testing

Nail Enamel <sup>8,23</sup>	Enamel Removers <sup>4,14</sup>	Cuticle Removers <sup>8,24</sup>	Sculptured Nails <sup>8,25,26</sup>	Artificial Nails <sup>8,27-29</sup>
Benzalkonium chloride	Acetone	Potassium hydroxide	2-hydroxyethyl acrylate	Cyanoacrylate adhesive
Colophony resin	Butyl acetate	Propylene glycol	Acrylic liquid monomer (ethyl methacrylate or isobutyl methacrylate)	Methyl ethyl hydroquinone
Drometrizole	Ethyl acetate	Trisodium phosphate	Benzophenone	Other adhesives
Formaldehyde	Methyl ethyl ketone	Trolamine	Butylhydroxytoluene (gel nails)	p-t butyl phenol resin
Glyceryl phthalate resin			Ethyl acrylate	Tricresyl ethyl phthalate
Guanine powder			Ethyl cyanoacrylate	
Nickel			Ethylene glycol dimethacrylate	
Nitrocellulose			Powdered polymethyl methacrylate or ethyl methacrylate polymer with benzoyl peroxide	
Several nail lacquers (water-soluble components)			Triethylene glycol diacrylate	
Toluene sulfonamide formaldehyde resin				



**Figure 5.** Keratin degranulation on the nail plate.

Apart from allergic contact dermatitis, artificial nails may cause onycholysis, paronychia, and onychomycosis.<sup>35</sup> A unique side effect of exposure to acrylate is the development of paresthesia of the distal fingertips. Nail splitting and dryness occurs after removal of artificial nails due to the loss of natural oils (Figure 1).<sup>36</sup>

### SCULPTURED NAILS

Sculptured nails are applied using a sensitizing liquid monomer (ethyl methacrylate) and a powder polymer (polymethyl methacrylate) cured with benzoyl peroxide, which then hardens directly onto the nail. An initial primer of methacrylic acid (a strong skin irritant) is applied to the nail to improve the adherence of the acrylate mixture to the nail plate.<sup>8</sup>

Allergic reactions to acrylic monomers in sculptured nails initially may present as pruritus that can progress to painful paronychia, paresthesia, nail dystrophy, and in some cases onycholysis. Permanent nail loss is rare.<sup>37</sup> Distant ectopic dermatitis may be noted on the face and eyelids.<sup>8</sup> The physician should consider patch testing for patients with sculptured nails and chronic nail dystrophy or new-onset periungual pathology (Table).

Acrylic monomers also can cause an irritant reaction that results in a thickening of the nail bed with possible onycholysis. Irritant reactions to methacrylic acid can

manifest as a burning sensation on contact with cuticles or the nail bed in the case of a thin nail plate.<sup>8</sup>

Fungal and bacterial colonization is more prevalent in sculptured nails because of their increased water content.<sup>38</sup> With prolonged use, there is an increased predisposition to infection as the acrylic loosens around the edges and leaves the nail folds exposed. It is important to reapply acrylic every 3 weeks to prevent paronychia.<sup>9</sup> To prevent onycholysis, it is important to keep the acrylic enhancements short and thin to maintain flexibility and decrease tension on the nail plate.<sup>39</sup>

### UV-CURED GEL NAILS

UV-cured gel nails use an alternate monomer mixture with the same powder polymer as sculptured nails. The primer and catalyst are not required for adherence or formation.<sup>1</sup> The gel is in a semiliquid form and is applied similar to a nail polish and cured by UV light, which hardens the gel. The lack of odor and ease of application make this service a popular choice in nail salons. It is important to note, however, that gel enhancement products can shrink up to 20%, producing a torque on the nail bed that results in a lifted and cracked nail plate.<sup>8</sup> Hypoallergenic gel nail products in which methacrylic acid is omitted also may cause contact sensitization because they still contain other acrylate functional monomers.<sup>35</sup> Gel that remains uncured may spread, resulting in distant contact dermatitis. Other adverse reactions in the nails that have been reported include paresthesia, subungual and paronychia eczema, and in some cases nail loss.<sup>8</sup> MacFarlane and Alonso<sup>40</sup> reported 2 cases in which UV lamp exposure in nail salons may have led to the development of squamous cell carcinoma in the fingers; therefore, this potential association should be recognized.

### NAIL WRAPPINGS

Nail wrappings are placed at the free edges to elongate and repair split, broken, or weak nails. To maintain the nails, this procedure must be frequently repeated. Fibrous substances such as linen, fiberglass, or silk are layered with clear nail polish and sensitizing glue such as methacrylate.<sup>8</sup> It is important to take precautions to avoid contact with the glue, as it may lead to contact dermatitis surrounding the nail with potential dermatitis of the eyes and dorsal hands.<sup>27</sup>

### SALON SANITATION

Nail technicians are responsible for instituting proper sterilization techniques in their salons. Sterilization of instruments between customers is important, as unclean equipment can promote rampant transmission of

infections such as paronychia, onychomycosis, and verruca.<sup>41</sup> Porous files used to remove calluses during a pedicure are not amenable to sterilization and may be associated with increased plantar wart virus transmission. It is best if customers bring their own tools or the salon uses disposable instruments. Although each state has its own guidelines for sterilizing nail salon instruments, most recommend using an Environmental Protection Agency–registered, hospital-grade disinfectant.<sup>1</sup>

In addition to predisposing one to onychomycosis, pedicure baths may be a breeding ground for mycobacteria, leading to furunculosis and subsequent scarring. In a large case series in northern California in 2002, filter cultures from footbaths in salons visited by patients presenting with furunculosis after a pedicure were positive for *Mycobacterium fortuitum*.<sup>42</sup> Patients presented with small, insect bite–like lesions that progressed to boils and hyperpigmented scars. Empirical treatment is recommended if clinical suspicion is high. It also is important to make sure that footbath filters are changed frequently as a precautionary measure.<sup>42</sup>

Vigilance in the licensing of nail salons is crucial to patient safety. Safety guidelines for nail technicians include making sure that footbaths are clean and that nondisposable instruments are autoclaved as well as minimizing cuticle manipulation during pedicures; patient safety measures include not shaving less than 24 hours prior to a pedicure and bringing personal nail instruments from home.<sup>39</sup>

### ONYCHOCOSMECEUTICALS

There are many organic substances, such as vitamins, amino acids, and minerals, that are sold under the broad label of nail supplements, though the efficacy of most of these substances is yet to be determined. It is well known that certain deficiencies can lead to nail dystrophy. Vitamin A deficiency causes eggshell nails,<sup>43</sup> iron deficiency leads to koilonychia and brittle nails,<sup>44</sup> and zinc deficiency results in fragile nails with a grayish discoloration as well as other nail plate abnormalities.<sup>45</sup> In such cases, correcting the deficiency may lead to improvement of nail dystrophy.

Overuse of supplements in nondeficiency states can lead to several adverse effects. An overdose of selenium supplements can actually result in nail loss, even though supplementation strengthens the nails in patients with a selenium deficiency.<sup>46,47</sup> Similarly, an overdose of vitamin A supplements also can lead to severe destruction of the nails.<sup>45</sup> It is interesting to note, however, that iron supplementation, even without overt deficiency, can lead to some improvement in brittle nails over a prolonged period of time.<sup>7</sup>

Biotin has been proven to improve nail thickness by 25% by increasing the amount of cytokeratins. It has also been shown to enhance nail growth and decrease lamellar splitting.<sup>48</sup> Daily treatment with 2.5 mg of biotin for at least 6 months has been shown to improve nail quality.<sup>49</sup> Biotin is used in the treatment of brittle nail syndrome with only minor side effects such as gastrointestinal tract upset. Nail improvement has been noted after 2 to 3 months of daily use.<sup>7</sup>

A daily 10-mg regimen of choline-stabilized orthosilicic acid, a bioavailable form of silicon, also appears to improve brittle nail syndrome by facilitating the formation of collagen.<sup>50</sup> It also has demonstrated some benefit in patients with psoriatic nail disease.<sup>45,51,52</sup>

High-dose vitamin E supplement (600–1200 IU) may improve yellow nail syndrome.<sup>53</sup> A combination of vitamin C, primrose oil, and pyridoxine has been suggested for brittle nails, but improvement of nail quality has not been proven.<sup>54</sup> Amino acid formulations with cystine have been suspected to improve nail growth and strength because of their positive effects on hyponychium cells, but these benefits have not been confirmed.<sup>7</sup>

## CONCLUSION

Nail cosmetics play an important role in the maintenance and improvement of nail aesthetics, and their use is pervasive throughout society. Despite the benefits, however, many nail products and their ingredients can lead to allergic, infectious, and idiopathic nail diseases. It is important for physicians to be aware of the potential adverse effects associated with nail cosmetics.

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