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### ABSTRACT

The nail as an anatomic structure protects the terminal phalanx of the digit from injury. Historically, it has served as a tool for protection and for survival. As civilizations developed, it attained the additional function of adornment. Nail beautification is a big industry today, with various nail cosmetics available, ranging from nail hardeners, polishes, extensions, artificial/sculpted nails, and nail decorations. Adverse events may occur either during the nail-grooming procedure or as a reaction to the individual components of the nail cosmetics. This holds true for both the client and the nail technician. Typically, any of the procedures involves several steps and a series of products. Separate “nail-bars” have been set up dedicated to serve women and men interested in nail beautification. This article attempts to comprehensively inform and educate the dermatologist on the services offered, the products used, and the possible/potential adverse effects related to nail-grooming and nail cosmetics.

**Key words:** Acrylic nail, gel nail, manicure, nail polish, sculptured nail

### INTRODUCTION

The earliest use of nail coloring dates back to ancient Egypt and China. The first nail polish was made from egg white, flowers, and wax. Natural henna was also used as a nail colorant. Specific colors like red, gold, and silver were chosen for royalty, and the common folk had to use lighter shades. In ancient China, gold and silver represented royalty. While red and black represented strength and boldness, pale colors denoted feebleness. Artificial nails date back as far as 600 BC to the Chou dynasty in China, where nails were made from gold, silver, and precious stones.<sup>[1]</sup>

Modern day nail polish was formulated in 1920 by the Charles Revson Company, which today is known as Revlon. They were inspired by the enamel paint used on cars to formulate something similar for the nails.

The modern day nail polish became commercially available in 1932.

### WHAT IS AN ATTRACTIVE NAIL?

Attractiveness of a nail is a subjective phenomenon. A nail is generally considered aesthetically pleasing if it has:

1. A smooth glossy surface.
2. No overhanging or ragged cuticle.
3. A tip extending beyond the nail.
4. An oval contour to the nail plate.
5. A gentle curve when visualized from the side.
6. Translucency so that the pink nail bed is clearly visualized.

The beauty of the nail can be further enhanced using various shades and colors of nail polish.

The most popular nail-grooming procedure is known as a manicure (for fingernails) and pedicure (for toenails).

### STEPS OF A MANICURE/PEDICURE

Prior to applying the nail polish, the hands/feet and nails undergo the following:

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1. The previous polish is cleaned off with a chemical remover and the nails are cut to the required length with nail cutters or clippers.
2. The hands/feet are soaked in warm water with a mild detergent to soften the nail plate and cuticle and to remove any dirt or grease from the surface.
3. A foot scraper or a pumice stone is used to buff away any rough skin or thick callus.
4. A cuticle softener (alkaline substances like 0.4% sodium and potassium hydroxide) is applied to the cuticles for 5–10 min. They dissolve the di-sulfide keratin bridges.
5. The cuticle is pushed back with a specially designed metallic or wooden stick, and then trimmed off with a cuticle cutter.
6. The surface of the nail is buffed with an emery board to smoothen any ridges.
7. The hands/feet are rinsed and dried, and an emollient cream is massaged to soften the skin and trap moisture into the nail plate.
8. The cream is cleaned off from the nail plate.

Now, the nails are considered suitable for nail polish application.

The ideal nail polish application procedure includes three layers:

1. Base coat: This is the first layer to be applied. It is transparent with a strong adhering capability due to higher resin content. It protects the nail plate from staining.
2. Nail polish: A plethora of colors are available, with or without a metallic finish. The expertise of the nail technician provides various styles of nail polish application, of which the “French nail manicure” is very popular.
3. Top coat: This transparent layer contains more of nitrocellulose and less resin, so as to protect the varnish from chipping.

Each product is applied consecutively with a 10-min gap in between applications [Figure 1].

### **NAIL POLISH/VARNISH/PAINT**

Nail polish serves the purpose of:

1. Beautification.
2. Strengthening weak brittle nails.

3. Camouflaging surface irregularities or discolorations. It can provide a youthful appearance to aged ridged nails.<sup>[2]</sup>

Nail polish is a complex combination of:

1. Film-forming agents (most commonly, nitrocellulose).
2. Resins (e.g., tosylamide–formaldehyde) for adherence.
3. Plasticizers (e.g., dibutyl pthalate) for flexibility.
4. Solvents (butyl stearate and acetate compounds) for keeping the polish in fluid state and to help in quick-drying once applied.
5. Thixotropic agents (e.g., bentonite) for keeping the ingredients uniformly suspended.
6. Various mineral pigments (calcium carbonate, zinc oxide, titanium dioxide, iron oxides), synthetic pigments (D and C red 6/7/19, FDC yellow).
7. Natural agents (guanine, bismuth, oxychloride, and micatitanium) for the color and shine of the nail polish.

### **HYPOALLERGENIC NAIL POLISH**

The most common allergen in nail polish is tosylamide formaldehyde resin (TSFR). Because of growing awareness, “toxin-free” nail polish is getting popular. This variety contains cellulose, acetate, butyrate, and polyester resin,<sup>[3]</sup> with plasticizers such as dibutyl phthalate for softness and pliability, dissolved in solvents (N-butyl acetate or ethyl acetate). Some manufacturers claim to have “toxic-free nail polish,” which is free of toluene, phthalate, and formaldehyde and contains natural pigments in a water base. Argan oil, which has a high content of amino acids, has also been used as an important ingredient.

### **NAIL HARDENERS**

These are applied as a base coat for the purpose of strengthening the nail plate. They may contain titanium–silicone–zirconium polymers, polytef, nylon, calcium, and biotin.<sup>[4]</sup> Those containing formaldehyde may cause paronychia and irritant dermatitis, and are not in common use anymore. Nail hardeners need to be cleaned off every 2–3 days to prevent onycholysis and chromonychia.<sup>[5]</sup>

### **NAIL POLISH REMOVER**

With the innumerable color choices available, nail polish is constantly changed to suit women’s moods

and clothes. This involves cleaning off the existing one with removers. The following varieties are available:

1. Acetone – the most commonly available. It has been reported to cause an irritant dermatitis.
2. Acetone-free nail polish removers containing ethyl acetate, butyl acetate, or ethyl lactate.
3. Nail polish remover pads containing gammabutyrolactone, which are safe and convenient to use. Rarely they get converted to GHB (gamma-hydroxybutyrate) resulting in systemic toxicity.

### FRENCH NAIL MANICURE

This method is used to provide a “natural” appearance to the nail. A pink color is applied to the main nail plate, while a white color is applied to the free edge, simulating a natural un-painted nail, picturing good health [Figure 2].

### NAIL ADORNMENT

1. The cosmetic appeal of nail polish can be enhanced with the application of ready-use plastic or metal artifacts immediately before the polish dries.
2. The design pieces are skillfully lifted from a template with forceps and placed on the freshly applied wet nail polish, in a planned pattern [Figure 3a and b].
3. This is then covered by a top coat, which prevents it from getting dislodged.
4. Nail design can also be made, allowing the first layer of color polish to dry completely and subsequently painting a second contrasting color on top of the first, with a design template.

### ARTIFICIAL NAILS

Artificial nails evolved from the need for lengthening or reinforcing soft, brittle, or damaged nails. These can be partially attached as nail tips or used to reinforce the entire length as sculpted nails (acrylic or gel based).

### NAIL TIPS

Ready-to-use plastic plates, shaped like nail tips are available at nail salons. These are glued to the free edge of the nails with adhesives containing methacrylate or ethyl 2-cyanoacrylate. The nail surface is filed roughly prior to gluing the nail tip, in order to improve adhesion.

The glued-on tips are then painted or decorated with nail art and finally coated with acrylic or gel [Figure 4a and b]. Entire plastic nails can be stuck on. The tips can be removed with acetone.

### SCULPTURED NAILS

These are either acrylic or gel based and are sculpted over the existing un-aesthetic nail. Both acrylic or gel-based nails involve a mix of a powder and a solution, applied to the nail. A disposable foil with a printed grid is used as a template for the application of materials.

#### Acrylic nails

A few drops of ethyl methacrylate mixed with powdered poly-methacrylate results in a polymerized mixture that needs to be applied quickly due to the instant setting potential. A uniformly thin layer is applied to achieve the desired effect. The powder contains benzyl peroxide, which acts as a catalyst, while hydroquinone acts as an inhibitor of polymerization. Individual brands may add titanium dioxide and permitted colors. A further modification of the process is the gluing of pieces of silk, linen, or fiber glass to the nail, prior to the acrylic application. These are called “nail wraps” and add strength to the nails. Acrylic nails can be removed with acetone.

#### Gel nails

The powder and the liquid phase of gels is akin to dental resin and requires specific UV-light exposure to set and cure (harden) the gel after application on the nail. These nails appear glossy, are aesthetically appealing, have greater strength for endurance to physical wear and tear, and need less after-care [Figure 5]. Gel nails can be removed only by completely buffing them off the nail plate. This results in physical damage to the nail plate during each removal. “Touch-up” procedures are required for both acrylic and gel nails. As the nail plate grows, a gap appears at the proximal end between the nail fold and the artificial nail [Figure 6] that needs to be filled up at regular intervals, usually every 2–3 weeks.

### ADVERSE EFFECTS

These can be broadly categorized as those due to the chemical components or complications during or subsequent to the nail-grooming procedure. Most reported adverse reactions due to the chemical components have been tabulated in Table 1.

**Procedural complications of a manicure/pedicure**

These may occur in the periungual tissue, the nail plate, or at distant sites due to an allergic contact dermatitis.

1. Cuticular cuts and “hang” nails are common with the cuticle-trimming procedure and can be very painful.

- 2. Irritant reactions or chemical burns following use of the cuticle softener are usually seen around the proximal paronychia fold.
- 3. Clipping nails when dry can cause onychoschizia, with horizontal splitting of the nail plate in layers, making it brittle.



**Figure 1: Bright-colored nail polish adds to the beauty of the hand**



**Figure 2: French Manicure – It stems from the idea of a healthy nail where the free edge of the nail is bright white and the proximal nail has a pink hue**



**Figure 3: (a and b) Nail adornment**



**Figure 4: (a and b) Nail art – Decorative art along with sparkles add to the final effect of the nail**

**Table 1: List of reported adverse reactions to individual constituents of nail cosmetics**

Nail cosmetic	Component	Reported side-effect(s)
Nail polish	Nitrocellulose	Allergic contact dermatitis <sup>[6]</sup>
	Formaldehyde	Allergic contact dermatitis <sup>[7]</sup> Paronychia <sup>[8]</sup> Desquamative gingivitis <sup>[9]</sup> Onycholysis <sup>[4,10]</sup>
	Tosylamide-formaldehyde	Outbreak of contact dermatitis <sup>[11]</sup> Allergic contact dermatitis (occupational) <sup>[12]</sup> Allergic contact dermatitis <sup>[13-15]</sup>
	Dibutyl phthalate	Allergic contact dermatitis <sup>[16]</sup> Decreased sperm mobility and viability <sup>[17]</sup> Altered development of the fetal testis <sup>[18]</sup>
	Butyl stearate D and C yellow 11	Contact dermatitis <sup>[19]</sup> Allergic contact chelitis <sup>[20]</sup>
Nail polish removers	Gamma butyrolactone	Withdrawal delirium with acute renal failure <sup>[21]</sup> Acute toxicity in 9 and 15 month olds <sup>[22,23]</sup> Rapid onset of coma, respiratory depression <sup>[24]</sup> Fatal and nonfatal intoxication <sup>[25]</sup>
Nail adhesive	Methyl acrylate	Skin sensitizer <sup>[26]</sup> Respiratory sensitizer <sup>[27]</sup>
	Ethyl 2- cyanoacrylate	Allergic contact dermatitis <sup>[28]</sup> Occupational asthma <sup>[29]</sup> paresthesia <sup>[30]</sup>
Acrylic nails	Methacrylate	Eyelid dermatitis <sup>[31]</sup> Allergic contact dermatitis <sup>[32]</sup> Occupational asthma <sup>[33]</sup>
	Hydroxyethyl methacrylate	Allergic contact dermatitis (occupational) <sup>[34]</sup>
	Benzoyl peroxide	Allergic contact dermatitis (occupational) <sup>[35]</sup>
Gel nails	UV light	Nonmelanoma skin cancer <sup>[36]</sup>
	Photobonded gel nails	Allergic contact dermatitis <sup>[37]</sup>

- Over-zealous buffing of the nail plate can thin the nail plate and cause fragility.
- Paronychias, bacterial, fungal, and viral infections, especially verrucae, can be inoculated or spread between patients with the use of non-sterile implements.
- Pedicure tubs in which hands and feet are soaked have been reported to cause *Mycobacterium fortuitum* infections from a nail salon in California.<sup>[38]</sup>

The physical process of nail beautification has its own set of adverse events, as have been enumerated earlier. Softening/pushing back/cutting of the cuticle, in nail parlance, is a very important step. Anatomically, the cuticle has a very important role in sealing the potential dead space below the proximal nail fold. A damaged cuticle exposes this walled-off space to external agents like detergents and bacterial, viral, and fungal pathogens. Subsequently, acute-over-chronic paronychia ensues, which, over time, results in nail dystrophy. Cuticle softeners contain alkaline chemicals that cause an irritant dermatitis. Dombrowski and Llyod reported a case of chemical damage to the cuticle and nail plate by application of a callus remover instead of a cuticle softener, under occlusion, resulting in arrest of cuticle formation.<sup>[39]</sup>

Separation of the nail plate from the nail bed can result from over-zealous clipping of the hyponychium or as a consequence of a “lever effect” following minimal trauma, especially in long “strengthened” sculpted nails.

Hapalonychia, the thinning of the nail plate postbuffing, results in weak foldable nails.

Onychoshizia may be attributed to faulty trimming when the nails are dry, leading to horizontal layering of the nail plate.

Repeated use of nail polish, especially deep colors like red, often stain the nail plate. Staining was reproduced with D and C red no 7, D and C red no 34, D and C red no 6 and FD and C yellow no 5 lake. The likelihood of staining increases if the pigments are dissolved and not suspended [Figure 7].

Patients may develop delayed hypersensitivity reactions around the painted nail and rarely present with acute contact dermatitis. Allergic contact dermatitis from nail polishes has been seen to affect distant sites like face and neck commonly, especially on the eyelids and around the mouth. Unusual involvement of other distant sites like the genitals and perianal region have also been reported.<sup>[40]</sup> TSFR was the seventh most common ingredient causing contact dermatitis in patients with a cosmetic allergy.<sup>[2]</sup>

Baran described surface friability of the nail plate, mimicking a white superficial onychomycosis, following the use of nail products [Figure 8]. The keratin granulations occurred more commonly when



**Figure 5: Gel nails – These look similar to acrylic nails but are stronger and appear more glossy**



**Figure 6: Development of a clear area at the proximal nail fold as the nail grows out. Note also the onycholysis in the little finger**



**Figure 7: Prominent staining of nail plate along with onycholysis results from regular and repeated use of nail polish and nail polish removers**



**Figure 8: Keratin granules simulating superficial onychomycosis**

the nail polish was kept on for several months or when it was re-applied without removing the first coat and also when a primer base coat was not applied.<sup>[41]</sup>

Nickel-sensitive patients may develop an allergic contact dermatitis due to the adornments. In such patients, adornments chosen may be of gold or may be nickel free.<sup>[42]</sup>

**RELEVANCE OF NAIL COSMETICS IN A HEALTHCARE SETTING**

Long fingernails harbor bacteria, and antimicrobial soaps/gels may not be sufficient for complete elimination. Long nails are cumbersome, reduce grip, and tend to puncture gloves. Hence, they are best avoided by medical professional in healthcare settings. Wynd *et al.* in their study on 102 perioperative nurses

concluded that chipped nail polish or nail polish worn for more than 4 days increased bacteria on fingernails.<sup>[43]</sup> Opaque nail polish can mask nail signs during a clinical examination. The possible role of nail varnish in altering pulse oximeter reading has long been debated. However, it has now conclusively been seen that there is no effect in the measurements from healthy or hypoxic subjects. Chan *et al.* suggest placing the probe in a side-to-side position on the finger to preclude any disparity in the measurements.<sup>[44]</sup>

**NAIL COSMETICS IN NAIL DISEASE**

Many dermatological diseases cause disfigurement of the nail plate, which may be cosmetically unacceptable to the patient and reduce his or her quality of life. The duration of treatment for most intractable nail disorders is long, with poor efficacy. While waiting for the therapeutic response, cosmetic camouflage helps

the patients tide over the mental discomfort.<sup>[45]</sup> Nail polish application may be adequate for camouflaging dyschromias and mild dystrophies. Gel or acrylic nails may be helpful in concealing moderate nail dystrophy. For cases of anonychia or severe nail dystrophy, a nail prosthesis may be the only option. This prosthesis consists of a false nail attached to a silicone finger glove molded to the specifications of the corresponding finger of the opposite hand.<sup>[46]</sup>

### NAIL COSMETICS IN CHILDREN

Nail cosmetics are generally not recommended for use in children. However, the author has seen mothers using it on their children's nails in order to break the nail-biting habit, the deterrent being the taste. This is not advisable, as there is always a possibility to develop adverse reactions.<sup>[47]</sup>

### OCCUPATIONAL HAZARDS FOR NAIL TECHNICIANS

Nail technicians are at a risk of occupational hazards due to constant exposure to chemicals used for various nail cosmetic procedures. Increasing number of technicians are sensitized to acrylate monomers used on sculpted nails. Some are at risk for developing occupational asthma due to the cyanoacrylates used.<sup>[29]</sup> McNary and Jackson concluded in their study that neither nail technicians nor consumers are at any additional risk when exposed to formaldehyde and toluene at their work place compared with exposure from commercial products at home.<sup>[48]</sup>

### UNUSUAL ADVERSE EFFECTS

Nail polish remover pads were reported to have caused bilateral pneumothoraces, pneumomediastinum, and respiratory obstruction in a 15-month-old child who accidentally sucked on them. Fortunately, with medical treatment, the child recovered completely.<sup>[23]</sup> Turgut *et al.* reported a case of bacterial endocarditis developing as a consequence of a pedicure.<sup>[49]</sup> A series of patients developing candidal osteomyelitis and diskitis, narrowed down to a nurse who was wearing artificial nails, was reported by Parry *et al.*<sup>[50]</sup>

### TESTING FOR ADVERSE REACTIONS TO NAIL COSMETICS

1. Nail polish should be tested as it is.
2. A specific resin can be tested in 10% petrolatum.
3. Nail acrylate allergy should be tested with 2-hydroxy methacrylate, ethyl cyanoacrylate,

and methyl methacrylate monomer 10% in olive oil.<sup>[51]</sup>

4. Patch testing for nail polish removers should be an open patch test, at a concentration of 10%, dissolved in olive oil.
5. Cuticle removers tested as a 2% aqueous concentration as an open patch test.

### TIPS TO PROVIDE TO PATIENTS VISITING A NAIL SALON

1. The nail salon should have a clean environment.
2. The nail technicians should be neatly attired and have clean nails.
3. Check how the nail implements are cleaned and sterilized. Implements like nail clippers, nail cutters, foot scrapers, callus removers, and electric drills are sterilized best with autoclaving or soaking in 7.5% stabilized hydrogen peroxide for 6 h or in >2.4% gluteraldehyde-based formulations for 10 h to remove all pathogenic organisms and spores. The trend at the parlors is to soak the instruments for 10 min in disinfectants like benzalkonium chloride.<sup>[52]</sup> These may still harbor bacteria, fungi, yeast, and viruses.<sup>[51]</sup>
4. Carrying one's own implements is a wise decision.
5. Nails should be cut only after soaking for 10–20 min in water to prevent onychoschizia.<sup>[4]</sup>
6. Over-zealous pushing back the cuticle or nipping the cuticle by the technician should be avoided, as it leads to infection and inflammation of the nail folds.
7. Nail polish should be left on for few days only, and cleaned off with acetone-free cleansers. Nail hardeners too need to be cleaned off every 2–3 days. Inform the patient about the probable staining effect of dark nail polish. Avoid layering on nail polish without cleaning off the old one.
8. Inform the patients about nail plate damage with application of artificial nails.
9. Any swelling, pain, redness, and growths around the nails should be attended to by a medical practitioner.

### CONCLUSION

Although nail cosmetics are advantageous for “beautifying” or concealing various nail disorders, adverse effects are a definite possibility. As dermatologists, a complete knowledge of various

nail products, nail-enhancement procedures, and anticipated complications and their management can result in better patient care.

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