Review Article

# Nail fragility syndrome and its treatment

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## Summary

For reasons of clarity, definitions are offered for strength, hardness, flexibility, brittleness and toughness of the nails. Six clinical types of nail fragility are delineated: longitudinal furrows and splitting (onychorrhexis), single longitudinal splitting, multiple crenellated splitting, lamellar splitting (onychoschizia), transverse splitting and nail friability. Changes may be observed in the keratin structure of fragile nails.

Nail brittleness is usually 'environmental' in origin, but sometimes may be part of a nail dystrophy. Household daily chores are particularly damaging. Among the acquired general causes, hypochromic anaemia and sideropaenia, arthritic deformities of the distal joints, peripheral vascular impairment and endocrinopathies are the best known.

Useful therapeutic approaches are updated. They entail protection with plastic gloves worn over light cotton glove linings, the use of nail hardeners composed of two main types of products: a modified nail varnish that functions as a base coat or a hardener, such as dimethyl urea, which overcomes the objections related to formaldehyde; a systemic drug, biotine, is still useful.

*Keywords*: biotine, dimethyl urea, formaldehyde, nail brittleness, nail fragility

## Introduction

Nail fragility syndrome and onychomycosis are probably the most common nail disorders encountered by dermatologists in their daily practice.

## Nail fragility results from an alteration in the consistency of the nail

The nail plate is a unique combination of strength and flexibility. It may be hard, soft, brittle or friable. The following definitions are offered.[1]

- *Strength* is the ability of the nail plate to withstand breakage.
- *Hardness* measures how easily the plate is scratched or dented.
- *Flexibility* determines how much the plate will bend. Moisture greatly influences nail plate flexibility.
- *Brittleness* shows how likely the nail is to break.
- *Toughness* is a combination of strength and flexibility.

Very soft nails are sometimes referred as to hapalonychia. Such nails may be thinner than usual (< 0.5 mm) and bend easily and break or split at the free edge. In some cases the nails, which assume a semitransparent, bluish-white hue, are referred to as 'egg-shell nails'. Hapalonychia has been noted in chronic arthritis, leprosy, myxoedema, acroasphyxia, peripheral neuritis, hemiplegia, cachexia and other states. However, occupational contact with chemicals is probably the most common cause. 'Soft nail disease'[2] is an unusual, congenital, nail dystrophy with anatomical and functional defects of the nail matrix.

Clinically, *nail fragility syndrome* encompasses six main types:[3]

- *Onychorrhexis* is made of shallow parallel furrows running in the superficial layer of the nail. It may result in an isolated split at the free edge, which sometimes extends proximally (Fig. 1).

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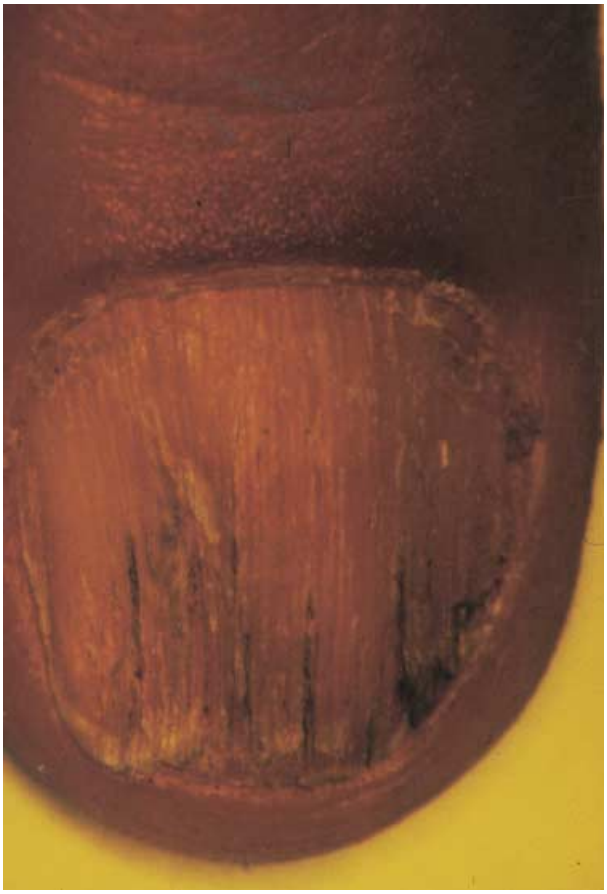

**Figure 1** Onychorrhexis.

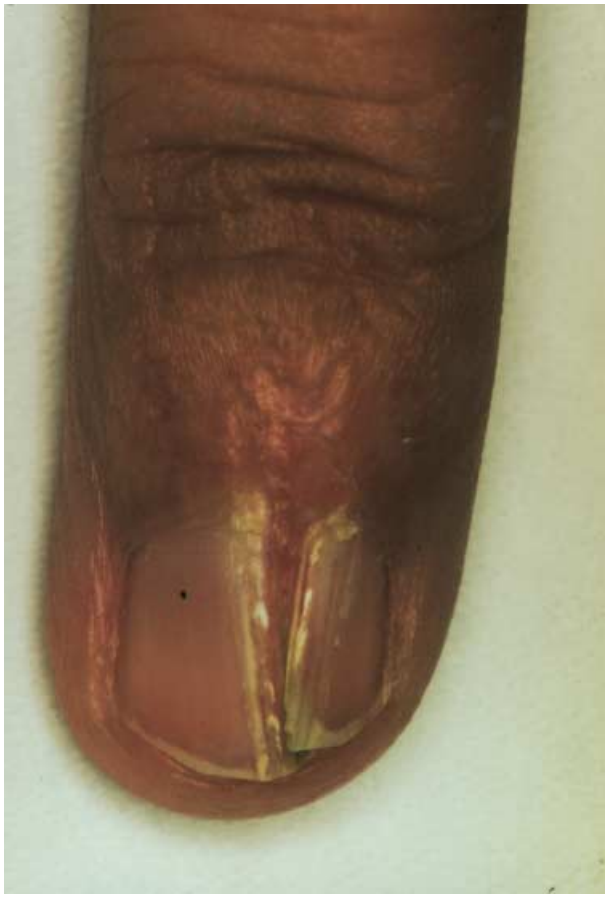

**Figure 2** Single longitudinal split (lichen planus).

- *A single longitudinal split* involving the entire nail plate is sometimes observed. It may be produced by focal matrix lichen planus (Fig. 2).
- *Multiple, crenellated splitting* which resembles the battlements of a castle and triangular pieces may easily be torn from the free margin (Fig. 3).
- *Lamellar splitting* of the free edge of the nail into fine layers. It may occur in isolation or associated with the other types of splitting. Proximal lamellar splitting may occasionally be observed in lichen planus and during etretinate or acitretine therapy (Fig. 4).
- *Transverse splitting* and breaking of the lateral edge, usually close to the distal margin (Fig. 5).
- *Friable nails* are brittle and the changes are often confined to the surface of the nail plate; this occurs in superficial white onychomycosis and may be seen after application of nail polish or base coat which causes 'granulations' in the nail keratin (Fig. 6). In advanced psoriasis (Fig. 7) and fungal infection (Fig. 8) the friability may extend throughout the entire nail.

**Figure 3** Multiple, crenellated splitting.

Changes in nail consistency may be due to impairment factors related to nail health, and include such elements as variations in the water content or the keratin constituent. Changes in the intercellular structures, cell membranes

**Figure 4** Lamellar splitting (onychoschizia).

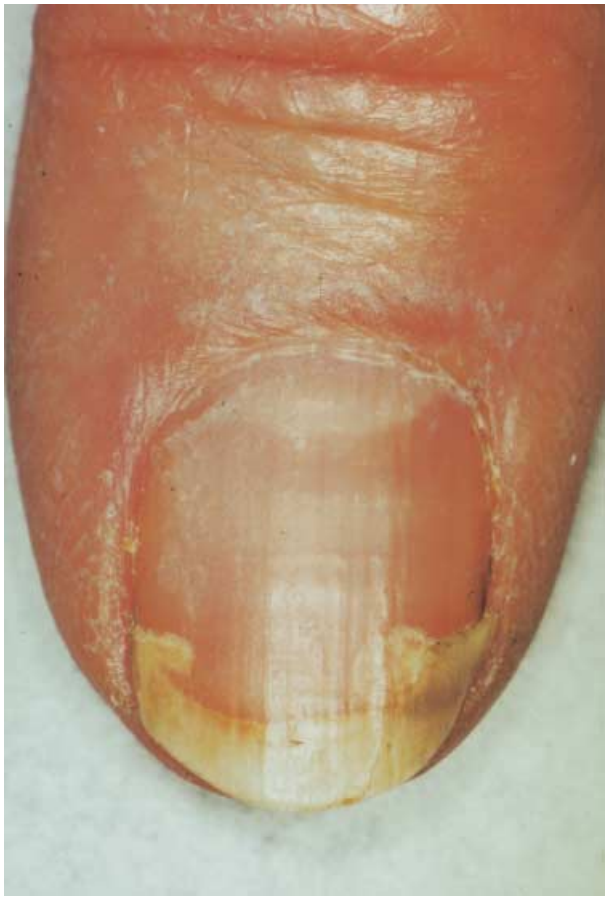

**Figure 5** Transverse splitting.

and intracellular changes in the arrangement of keratin fibrils have been revealed by electron microscopy[4] Normal nails contain ≈ 15% water.[5] After prolonged immersion in water this percentage is increased and the nail becomes flexible and soft; this makes toenail trimming much easier. A low lipid content may decrease the nail's ability to retain water. If the water content is considerably reduced, the nail becomes rigid and brittle. Splitting, which results from plate brittleness is probably partly due to repeated uptake and drying out of water.

The keratin content may be modified by chemical and physical insults especially in occupational nail disorders. Amino acid chains may be broken or distorted by alkalis, oxidizing agents and thioglycolates, such as chemicals employed in the permanent waving processes. These break or distort the multiple -S=S- bond linkages that join the protein chains to form the keratin fibrils. Keratin structure can also be changed in genetic disorders.[6] In some congenital conditions, such as dyskeratosis congenita, the nail plate is completely absent, or reduced to thin, dystrophic remnants.

The composition of the nail plate is sometimes related to generalized disease. High sulphur contents predominate in the form of cystine, which contributes to the stability of the fibrous protein by the formation of disulphide bonds. Tricholhis-dystrophy is associated with low sulphur content. A lack of iron can result in softening of the nail and koilonychia; conversely, the calcium content in the nail would appear to contribute little towards its hardness. Calcium is mainly in the surface of the nail, in small absorbed quantities, and X-ray diffraction shows no evidence of calcite or apatite crystals. Damage to both the central and peripheral nervous systems may result in nail fragility.

## Causes of nail fragility

These may be local or, less frequently, systemic.

### Local causes

They may be due either to nail plate impairment or to matrix impairment.

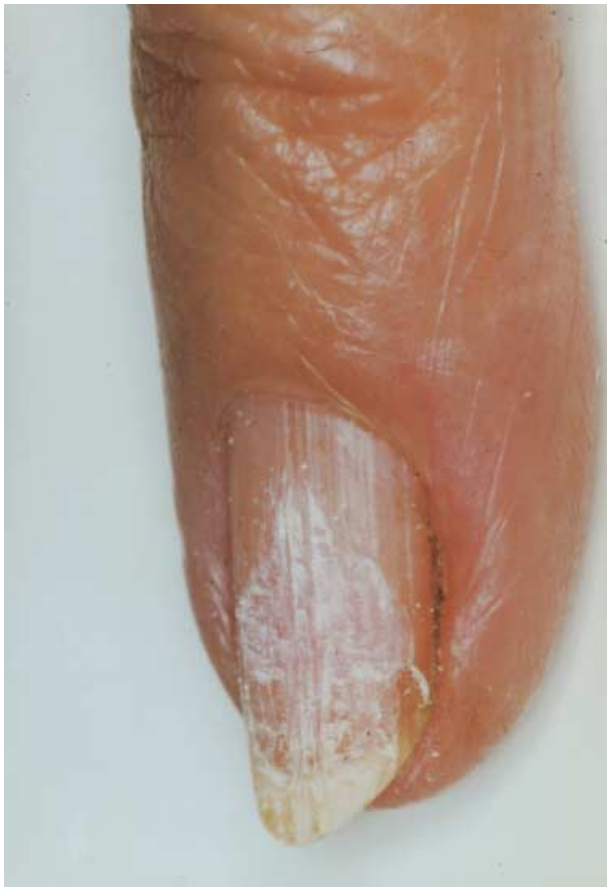

**Figure 6** Nail friability due to keratin granulations.

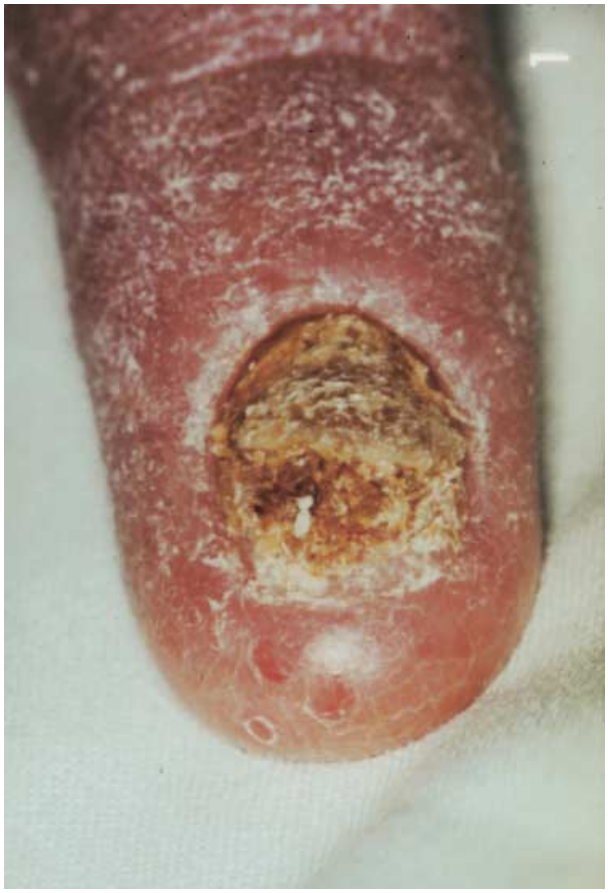

**Figure 7** Nail friability due to severe psoriasis.

The nail may be damaged by trauma or by chemical agents such as detergents, alkalis, various solvents and sugar solutions and, especially by hot water.

The nail plate requires 5–6 months in order to regenerate and therefore it is vulnerable to daily insults. Therefore, treatments that would increase the rate of nail growth would be beneficial in the treatment of brittle nails.[7] Those carrying out household chores are very susceptible; particularly at risk are the first three fingers of the dominant hand. Anything that slows the rate of nail growth will increase the risk. Consequently, it is higher in the elderly. In addition, the age-dependent decrease in cholesterol sulphate levels may also explain the higher incidence of brittle nails in women.[8] Cosmetic causes are rare. Some varnishes will damage the superficial layers of the nail. Drying may be enhanced by some nail varnish removers[9] and soaking fingers in a warm soapy solution, to remove the cuticle, is especially problematic; this is common practice among manicurists. It has been shown that climatic and seasonal factors may affect the hydration of the nail plate.

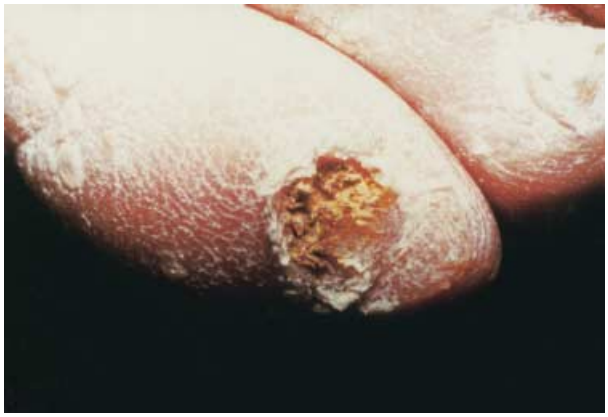

**Figure 8** Nail friability in long-standing total dystrophic fungal nail infection (Courtesy S. Goettmann-Bonvallot, Paris).

Fragility, due to thinning of the nail plate, may be caused by a reduction in the length of the matrix. Diminution, or even complete arrest of nail formation over a variable width may be result of many dermatoses such as eczema,

lichen planus, psoriasis, acanthosis nigricans and impairment of the peripheral circulation. The frequency of nail fragility in alopecia areata lends credence to the popular belief that nail and hair disorders are often associated.

Lubach and Beckers[10] have shown that in women the bridges between nail corneocytes are possibly weaker than in men as a constitutional characteristic. Accordingly, frequent, alternating periods of hydration and drying increase the incidence of brittle nails, particularly in women.

### General causes

Among these are included hypochlorhydria, hypochromic anaemia, reduction in serum iron, arsenical intoxication, infection, endocrinopathies, diseases which produce severe, generalized effects, arthritic deformities of the distal joints, periphered vascular impairment, deficiencies in vitamins A, C, B6 and zinc, osteoporosis and osteomalacia: also, there are numerous, inherited defects associated with atrophy of the nail. The diverse constituents of the nail plate, especially the enzymes necessary for the formation of keratin, are subject to genetic influences and changes in them are manifested in the form of hereditary disease such as trichothiodystrophy.

## Local treatment for nail fragility

Moisture (excess hydration) and trauma must be avoided at all costs; routine household chores are particularly damaging. Protection with rubber or plastic gloves worn over light cotton glove liners should be used in order to avoid frequent direct contact with water.

A warm environment and hyperaemia may lead to faster growth. This may bring about a reduction in the time the nail plate is exposed to repeated minor chemical and physical actions that accentuate nail fragility.

There is no efficient barrier cream able to prevent oversoftening of the nails due to water and detergents. After hydration, the nail plate should be massaged, preferably with an oil that can penetrate and seal the upper surface of the nail plate, i.e. low molecular mass natural oils such as olive oil (squalane), rice brand or jojoba oil. Mineral oil or a lubricating cream that occlude the nail's surface will prolong moisturiazation, but their effectiveness wears off more quickly than absorbing oils. Warm oil soaks can improve flexibility chiefly by improving oil penetration, which enhances the moisture content and improve flexibility. Under experimental conditions hydration may be further enhanced by the addition of phospholipids, which have been shown to be effective in increasing and maintaining nail flexibility.[11] This may result from an occlusive effect of the applications which may delay the evaporation of water. Base coat, nail polish and a hard top coat act in a similar manner and also have a splint-like effect in strengthening the nail, which should be kept short.

### Nail hardeners

There are two main types of products that make nail-hardening claims. In one group, the products are just modified nail polish containing, among their ingredients, nylon fibres, acrylate resin and hydrolysed proteins. They either function as a base coat for nail polish or as a stand-alone treatment. These products provide a protective coating, therefore the implied benefits come from the added strength and durability of the coating itself, rather that changes to the physical properties of the nail plate. These products may also consist of polyesters, acrylics and polyamides. These nail hardeners are essentially a modification of clear nail polish with different solvents and resin concentration for maximum adhesion. They are the first coat applied to the clean nail plate, functioning as a base coat to allow better adhesion of the coloured nail coating.

The second type of hardener chemically alters the structure of the nail. These products may contain up to 5% formaldehyde tissue fixative, but are designed in the USA to be applied only to the free edge of the nail while the skin is shielded. Most products never exceed 3% formaldehyde, the more widely sold brands are under 1%. Higher concentrations of formaldehyde can adversely affect both the nail plate and the surrounding tissue. Adverse changes can quickly occur, sometimes after only a few weeks of use, especially if erroneously applied to nails that are brittle or splitting. Formaldehyde can worsen such conditions and should only be used for improving weak and/or thin nails that need greater surface hardness and more rigidity. Also, companies selling these products generally disregard requirements for skin shields, so skin exposure can be significant. Products containing < 0.2% formaldehyde seems to have little or no positive benefits on hardness of the nail plate.

Formaldehyde permanently alters the structure of the nail plate by cross-linking the keratin, which can quickly lead to embrittlement because cross-link density increases over time with continued regular use. Continued use also allows a deeper penetration into the plate, further affecting the bulk properties of the natural nail. Increased cross-link density increases the surface hardness of the nail plate, but it also lowers flexibility while increasing strength, resulting in an imbalance called brittleness. The property that people are unknowingly seeking is toughness. This occurs when there exists a favourable balance between strength and flexibility. Because the general public does not understand how or why these products work, they

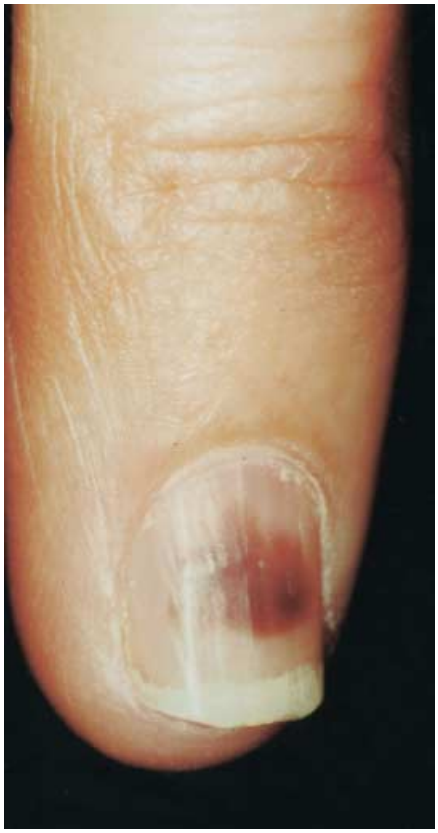

**Figure 9** Formaldehyde complication: subungual haemorrhage.

often apply the products to nails that are already overly brittle or rigid and therefore not suitable for further hardening. Even on nails that could benefit, these products are frequently misused. The preparations work so well on thin weak nails, that users see an almost instant improvement, which encourages repeated use and frequently excessive use. After several weeks of success, the nails can eventually become overly hard and rigid. Continued use can cause splitting, cracking and breaking which unaware users can misinterpret. This will often cause them to continue to use these products with even greater frequency leading to the problems associated with over-exposure to this ingredient.

Formaldehyde preparations may cause nail changes including a bluish discolouration, which may turn red, with intense throbbing. Resolving haemorrhages produce reddish-rust (Fig. 9) or yellow discoloration of the nail. Formaldehyde can also be responsible for paronychia, onycholysis, subungual hyperkeratosis and dryness of the fingertips, but nail shedding is uncommon. Pterygium inversum has been observed, sometimes accompanied by severe pain necessitating systemic corticosteroid.

Isolated onycholysis and ectopic contact dermatitis, even associated with haemorrhages of the lips in nail biters, have been reported. Airborne contact dermatitis of the face may also be seen.

Formaldehyde (1–2% in water) should be used for patch testing, but caution is necessary in interpreting the reactions, because the agent also acts as an irritant.

In recent years, a new nail-hardening ingredient has been introduced which over comes the objections related to formaldehyde. The ingredient, dimethyl urea (DMU), is non-sensitizing and 2% concentrations in a basecoat preparation do not overly cross-link the keratin. The higher molecule mass and relative increase in hydrophobicity prevent DMU from penetrating as deeply into the plate as formaldehyde. This effectively limits the cross-linking action to the surface of the plate thereby dramatically reducing the potential for over-hardening and embrittlement. Further, the greater the cross-linking on the surface, the more restricted DMU penetration will become, essentially creating self-limiting cross-linking reaction while having the additional benefit of being non- sensitizing.

Other alternatives to formaldehyde hardeners are aluminium chloride (5% in water) tannin and nail creams with a low water (30%) and high lipid content for minimizing nail fragility.

### Nail mending and wrapping[12]

The purpose of nail mending is to create a splint for a partially fractured nail plate or one longitudinal split extending the full length of the nail. The most basic and most temporary method starts by laying a thin coating of cyanoacrylate glue on the nail followed by a thin coating of a nail polish containing reinforcing fibres. A piece of thin paper or fabric is cut and shaped to fit over the nail surface. This is then embedded in nail polish before it dries, followed by several additional coats. Conversely, a piece of thin paper or fabric (i.e. silk) is applied directly over the crack and subsequently sealed to the nail with cyanoacrylate adhesive or no-light gel. The latter is the most popular and durable technique.

In nail wrapping or 'wraps', the free edge of the nail should be long enough to be splinted with paper, silk, linen or fibreglass and fixed to the plate with cyanoacrylate glue–low molecular mass resins which polymerize when exposed to moisture in the air or in the natural nail's surface, forming the hard nail coating that is both the base and top coats of the nail wrap.

The activator for cyanoacrylate wraps is a catalyst to harden wrap coating. The most important ingredient in cyanoacrylate catalysts is *N*,*N*-dimethyl-*p*-toluidine

  

(DMPT) in a solvent carrier. Methaemoglobinaemia with resultant cyanosis may follow its ingestion. DMPT is typically 0.5% of the formulation and hydroquinone ≈ 0.001%. The ethyl acetate and trichloroethane that set the gel do not promote curing, but are merely solvents.

Silk wraps are sheer and very thin. Linen is thicker and offers increased strength, but inhibits cyanoacrylate penetration to the nail, thus lowering adhesion. Fibreglass combines many benefits of both silk and linen.

Most wrap systems consist of a few basic elements: an adhesive resin composed of cyanoacrylate, a mesh material, i.e. fibreglass or silk, an activator or catalyst that cuts the hardening time to seconds.

## Systemic treatment for nail fragility

Zaun[13,14] demonstrated that brittle nails tested using a standardized micrometric method, swell significantly less than normal nails: measurement of these 'swelling properties' may be the best documented and most reliable method for the treatment of brittle nails. Qualitative data can also be obtained by scanning electron microscopy. Measurement of the transonychial water loss and assessment of the thickness and density of nails by ultrasound have also been used successfully.

Systemic treatment may be helpful. Oral iron (given for 6 months), even in the absence of demonstrable iron deficiency may be of some value. Campbell and McEwan[15] suggested the following regime: evening primrose oil (Efamol G) 2 capsules t.i.d., pyridoxine 25–30 mg per day and ascorbic acid 2–3 g per day.

Gelatin has been abandoned and, more recently, biotin that increases linear nail growth has been suggested for treating brittle nails.[16–18]

## Conclusion

More precise definitions of the terms relating to the various types of nail fragility are offered. It is hoped that they will improve the clinician's ability to delineate the various conditions encountered in this field.

In addition, ways of limiting vulnerability to nail damage in daily life, associated with the application of dimethyl urea, a new local hardener, are discussed.

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