Review Article

Brittle nails

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Summary

Nail brittleness is a common complaint characterized by weak inelastic nails that split, flake and crumble. It may be a consequence of factors that alter nail plate production and/or factors that damage the already keratinised nail plate. It is often idiopathic. It can also be caused by many dermatological and systemic diseases, nutritional deficiencies, drugs and traumas. Environmental and occupational factors that produce progressive dehydration of the nail plate have an important role in nail brittleness.

Treatment of brittle nails is often difficult. Preventative measures, together with oral supplementation of vitamins (especially biotin), oligo-elements and amino acids, can be useful in improving nail strength. Cosmetic treatment affords camouflage and a degree of protection.

Keywords: ageing, integral lipids, nail cosmetics, nail fragility, onychorrhexis, onychoschizia

Introduction

Nail brittleness is a common complaint affecting up to 30% of women over 50 years of age.

It is characterized by nails that split, flake and crumble, becoming soft and losing elasticity (Fig. 1).

Patients with nail fragility complain of cosmetic and functional problems, such as difficulty in wearing tights without laddering them.

Anatomy of the nail

The nail plate is a fully keratinised structure made up of about 25 layers of tightly packed keratinocytes and produced by the germinative epithelium of the nail matrix. The nail plate is 0.5–1 mm thick and its surface is normally smooth. As it grows, the nail plate emerges from the proximal nail fold and progresses distally, lying across and tightly adhering to the nail bed. At the tip of the digit the nail plate detaches from the underlying tissues at the hyponychium. Proximally and laterally, the nail plate is surrounded by the nail folds, which protect the matrix from the environment. The nail matrix is responsible for the production of the nail plate and consists of an epithelium that keratinises without the formation of a granular layer. Nail matrix keratinization follows an oblique axis, as cells move upward and distally during the process of maturation and differentiation.

The nail plate is made up of three layers:[1]

- The dorsal nail plate, which is produced by the proximal portion of the nail matrix and is 0.08–0.1 mm thick, consisting of tight, flattened cells. This portion gives the nail hardness and sharpness.
- The intermediate nail plate, which is produced by the distal matrix and is 0.3–0.5 mm thick, consists of wide and irregular cells. This portion gives the nail flexibility and elasticity.
- The ventral nail plate, which is produced by the nail bed and is 0.06–0.08 mm thick, consists of keratinocytes derived from nail bed keratinization. This portion is necessary for the adhesion of the nail plate to the nail bed.

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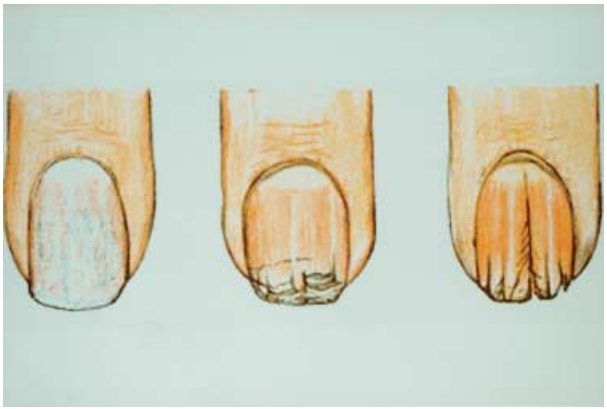

Figure 1 Different types of nail brittleness: (a) keratin granulation; (b) onychoschizia; (c) onychorrhexis.

The distal portion of the nail matrix is visible through the transparent nail plate as a white distally convex half moon, the lunula. Above the lunula, the nail plate is thinner and consists only of the dorsal and intermediate portions.

The nail plate keratinocytes are made up of 80–90% hard hair-type keratin filaments and 10–20% soft skin-type keratin filaments. The keratin fibres are orientated into three layers.

In the dorsal and ventral nail plate the skin-like keratin filaments are orientated in two directions, parallel and perpendicular to the growth axis. In the intermediate nail plate the hair-like keratin filaments are orientated perpendicularly to the growth axis.[1]

Nail hardness is mainly the result of high sulphur amino acids, particularly cystine, and tight keratin cross-links. The keratin protein in nails is hardest at a slightly acidic pH. Adhesion between cells is facilitated by membrane-coating granules with linkage by lipids, such as acylceramides.

Nail plate production occurs continuously, from the 15th week of embryonic life until death. Under normal conditions, the mean growth rate of a fingernail is 3 mm/month and that of a toenail is 1 mm/month.

Nail brittleness may be a consequence of factors that alter nail plate production and/or factors that damage the already keratinised nail plate (Table 1).

Idiopathic nail brittleness

This is the most common cause of nail brittleness and is almost exclusive to fingernails. The nails show longitudinal ridging and fissuring, transverse splitting and horizontal lamellar separation of the distal nail plate.

Scanning electron microscopy studies indicate that nail brittleness is associated with an intrinsic or acquired defect in the intercellular cement that holds together nail plate keratinocytes.[2–4] Brittle nails have a disorganized protein and lipid structure with a dishomogeneous orientation of keratin filaments.[1]

Table 1 Causes of nail brittleness.

Primary factors	female gender
	old age, psoriasis
Dermatoses	eczema, lichen planus, alopecia areata, lichen striatus, scleroderma
	Darier's disease
	onychomycosis
Systemic diseases[10]	iron deficiency anaemia, osteoporosis, haemodialysis, cachexia
	hypo & hyperthyroidism, hypopituitarism, diabetes mellitus
	neuropathies
	peripheral arterial disease
	bronchiectasis
	tuberculosis, syphilis
	sarcoidosis, amyloidosis
	gout
	pregnancy
Drugs	antimetabolites
	gold, arsenic, penicillamine
	antiretrovirals
	retinoids
Nutritional deficiencies[10]	iron
	vitamins A, B, C, D, E, H
	zinc, selenium
Traumas	water, soap, detergents, manicuring
	occupational

In women, the intercellular keratinocyte bridges are constitutionally weaker than in males. Old age further weakens these bridges.[5]

Environmental and occupational factors that lead to progressive dehydration of the nail plate play an important role in the development of nail brittleness.

The nail plate is very porous and the elimination of water is estimated to be comparable to the elimination from the palms. Normal nails contain 18% water and this content determines nail flexibility; when the amount of water is reduced to less than 16%, the nails become brittle.

Water is stored above all in the ventral portion of the nail plate. Dehydration is more rapid if nails are not kept short. Several factors are able to influence the water content of the nail plate, including lipids.[6] Normal nails contain 5% lipids which can only be found in the dorsal and ventral portion of the nail plate and are organized in a bilayer structure, parallel to the nail surface. Lipids fill certain ampullar dilations of the dorsal plate and intercellular spaces in the ventral plate. Low lipid content decreases the nail's ability to retain water. A recent study shows a decrease in cholesterol sulphate in the nail plate with age, especially in women, suggesting an important role of lipids in the development of nail brittleness in postmenopausal women.[7]

These data also suggest that environmental conditions may cause a variation in the incidence of nail fragility between women and men, but are not directly responsible for it, because an intrinsic predisposition to nail fragility is also necessary.[8]

Clinically there are two different types of nail fragility:

Lamellar onychoschizia (Fig. 2)
The distal portion of the nail plate shows a lamellar exfoliation into fine horizontal layers. Triangular pieces may easily be torn from the free margin. This type of nail fragility is almost exclusive to fingernails and it is typical of people who wash their hands too frequently (e.g. housewives, doctors and nurses).

Figure 2 Onychoschizia: lamellar splitting of the free edge of the nail plate.

Figure 3 Onychorrhexis: fissuring of the distal nail plate.

Onychorrhexis (Fig. 3)
This term was originally coined by Dubreuilh and describes an isolated split at the free edge, which sometimes extend proximally. The nail plate is thin and presents parallel furrows running in the superficial layer. It is particularly frequent among the elderly.

These two types of nail fragility may occur alone or in association.

Secondary nail brittleness

This type of nail brittleness can be related to a large number of dermatological or systemic diseases, nutritional deficiencies and drug intake, which affect the nail matrix or, less frequently, the nail plate.

The clinical aspects of nail brittleness as a result of nail matrix damage can vary depending on the site and the extension of the injury. Nail plate thinning resulting from proximal nail matrix damage always involves the whole nail length and is often associated with abnormalities in

Figure 4 Nail thinning, fissuring and splitting as a result of lichen planus.

Figure 5 Darier's disease: a longitudinal streak can be seen along the nail plate.

the superficial nail plate. Damage to the distal matrix, on the other hand, may produce alterations in the shape of the nail plate free edge, but not of the superficial nail plate.

Dermatological diseases[9]

Dermatoses such as psoriasis, lichen planus, lichen striatus, alopecia areata, Darier's disease and eczema may involve the nail apparatus.

For example, up to 50% of patients affected by psoriasis present nail abnormalities that are frequently associated with nail brittleness. When the proximal part of the nail matrix is involved, the nail plate presents irregular and deep pits.

About 10% of patients with lichen planus have specific nail involvement. Most commonly the nail changes consist of thinning, longitudinal ridging and distal splitting of the nail plate (Fig. 4).

The inflammatory reaction of lichen planus can result in the destruction of matrix cells with pterygium. However, when the length of the matrix is only reduced the nail plate becomes thinner.

If the process is localized and persistent, small longitudinal grooves are formed, but if the inflammation is milder, longitudinal ridging is formed instead of grooves.

In lichen striatus, nail involvement is similar to that of lichen planus, but typically, only half of the nail plate is affected.

Approximately two of three patients with alopecia areata have nail changes, such as pits resulting from proximal nail matrix involvement, onychorrhexis and thinning. Changes may be seen in one, several or all of the nails.

In Darier's disease, nail signs occur most commonly in the severely affected patients. When the disease affects the matrix, a white longitudinal streak can be seen along the nail plate, with distal splitting at the free edge (Fig. 5).

Eczema, like other inflammatory diseases, can affect the nail matrix resulting in nail brittleness and lamellar exfoliation.

White superficial onychomycosis is one example of nail fragility as a result of nail plate damage. In this type of onychomycosis, the fungal hyphae colonise the most superficial layers of the nail plate that present white, opaque and friable spots because of keratin digestion by fungi (Fig. 6).

Systemic diseases and general conditions[10]

Brittle nails have also been linked with systemic diseases, nutritional deficiencies and drug intake, but they are often only a specific symptom that accompanies these conditions.

The impairment of peripheral circulation as a result of arteriopathy or neurological disorders may lead to a reduced nail matrix vascularisation with production of a thin nail plate.

Patients with endocrine system disorders may present brittle nails, slow nail growth and longitudinal ridging and fissuring.

Nail changes, characterized by brittleness and softness, are present in about 5% of cases of hyperthyroidism and are often reversible following successful therapy.

The nails are affected in 90% of patients with hypothyroidism. Nails are typically thin, brittle, slow growing and with longitudinal or transverse striations.

Onycholysis, increased fragility, longitudinal ridging and crumbling may occur in amyloidosis (Fig. 7).

Most unusual changes in infectious diseases are nonspecific. Syphilis has been associated with nail thinning, fissuring of the free margin and nail fragility.

Nail changes in pregnancy include transverse grooving, increased brittleness and softening. These changes may occur as early as the sixth week of pregnancy.

Systemic drugs such as retinoids or antiretrovirals can be responsible for lamellar onychoschizia. In these cases

Figure 6 Surface nail fragility as a result of white superficial onychomycosis.

the brittleness is such that the nail plate breaks easily and gives rise to tiny spicules that penetrate the periungual furrows causing the formation of pseudo-pyogenic granulomas.

A severe deficiency of vitamins, oligo elements and amino acids from daily food intake may result to nail fragility and thinning. Vitamin A strengthens nails and helps their growth; vitamin B6 helps the body assimilate proteins; vitamin B12 assists in the circulation and blood flow through the nail matrix; vitamin C strengthens against infections; vitamin D helps utilise calcium; vitamin H (biotin) stimulates cell renewal and improves both the strength and the growth of the nail and reduces moisture loss. The nail plate is rich in iron, zinc and selenium. The relevance of these oligo elements is not exactly known.

The role of traumas

Traumas significantly contribute to nail plate damage altering both the nail plate surface and the nail matrix.

Figure 7 Nail fragility resulting from amyloidosis.

Nail fragility can be caused by microtraumas resulting from everyday working, as in shoemakers, ironmongers or carpenters. Occupational contact with solvents and solutions (chemical/medical personnel, photographers or painters) can modify the keratin content of the nail plate, break the amino acid chains and dehydrate the superficial layers.

Onychotillomania and onychophagia are another two causes of traumatic brittle nails.

Normally, the use of nail polish may be helpful as it slows down evaporation of water from the nail plate from 1.4 to 0.6 mg/cm^2/ h[11] but the abuse of some nail varnishes can damage the superficial layers of the nail causing 'granulations' in the nail keratin that clinically appear as fine and scaling white spots (Fig. 8). Moreover, drying may be enhanced by some nail polish removers and by warm soapy solutions used for removing cuticles.

In 1999, Baran *et al*. described a new variant of nail fragility, the so-called bidet nails, occurring in women excessively concerned about hygiene. The pathogenesis of bidet nails is a repeated traumatisation of the three middle fingernails against a smooth hard surface. Clinically, the nails show a triangular area of marked thinning with its base lying at the free edge of the nail and a wedge-shaped incisure.[12]

This particular type of nail fragility is frequently seen in tailors who repeatedly scrape the fabric to stretch it (Fig. 9).

Treatment

If nail brittleness is the result of a dermatological or a systemic condition, the first thing to do is treat the disease to obtain an improvement of the symptom. However, most patients with brittle nails have an idiopathic nail fragility.

Although there is no evidence-based data proving that these measures are effective, it seems that oral

Figure 8 Friability of the nail keratin as a result of nail varnish.

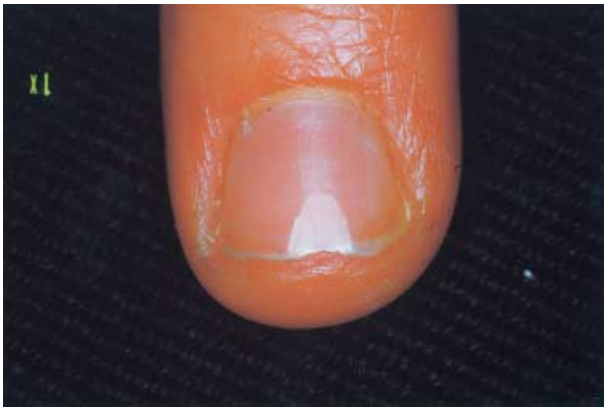

Figure 9 Bararis bidet nail. Nail thinning restricted to a triangular area that extends from the central portion of the nail plate to its free edge.[11]

supplementation with vitamins (especially biotin), oligo elements and amino acids can be useful in improving nail strength.[3] Biotin can be useful because it may improve the synthesis of the lipid molecules that produce binding between nail plate keratinocytes. Several studies have demonstrated clinical improvement in patients who received biotin supplementation.[13] In the authors' experience, iron supplementation may be very effective when ferritin levels are below 10 ng/mL.

Calcium supplementation does not contribute to the hardness of the nail.

Nail moisturizers are useful in patients with brittle nails. They may contain occlusives, such as petrolatum or lanoline and humectants, such as glycerin and propylene glycol. Proteins, fluorides (ammonium hexafluorophosphate) and silicium can also be useful. Alpha-hydroxy acids and urea may also be added to increase the water-binding capacity of the nail plate.

There is no evidence that topical biotin, botanical extracts and topical gelatin (a protein source of nine essential amino acids) are effective in treating nail dehydration.

Cosmetic treatment[14,15]

Brittle nails have created a great deal of interest among people affected as well as cosmetic industries and nail salons. Various products are commercially available to enhance the appearance of nails but there are no data proving their efficacy and only adverse reactions are reported.

Table 2 Measures recommended in case of nail brittleness.

Contact with water and detergents reduced
Cotton gloves worn inside rubber gloves
Nails kept short and squared
Use of nail polish removers limited, especially spirit based ones (twice a month maximum)
Nail polish may be helpful
After any soaking, nails should be rehydrated with topical moisturizers
Long-term wearing of artificial nails avoided
Work-related microtraumas avoided
Cuticles left uncut
Manicuring with sharp tools avoided
Nails filed in only one direction

These products are known as:
- nail hardeners;
- nail strengtheners;
- fortifying nail builders.

Such products, however, differ in their advertised properties, but not in their formulation. Soft nails, which snap easily when bent, require hardening. Fully developed nails, which are prone to splitting but are not soft, need strengthening. Thin nails, where the nail plate is poorly formed and often brittle, require building.

All products are essentially a modification of nail enamels with different solvent and resin concentrations, and with the addition of various substances such as keratin, vitamins, calcium fluoride, natural oils and nylon fibres. They are generally used as a base coat which is claimed to allow their constituents to move through the porous structure of the nail plate to provide strength and flexibility which helps reduce breakage. They may actually act as a protector, preventing contact of detergents and solutions with the nail plate and decreasing nail water vapour loss.

The prolonged regular use of nail hardeners may paradoxically cause brittle nails as the cross-link density rises over time and the flexibility is reduced. When the nail plate is too rigid, it is also more prone to breaking and peeling. Moreover, the hardeners need to be periodically removed with a nail polish remover.

In recalcitrant fragility, nail wrapping limited to the distal portion of the nail may afford protection and camouflage. This method, as well as preformed artificial nails and sculptured nails, can considerably improve brittle nails.

Conclusions

Nail brittleness is caused by a combination of intrinsic nail fragility and environmental exposure to damaging substances. Optimal management requires protective measures, vitamin and iron supplementation.

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