Nail formation and some nail disorders

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Synopsis—The flat NAIL of some primates, including man, is unique and is usually formed from one area of the nail fold invagination called the MATRIX. This is deeply placed below two layers of EPIDERMIS and is therefore well protected from injury. Alternative methods of nail formation more closely resemble the formation of a mammalian claw and may be regressions to a more primitive state.

Conventional nail cosmetics are well tolerated but modifications to improve their stability or their ease of application have caused DAMAGE to nails on a number of occasions. The use of FORMALDEHYDE as a nail HARDENER has also caused trouble and should be abandoned. Leakage of a few tints from nail varnish, resulting in a yellow pigmentation of the nail, not readily removed, has caused distress in some patients.

Damage caused by nail COSMETICS is much less than damage caused by patients themselves either by biting, playing with the nails or over-active MANICURE.

The deep position of the matrix has disadvantages when it comes to treatment of naturally occurring DISEASES as it is very difficult to reach with medicaments.

The mechanism of nail formation is a subject of debate. The fact that the nail is formed from an invagination of epidermis situated on the dorsum of the distal phalanx is not in dispute. The dispute is concerned with the extent of the invagination which takes part in nail formation. The generally held and traditional view is that the nail is formed only from the proximal part of the floor extending from the junction of floor and roof behind to the anterior margin of the half-moon (lunula) in front. A small

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portion of the roof may also be involved (Fig. 1). The portion of the in-vagination which produces nail is known as the matrix and is largely under cover of the roof of the nail fold and the overlying skin at the base of the nail.

Figure 1. Diagram to show traditional theory of nail formation:
(a) Nail plate.
(b) Skin at base of nail.
(c) Roof of nail fold.
(d) Nail matrix.
(e) Nail bed.

Barton Lewis (1) questioned the traditional view and produced evidence to show that the nail is formed in three layers which he called dorsal, intermediate and ventral nails. The dorsal nail is formed from part of the roof and a small part of the floor of the nail fold, but may be lost before the free edge of the nail is reached. The intermediate nail is formed from the remainder of the traditional matrix, while the ventral nail arises from the whole of the nail bed distal to the half-moon (Fig. 2). A third and very old

Figure 2. Diagram to show Lewis's theory of nail formation:
(a) Nail plate.
(b) Skin at base of nail.
(c) Roof of nail fold.
(d) Portion of matrix forming 'intermediate nail'.
(e) Nail bed forming 'ventral nail'.
(f) Portion of matrix forming 'dorsal nail'.

theory (Boas (2)) maintains that the exposed nail bed is sterile except for a small portion close to the point of separation of the nail from its bed. This area is given the German name ‘solenhorn’ (Fig. 3).

![Figure 3. Diagram to show method of nail formation according to Boas:](image)

- (a) Nail plate.
- (b) Skin at base of nail.
- (c) Roof of nail fold.
- (d) Nail matrix.
- (e) Sterile nail bed.
- (g) ‘Solenhorn’.

There is support for all three theories and the author believes all three methods of nail formation may occur. Support for the traditional view comes from experiments with the squirrel monkey, an animal with a flat nail very similar to that of man (3,4). Support for Lewis’s view comes from histochemical staining (5) and from electron-microscopic studies (6). Large amounts from the nail bed are seen in a few pathological conditions. The third view would be supported by any surgeon who has undertaken total nail ablation only to find spicules of nail appearing later close to the tip of the digit. The mammalian claw is formed in two layers so that the alternative methods of nail formation may represent a reversion to a more primitive state.

The rate of growth of finger nails in health varies from 1.2 mm per week down to 0.5 mm. There is a gradual slowing with age, so that most of the more rapidly growing nails will be found in children and the slower rates in old age. Pathological conditions can alter the rate of nail growth. The commonest cause for increased rate of growth is psoriasis, but many nails when they become partially separated from their bed (onycholysis) also grow faster than normal. Very slow rates of growth are usually the result of a few uncommon developmental conditions.
A strong healthy nail is of course dependent on a good blood supply. Under normal circumstances the blood supply to the nail fold is abundant but the arteries are very exposed and are liable to go into spasm in cold weather. In some people this is very common and the nail may be deprived of a good supply of blood for hours at a time. Under these circumstances the nail is liable to become thin, ridged and splits develop along the ridges. These people are also very liable to develop chronic infection of the nail fold, a condition known as chronic paronychia and one of the commonest nail disorders. Although the same change can result from organic arterial damage, spasm is more important as anastomotic vessels can open up to replace injured vessels. Iron deficiency anaemia produces a somewhat similar change when thinning and spoon shaping (koilonychia) are most often found.

Before leaving the anatomy of the nail organ one must say a few words about the cuticle. This is a compound structure consisting of the true cuticle and the eponychium. Each is composed only of soft keratin, the upper layer being derived from the epithelium of the skin at the base of the nail and the eponychium from a similar extension forward of the epithelium of the roof of the nail fold invagination. The two are usually closely united and successfully seal off the potential space between the nail plate and roof of the nail fold.

Like hair and wool, the nail contains a fair quantity of water and it can readily take up more in moist surroundings. It is uncertain how much of the water content comes from deeper structures and how much from the atmosphere. There is no doubt, however, that nails take up moisture freely on soaking in water and lose it fairly quickly on removal. A nail in good condition contains about 16% of water. Nail keratin becomes saturated at about 30%; at this level it loses its lustre, becomes opaque and quite soft. Below 16% the nail becomes brittle and cracks easily.

The implications of the anatomical structure of the nail organ and its interference by natural or artificial means will now be considered.

Taking the traditional view as the most common method of nail formation, it might be expected that the nail would separate from the nail bed very readily. That this does not occur is due to alternating ridges and grooves on the undersurface of the nail plate which interdigitate with similar grooves and ridges on the nail bed. Nevertheless separation of the nail from its bed is one of the commonest nail symptoms. It is a symptom of many diseases mainly local but occasionally general. However, it can also occur frequently without apparent cause (Fig. 4) but in many of these...
Figure 4. Onycholysis affecting tips of nails.
Figure 5. Lamellar dystrophy.

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there may be a minor traumatic element. It is essentially a disease of women and is seen more often in persons who like to keep their nails long. The disadvantages of a loose nail are that it feels uncomfortable, looks unsightly and the space below the nail is likely to collect dirt which is difficult to remove. The space is moist and warm and very easily becomes secondarily infected often with Gram-negative organisms. Pseudomonas aeruginosa infection is especially liable to occur and makes the overlying nail appear bluey-green or black in colour. Malodour may also develop and add to the patient’s distress.

A minority of these cases has undoubtedly been caused by nail cosmetics. Some of you will recall that several years ago a base coat was marketed which produced onycholysis in many persons (7). It could be shown that phenol from the base coat penetrated the nail and could be detected on its under surface. This resulted in a reaction either as a result of primary irritation or of an allergic nature and caused the separation. More recently the same change has been observed from the use of nail hardeners containing formaldehyde (8). There is no doubt that these preparations harden the nail but they are also liable to cause separation at the tips of the nails. In most cases encountered by the author the preparation had been used more frequently than recommended by the makers, but this was not always so. Once the nail comes loose it is very difficult to get it to re-attach.

Another common nail symptom is splitting into layers or lamellar dystrophy (Fig. 5). When a nail is made in three layers splitting might be expected to occur frequently. This is a simple explanation but may not be the whole answer. It is again a disease mainly of women, especially those who like to keep their nails long. Atmospheric conditions certainly play a part and repeated wetting and drying may be a factor. It is for this condition that nail hardeners are often used. A safe nail hardener is urgently needed. Gelatin by mouth has not proved of much value.

Are there any other dangers from nail cosmetics? Nail varnish or polish is generally very well tolerated and seldom causes damage to the nail or its surroundings. Dermatitis of the eyelids and sides of the neck is well recognized as a contact dermatitis from resins in the varnish. Occasionally a nail will become yellow after the application of a varnish of a different hue. This is due to the leakage of a tint from the varnish into the nail. It is quite harmless but may cause great distress to a sensitive patient. This condition is difficult to reproduce experimentally.

To avoid time wasting in the application of nail varnish, stick-on nail
dressings were marketed for a short time some years ago. They caused a
great deal of damage very quickly and it seemed probable that this was due
to their impermeability. Increased water content of the nail built up as a
result of exclusion from the atmosphere so that the nail became soft and
was damaged when the dressing was removed. Even so short a time as 48 h
of use was sufficient to cause damage (9). False nails, if firmly attached
to the nail, are likely to cause similar changes. False nails may be used to
hide an underlying defect such as nail biting or psoriasis, but are often used
simply for cosmetic purposes. Complete disruption of the nail can result
in a few cases.

These mishaps from nail cosmetics are very few compared to the
damage caused by patients themselves! Nail biting is an extremely common
habit and usually results in ugly ragged nails chewed right down to the
hyponychium. Greater damage can be caused by biting the cuticle or by
biting over the matrix. Pushing back the cuticle is carried out as a routine
by many people. Carefully done this will do no harm, but over enthusiasm
can cause regular cross white striations (Fig. 6) or cross ridging of the nail.
Occasionally it may open up the potential space between the nail plate and
dorsal nail fold and initiate chronic paronychia. Another habit which can
produce a very ugly nail is playing with a nail, usually a thumb nail, with
one of the other fingers on the same hand. This can be done quite un-
consciously and produces a nail with a depression down the centre and a
number of cross ridges extending from it almost to the sides of the nail
(Fig. 7).

The nail matrix is responsible for the greater part of nail formation
whichever method exists, and owing to its anatomical position is well pro-
tected so that it is seldom damaged except by severe trauma. Occasionally,
however, chemicals manage to get through to it and cause temporary or
permanent loss of the nail (Figs. 8 and 9). This has occurred in recent years
by accidental exposure to strong solutions of paraquat or diquat, dipyri-
dilium compounds used as weed killers. The solutions are not generally
available to the public but are used by farmers and foresters (10). The nail
matrix is however often involved in skin diseases, especially psoriasis, and
its protected position makes treatment very difficult.

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Figure 6. Leuchonychia striata due to over zealous manicure.

Figure 7. Habit-tic deformity.

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Figure 8. Early nail loss from contact with a weed killer.

Figure 9. Complete permanent nail loss from contact with a weed killer.

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REFERENCES


DISCUSSION

MR. M. G. DENAVARRE: Did I understand that when you see extensive whitening in the nail this indicates that the nail is splitting? Do you mean between the lamellae?

THE LECTURER: Actual splitting of the layers.

MR. K. V. CURRY: You showed us the effect of nail preparation on finger nails, and on a particular slide there were three fingers which presumably came from the same person. On two of them one could see the staining of the nail. On the third one it was much worse. Do you come across this effect often in that one or more finger nails respond completely differently to the rest, and is this due to some other factor that perhaps has not been discovered yet?

THE LECTURER: This was done deliberately. The patient was removing all her varnish and was asked to leave some so that we could see the original colour. Therefore the finger that showed a lot of colour was showing the varnish and not the 'leak' from the varnish, which was the paler colour seen on the other nails.

MR. J. M. BLAKeway: Did you go back to the manufacturer to find out which particular dye or colour was causing the trouble?

THE LECTURER: Yes, it has been published by Calnan (11).

MR. R. Chudzikowski: American regulations allow 4% formaldehyde in nail hardening preparations. Do you consider this level safe?

THE LECTURER: I find it rather difficult to answer that question.

MR. J. S. Cannell: You mentioned the injurious effects that can arise from the use of concentrated solutions of paraquat. Those are concentrated solutions but I

wonder whether there is any danger at all in the normal, garden use, of paraquat solutions?

The Lecturer: Absolutely no danger from the ordinary use once it is diluted to the concentration advised. For the ordinary gardener it is put up in granular form which is even safer and can be handled with impunity, but even the diluted liquid is claimed to be safe.

Dr. C. Prottey: Would you comment further on your statement that enzyme-detergents have caused nail loss? Is this due to a synergistic effect of either the detergent upon enzyme action or vice versa? Does either the enzyme or the detergent penetrate to the matrix? Is the complaint due to excess concentrations of enzyme-detergent, as in paraquat-induced nail loss? Is this complaint a common one?

The Lecturer: It seems probable that there is a dual effect here. The solution gets underneath the nail and causes separation, and secondly, it may destroy the cuticle and get right through to the matrix in that way. It might be due to either of these two mechanisms.

Dr. C. Prottey: Were the concentrations used high compared with, say, the paraquat effect where you state that the effect is due to very high concentration? Are you saying that this is relatively uncommon because the concentrations in this particular case were high? Or is it more common than we would believe?

The Lecturer: In ordinary handlers of the detergent (housewives or equivalent) it was the same as recorded in the Nottingham group with dermatitis due to it. The solutions would therefore not have been concentrated.

Prof. F. J. Ebling: Women are the sex who are mostly putting their hands in detergents, and who are constantly grooming their nails. In view of the emphasis you put on the value of the cuticle in preventing damage to the base of the nail, would you recommend that women do not groom their nails?

The Lecturer: I always recommend that the patients must not push back the cuticle. I think if done carefully by a cosmetologist it is safe, but if done by the patients themselves, it can be dangerous. Leuchonychia striata is shown in Fig. 6 and is entirely due to pushing back the cuticle. It must have been done quite viciously. As soon as we stopped the nurse doing it the nail grew out normally, there was no question as to the cause.

Mr. J. M. Blakeway: I was struck by the slide of the thumb that had been treated with cortisone under occlusion. The state of the skin on the occluded side was very much smoother and demonstrated very well the effect of cortisone on the skin. In the early part of your paper you reviewed at least three series of nail formation. You referred to the Barton-Lewis theory, the last as I recall, of these three. Which do you think is the more valid?

The Lecturer: I do not think there is any doubt that the traditional view of nail formation, viz. that it all arises from the matrix is the commonest form. Especially under pathological conditions. Lewis's theory is correct, but there may be some argument here as to whether one is using the definition of a nail correctly. Is the material that is being added from the nail bed true nail or is it something else, an
intermediate keratin one might say? Histochemical studies show that this material from the nail bed is, in fact, different from the true nail keratin, but it is arguable. Is everything that looks like a nail, a nail? I think this argument has not been really solved.

Mr. C. J. Kirk: Could you tell me whether fat solvents as such have any peculiar effect on nails?

The Lecturer: Apart from the general effect on the epidermis, none that I know of.