Anatomy of the nail unit and the nail biopsy

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Abstract

The nail unit is the largest and a rather complex skin appendage. It is located on the dorsal aspect of the tips of fingers and toes and has important protective and sensory functions. Development begins in utero between weeks 7 and 8 and is fully formed at birth. For its correct development, a great number of signals are necessary. Anatomically, it consists of 4 epithelial components: the matrix that forms the nail plate; the nail bed that firmly attaches the plate to the distal phalanx; the hyponychium that forms a natural barrier at the physiological point of separation of the nail from the bed; and the eponychium that represents the undersurface of the proximal nail fold which is responsible for the formation of the cuticle. The connective tissue components of the matrix and nail bed dermis are located between the corresponding epithelia and the bone of the distal phalanx. Characteristics of the connective tissue include: a morphogenetic potency for the regeneration of their epithelia; the lateral and proximal nail folds form a distally open frame for the growing nail; and the tip of the digit has rich sensible and sensory innervation. The blood supply is provided by the paired volar and dorsal digital arteries. Veins and lymphatic vessels are less well defined. The microscopic anatomy varies from nail subregion to subregion. Several different biopsy techniques are available for the histopathological evaluation of nail alterations.

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The nail unit represents an integral part of the tip of the digits. It protects the dorsal aspect of their most distal part, but is also a most versatile tool for defense and dexterity. Our fingertips are extremely important sensory organs, and the nail enhances this function. The nail unit consists of 4 different ectodermal and mesenchymal components: the matrix, nail bed, nail plate, and nail folds (Figure 1). Changes of the nail unit are often treated surgically, and a profound knowledge of the anatomy, physiology, and growth characteristics is essential for this important part of dermatosurgery.[1]

Development of the nail unit

Fingers and toes are discernable at gestational week 8. From the 9th week onwards, the nail development starts on the tip of the digit. A cocktail of signaling proteins induces a densification of the epidermis called placode. From here, an epithelial peg grows in the proximal direction. At week 13, the primordial nail can be identified, and only one week later, the first part of the nail plate is visible. Most of the nail field is covered with a thin plate at week 17. Distal phalanx and nail grow together from week 20 on, and at this time, the nail is also histologically differentiated.[2] Although hair and nail development have much in common, special growth and signaling factors are required for the correct dorsal localization of the nail organ, and the underlying bone is necessary for the induction of the nail anlage. Genetically, a banded pattern is discernable[3] which may be the explanation for the particular nail involvement in lichen striatus.[1]

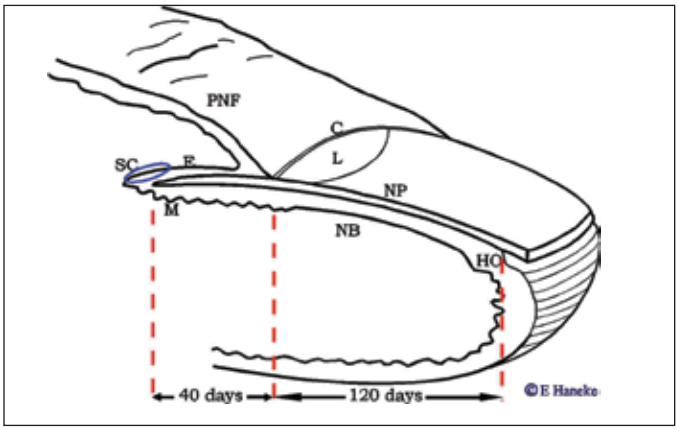

FIGURE 1. Schematic illustration of the nail unit of a finger. It takes approximately 40 days for the nail to grow from the apical matrix to the lunula border and another 120 days to the hyponychium (red dotted lines). Abbreviations: C, cuticle; E, eponychium; HO, hyponychium; L, lunula; M, matrix; NB, nail bed; NP, nail plate; PNF, proximal nail fold; SC, presumed area of stem cells (blue oval).

Macroscopic anatomy of the nail unit

The nail unit is made up of epithelial and connective tissue compartments. It forms a functional unit with the entire digital tip, and contains the bone of the distal phalanx, the distal interphalangeal joint with its tendons and ligaments, 2 compartments of adipose tissue of the digital pulp, innumerable nerves and highly specialized sensory nerve organs, abundant blood supply, and lymphatic vessels.

The nail unit consists of: the nail matrix, which is the sole structure to produce the nail plate and which is almost completely covered by the proximal nail fold; the nail bed epithelium responsible for the firm attachment to the dermis of the nail bed; the hyponychium, marking the distal end of the nail bed and sealing the subungual space; the proximal nail fold, the undersurface of which is the eponychium firmly attached to the underlying nail plate and forming

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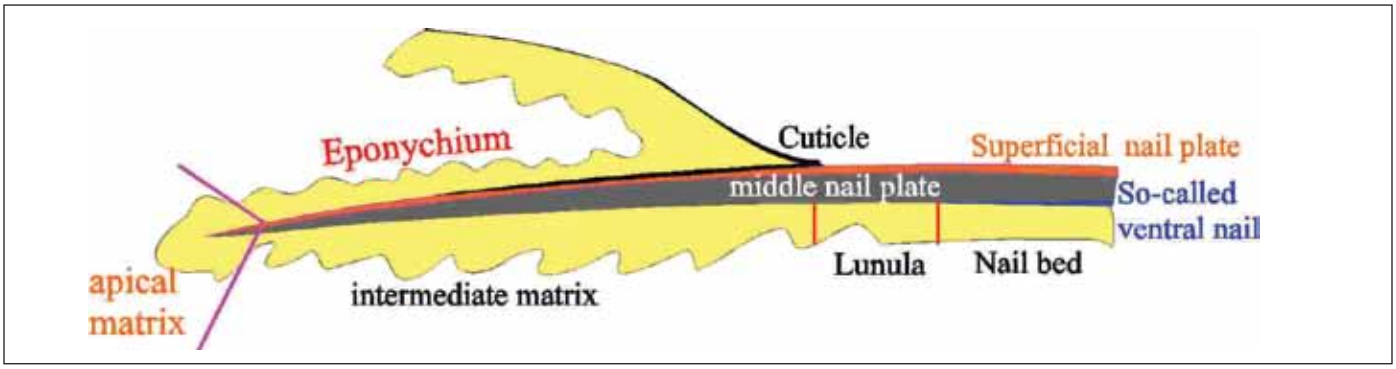

FIGURE 2. Layers of the nail plate. The apical matrix produces the superficial nail plate layer, the intermediate matrix the bulk of the nail plate called middle layer, and the nail bed produces just a thin layer of subungual keratin. The eponychium and cuticle stem from the ventral surface of the dorsal (proximal) nail fold. The lunula is the visible portion of the matrix.

the cuticle at its free end; the latter seals the nail pocket; the lateral nail folds framing the nail plate and giving support; and the dermis of the nail matrix and bed that lie directly on the periosteum of the bone except for the proximal matrix where one can find some fat cells under the dermis.[4]

The nail plate is what the lay public means when one speaks about the nail, and is the product of the matrix. It makes up for about one quarter to one third of the entire length of the nail unit, and is hidden under the proximal nail fold except for its most distal portion, which is normally seen as the whitish lunula in the thumb, index, and middle fingers, as well as the big toe.[5] The distal lunula border is convex and runs parallel to the most proximal (or apical) matrix.[8] The matrix forms a parallel band and reaches proximally in its lateral portions giving rise to the matrix horns. The length of the matrix correlates with the thickness of the nail plate. The apical matrix forms the most superficial layers of the nail plate, which is characterized by markedly flattened cells that are chemically and physically highly resistant. The middle matrix is responsible for the middle layer of the nail plate and the distal matrix for its deep layers (Figure 2). The nail plate cells are higher in its deeper layers. Damage to the apical matrix will be seen as nail surface alterations whereas those of the middle and distal matrix are located in the nail plate and may disturb the optical coherence of the nail. The matrix epithelium consists of a basal and a superficial compartment. The basal compartment consists of relatively small basophilic basal and suprabasal cells. The superficial compartment consists of a multitude of eosinophilic cells of the prekeratogenous and keratogenous zones with condensed nuclei. At the time of onychotization, these cells lose their nuclei and abruptly transform into onychocytes. The transition zone between the basal and suprabasal compartments is apparently a weak area as the superficial compartment remains attached to the nail plate after avulsion, and when there is a split formation in the histological sections, it is seen here.[7]

The matrix contains melanocytes that are inactive in light-skinned individuals, and may be activated by chronic repeated trauma such as friction, photochemotherapy with psoralens, drugs and toxins, hormones, and skin, regional, and systemic diseases. In dark-skinned persons, nail pigmentation is physiological.[8] In the histological sections of normal nails, most matrix melanocytes are in a suprabasal position, and those in the distal matrix are more active than those in the proximal matrix.[9] Melanocytes in the nail bed are about 4 times less frequent and usually remain dormant.[10] Even in *in situ* melanomas that extend from the matrix to the hyponychium, melanocytes in the nail bed are much less frequent than in the matrix and hyponychium. The intraepithelial melanocytes are usually well demonstrated with HMB45 and Melan A;[11] whereas protein S100, MITF and Sox10 often produce an irregular staining. However, S100 is more reliable for invasive melanoma cells. The nail unit has an immune privilege protecting it on one side against a variety of inflammatory reactions, but also weakening a number of defense reactions.[12] Merkel cells are also present in the nail matrix although the results of different research groups differ.[13,14]

The nail bed is as important for a normal nail as the matrix; when the plate is firmly attached to it, the plate shows its normal transparency with the pink nail bed color. The bed epithelium is relatively thin. Its cells increase in size while migrating upward. The uppermost cells are similar to those of the inner hair sheath and produce orthokeratin without an intermediate granular layer; instead, any granular layer is a sign of disturbance of its maturation. The very thin keratin layer enables the nail plate to slide over the bed without losing its connection with the bed. A granular layer appears in the distal nail bed marking the transition to the hyponychium; this structure is now called the nail isthmus.

The nail bed epithelium forms rete ridges that run parallel and exhibit 4 to 6 layers of longitudinally running capillaries one above the other. When thrombosis occurs, the so-called splinter hemorrhages form.

The hyponychium is a specialized structure responsible for the physiological separation of the nail plate from the nail bed. It forms the distal groove and is strongly keratinized. It prevents foreign substances from entering under the nail plate; and must not be damaged with sharp manicure instruments. The pulp epidermis is distal of the hyponychium exhibiting the ridged skin pattern with a marked granular layer, a stratum lucidum, and a thick horny layer. When the nail does not separate from the nail bed, an inverse pterygium develops.

The proximal nail fold is a narrow wedge of tissue covered with epidermis on its dorsal and ventral surfaces. Sebaceous glands as well as hair follicles are absent. Its free margin forms an acute angle which bears the cuticle. This keratin structure mainly derives from the stratum corneum of the ventral surface, which is attached to the nail plate and pulled out with the growing nail. It is an important protective structure as it seals the nail pocket. The cuticle is lost spontaneously when either the free margin of the proximal nail fold thickens (eg, due to inflammation) or when the nail stops growing

(ie, yellow nail syndrome). Immediately proximal to the cuticle, horizontally running capillaries are seen that are said to exhibit characteristic changes in a variety of collagen diseases. The undersurface of the nail fold exhibits a flat epidermis without a rete relief, but with a granular layer and orthokeratosis. It lies on the nail and is called eponychium. Deep in the nail pocket, the apical matrix begins where the nail stem cells are located.[15]

The lateral nail folds are connective tissue bulges coming from the lateral aspects of the proximal nail fold and flatten distally. They give support to the nail plate,[16] and should therefore not be wantonly sacrificed in the treatment of ingrown nails.

The perionychium comprises all connective tissue of the nail unit. The dermis of the matrix and nail bed are intimately connected with the underlying phalanx. The morphogenetic dermis is positive for CD10 and CD34 like perifollucular connective tissue. It is called onychodermis,[17,18] and is responsible for the neogenesis of matrix and nail bed epithelium after superficial tangential biopsies.[19] Some fat cells are seen between the dermal collagen and the bone,[20] but their number depends greatly on the area of sectioning. Fat cells are sparse and probably function as a cushion for the matrix and proximal nail bed.

The blood supply of the nail unit is rich stemming from the paired volar and dorsal proper digital arteries. They virtually merge at the level of the distal interphalangeal joint where they can easily be compressed manually by an assistant. From here, they arborize again giving rise to arcades that supply the proximal nail fold, the matrix, and the nail bed. The latter run around the circumference of the bone and are protected laterally by the interosseous ligaments, unique structures running on both sides from the condylus at the base of the distal phalanx to the lateral extension of the corona unguicularis. Between these arcades, many longitudinally arranged small arteries run parallel; the longitudinal arrangement of both the capillaries of the nail bed rete ridges and these arteries are the reason why biopsies of the nail bed should, if possible, always be oriented longitudinally. The venous drainage is much less complex and systematic examinations of the lymphatic vessels are still lacking. There are hundreds of glomus bodies in the matrix and nail bed serving as organs for thermoregulation. They consist of afferent and efferent vessels with vascular lumina in between, the latter being surrounded by richly innervated glomus cells with a myoepithelial function. They are thought to be the origin of the glomus tumors, specific hamartomas mainly occurring in the nail organ and characterized by a unique symptomatology of pain. Furthermore, in many sections of the nail matrix and bed, vessels are found that display an asymmetrical cushion of loosely packed smooth muscle cells. Their function is not exactly known.

The distal interphalangeal joint is a unique structure lying close to the apical matrix. This is seen as the reason for the frequent nail involvement in psoriatic arthritis. It is a hinge joint that is stabilized by the tendons of the extensor and flexor digitorum muscles plus lateral ligaments merging both volarly as well as dorsally to form the ventral and dorsal aponeuroses. Fibers of the extensor tendon radiate into the proximal nail fold forming a holster for the matrix.[21] The insertion of the flexor and extensor tendons is not only at the proximal margin of the distal phalanx, but extends over the proximal third. The intimate anatomic and functional relations of the nail with the tendons, ligaments, and joints led some authors to call the nail a musculo-skeletal appendage.[22] The distance between the apical matrix and the bone and joint is approximately 1 to 1.4 mm. [5,23]

The bone of the terminal phalanges has lateral condyles, from which the interosseous ligament bridges the space to the lateral extensions of the corona unguicularis. The circumferential arterial (and venous) arcades providing the nail matrix and bed are protected from compression by these ligaments. As already outlined above, the anlage of the terminal phalanx bone is necessary for the induction of the nail unit, and the bone size and shape define the size and shape of the overlying nail.[24]

Biology and physiology of the nail unit

Although the nail plate and hair shaft are biochemically identical, there is a profound anatomical and physiological difference. In contrast to hair, nail growth remains continuous life-long and is not cyclical. The nail is not hormone-dependent, and there is no process comparable to androgenetic alopecia although the nail growth rate proportionately declines with age.[25] It does not lose its pigment with age like the hair; instead, nails in darkly pigmented individuals tend to become more pigmented. The cells of the nail plate increase in size with age.[26]

Fingernails grow about 3 times faster than toenails. The middle fingernail of the dominant hand is the fastest-growing nail, growing roughly 0.1 mm per day or 3 to 4 mm a month. The shorter the digit, the slower the nail grows. The nail of the big toe grows about 0.03 mm/day which is approximately 1 mm per month. Whereas a fingernail takes about 160 days to grow out, the great toenail may take up to 18 months. Warm temperatures and physical activity accelerate nail growth; whereas cold climate, high altitude, age, and inactivity decelerate nail growth. Some azole antifungal drugs (ie, itraconazole and fluconazole), and to a lesser extent, retinoids speed up nail growth. Cytotoxic drugs lead to slower nail growth. Whether or not biotin (often called the hair and nail vitamin), zinc, iron, and many other so-called essential elements can improve nail growth and quality still remains to be proven. For biotin to be effective in some respect, a daily dose of 5 - 10 mg is necessary; it is not clear whether the effect is due to its vitamin character or a pharmacologic action. The chemical structure of nail keratin is genetically regulated. It cannot be influenced by diet as is evidenced by the excellent quality of hair and nails in people coming from the poorest regions of the world. It consists of keratin fibers that are embedded in a sulfur-rich matrix. A lack or deficiency of sulfur-containing aminoacids would be seen first in hair, which grows up to 10 times faster than the nails. There is almost no proline in the nail, which is the reason why giving collagen for brittle nails is useless. There is very little calcium in the nail, and the calcium in the nail is mainly in the form of hydroxyl apatite. It is bound intracellulary to lipoproteins,[27] and does not add to the stability of the nail plate. Most of the calcium is found on the nail and not in it as it is the result of environmental pollution. Fluoride, although often advertised for brittle nails, is not a factor of nail firmness. The nail alterations seen in defined deficiency states must not be taken as proof that the addition of calcium, zinc, iron, fluoride, silica, and many other substances in otherwise healthy persons with normal serum levels would be able to improve the nails' consistency. Onychoschizia, which defines lamellar splitting of the nail, and onychorrhexis, defining longitudinal splitting, are almost exclusively seen on finger nails underlining the importance of environmental and professional factors, such as hydration and dehydration, that cause leaching of important structural lipids

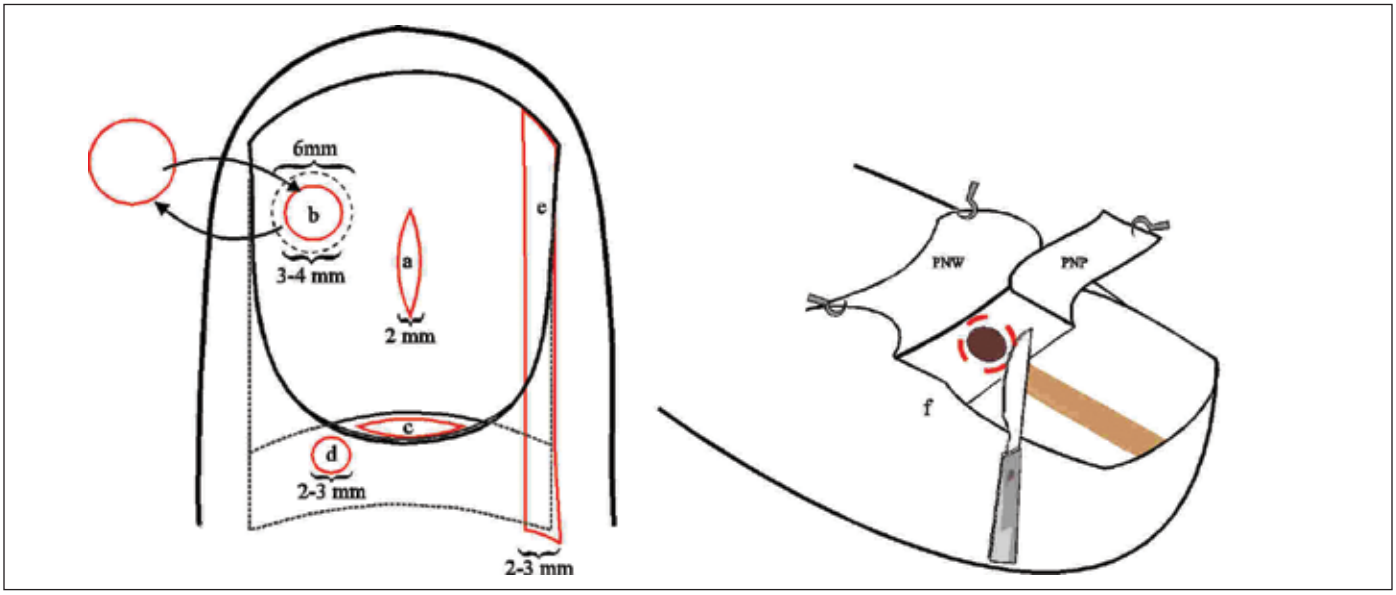

FIGURE 3. Nail biopsies. **a)** Fusiform nail bed biopsy, its long axis is longitudinal. **b)** Punch biopsy of the nail bed with a bigger punch of the nail plate. **c)** Fusiform matrix biopsy, its longitudinal axis is transverse. **d)** Punch biopsy of the matrix. The diameter is not larger than 3 mm. **e)** Longitidunal nail biopsy. **f)** Tangential nail biopsy.

and proteins. Since the nails grow slower with age, they are exposed longer to harmful influences. This is the reason why fragile nails are more common in elderly ladies.

The nail grows slowly and many substances from the environment may be deposited in it. They can often be demonstrated in the nail for many months. Alkaline and acids as well as environmental influences may change the amount of disulfide bonds and decrease the sulfur content.[28] Analyses of certain elements may give information about the health of the individual.[29] However, these methods cannot distinguish between exogenous impurities and endogenous substances. Like hair analyses, those of nails can give information on the uptake of or exposition to foreign materials and abnormal metabolites. Higher concentrations of D-aminoacids were seen in diabetes mellitus.[30] Various drugs, illegal doping substances, essential elements, heavy metals, and poisons can often be demonstrated over many months up to a year or more.[31-33] Arsenic ingested with drinking water or intoxication can be found in the nail.[34] However, the calcium or magnesium content of the nail does not reflect the degree of mineralization of the bones.[35] Some drugs such as azole antifungals are keratinophilic and concentrated in the nail over a long period of time.[36,37] The DNA of nails and nail debris allows the identification of a cadaver and often even of a potential aggressor.[38,39] DNA samples remain stable in air but degrade within a month in a humid environment.[40]

Nail biopsies

A considerable number of methods are available for the examination of nails. Imaging techniques have revolutionized nail diagnostics in the last 2 decades. However, none of these often sophisticated and expensive techniques is as safe as histopathology. Dermatoscopy and a reflectance confocal laser scanning microscopy often aid in making a diagnosis, but they are hampered by the fact that the nail is only a semitransparent keratin plate not permitting direct visualization.[41] Intraoperative matrix dermatoscopy is an invasive method[42] as is intraoperative confocal laser microscopy.[43] High-resolution magnetic resonance and variable frequency ultrasound give some information but cannot substitute a histological analysis of a biopsy specimen.

For a good result, the biopsy must fulfill some requirements. First, one must know why, what, when, where, and how to biopsy.[44] Second, one has to have a laboratory with experience handling nail biopsies. And third, a dermatopathologist with experience in nail pathology is needed. Furthermore, there is a difference between a diagnostic or excisional biopsy.

The physician must decide what material will be needed to make a diagnosis; ie, either the nail plate, matrix, nail bed, nail folds or hyponychium. Each requires a particular biopsy technique. A nail biopsy is indicated either when a clinical diagnosis cannot be made with certainty but the undiagnosed condition threatens to cause irreparable nail dystrophy, or when the clinical diagnosis requires long-term treatment with drugs that potentially have serious side effects, or when a malignancy is suspected.

The biopsy is ideally taken from the site where the nail tissue change is most obvious. However, this is often not seen through the nail, particularly when it is nontransparent. When the nail plate is onycholytic, it is cut off and sent in for histopathological examination. A longitudinal streak in the nail must be biopsied at its origin in the matrix, particularly when a melanocytic lesion is suspected. Changes of the nail plate surface originate from the apical matrix and require a biopsy from there; however, apical matrix biopsies have a high risk of post-biopsy nail dystrophy. Lesions in the lateral nail quarter are best diagnosed with a lateral longitudinal nail biopsy, which includes the proximal nail fold, the matrix, bed, and hyponychium; and gives information about the course of the disease over a period of 6 to 12 months.

An important issue is whether or not the nail plate has to be avulsed before either the nail bed or matrix biopsy. A very thick and nontransparent nail must be removed over the site of the potential

pathology to be biopsied in order to identify the biopsy location as well as to avoid sectioning such a thick nail, which would result in too much force necessary to do the surgery. Often, a partial nail avulsion is completely sufficient.[45] Softening of the nail for several days with 40% urea paste under occlusion is another possibility.

Another important consideration is how to perform the biopsy. For the diagnosis of most cases of onychomycosis, a nail clipping with as much of the subungual keratotic debris as possible is adequate. It can be sent to the laboratory as dry material without fixation. However, the accompanying request form should include the suspected clinical diagnosis specifying the type of onychomycosis, previous antifungal and other nail treatments, as well as requested special stains in addition to Periodic acid–Schiff such as Grocott or Gridley. For the histopathological diagnosis of white superficial onychomycoses, a superficial layer of the nail plate may be "carved" from the nail plate surface. Many labs have problems with cutting good sections. This can be greatly facilitated by immersing the nail specimen for 3 days into Cedar oil. It can then also be shortly fixed in formalin without making the nail too hard for sectioning. Another possibility to soften the nail is immersion into 10% urea solution overnight.

Punch biopsies are useful for circumscribed lesions of the nail bed, matrix, and nail folds. The punch diameter must not be larger than 3 mm for matrix biopsies and not larger than 4 mm for nail bed biopsies. The punch hole may be stitched with a double suture in the nail fold and hyponychium but usually requires no suture in the matrix and nail bed. A double-punch technique is sometimes recommended for the nail bed or matrix. A 6 mm punch is used to create a hole in the nail plate and the smaller punch is used for the matrix or nail bed; this facilitates freeing the specimen from the bone. A punch of the nail plate only is useful for the diagnosis of proximal subungual onychomycosis. A portion of the nail plate can be taken without anesthesia as the nail plate in this area is not attached to the underlying matrix. Half of the nail disc can be sent for histopathology, the other half for fungal culture. The nail plate is hard and often requires prebiopsy softening, which is best done with a 10-minute bath in lukewarm water that may contain some chlorhexidine. The nail rapidly absorbs water, making it much softer and easier to cut with a punch or scalpel. The CO_2 laser is another option to cut the nail plate with minimal trauma.

A fusiform biopsy of the nail bed is always taken in the longitudinal direction of the nail in order to respect the peculiar longitudinal arrangement of the rete ridges and their blood vessels. The section removed should be approximately 6 mm long and 2 mm wide. Care has to be taken to precisely mark this thin piece of tissue so that it will be embedded and sectioned in the lab in the correct orientation. Further, this narrow but long specimen must be cut longitudinally to allow a long section to be performed. The biopsy site is sutured with 6-0 absorbable material.

A fusiform biopsy is also ideal for matrix lesions wider than 3 mm. Matrix biopsies are always oriented transversally in order to avoid a longitudinal scar in the matrix, which would inevitably lead to a split nail. Its distal incision should run parallel to the lunula border. Again, the fusiform matrix biopsy should be very narrow and sectioned along its longitudinal axis in the histopathology lab. Suturing with very fine material is easy; however, the stitches should not be tied too tightly.

A biopsy of a suspected submatrical tumor is performed after the (partial) nail avulsion. The lesion is localized and either a slightly arched incision is made parallel to the lunula border in the matrix or a straight longitudinal incision is made in the nail bed. The wound margins are held up with fine skin hooks and the subepithelial lesion is meticulously dissected from the surrounding connective tissue. The incision is sutured with absorbable 6-0 stitches and the nail plate laid back and fixed with figure-8 sutures.

A longitudinal nail biopsy provides the most accurate information. This should always be performed laterally in order to avoid a split nail after the biopsy. A straight incision is carried out from the distal dorsal interphalangeal joint crease through the proximal nail fold, nail plate, matrix, and nail bed to the hyponychium about 3 mm medial from the lateral nail margin. A second incision is made parallel to the first one, again from the distal joint crease through the proximal nail fold all along the lateral nail groove to the hyponychium, to meet the first incision. This gives a long narrow rectangular block of tissue that contains all nail components. As the nail grows slowly and once formed does not change, the information gathered from the biopsy is over a time period of many months. Care has to be taken not to leave the most proximal lateral matrix portion behind. This can be avoided by slanting the second incision slightly laterally in its proximal portion or to look for matrix remnants and extirpate them. The incision is sutured with alternating stitches through the proximal nail fold without touching the matrix and back-stitches in the proximal half of the lateral nail fold in order to raise it and avoid making it disappear. The distal lateral nail fold and hyponychium are sutured as usual. They are removed 12 to 14 days after the procedure.

Pigmented streaks in the nail pose a specific and often difficult problem that may be twofold; ie, failure to take a biopsy may delay the diagnosis of a potentially malignant process, but an unnecessary biopsy may cause postsurgical nail dystrophy. To overcome this delicate problem, a tangential biopsy technique was developed permitting diagnostic biopsies to be taken virtually without the risk of post-biopsy nail dystrophy. The proximal nail fold is separated from the underlying nail plate with a blunt nail elevator and incised on both sides allowing it to be tilted back. The proximal portion of the plate is detached from the matrix and cut transversely at the level between the proximal third and half; this cut is performed from the side where the streak is located approximately 5 mm beyond the streak, and the nail is elevated thus permitting the origin of the melanonychia to be identified. A very shallow incision is made around the melanocytic matrix lesion with an adequate safety margin. A #15 scalpel blade is held parallel to the matrix surface; with little pressure, a very thin slice of matrix is horizontally excised using sawing motions with the scalpel. This slice of tissue should be thin enough that the scalpel blade shines through, which generally gives a specimen of less than 1 mm thickness. This is transferred from the scalpel onto filter paper where it sticks ensuring that it remains perfectly spread out. The specimen along with the filter paper can be placed into the fixative. A drawing on the filter paper may give more information to the histopathology lab concerning the exact localization of this tangential matrix biopsy.[46,47] The elevated nail plate is laid back and fixed with a stitch and the nail fold is finally laid back. Stitches or suture strips may be applied. Healing is uneventful and complete re-epithelialization of the superficial wound with matrix epithelium is complete within 2 weeks. This is at least partly due to the fact that the repositioned nail plate always contains the superficial compart-

ment of the matrix epithelium. When the histopathology shows a benign melanocytic process, the tangential excision is usually sufficient. However, when it shows a malignant melanoma a re-excision of the entire nail organ follows.

The technique of tangential excision has proved to be highly effective and curative in most benign melanocytic lesions.[48] Particularly in children, longitudinal melanonychias are mainly due to junctional nevi. It depends on the type of excision whether there will be a marginal recurrence or not. Nevi are thought to be mosaics and they are scheduled to reach a certain size.[49] When the primary excision was not large enough, the melanocytic lesion will not have been completely removed and a recurrence appears. This does not depend on the depth of excision, but on the surface. We have shown that even a complete superficial excision of the matrix allows complete nail regeneration.

Conclusion

The nail unit is the largest cutaneous musculo-skeletal appendage. Knowledge of its unique embryology, anatomy, biochemistry, and pathology is a prerequisite for exact diagnoses and therapy. Adequate biopsy techniques enable precise histopathological evaluations.

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