Nail Biology:
The Nail Apparatus

- Nail plate
- Proximal nail fold
- Nail matrix
- Nail bed
- Hyponychium
Figure 1. A dorsal view of the nail unit (a) shows the proximal extension of the nail matrix (dotted lines). A sagittal view (b) demonstrates the structure of the nail unit and the underlying tissue and bone. When any portion of the matrix is damaged, permanent nail deformity may result.
Nail Biology:
The Nail Apparatus

- Lies immediately above the periosteum of the distal phalanx
- The shape of the distal phalanx determines the shape and transverse curvature of the nail
- The intimate anatomic relationship between nail and bone accounts for the bone alterations in nail disorders and vice versa
Nail Apparatus:

**Embryology**

- *Nail field* develops during week 9 from the epidermis of the dorsal tip of the digit
- Proximal border of the nail field extends downward and proximally into the dermis to create the *nail matrix primordium*
- By week 15, the nail matrix is fully developed and starts to produce the nail plate
Nails develop from thickened areas of epidermis at the tips of each digit called **nail fields**. Later these nail fields migrate onto the dorsal surface surrounded laterally and proximally by folds of epidermis called **nail folds**.
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1. Developing cartilage/bone
2. Nail anlage
3. Nail field with its proximal (4) and distal (5) fold
4. Primordial matrix
5. (Fully developed) nail matrix
6. Proximal nail fold
7. Nail plate
8. Nail bed
9. Hyponychium

Nail Function

- Protect the distal phalanx
- Enhance tactile discrimination
- Enhance ability to grasp small objects
- Scratching and grooming
- Natural weapon
- Aesthetic enhancement
- Pedal biomechanics
The Nail Plate

• Fully keratinized structure produced throughout life
• Results from maturation and keratinization of the nail matrix epithelium
• Attachments:
  • Lateral: lateral nail folds
  • Proximal: proximal nail fold (covers 1/3 of the plate)
  • Inferior: nail bed
  • Distal: separates from underlying tissue at the hyponychium
The Nail Plate

- Rectangular and curved in 2 axes
  - Transverse and horizontal
- Smooth, although longitudinal ridging ↑ with age
  - Ridge pattern used for forensic identification
- Homogeneously pink due to underlying vessels
- Free edge is white
The Nail Plate

- Lunula:
  - visible portion of the nail matrix
  - white, half-moon shaped area
  - plate loosely attached to underlying epithelium
The Nail Plate

- **Onychocorneal Band**
  - Thin, distal transverse white band
  - Marks distal portion of attachment of plate to bed
  - Anatomic barrier against environmental hazards
  - Disruption allows plate detachment (onycholysis)

- **Onychodermal Band**
  - Thin, distal pink band separating onychocorneal band from the free edge of the plate
ANATOMICAL STRUCTURE OF THE NAIL APPARATUS

- Free edge of the nail
- Hyponychium
- Onychodermal band
- Nail plate
- Lateral nail fold
- Lunula
- Eponychium (cuticle)
- Proximal nail fold

Diagram:
- Lateral nail fold
- Lunula
- Proximal nail fold
- Onychodermal band
- Distal nail edge
- Nail plate
- Distal groove
- Hyponychium
- Proximal nail edge
- Eponychium (cuticle)
- Nail bed
- Eponychium (cuticle)
- Distal nail matrix
- Proximal nail fold
The Nail Plate: Transverse Anatomy

- Nail plate consists of three portions:
  - Dorsal, intermediate, and ventral plates
  - Dorsal and intermediate plates are produced by the nail matrix
  - The ventral plate is produced by the nail bed

- Above the lunula, the plate consists only of the dorsal and intermediate portions
Nail Plate Thickness

- Plate progressively thickens from point of emergence to distal tip
  - Mean thickness distal toenail: 1.65mm/1.38mm (m/f)
  - Mean thickness distal fingernail: 0.6mm/0.5mm (m/f)
- Thickness ↑ with age, esp. in 1st two decades
- Thickness depends on the length of the nail matrix and the nail bed
Nail Plate Thickness

- Thinning of the nails is usually a matrix disorder

- Thickening of the nails is usually a consequence of nail bed disorders
Proximal Nail Fold

• Consists of dorsal and ventral portions

• The dorsal portion is continuous with and anatomically similar to the skin of the dorsal digit but thinner and devoid of pilosebaceous units
Proximal Nail Fold

- The ventral portion is invisible from the exterior and is continuous proximally with the germinative nail matrix
- It adheres to and covers $\frac{1}{4}$ of the nail plate and keratinizes with a granular layer
- The limit between the proximal nail fold and the nail matrix can be histologically established at the site of disappearance of the granular layer
Proximal Nail Fold:

Cuticle

- Formed by the horny layer of the proximal nail fold
- Attached to the superficial nail plate
- Prevents separation of the plate from the fold
- Integrity of the cuticle is essential for nail homeostasis in this region
Proximal Nail Fold

- Dermis of the proximal fold contains capillaries that run parallel to the surface
- Arterial and venous limbs of the capillaries are arranged in parallel rows and appear as fine regular loops
- Proximal nail fold capillary morphology is altered in connective tissue diseases
Nail Matrix

- Specialized epithelial structure that lies above the midportion of the distal phalanx
- Consists of a proximal (dorsal) and a distal (ventral) portion
- Nail matrix keratinocytes keratinize in the absence of a granular layer to form the nail plate
Nail Matrix Keratinization

- Maturation and differentiation of nail matrix keratinocytes occurs in a distally oriented diagonal axis (unlike the epidermis)
- Keratinization of the proximal (dorsal) nail matrix cells produces the dorsal nail plate
- Keratinization of the distal (ventral) nail matrix cells produces the intermediate nail plate
**Nail Matrix**

- Cornified onychocytes are composed mainly of keratin filaments, high sulfur matrix proteins, and the marginal band, which consists of precipitated cytoplasmic proteins.
- During keratinization of onychocytes, DNases and RNases degrade nuclear fragments. Incomplete degradation of nuclear material results in transient leukonychial spots.
Nail Matrix Melanocytes

- Usually quiescent but can become activated and synthesize melanin, which is transferred to surrounding keratinocytes.
- Distal migration of melanin-containing keratinocytes gives rise to a diffuse or banded nail pigmentation (physiologic or pathologic).
- Nail matrix melanocytes of Caucasians do not contain mature melanosomes which are normally found in the nails of Asians and blacks.
Nail Bed

- Extends from the distal margin of the lunula to the onychodermal band
- Nail bed epithelium is thin (2-5 cell layers) and firmly attached to the nail plate
- Nail bed keratinization produces a thin, horny layer that forms the ventral nail plate
- No granular layer and sparse melanocytes
Hyponychium

- Marks the anatomic area between the nail bed and the distal groove, where the nail plate detaches from the distal digit
- Anatomy is similar to plantar and volar skin (a granular layer is present)
- Normally covered by the distal nail plate
Antigenic structure is identical to that of the epidermis and is consistent throughout all portions of the nail apparatus.

Thus, the nails are commonly involved in diseases associated with attack on BMZ components.
Blood and Nerve Supply

- Nail Apparatus: lateral digital arteries and nerves

- Nail Bed: encapsulated neurovascular structures called *glomus bodies* contain one to four AV anastomoses and nerve endings
  - regulate blood supply to the digits in cold weather
Chemical Properties of the Nail Plate

- Low-sulfur keratins embedded in an amorphous matrix of high-sulfur proteins rich in cystine.
- Water (20%)
  - $<18\% = \text{brittle}; >30\% = \text{opaque and soft}$
- Lipid ($<5\%$): mainly cholesterol
- Trace inorganic elements: iron, zinc, calcium
  - Do not contribute to nail hardness
Chemical Properties

- Nail keratins:
  - 80% hard “hair-type” keratins
    - Acidic Ha 1-4 and basic Hb 1-4 keratins
  - 20% soft “skin-type” keratins
    - Epithelial keratins 5, 6, 14, 16, 17
Nail Growth

- Proceeds from 15 weeks IUL until death
- Fingernails:
  - 3mm per month
  - 3-6 months for replacement
- Toenails:
  - 1mm per month
  - 12-18 months for replacement
Nail Growth

- Decreased Growth
  - Age > 50
  - Systemic illness
  - Malnutrition
  - Vascular disease
  - Peripheral neuropathy
  - Antimitotic drugs
  - Onychomycosis
  - Yellow nail syndrome

- Accelerated Growth
  - Pregnancy
  - Finger trauma
  - Psoriasis
  - Oral retinoids
  - Itraconazole
Nail Clippings Can Be Evaluated For...

- Drugs, chemicals and toxins
- DNA analysis
- Blood group typing
- Individual identification
Nail Signs

3 categories based on site of pathology:

- 1. Nail matrix
- 2. Nail bed
- 3. Nail plate (deposition of pigment)
### Table 71.1 Correlation of nail findings with anatomical site of nail damage.

<table>
<thead>
<tr>
<th>Affected site</th>
<th>Clinical manifestation</th>
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</thead>
<tbody>
<tr>
<td>Proximal matrix</td>
<td>Beau’s lines, Pitting, Longitudinal ridging, Longitudinal fissuring, Trachyonychia</td>
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<tr>
<td>Distal matrix</td>
<td>True leukonychia</td>
</tr>
<tr>
<td>Proximal + distal matrix</td>
<td>Onychomadesis, Koilonychia, Nail thinning</td>
</tr>
<tr>
<td>Nail bed</td>
<td>Onycholysis, Subungual hyperkeratosis, Apparent leukonychia, Splinter hemorrhages</td>
</tr>
</tbody>
</table>
Nail Signs due to Abnormal Matrix Function

- Beau’s Lines
- Pitting
- Onychorrhexis
- Trachyonychia
- Onychomadesis
- Koilonychia
Beau’s Lines

- Transverse depressions due to disruption of proximal matrix mitotic activity
- Depth: extent of damage
- Width: duration of insult
- Mechanical trauma
- Proximal nail fold dz
- Systemic insult (all nails)
Beau’s Lines
Onychomadesis (nail shedding)

- Proximal detachment of the nail plate from the proximal nail fold
- Due to a severe insult that produces complete arrest of matrix activity
- Causes are the same as for Beau’s Lines
Onychomadesis
Pitting

- Punctate depressions of the nail plate surface
- Foci of abnormal keratinization of the proximal matrix results in clusters of parakeratotic cells in the dorsal plate
- Clusters easily detach, leaving pits
Pitting
What diseases produce pitting?

- Psoriasis- deep and irregular
- Alopecia areata- superficial and geometric
- Eczema
Pitting
Onychorrhexis

- Longitudinal ridging and fissuring of the plate
- Diffuse thinning
- Indicates diffuse damage to the nail matrix
  - Lichen planus
  - Vasculopathy/ischemia
  - Trauma, Tumors
  - Normal aging
Trachyonychia
(20 Nail Dystrophy)

- Nail roughness due to excessive longitudinal ridging
- Proximal nail matrix damage by:
  - Alopecia areata
  - Lichen planus
  - Psoriasis
  - Eczema
Nail Disorder due to Distal Matrix Abnormality
True Leukonychia
True Leukonychia

- Nail plate has a normal surface but loses its transparency and appears white because of parakeratotic cells within the ventral portion.

- Caused by diseases that disturb distal nail matrix keratinization.
True Leukonychia:
3 Morphologic Variants

- **Punctate:**
  - opaque white spots, move distally with nail growth
  - Due to trauma, common in kids

- **Transverse:**
  - Multiple opaque white parallel lines, traumatic
  - Women: matrix trauma from manicures

- **Diffuse / Total**
  - Rare. Sometimes hereditary. May be assoc. w/ keratoderma and other congenital defects such as deafness
Partial/Punctate Leukonychia
Transverse Leukonychia
Leukonychia Totalis
Koilonychia (Spoon Nails)

- Thinned, concave nail plate due to upward eversion of the lateral edges
- Physiologic in kids
- Iron deficiency anemia
- Plummer-Vinson
- Hemochromatosis
What is this disease?

Iron Deficiency
Plummer-Vinson Syndrome
Esophageal webs, iron deficiency anemia, and koilonychia.
Nail Signs due to Nail Bed Disorders

- Onycholysis
- Onychauxis
- Apparent Leukonychia
- Splinter hemorrhages
Onycholysis

- Distal nail plate detachment from bed
  - Environmental exposure
  - Psoriasis
  - Infection
  - UVR +/- TCN
  - Hyperthyroidism
  - Subungual tumor
Onycholysis
# Causes of Onycholysis

## Most Common Etiology

<table>
<thead>
<tr>
<th>Environmental</th>
<th>Primary Skin Disorders</th>
<th>Infections</th>
<th>Drugs</th>
<th>Metabolic/Systemic Disorders</th>
<th>Tumors</th>
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</thead>
<tbody>
<tr>
<td>Exposures</td>
<td>UV (photonycholysis in the absence of medications)</td>
<td>Psoriasis</td>
<td>Candida spp. (may be secondary invaders)</td>
<td>Tetracyclines</td>
<td>Metabolic/ Systemic Disorders</td>
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<tr>
<td>Irritants</td>
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<td>Dermatophytes</td>
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<td>Tumors</td>
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<td>HPV</td>
<td>Hyperthyroidism</td>
<td>Subungual exostoses</td>
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<tr>
<td>Trauma</td>
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<td>SCC</td>
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## Clues to Diagnosis

| History | Additional nail findings e.g., oil drop changes, pits | Additional nail findings e.g., chronic paronychia, yellow color, thickening | History | Multiple nails | Single nail |
| Fingernails vs. toe nails | Nail bed changes e.g., scale | Nail bed changes e.g., scale, verrucous lesions | Minimal, if any, nail bed changes | Minimal, if any, nail bed changes | Nail bed findings |
| Minimal, if any, nail bed changes | Associated hemorrhage | Green discoloration 2° to pyocyanin | Wood’s lamp examination | Additional cutaneous findings | Radiograph |
| Associated hemorrhage | | Fungal and bacterial cultures | | TFTs | Biopsy specimen |

## Less Common Etiologies

| Allergens, e.g., formaldehyde, mono(meth)acrylates, cyanoacrylates | Lichen planus | Saprophytes | Fluoroquinolones | Yellow nail syndrome |
| Lichen striatus | Blistering diseases (epidermolysis bullosa, pemphigus vulgaris, pemphigoid) | Scabies | Taxanes | PCT |
| Other disorders (ectodermal dysplasias, sarcoidosis, Langerhans cell histiocytosis, Darier’s disease, keratosis lichenoides chronica) | Other drugs (anthracyclines, captopril, chlorazepate, etoposide, gemcitabine, mycophenolate, phenothiazines, quinine, retinoids, sodium valproate, thiazides, 5-fluorouracil) | | NSAIDS | Pseudo PCT (drugs, dialysis) |
| | | | Other drugs | EPP |
| | | | (anthracyclines, captopril, chlorazepate, etoposide, gemcitabine, mycophenolate, phenothiazines, quinine, retinoids, sodium valproate, thiazides, 5-fluorouracil) | | |

Onychauxis

- Nail plate appears thickened due to subungual scales (nail bed hyperkeratosis)
- Nail bed involvement by:
  - Psoriasis
  - Onychomycosis
  - eczema
Onychauxis
“Ram’s Horn Nails”
Apparent Leukonychia

- Nails are white because of abnormalities in the color of the nail bed
- Nail plate transparency is maintained and the leukonychia does not move distally with nail growth
- White color fades with pressure
Apparent Leukonychia

- **Terry’s Nails: cirrhosis**
  - Whole nail is white except 2mm distal red band

- **Muehrcke’s Nails: hypoalbumin; chemotherapy**
  - Multiple transverse white bands parallel to lunula

- **Half and Half Nails: chronic renal disease**
  - Leukonychia of the proximal half of the nail
Terry’s Nails (cirrhosis)
Splinter Hemorrhages

- Dark-red, longitudinal, distal subungual lines
  - Trauma
  - Psoriasis
  - Onychomycosis

- Proximal splinters
  - Endocarditis
  - Vasculitis
  - Trichinosis
  - APA Syndrome
Nail Signs due to Deposition of Pigment

- **Exogenous-** convex proximal border
  - Opposite of lunula
- **Endogenous-** concave proximal border
  - Parallels lunula
- **Subungual-** onycholysis