



The diagram shows a side view of a foot with a cross-section of a toe. The toenail is depicted with several colored layers: a blue base, a pink layer, a yellow layer, and a green layer. Blue lines with circular endpoints point from the text labels to specific parts of the nail and the surrounding skin.

Onychomycosis

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Introduction

- Onychomycosis (OM)
 - an invasive fungal infection of the nails
 - Can be primary or secondary
 - Risk factors
 - Tinea pedis, preexisting nail dystrophy (e.g. Psoriatic pitting), communal exposure, peripheral vascular disease or diabetes (reduced circulation), immunocompromise
 - most common disease of the nails
 - approximately half of all nail abnormalities (Motamed et al., 2016)
 - toenails are 25 times more susceptible to infection than fingernails (Doughty & McNichol, 2016)
 - likely due to added injury; pressure to toenail plate; dark, moist environment; slower growth
 - caused by dermatophytes, yeasts, and non-dermatophyte molds (NDMs)
- OM Prevalence
 - Unspecified: 2-18% of the population (McCance & Huether, 2014)
 - Europe: affecting 20–50% of people aged over 60 years (Yau et al., 2018)
 - World wide: up to 26% in the general population (Grover & Khurana, 2012)
 - Unspecified: about 20% of patients aged 40–60 years and up to 50% of patients at the age of 70 years (Tabara et al., 2015)



Causes of OM

- Causes

- Dermatophytes (cause “tinea unguium”)

- 85–90% of OM cases (Yau et al., 2018)
 - fungal organisms that all require keratin for growth
 - » *Microsporum spp.*
 - » *Epidermophyton spp.*
 - » *Trichophyton spp.*
 - *T. rubrum*
 - Distal lateral subungal onychomycosis (DLSO)
 - *T. interdigitale*
 - *T. mentagrophytes*
 - Superficial white onychomycosis
 - highly resistant
 - survive for long periods
 - » moist and dark environments
 - » toenails are more susceptible than fingernails

Trichophyton rubrum Infection



de Hoog et al. (2016)

Trichophyton rubrum



de Hoog et al. (2016)

- Non-dermatophyte molds

- 2–5% of OM cases (Yau et al., 2018)
 - *Scopulariopsis spp.*
 - » proximal subungual onychomycosis of great toenail
 - *Fusarium spp.*
 - » proximal subungual leuconychia
 - » (sub)acute paronychia
 - *Acremonium spp.*
 - » DLSO
 - *Onychocola canadensis*
 - *Aspergillus spp.*
 - » chalky deep white nail
 - » rapid involvement of lamina
 - » painful perionyxis without pus
 - *Neoscytalidium spp. (Scytalidium spp.)*
 - » Lateral and distal onychomycosis
 - » extensive onycholysis
 - » finger paronychia
 - typically affect toenails
 - fingernails are rarely affected
 - commonly found as soil saprophytes or plant pathogens
 - generally not keratinolytic
 - secondary invaders of the nail plate
 - Utilize previous keratin destruction by dermatophytes, trauma, or another nail disease

- Yeasts

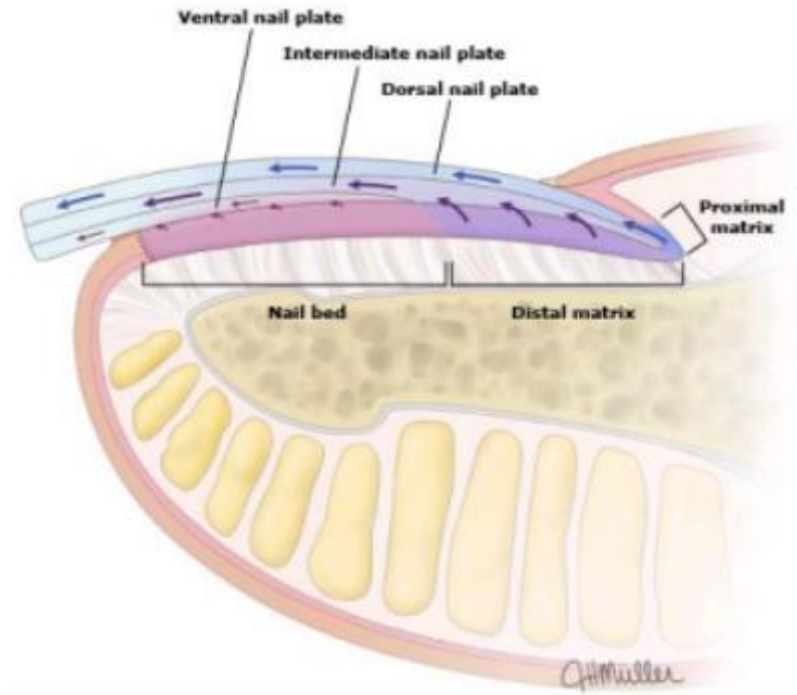
- 5–10% of OM infections (Yau et al., 2018)
 - *Candida spp.*
 - » *C. albicans*
 - » *C. parapsolosis*
 - affecting fingernails more often than toenails
 - » Chronic proximal paronychia
 - » Hyperkeratosis of whole nail plate
 - » Distal and lateral onycholysis

Nail Features

- Function
 - Protects the distal phalanx and surrounding soft tissue
 - Provides additional sensory information
 - Counter-balances upward pressure
- Growth
 - Finger nail growth
 - 3 to 6 months for full regrowth
 - Toe nail growth
 - 12 to 18 months for full regrowth
 - Rate of growth is dependent on available nutrients and circulation

Nail Structure

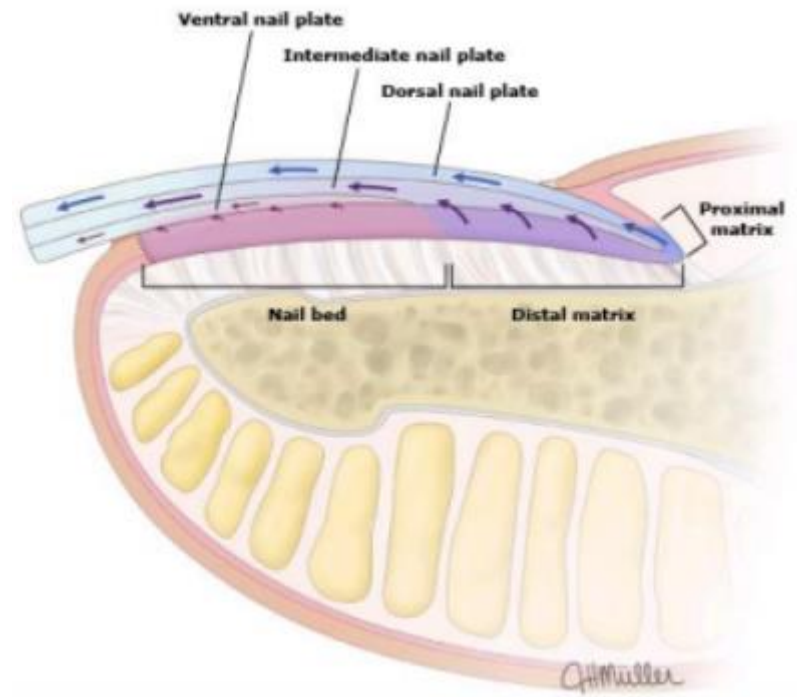
- Nail plate
 - Dorsal
 - Created by keratinization of the proximal (dorsal) matrix
 - Tight intercellular junctions
 - Increased calcium content
 - Intermediate
 - Created by keratinization of the distal (ventral) matrix
 - Ventral
 - Created by keratinization of the sterile matrix
 - Flexible intercellular junctions



Memorang, Inc. (2019).

Nail Structure, cont.

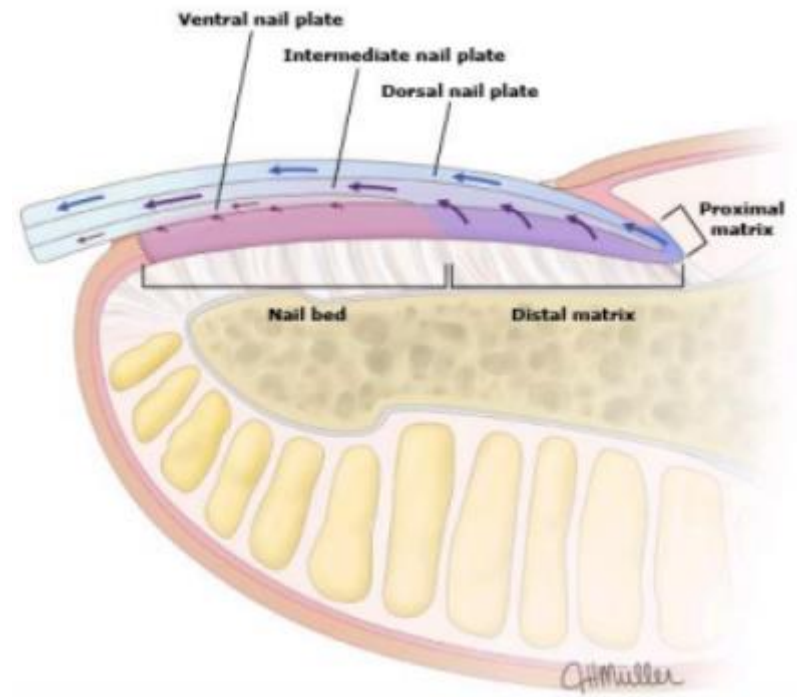
- Nail matrix
 - Contains Melanocytes, Langerhans cells, Merkel cells, and macrophages
 - Langerhans cells and macrophages are functionally impaired
 - Proximal (dorsal) matrix
 - Distal (ventral) matrix
 - Visible as the lunula (white half-moon-shaped area)
 - Nuclear fragments cause light diffraction
 - Nail matrix epithelium is thicker than the sterile matrix epithelium; capillaries are less visible



Memorang, Inc. (2019).

Nail Structure, cont.

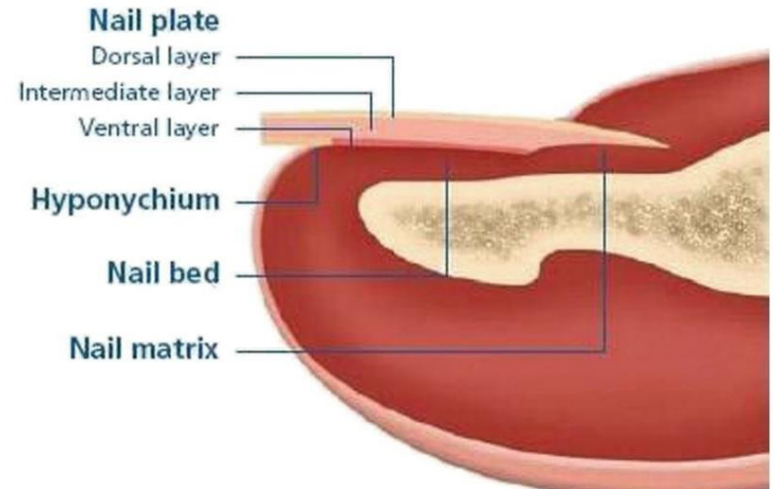
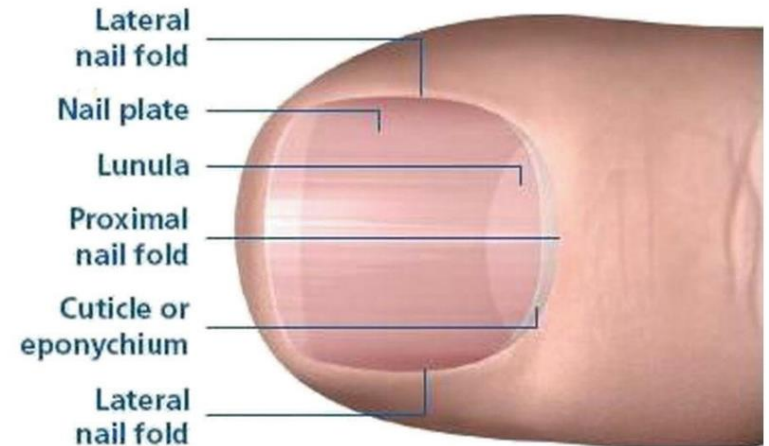
- Sterile matrix (nail bed)
 - Contains Merkel endings and Meissner's corpuscles
 - Attaches nail plate
 - Begins after the lunula (distal matrix)
 - Ends at the hyponychium



Memorang, Inc. (2019).

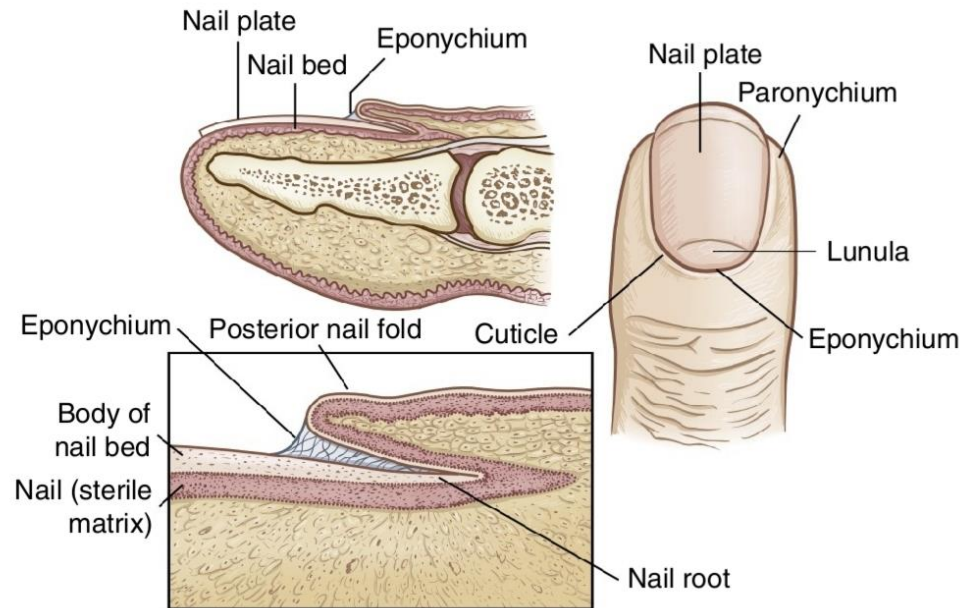
Nail Structure, cont.

- Distal nail fold
 - Protects the hyponychium
- Lateral nail fold
 - Encloses lateral free edges
 - Protects the paronychia
- Proximal nail fold
 - Protects the matrix
 - Attached to the nail plate by the eponychium
 - High density of CD4+ cells



Nail Structure, cont.

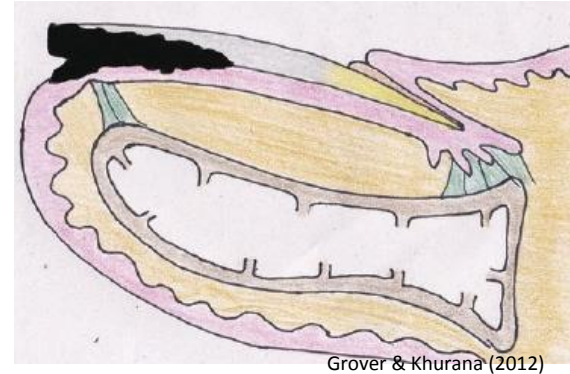
- Hyponychium
 - Creates appearance of the Onychodermal Band
 - Sheds dead skin known as the distal sole horn
- Paronychium
- Eponychium
 - Epidermal ridges that attach the epidermis to the subungual structures
 - Sheds dead skin known as the cuticle



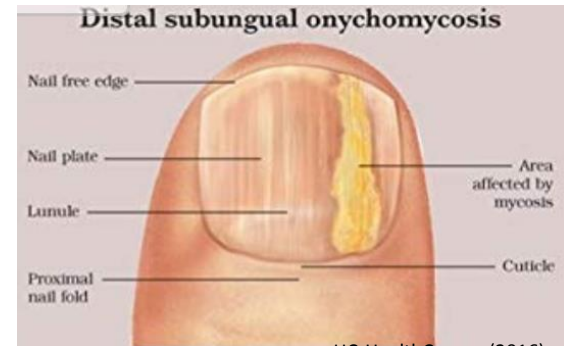
McCance & Huether (2014)

Onychomycosis - DLSO

- Distal lateral subungual onychomycosis (DLSO)
 - Most common type
 - Infection
 - Starts with the keratin of the hyponychium
 - Infection progresses to nail bed, then nail plate
 - Moves proximally through the nail plate
 - Physical traits
 - Mild inflammation with focal parakeratosis
 - Subungual hyperkeratosis and onycholysis
 - Thickening/distortion of nail plate
 - Caused by dermatophytes
 - *T. rubrum*, *T. mentagrophytes*, *T. tonsurans*, and *E. floccsum*
 - Co-morbidities
 - *Tinea pedis*
 - *Tinea mannum*



Grover & Khurana (2012)



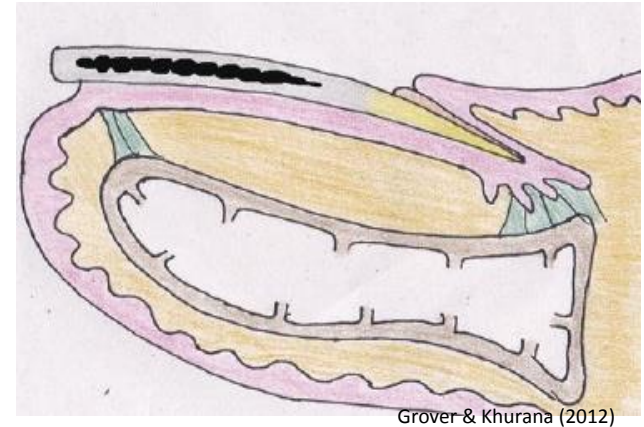
HC-HealthComm (2016)



Yau et al. (2018)

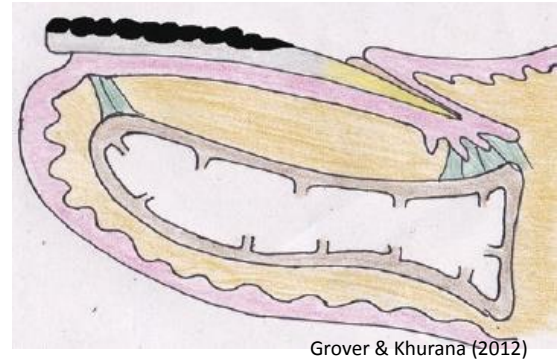
Onychomycosis - EO

- Endonyx onychomycosis (EO)
 - Infection of nail plate
 - Preference for hard keratins
 - Caused by dermatophyte (tinea capitis pathogens)
 - *Trichophyton soudanense*
 - *T. violaceum*
 - most common among patients of African descent
 - Rare in the US
 - Physical traits
 - Milky-white discoloration
 - Fungal hyphae are visible in nail plate
 - No nail bed hyperkeratosis or onycholysis
 - No fungal elements in the nail bed
 - Irregular, wide waves
 - Pits and lamellar splits



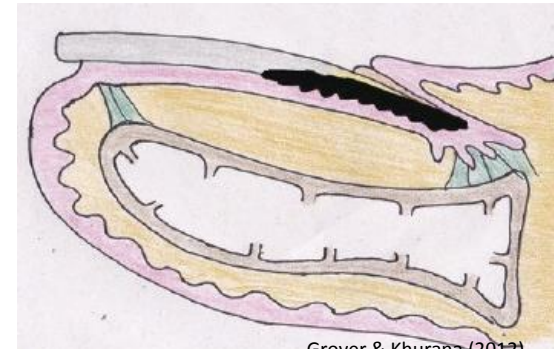
Onychomycosis - SWO

- Superficial white onychomycosis (SWO)
 - Rare infection at dorsal nail plate
 - Primarily affects toenails
 - Superficial white patches
 - Caused by:
 - *T. mentagrophytes*
 - *Aspergillus terreus*,
Fusarium oxysporum,
Acremonium spp.
 - *T. rubrum* in HIV patients

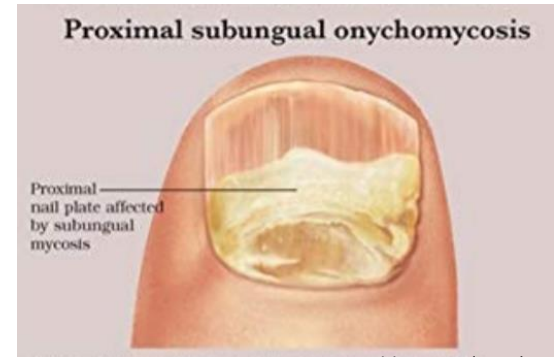


Onychomycosis - PWSO

- Proximal white subungal onychomycosis (PWSO)
 - Infection
 - Starts at stratum corneum of the proximal nail fold
 - Moves to matrix and underside of nail plate
 - Spread lymphatically in immunosuppressed patients
 - Paronychia with discharge
 - Commonly caused by *T. rubrum*
 - Presents as:
 - Leukonychia, proximal onycholysis, subungal hyperkeratosis, destruction of proximal nail plate
 - Patterns can be:
 - Proximal to distal longitudinal leukonychia pattern
 - Isolated transverse leukonychia band
 - Multiple transverse bands



Grover & Khurana (2012)



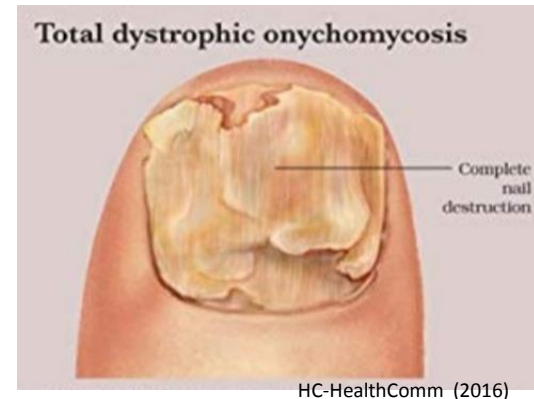
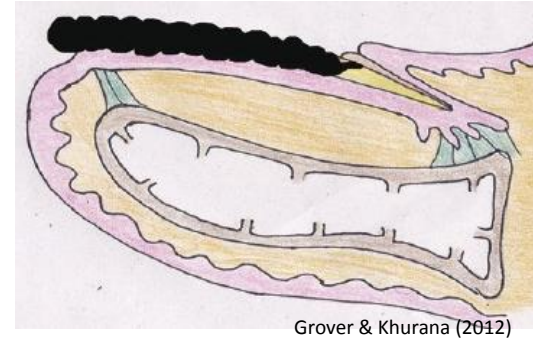
HC-HealthComm (2016)



Yau et al. (2018)

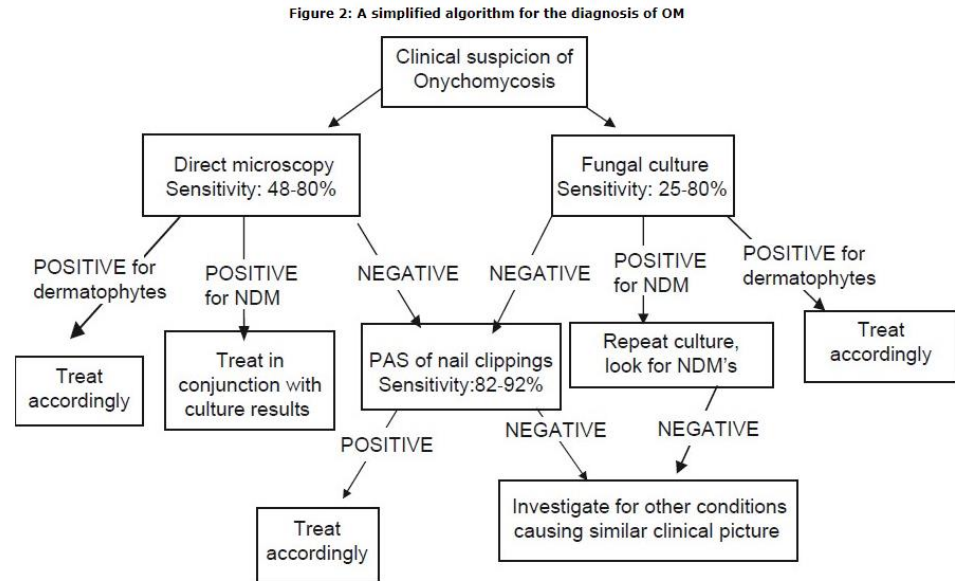
Onychomycosis - TDO

- Total dystrophic onychomycosis (TDO)
 - Destruction of nail plate, nail bed, and matrix
 - Appears thick and dystrophic with a crumbly texture
 - Causes:
 - Primary: Chronic mucocutaneous candidiasis
 - Secondary: resulting from aforementioned types of onychomycosis



Onychomycosis Diagnosis

- Related positive indicators
 - Tinea pedis within the past year
 - Scaling on sole of foot
 - White, crumbly patches on nail surface
 - Abnormal color of nail plate
- Diagnosis
 - Requires laboratory testing before treatment
 - Direct microscopy and cultures



Grover & Khurana (2012)

Differential Diagnosis

Psoriasis



Lichen planus



Yellow nail syndrome



Koilonychia



Terry's nails



Onycholysis



Table 1: Examples of clinical indicators for differential diagnosis of onychomycosis

Clinical indicators	Description
Punctate leukonychia	White spots on the nails; leukonychia is total whitening of the nail plate
Trauma or injury	Very similar appearance of onychomycosis, causing the nail to lift from the nail bed (onycholysis), thicken (onychauxis) or develop white marking
Psoriasis	Pitting of the nails; yellow-red nail discoloration under the nail plate that resembles a drop of blood or oil
Lichen planus	Ridged nails, melanonychia, thinning of the nail plate and nail dystrophy
Yellow nail syndrome	Loss of cuticle, yellow-greenish discoloration of the nails with thickening and curvature
Anaemia	Abnormal shape of the fingernail (koilonychia) with thinning, raised ridges and an inward curve
Chronic eczema	Pitting of the nail with ridging, adjacent skin involvement with vesicles, scaling and erythema
Chronic renal failure	Proximal nail bed whiteness and distal nail bed red/pink/brown discoloration (called half and half nails); absent lunula and tiny blood clots under the nail (splinter haemorrhages)
Source: Neale's Disorders of the Foot ^[19] , Onychomycosis (<i>Tinea unguium</i> , Nail fungal infection) [20]	

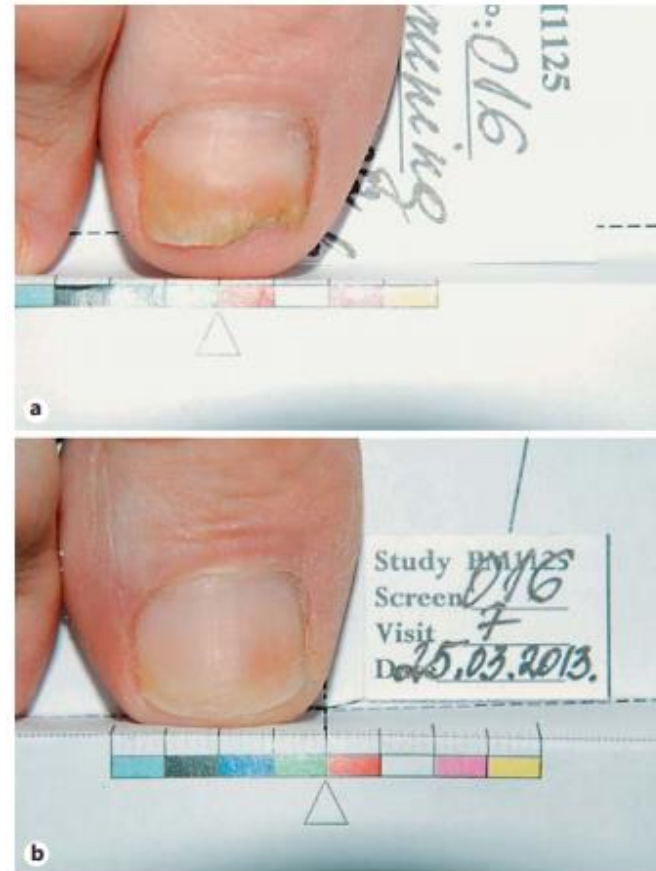
(Yau et al., 2018)

(Adigun, 2019)

Topical Treatments

- Topical treatments
 - Poor penetration due to hard/dense ventral nail structure (drug concentrations reduced 1000 times from outer nail plate to inner nail bed (Yau et al., 2018))
 - Monotherapy of OM with topical treatments is recommended for:
 - Superficial white onychomycosis (except for transverse or striate infections)
 - Early DLSOM where less than 50-80% of the nail plate is affected (sterile matrix) and without:
 - longitudinal, yellow streaks
 - yellow onycholytic areas in the central portion of the nail (dermatophytoma)
 - lunula involvement (distal matrix)
 - When systemic antifungals are contraindicated or not tolerated
 - onychomycosis due to molds (except for those due to *Aspergillus* sp.)
 - patients requiring maintenance therapy after a course of oral therapy

Ciclopirox before and after



(Iorizzo et al., 2015)

Topical Treatments, cont.

- Amorolfine
 - topical nail lacquer
 - inhibits sterol synthesis in fungal cell wall, depletion of ergosterol and accumulation of non-typical spherical sterols
 - mild (less than 3 nails) DLSOM patients aged 18+ years
 - broad-spectrum synthetic fungicidal
 - high activity against dermatophytes, other fungi, yeasts and molds
 - recommended for limited monotherapy
 - more effective when used with oral treatments
 - effective against:
 - dermatophytes (*Trichophyton spp.*, *Microsporum spp.*, *Epidermophyton spp.*)
 - yeasts (*Candida spp.*, *Cryptococcus spp.*, *Malassezia spp.*),
 - some molds (*Alternaria spp.*, *Hendersonula spp.*, *Scopulariopsis spp.*) other pathogenic fungi (*Cladosporium*, *Coccidioides*, *Histioplasma*, *Sporothrix*)
 - not against bacteria except *Actinomyces*
 - (Yau et al., 2018; Tabara et al., 2015)
- Ciclopirox
 - topical nail lacquer
 - decrease in activity of metal-dependent enzymes which affects ion transport through cytoplasmic membranes
 - broad antifungal activity
 - effective against:
 - Dermatophytes (*Trichophyton spp.*, *Microsporum spp.*, *Epidermophyton floccosum*)
 - yeasts (*Candida spp.*, *Malassezia furfur*, *Cryptococcus neoformans*, *Saccharomyces cerevisiae*)
 - molds (*Scopulariopsis brevicaulis*, *Aspergillus spp.*, *Fusarium solani*)
 - Gram-positive bacteria (*Staphylococcus spp.*, *Streptococcus spp.*)
 - Gram-negative bacteria (*Escherichia spp.*, *Proteus spp.*, *Klebsiella spp.*, *Salmonella spp.*, *Shigella spp.*, *Bacillus spp.*, *Pseudomonas spp.*)
 - Mycoplasma
 - (Tabara et al., 2015)



Systemic Therapy

- Systemic therapy
 - for adults with confirmed OM
 - advised when self-care strategies are unsuccessful or inappropriate
 - terbinafine and azoles
 - cause inhibition of ergosterol synthesis
 - absorbed into the nail matrix and remain active for several months
 - Liver function tests every 4-6 weeks
 - (Tau et al., 2018; Adams et al. 2019)
- Terbinafine (Lamisil)
 - Risk of developing lupus erythematosus-like effect; worsens symptoms of psoriasis
 - 250 mg/day for 6 weeks (fingernails) or 12 weeks (toenails)
 - Liver function: 4–6 weeks
 - Abdominal discomfort, anorexia, arthralgia, diarrhea, dyspepsia, headache, myalgia, nausea, rash, urticaria
- Itraconazole (Sporanox)
 - Effective against Aspergillus
 - metabolized in the liver to hydroxyitraconazole (antifungal properties as well)
 - Risk of heart failure; contraindicated for ventricular dysfunction or heart failure
 - 200 mg/day for 6 weeks (fingernails) or 12 weeks (toenails)
 - Pulse treatment for fingernails only
 - Liver function: 4–6 weeks
 - Abdominal pain, diarrhea, dyspnea, headache, hepatitis, hypokalemia, nausea, rash, taste disturbances, vomiting
 - » (Tau et al., 2018; Adams et al. 2019)

Terbinafine



Itraconazole



Other Therapy

- Combination therapy (best efficacy)
 - Topical and systematic combination therapy may provide synergistic antimicrobial activity
 - recommended for patients who have responded poorly to topical treatment alone
 - » (Yau et al., 2018)
- Photodynamic therapy (scarce data)
 - combines light irradiation and a photosensitising drug to cause destruction of selected cells
 - Laser therapies, such as neodymiumyttrium-aluminum-garnet and low-level laser, are aimed to selectively inhibit fungal growth
 - These alternative therapies may be appropriate because they are selective to local infection and avoid systemic side effects; however, robust data are scarce^[5] and they are not offered on the NHS.
 - » (Yau et al., 2018)
- Lifestyle patient education (to limit growth)
 - Avoid
 - prolonged exposure to warm, damp conditions
 - occlusive footwear
 - nail trauma
 - cosmetic nail varnishes or artificial nails
 - sharing nail clippers with others
 - walking without footwear in public areas
 - cutting nails too short
 - Ensure
 - proper nail care
 - meticulous hygiene of the affected foot
 - washing and drying feet daily, especially between the toes
 - using the correct footwear to prevent trauma
 - using antifungal powder to help keep shoes pathogen free
 - replacement of all old shoes and old socks to prevent re-infection
 - breathable or antimicrobial socks (e.g. cotton, bamboo, or sliver fiber)
 - treating all family members to prevent cross infection
 - » (Yau et al., 2018)



Conclusion

- “The management of OM depends on the type, extent, and severity of nail involvement, symptoms, and pre-existing conditions.
- The aim of treatment is to eradicate the pathogen, restore the nail and prevent re-infection.
- OM is challenging to treat and affected nails may never return to normal as the infection may have caused permanent damage.
- As OM has a high relapse rate of 40–70%, advice on preventative and appropriate self-care strategies to avoid re-infection should be offered to patients.”
- OM is a preventable nail disorder.
- When provided the ideal growing conditions, it will advance when nail trauma allows for invasion.
- OM is very difficult to eradicate due to the hard, dense nail plate which protects the pathogen and limited body defenses of the nail apparatus.
- Prevention must be addressed for at risk patients.

» (Yao et al., 2018)



Doughty & McNichol (2016)

Q: How often do patients leave their socks on during a head to toe assessment?

Q: How often do health care professionals provide foot care related patient education?

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