FOX – Podiatry Applications

- The Nail – Common terms & Anatomy
- Onychomycosis – Causes and Background
- Onychomycosis – Classification
- Treatment Basics
The Nail - Areas definitions

- Proximal nail fold
- Nail plate area
- Lateral nail fold (Nail groove)
- Distal area
The Nail - Anatomy

Cuticle
A transparent thin fold of dead skin protecting the new grown nail

Nail plate
made of translucent keratin protein

Eponychium
"seals" the proximal nail plate & bed

Lunula
("small moon") the visible part of the matrix
The Nail - Anatomy

- Lunula
- Eponychium
- Nail plate
- Hyponychium: distally "seals" the nail bed
- Nail bed
- Nail matrix

Eponychium proximally "seals" the nail bed.
The Nail - Growth

The matrix, the Mother of the Nail, is the part of the nail unit that lies underneath the proximal nail fold just in front of the nail root. The leading edge of the matrix is seen as the lunula. The matrix cannot be seen on all nails, but is generally seen on the thumbs, index and middle fingers. The soft, plump cells that comprise the nail plate are developed in the matrix. As they grow out, they loose their inner material and become flat, hard and translucent.

The oldest cells are the most compact, making the nail plate harder and more dense closest to the free edge. The longer the matrix, the more cells it can produce, resulting in a thicker nail plate. Any damage to the matrix can be seen on the emerging nail plate.
The Nail - Growth

The nail plate is held together by strong, interconnecting bands of protein fibers, and is kept flexible by a sticky residue of oils and moisture that constantly flow upward from the nail bed. When this residue transmits through the plate, it creates a matte shine on the surface of the plate. It is also the substance that allows the nail plate to bend and flex under pressure.

The plate rides forward on the nail bed in a "rail and groove" effect - much like a train riding on its tracks. As we mature, the nail bed produces less oil and moisture, and this rail and groove effect becomes evident as vertical ridges in the plate.

Many factors determine nail growth, and each fingernail will grow at different rates. Heredity and health determine how fast the nail plate will grow, although the growth slows as we age.
The Nail - Growth

People who use their hands a lot usually experience a faster growth rate. The thumbnail will grow about 1 1/2 inches per year, and the left thumb will usually grow faster than the right. The index fingernail will grow the fastest, followed by the pointer and ring finger, which grow at almost the same rate. As a rule, the longer the finger, the faster the plate will grow.

Nails also grow faster in summer than in winter, and faster during pregnancy. After pregnancy, the rate drops back to normal. Age also affects the growth rate with nail growth peaking between 10 and 14 years and slowly declining after age 20.

Factors that slow nail growth include:

- Being immobilized or paralyzed
- Poor circulation
- Malnutrition
- Lactation
- Serious infections
- Psoriasis and certain medications
The Nail - Growth

Some people erroneously believe that eating certain foods or using special creams, oils or lotions will increase the growth rate.
Although the nail plate requires certain nutrients for proper growth, there is very little evidence that eating any particular food will cause them to grow faster.

Creams, oils and lotions are sometimes sold as 'growth accelerators', although these claims are false, misleading and illegal.

No cosmetic product may claim that it can alter or change any body function.
These products and others are only for beautifying the nail plate, and only medical drugs can make such claims.
Onychomycosis - General

Fungal infection that causes the fingernails or toenails to thicken, discolor, disfigure and split is called Onychomycosis (also known as tinea unguium). Without treatment, the nails will turn so thick that they press against the side of the shoes, causing strain, irritation and pain.

Onychomycosis is not easy to treat because nails develop slowly and receive very little blood supply.

Diabetic patients commonly develop Onychomycosis because blood circulation is reduced in the extremities, and the body's capability to fight infections is compromised. Small cuts, infections, and foot injuries can have serious consequences for diabetics.
Onychomycosis – Pathogens

**Dermatophytes** (the primary fungi family that cause Onychomycosis)

- **Trichophyton rubrum** (T. Rubrum)
  
  Responsible also for athlete’s foot, jock itch, and ringworm

  ![Yellowish “oily” deep nail](image)

- **Trichophyton mentagrophytes** (T. Mentagrophytes)
  
  Has at least five different variants.

  ![White superficial nail](image)

**Yeast**

- **Candida Albicans** or **Candida Parapsilosis**.
  
  These infections are less frequent though produce similar symptoms.

  ![Surrounding tissue effects](image)
Onychomycosis – Treatment methods

- **Topical** drug treatment for Onychomycosis is not usually successful because they are unable to penetrate the nail plate and rapid recurrence can occur after discontinuing use.

- **Oral** antifungal agents are more effective although more toxic with a significant risk of liver toxicity, prolonged loss of taste, and life threatening drug interactions.

- **Surgical** – is used as fungal resistance can occur when the oral antifungal agents are used on a long term basis. Topically applied antifungal drugs may work somewhat better adjunctive to surgical removal or chemical dissolution of the nail plate. Yet, this often ineffective and traumatic procedure leaves the subject without a nail for months at risk for re-infection.
Onychomycosis – How Laser affect the pathogens

**Photoinactivation**
Laser infrared radiation was shown to irreversibly deform the fungi cell cytoplasmatic membrane, a process known as inactivation of membrane transport system.

Infrared laser radiation, creates reactive oxygen species (ROS), which able to irreversibly alter the chemical **chitin**, that makes the fungi cell membrane.
Onychomycosis – How Laser affect the pathogens

Heat

Mycelium is the vegetative part of a fungus. It is through the mycelium that a fungus absorbs nutrients from its environment.

The infrared heat, affect the Mycelium and denatures the enzyme that the fungus uses in order to digest the nail's keratin protein.

Laser heat basically solidify the enzyme, like cooking an egg...

Fungi are heat sensitive above 55°C, so absorption of laser energy that results in sustained photothermal heating of the mycelium (10+ minutes) is likely to result in fungicidal effects.
Onychomycosis - Laser therapy - secondary affect

The heat caused by the infrared laser, stimulate blood circulation. Additionally, temperatures of over ~40°C at the nail bed, are known to cause significant local white blood cells increment. This mechanism assist further in fungi eradication as well as better quarantine it.
Onychomycosis – How Laser affect the pathogens

Why doesn’t the laser eradicate the fungus pathogens completely in one session?

Because fungi leaves behind **Spores** which are incredibly resistant to heat and chemicals.

Spores are like eggs, and will hatch when the time is right. After hatching, it’s easy to eradicate them with the laser.
Summary

One of the main advantages of laser therapy is its selective bactericidal effect. Laser light causes destruction of pathogenic microorganisms and also stimulates the reparative process.

Near infrared photo-inactivation of bacteria and fungi at physiologic temperatures has been asserted by several studies on Staphylococcus aureus, Escherichia coli, Candida albicans, Trichophyton rubrum and Trichophyton mentagrophytes. ¹

In this particular trial, no observable damage to the nail matrix was observed, yet photo-damage to the pathogens was achieved.

The key to success with this treatment is penetration through the entire nail plate without damage to the nail bed or matrix.

¹. Journal of Photochemistry and Photobiology B: 1995; Vol.32 (Issue 3) 139-154
Onychomycosis – Common symptoms

- Brittleness
- Change in nail shape
- Crumbling of the outside edges of the nail
- Debris trapped under the nail
- Loosening or lifting up of the nail
- Loss of luster and shine
- Thickening of the nail
- White or yellow streaks on the side of the nail
Onychomycosis - Classification

- **Distal and Lateral**
  - Subungual (DSO)

- **White Superficial**
  - (WSO)

- **Proximal**
  - Subungual (PSO)

- **Total dystrophic**
  - (all 3 sites affected)
Onychomycosis - Classification

Distal and Lateral
Subungual Onychomycosis

The easiest way for the fungus to enter...

Happens when the **Hyponychium**
(which normally "seals" the nail bed)
is cracked or damaged, and allow
the fungi to invade.
(Most often caused by *T. Rubrum*).

This type has strong genetic origin.
Onychomycosis - Classification

White Superficial

The fungus directly invades the surface of the nail and it is recognized as white to dull-yellow patches anywhere on the surface of the toenail.

As the infection progresses, these patches join and cover the entire nail plate. The nail becomes rough, soft and crumbly.

Most often caused by *T. Mentagrophytes*.
Onychomycosis - Classification

Proximal subungual

The least common form in healthy persons. Most often caused by *T. Rubrum* that invades the nail through the proximal nail fold, penetrates the newly formed nail plate and then migrates distally.

It usually occurs in immune-compromised persons and is considered a clinical marker of human immunodeficiency. (Though Proximal Subungual Onychomycosis can also arise secondary to local trauma).
Onychomycosis - Classification

Candida

Patients with chronic mucocutaneous candidiasis may develop candidal infection of the nails. Candida species may invade nails previously damaged by infection or trauma. Candidal paronychia more commonly affects the hands and usually occurs in persons who frequently immerse their hands in water.
Treatment Technique

Approx. 2 mm/s
Up to 1 cm

White Handpiece
(4mm beam spot size)
Treatment technique - Guidelines

Use a painting motion to uniformly cover the nail with multiple passes in a grid pattern.

Typical total energy delivered through the large nail, in one pass should be about 500 J (Joules) which is displayed in the lower right corner of the display screen. Typically 3 passes needed for a total of ~1,500 J. Treatment time is approx. 2.5 minutes (without interruption). This may approach a threshold of discomfort for the patient. If necessary, pause momentarily during the treatment. Touch the pulse counter to reset to zero before treating additional nails.
Onychomycosis – Protocol remarks

1. A typical Laser treatment protocol consist of 3-4 sessions with 4-6 weeks interval.

2. Nail debridement is recommended before treatment.

3. Time taken to treat each nail is approximately 2-2.5 minutes.

4. Patients should be treated without using anesthetics; Patients may report on some discomfort and occasional sensation of a “hot sensation” throughout and post the treatment.

5. It is highly advisable to use a fresh pair of socks post the treatment, as well as use topical antifungal medications, both on the nail/s as well as spray the shoes/socks.

Despite the high success rate with laser treatment, it is not a definitive cure for Onychomycosis. Therefore and because it can recur, preventative maintenance treatments might be recommended every 12 months.