Available online on 15.10.2025 at http://ajprd.com

Asian Journal of Pharmaceutical Research and Development

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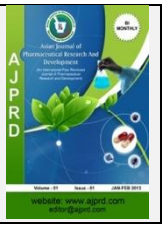

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Review Article

Onychomycosis: A Comprehensive Review of Epidemiology, Diagnosis, and Emerging Therapeutic Strategies

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A B S T R A C T

Onychomycosis is a prevalent fungal infection that affects the nail unit and accounts for over half of all nail-related disorders worldwide. It is mainly caused by dermatophyte species such as Trichophyton rubrum and T. mentagrophytes, although non-dermatophyte molds like Aspergillus and Fusarium, as well as yeasts such as Candida, can also contribute. The infection causes nail discoloration, thickening, brittleness, and discomfort, often leading to a noticeable decline in quality of life. Its occurrence increases with age and is more common among people with diabetes, peripheral vascular disease, compromised immunity, or those undergoing hemodialysis.

Accurate diagnosis depends on proper nail specimen collection and confirmation through laboratory techniques such as microscopy, culture, or advanced molecular tools like PCR and immunoassays, which offer greater precision than traditional methods.

Treatment involves systemic antifungal agents—such as terbinafine, itraconazole, and fluconazole—or topical formulations like ciclopirox, amorolfine, efinaconazole, and tavaborole. However, oral antifungals can cause liver toxicity and drug interactions, while topical therapies often have limited nail penetration. To address these challenges, novel drug delivery systems such as antifungal nail lacquers have been developed. Econazole nitrate-based lacquers containing film-forming agents, plasticizers, and permeation enhancers improve nail permeability and sustain drug release. Innovative options like iontophoresis, photodynamic therapy, and laser-assisted delivery further enhance effectiveness.

Despite progress, recurrence and reinfection are frequent due to residual fungal spores and environmental exposure. Therefore, long-term success depends on patient education, consistent treatment adherence, and preventive practices such as maintaining nail hygiene and using antifungal prophylaxis.

Keywords: Onychomycosis, antifungal nail lacquer, econazole nitrate, dermatophytes, transungual drug delivery, topical antifungal therapy, PCR diagnosis, permeation enhancer.

A R T I C L E I N F O: Received 11 Feb 2025; Review Complete 05 April 2025; Accepted 18 August 2025. ; Available online 15 Oct. 2025

Cite this article as:

Godse MC, Kadam NN, Onychomycosis: A Comprehensive Review of Epidemiology, Diagnosis, and Emerging Therapeutic Strategies, Asian Journal of Pharmaceutical Research and Development. 2025; 13(5):000-000, DOI: http://dx.doi.org/10.22270/ajprd.v13i5.000

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INTRODUCTION

Onychomycosis is the most common nail disorder, accounting for more than 50% of all nail diseases. It is a fungal infection of the nail unit caused predominantly by dermatophytes (Trichophyton rubrum, T. mentagrophytes, Epidermophyton floccosum), but also by non-dermatophyte molds (Scopulariopsis brevicaulis, Aspergillus spp., Fusarium spp.) and yeasts (Candida spp.). The condition is characterized by nail discoloration, thickening, brittleness, and in severe cases, pain and functional impairment. Its prevalence varies globally—from 2–3% in the general U.S. population to up to 13% in Finnish men—and increases significantly with age, affecting nearly 30% of individuals over 60 years old. Although uncommon in children, cases may occur due to occlusive footwear and shared environmental exposure. Several factors predispose individuals to onychomycosis, including humidity, occlusive footwear, repeated trauma, diabetes mellitus, peripheral vascular disease, HIV infection, immunosuppression, and genetic susceptibility. Furthermore, onychomycosis often coexists with other fungal infections such as tinea pedis or tinea manuum, and may serve as an indicator of systemic diseases like diabetes or immunocompromise associated with HIV. Beyond the physical manifestations, the condition also affects psychological and social well-being, leading to reduced self-confidence and impaired quality of life.

Among special populations, patients undergoing hemodialysis are particularly prone to nail and skin alterations due to systemic effects of chronic renal disease and its etiologies, such as diabetes mellitus, hypertension, glomerulopathies, and polycystic renal disease. Common dermatological findings include xerosis, pruritus,

hyperpigmentation, and fungal infections, with onychomycosis representing one of the most frequent nail disorders—accounting for up to 90% of toenail pathologies in this group. The prevalence of onychomycosis among hemodialysis patients ranges from 19% to 51.9%, with dermatophytes being the predominant pathogens (≈71%), followed by non-dermatophyte molds (≈20%) and yeasts (≈8%), the latter more frequent among older individuals and those with diabetes or psoriasis. The risk increases with advanced age, male gender, diabetes mellitus, psoriasis, renal transplantation, and HIV infection, though the influence of hemodialysis duration remains uncertain.

Current therapeutic strategies for onychomycosis include systemic oral antifungal agents and topical formulations. Oral treatments, though effective, are often limited by hepatotoxicity and drug interactions, leading to patient reluctance and physician caution. Topical therapies, while safer, are hampered by the dense, keratinized, and low-permeability structure of the nail plate, which restricts drug diffusion. Therefore, innovative drug delivery systems are under investigation to enhance transungual penetration. Recent approaches include chemical and physical permeation enhancement, colloidal carrier systems, and polymeric film-forming lacquers. Nail lacquers, in particular, form a drug-loaded polymeric film upon solvent evaporation, ensuring prolonged contact and sustained drug release at the nail surface. However, their effectiveness depends on optimizing hydration, film properties, and penetration enhancement mechanisms. Chemical enhancers and pre-treatment methods, such as keratolytic or humectant solutions, can increase drug diffusion by disrupting keratin bonds and improving nail hydration.

In alignment with the Quality by Design (QbD) principles outlined in ICH guidelines Q8(R2), Q9, and Q10, modern pharmaceutical development focuses on defining a Quality Target Product Profile (QTPP) and identifying Critical Quality Attributes (CQAs), Material Attributes (CMAs), and Process Parameters (CPPs) to ensure robust product performance. Econazole nitrate, an imidazole antifungal agent with broad-spectrum activity, acts by inhibiting 14α-lanosterol demethylase, thereby disrupting ergosterol synthesis and compromising fungal cell membrane integrity. Building on these insights, our research focuses on developing an optimized econazole nitrate-based antifungal nail lacquer designed for enhanced transungual delivery. The formulation integrates polymeric film formation with multi-mechanism permeation enhancement, including pre-treatment with humectant and keratolytic agents to improve nail hydration and drug diffusion. Evaluation of the developed lacquer demonstrated superior econazole permeation and drug release compared with control formulations, supporting its potential as an effective topical therapeutic approach for onychomycosis.[1,2,3]

- **What Is Onychomycosis?**

  Onychomycosis is a fungal infection of the nails that can involve either the fingernails or toenails. This long-lasting condition can lead to pain, discomfort, and difficulty in performing daily activities, while also impacting a person's physical and emotional well-being. The infection often persists despite treatment and does not clear on its own. Additionally, if left untreated, affected nails can spread the infection to others or contaminate shared spaces.[4]

- **Etiology**

  Onychomycosis is a fungal nail infection caused by dermatophytes, non-dermatophyte molds (NDMs), and yeasts, leading to nail discoloration, thickening, and separation from the nail bed.

  Dermatophytes are responsible for 60–70% of cases, with Trichophyton rubrum being the most common cause of distal and proximal subungual onychomycosis. Other species include T. mentagrophytes (linked to white superficial onychomycosis), Epidermophyton floccosum, T. tonsurans, T. verrucosum, and T. violaceum.

  Non-dermatophyte molds (20–30%) are opportunistic pathogens that infect damaged nails. Common species include Aspergillus spp., Fusarium spp., Scopulariopsis brevicaulis, Chaetomium globosum, Cladosporium carrionii, and Neoscytalidium dimidiatum, along with rarer fungi such as Exophiala jeanselmei and Penicillium marneffei.

  Yeasts (10–20%), mainly Candida species (C. albicans, C. parapsilosis, C. tropicalis, etc.), typically affect fingernails, especially in people with moisture exposure, diabetes, or immunosuppression.[5]

- **Epidemiology**

  In post-industrialized countries, onychomycosis affects over 10% of the population. Several studies around the world report similar figures. For instance, a Finnish study involving 800 participants found a prevalence of 8.4%, while two large Canadian studies, with 2,001 and 15,000 participants, reported prevalence rates ranging from 6.5% to 9.1%.

  Initially, many experts considered onychomycosis a relatively minor medical concern. However, evidence suggests that its prevalence has steadily risen over the past few decades. Supporting this trend, a 1979 study in the United States (n = 20,000) reported an overall prevalence of 2.18%. By 1997, another U.S. study (n = 1,038) found that the prevalence had increased to 8.7%, and a large multicenter North American study in 2000 (n = 1,832) estimated it at 13.8%.

  A similar increase has been observed in Indonesia, where the incidence of onychomycosis rose from 3.5% in 1997–1998 to 4.7% in 2003. Data from the Achilles Project, a survey conducted in 1999 among patients visiting physicians, also highlighted a high prevalence: 26% in Europe (Belgium, Netherlands, Luxembourg, Switzerland, Hungary, Great Britain, Poland; n = 22,760) and 22% in East Asia (China, South Korea, Taiwan; n = 43,914). Overall, the study concluded that approximately two out of every ten patients showed signs of onychomycosis.[6]

- **Pathogenesis**

  Onychomycosis develops when fungi—such as dermatophytes, yeasts, or non-dermatophyte molds—

come into direct contact with the nail. The nail unit is particularly vulnerable to infection because it lacks strong cell-mediated immune protection. These fungi are able to invade the nail plate by secreting enzymes that degrade keratin, proteins, and lipids. When the body's defenses are compromised, the likelihood of infection increases [14]. The specific type and site of fungal invasion determine the clinical form of onychomycosis that develops. Additionally, the ability of fungi to form biofilms contributes to antifungal resistance and allows them to persist despite treatment efforts.[7]

- **Prevalence of Onychomycosis**

The occurrence of onychomycosis is influenced by age, occupation, climate, and travel habits. Its incidence tends to rise among the elderly, individuals with HIV or on immunosuppressive therapy, avid athletes, those using public swimming pools, and people who wear tight or occlusive footwear. Men are more commonly affected, likely due to more frequent nail injuries during sports and recreational activities.

Toenails are about seven times more likely to be affected than fingernails, partly because they grow roughly three times slower. In India, additional risk factors include walking barefoot, wearing poorly fitting shoes, nail biting (onychophagia), and occupational exposure to chemicals. Other contributing factors include nail trauma, peripheral vascular disease, smoking, and psoriasis, all of which can increase susceptibility to nail fungal infections.[8]

- **Risk Factors for Onychomycosis**

A. General Population

1. Age - The likelihood of developing onychomycosis increases as people get older.
2. Weakened Immune System - Individuals with compromised immunity are more prone to fungal nail infections.
3. Diabetes Mellitus (DM) - High blood sugar, reduced circulation, and impaired immune response in diabetic patients make nails more susceptible to fungal infections.
4. Family History - Genetics or shared environmental factors may increase the risk of developing nail fungus.
5. Peripheral Vascular Disease - Poor blood flow can slow healing and make infections more likely.
6. Skin and Nail Conditions - Certain conditions affecting the nails or surrounding skin can predispose someone to infection, including:Excessive sweating (hyperhidrosis), Psoriasis, Thick or deformed nails (onychogryphosis), Nail injuries or trauma

B. Diabetic Patients

1. Having Diabetes - Diabetic individuals are nearly three times more likely to develop toenail fungus compared to those without diabetes.
2. Compromised Circulation (Peripheral Vascular Disease) - Poor blood flow slows healing and increases infection risk.
3. Peripheral Neuropathy - Nerve damage can make it harder to notice infections or nail problems early.
4. Impaired Immunity and High Blood Sugar - Both factors create a favorable environment for fungal growth.

C. Chronic Kidney Disease / Hemodialysis Patients

1. Chronic Kidney Disease / Uremia - Changes in skin structure and blood vessels due to uremia can weaken the skin and nails, making fungal infections more likely.
2. Length of Hemodialysis Treatment - The longer a patient has been on dialysis, the higher the risk of developing onychomycosis.
3. Diabetes in Dialysis Patients - Diabetes further increases susceptibility to fungal nail infections in patients undergoing hemodialysis.
4. Combined Immune Suppression- qThe combination of diabetes and uremia can significantly impair immunity, increasing vulnerability to nail fungal infections.[9]

Prognosis

The overall outlook for onychomycosis is generally favorable when treated properly. However, certain factors can make therapy less effective. For instance, yellow streaks along the sides of the nail, the presence of dermatophytoma, and infections caused by non-dermatophyte molds—especially Fusarium species—often respond poorly to treatment.

Other factors that can negatively affect recovery include poor adherence to medication, older age, severe or long-standing infection, involvement of the nail matrix, thick subungual hyperkeratosis (greater than 2 mm), "two feet–one hand" syndrome, and weakened immunity.

Treatment failures may also occur because topical antifungal agents have limited ability to penetrate the dense nail plate, while the infection itself tends to be deep-rooted and resistant. Recurrence is fairly common, with rates reported between 10% and 53%, typically appearing within three years after completing therapy. These recurrences may result from either a relapse of the original infection or a new fungal reinfection.[10]

Identification of Fungi In Situ in Nail Samples

Traditional culture methods for diagnosing onychomycosis are often unreliable—around 35% of cultures show no fungal growth, and many isolates are non-dermatophyte molds (NDMs) that may be contaminants. To address these limitations, polymerase chain reaction (PCR) and real-time PCR have become effective alternatives for detecting dermatophytes, yeasts, and NDMs directly from nail samples.

PCR assays may use species-specific or pan-fungal primers, providing accurate and rapid results within 48 hours, compared to a week or more for cultures. PCR detects fungi in up to 70% of cases with negative cultures and has

confirmed that NDMs like Fusarium, Acremonium, and Scopulariopsis species are true pathogens. Studies show that NDMs may account for about 20% of onychomycosis cases, higher than previously estimated.

Immunological detection methods are also emerging. Monoclonal antibody-based test strips (e.g., Dermatophyte Test Strip, FungiCheck) can rapidly identify Trichophyton species from infected nails. These antibodies target dermatophyte-specific polysaccharide antigens but may also cross-react with Aspergillus and Fusarium species.[11]

Diagnosis of Onychomycosis

Accurate diagnosis of onychomycosis is essential before starting treatment, as relying solely on clinical appearance can be misleading. While roughly half of all nail dystrophies are fungal, not every abnormal nail is caused by infection. Treatment is long-term, requiring full regrowth of the nail—around 12 months for toenails and 6 months for fingernails—to determine if it has been successful. Waiting for a trial of treatment to confirm the diagnosis is impractical, and without proper diagnosis, it's unclear whether lack of improvement is due to treatment failure or an incorrect initial diagnosis. Although laboratory tests may seem costly, their expense is minor compared to the cost of unnecessary or inappropriate treatment.

Laboratory diagnosis involves microscopy to visualize fungal elements and culture to identify the causative species. The accuracy of these tests depends on sample quality, the experience of the microscopist, and the laboratory's ability to distinguish between true pathogens, harmless saprophytes, and contaminants.

For dermatophyte infections, which primarily affect the nail bed, the most proximal infected area often provides the best sample. In distal and lateral subungual onychomycosis (DLSO), material should be collected from under the nail using a small scraper. If the nail is partially detached (onycholytic), the underside and nail bed can be scraped, submitting as much material as possible to improve detection, since fungal elements may be sparse. For white superficial onychomycosis (WSO), scraping the nail surface is sufficient. Proximal subungual onychomycosis (PSO) is rare and may require scraping with a scalpel or even a punch biopsy to obtain full-thickness nail and nail bed samples.

Some of the collected material is treated with 20% potassium hydroxide (KOH) on a glass slide and examined under a microscope after 15–20 minutes. Adding Parker's blue/black ink can enhance visualization of fungal hyphae. Care must be taken, as inexperienced observers may mistake cell walls for fungal elements.

The remaining sample is cultured on Sabouraud's glucose agar, often with antibiotics, and incubated at 28 °C for at least 3 weeks, as dermatophytes grow slowly. Direct microscopy can be performed by clinicians, but it requires regular practice and expertise. Cultures should be processed in specialized mycology laboratories to avoid misinterpretation.

It is important to remember that incorrect diagnosis is the most common reason for treatment failure, often due to relying solely on clinical signs or misreading laboratory results. Histology is rarely needed and is generally reserved for other nail disorders, such as psoriasis, which may show Candida on culture but is not usually the true cause of fungal infection.[12]

Specimen Collection for Onychomycosis Diagnosis

Accurate diagnosis of onychomycosis depends on proper specimen collection and handling. Nails should be cleaned with alcohol before sampling to remove contaminants. The collection site and method vary by infection type:

DLSO: Clip the nail near the base and scrape the underside and nail bed, discarding surface debris.

PSO: Pare the nail at the lunula and collect white debris from the deeper layers.

WSO: Collect only white spots beneath the surface.

Candida infections: Sample from proximal/lateral nail edges or the undersurface if onycholysis is present.

TDO: Any abnormal nail portion can be used.

Samples are divided for microscopy and culture, with fine shavings preferred. Collection should occur 2–4 weeks after stopping antifungal therapy to avoid false negatives. Specimens should be stored in sterile containers or paper packets (e.g., Dermapak™) and processed within a week, though fungi can remain viable for months. Proper technique ensures reliable diagnostic results and effective treatment planning.[13]

Treatment of Onychomycosis

The management of onychomycosis depends on the clinical form of the infection, the number of nails involved, and the overall severity. Each treatment option comes with specific limitations—oral antifungal drugs can interact with other medications and carry a risk of hepatotoxicity, while topical agents are often less effective without prior nail debridement. Consequently, combining oral (systemic) and topical therapies is often considered the most effective approach for achieving cure and preventing relapse.

I. Topical Treatment

Effective topical therapy for onychomycosis requires adequate drug penetration through the dense and impermeable nail plate. This is challenging, and recurrence or reinfection occurs in approximately 20–25% of patients. To improve outcomes, topical agents are often combined with systemic antifungals, mechanical debridement, or chemical nail avulsion. In mild cases—particularly white superficial onychomycosis (WSO) or distal and lateral subungual onychomycosis (DLSO) affecting less than half of the nail—topical therapy alone can be sufficient. Treatment duration typically ranges from 6 to 12 months.

Common topical agents include:

Amorolfine 5% lacquer: Applied once weekly. It has fungistatic and fungicidal activity against dermatophytes, molds, and yeasts. Recommended mainly for mild cases without nail matrix involvement or when one or two nails are affected.

Ciclopirox 8% lacquer: Applied daily. It possesses antifungal, anti-inflammatory, and anti-allergic properties. Available in

both water-soluble and non-water-soluble formulations, the former offering improved nail permeability.

Newer topical agents:

Efinaconazole 10% solution: A triazole antifungal approved in 2014 for mild to moderate DLSO. It is applied daily without the need for nail debridement and demonstrates efficacy comparable to oral itraconazole. Clinical studies involving over 1600 patients have confirmed its effectiveness, especially in early disease stages.

Tavaborole 5% solution: A lightweight, water-soluble lacquer approved in the U.S. for toenail onychomycosis. Phase II studies have shown good efficacy and safety, while phase III data are awaited.

Luliconazole 10%: An imidazole antifungal with both fungicidal and fungistatic effects, demonstrating good tolerability and safety in clinical trials for moderate to severe DLSO.

Other investigational topicals include terbinafine-based formulations such as sprays (TDT 067) and lacquers (MOB-015, TMI-358), which are currently in various phases of clinical trials.

Emerging topical alternatives:

Photodynamic therapy (PDT) and laser treatments are gaining attention as non-invasive approaches. PDT uses a photosensitizing agent combined with light exposure to produce reactive oxygen species that destroy fungal cells. Common photosensitizers include methylene blue, toluidine blue, porphyrins, and 5-aminolevulinic acid. Although effective in small studies, PDT requires multiple sessions and lacks standardized protocols for light source and frequency.

Similarly, various laser systems—such as carbon dioxide (CO_2), Nd:YAG (1064 nm), and diode lasers (870–930 nm)—have been FDA-approved to improve the cosmetic appearance of infected nails. Clinical studies have reported variable mycological cure rates (up to 87.5% with Nd:YAG lasers), but the evidence remains inconsistent due to differing study designs and definitions of cure. More controlled trials are needed to establish their long-term efficacy.

II. Systemic Treatment

Systemic antifungal therapy is recommended for severe DLSO, proximal subungual onychomycosis (PSO), or deeply infiltrative white superficial infections. The main oral antifungal agents—terbinafine, itraconazole, and fluconazole—have significantly improved cure rates, achieving up to 90% mycological cure for fingernails and around 80% for toenails.

Common regimens include:

Terbinafine: 250 mg daily for 12 weeks (continuous therapy) or 500 mg/day for four weeks on and four weeks off (pulse therapy).

Itraconazole: 400 mg/day for one week each month; typically two cycles for fingernails and three for toenails.

Fluconazole: 150–300 mg weekly for at least six months; less effective than terbinafine or itraconazole.

Both terbinafine and itraconazole pulse therapies are safe and effective, even in diabetic patients. Combination regimens using topical and systemic antifungals are often employed in practice, though comparative studies are limited.

Treatment challenges include infection with non-dermatophyte molds—such as Neoscytalidium, Scopulariopsis, and Fusarium—which respond poorly to systemic antifungals. In such cases, topical therapy combined with mechanical nail plate removal is preferred. When Candida species are isolated, terbinafine should be avoided since it lacks efficacy against yeasts. Candida onychomycosis often indicates underlying conditions like diabetes or immunosuppression, warranting further evaluation.

In advanced or dystrophic cases with dermatophytomas or lateral nail involvement, surgical or chemical nail avulsion in combination with systemic or topical antifungal therapy (particularly itraconazole or terbinafine) may be required.

Because nail growth is slow—especially in older adults—therapy must be continued for several months. Drug choice should be guided by the infection type, severity, causative organism, and patient comorbidities. For most patients presenting with mild DLSO affecting one or two toenails, topical antifungal therapy combined with regular nail trimming or debridement remains the preferred option.[14]

FDA-Approved Treatments for Onychomycosis

Oral Antifungals:Oral antifungal drugs are the most effective for onychomycosis because they reach the infection via the bloodstream.

Terbinafine (Lamisil®): An FDA-approved allylamine for both toenail and fingernail infections. It inhibits squalene epoxidase, disrupting ergosterol synthesis and causing fungal cell death. Common side effects include liver toxicity, taste/smell changes, and blood disorders. It may interact with drugs metabolized by CYP2D6.

Itraconazole: An FDA-approved triazole for toenail infections; it inhibits sterol 14α-demethylase, impairing fungal membranes. Fluconazole is used off-label, while ketoconazole is avoided due to hepatotoxicity. Azoles can cause CYP3A4-mediated drug interactions with statins, calcium channel blockers, and sedatives.

Topical Antifungals:Used for mild to moderate cases or when systemic therapy is unsuitable.

Ciclopirox 8% Nail Lacquer: Inhibits fungal enzymes by metal chelation; applied daily for 48 weeks, with minimal systemic absorption and mild local irritation.

Efinaconazole 10% Solution (Jublia®): A triazole that inhibits lanosterol 14α-demethylase; applied daily for 48 weeks, with mild local reactions.

Tavaborole 5% Solution (Kerydin®): A boron-based agent that blocks leucyl-tRNA synthetase to inhibit protein synthesis. Its small size enables deep nail penetration. Daily use for 52 weeks is safe and effective, causing only mild redness or peeling.[15]

Antifungal Nail Lacquer

"An antifungal nail lacquer is a topical formulation specifically designed to treat onychomycosis by delivering antifungal agents directly to the infected nail. It forms a film over the nail surface, allowing sustained drug release and improved penetration through the nail plate to effectively target fungal pathogens."[3]

Mechanism of Drug Delivery via Nail Lacquer

1. Application: The lacquer, containing the antifungal drug, penetration enhancers, and film-forming polymers, is applied to the nail surface.
2. Disulfide Bond Disruption: Chemical agents in the formulation break disulfide bonds in nail keratin, loosening the dense nail structure.
3. Pore Formation: This creates micro-pores and channels that increase nail permeability.
4. Film Formation: As the solvent evaporates, a thin polymeric film forms on the nail, serving as a drug reservoir for sustained release.
5. Drug Diffusion: The drug gradually penetrates through the pores into the nail bed, aided by increased nail hydration and structural modification.[16]

Emerging Topical Therapies for Onychomycosis: Future Perspectives

Topical treatment of onychomycosis remains difficult due to the nail's dense structure, which severely limits drug penetration. Enhancing drug delivery is therefore a major focus. Current strategies include using chemical enhancers like thioglycolic acid and humectants such as panthenol to improve hydration and permeability, as well as optimizing the viscosity of lacquers for better application and diffusion.

Physical methods such as iontophoresis and laser therapy are being explored to increase drug absorption through the nail plate, while mechanical or chemical nail removal (e.g., with 40% urea) helps expose the infection site for more effective treatment. Photodynamic therapy—using photosensitizers like 5-aminolevulinic acid combined with light exposure—has shown promising results with minimal side effects.

Finally, combination therapy (topical plus systemic antifungals) demonstrates the highest success rates, significantly improving clinical and mycological cure rates compared to monotherapy. Overall, future progress lies in integrating advanced delivery systems with multimodal treatment strategies.[16]

Clinical Management of Patients Undergoing Treatment

Although the risk is relatively low, antifungal medications can sometimes cause liver damage, so it's important to keep this in mind during therapy. For patients on continuous treatment with terbinafine, fluconazole, or itraconazole, liver function should be checked before starting and periodically throughout treatment. Those taking terbinafine should also have routine blood counts monitored.

In contrast, patients on itraconazole pulse therapy typically do not require regular lab monitoring, and there are currently no clear guidelines for testing during intermittent fluconazole use. Regardless of the regimen, patients should be well-informed about potential side effects and instructed to report any symptoms that might suggest liver problems or other adverse reactions—such as yellowing of the skin or eyes, abdominal pain, fatigue, nausea, vomiting, dark urine, or pale stools.[17]

CONCLUSION

Onychomycosis is a widespread fungal nail infection that negatively impacts comfort, appearance, and quality of life. It has a multifactorial cause involving dermatophytes, non-dermatophyte molds, and yeasts, making accurate diagnosis through microscopy, culture, and advanced molecular methods like PCR essential.

Systemic antifungals such as terbinafine and itraconazole remain the most effective treatments but carry risks of liver toxicity and drug interactions. Topical therapies are safer but face challenges due to poor nail penetration; however, innovative film-forming lacquers and permeation enhancers have improved local efficacy.

Emerging technologies like photodynamic therapy, iontophoresis, and laser treatment offer promising non-invasive options, while combination therapy (systemic + topical) yields higher cure rates and lowers relapse risk. Lastly, patient education on adherence, hygiene, and prevention is vital for sustained treatment success and recurrence prevention.

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