Fungal infections generally prefer environments of high temperature and high humidity; therefore, they generally occur most frequently in tropical and subtropical areas. Pathogens generally responsible for the various superficial fungal infections include Trichophyton, Microsporum, and Epidermophyton.

Symptoms and Description

Athlete’s foot may present as (1) macerated, boggy, whitened, odorous, and itching skin between the toes, (2) an acute vesicular inflamed and fissuring condition also accompanied by odor and itching, or (3) a fine scale over the bottom part of the foot (moccasin-type tinea pedis). Each form may become more symptomatic during the summer months. Especially with the emphasis on personal health and exercise, fungal infections of the feet have become quite common and are easily transmitted from person to person if proper precautions are not observed. Some individuals appear to be more susceptible than others. The causative agent in most athlete’s foot infections is the trichophyton species. Upon initial contact, patients commonly complain of, or present with, itching, burning, or stinging symptoms involving the feet.

Body ringworm occurs over the body and appears typically as an oval, scaly patch with an inflamed border. The skin in the center of the lesion actually appears normal. Ringworm lesions are most often on the exposed areas of the body, such as the face and arms. Generally, a history of exposure to an infected cat is often involved, usually indicating a microsporum infection. The most common pathogens include Trichophyton rubrum. Symptoms may include itching and a classic ring-shaped lesion that may have an advancing scaly border and central clearing, occasionally with hyperpigmentation. These rings spread peripherally, and the borders may contain vesicles or pustules.

Jock itch affects the groin area with sharply defined lesions with inflamed borders and reddish-brown centers. The itching becomes very intense and can become painful; increased skin maceration can occur if sweating accumulates. Jock itch can be irritated with tight-fitting undergarments.

Scalp ringworm usually presents as a circular patch of scaly skin accompanied by a limited area of alopecia. Patients may appear with (1) scaly, dry, non-inflammatory dermatitis with other patchy areas of involvement, (2) active, inflamed weeping lesions, or (3) cup-shaped crusts around several hairs that expand to involve the entire scalp. Household animals can transmit fungal infections to occupants in a house, as in the case of ringworm infections.

Onychomycosis (tinea unguium, nail infections) changes the appearance of the nails from normal and shiny to that of being dull, opaque, and yellowing; they also become thick, brittle, and crumbly. Onychomycosis is a trichophyton infection of one or more (but rarely all) fingernails or toenails. Generally, the most commonly found microorganism is Trichophyton rubrum. The nails become lusterless, brittle, and hypertrophic; the substance of the nail becomes friable. Patients may become embarrassed because the nails may become thick and unsightly due to a buildup of by-products from fungal growth. Nail infections are very difficult to
treat because access to the causative microorganism is limited, nail growth is slow, and long duration of therapy is usually required. Fungal involvement generally responds more rapidly than toenail involvement. In many cases, avulsion of the nail is required either surgically or chemically. Urea 40% topical preparations are commonly used for this procedure.

**Treatment of Fungal Infections**

Outcomes of successful treatment can be assessed by asymptomatic relief, eradicating the infection, and preventing future infections.

**Athlete's foot** can be treated using either local or systemic measures. During the "macerated stage," local measures may include treatment with aluminum subacetate solution, topical imidazoles, or ciclopirox, terbinafine, or butenafine. During the "dry and scaly stage," the addition of urea 10% preparations under an occlusive dressing may enhance the efficacy of the topical treatment. Systemic measures may include itraconazole or terbinafine; griseofulvin should only be used in severe cases.

**Ringworm** (body and scalp) treatment can include local and systemic measures. Locally, miconazole, clotrimazole, ketoconazole, econazole, sulconazole, miconazole, ciclopirox, and terbinafine have been used. Systemic measures have included orally administered griseofulvin, itraconazole, and terbinafine.

**Onychomycosis** can be treated either locally or systemically, but local treatment has relatively low efficacy (10% or less). If the involvement is minimal and if the patient is motivated, local (topical) treatment may be effective. Another approach is to use a 40% area topical preparation for nail avulsion, prior to beginning treatment with an antifungal agent. In some cases, the antifungal treatment may begin after a few weeks of urea 40% treatment. The 40% urea will soften the nail and enable it to be removed over a period of time. Also, surgical or mechanical removal of the nail can be used. Drugs commonly used include ciclopirox and naftifine. Systemic treatment may involve griseofulvin, itraconazole, fluconazole, or ketoconazole. In some cases, local and systemic treatments have been combined.

**Recent Research Involving Onychomycosis**

In one study, 55 patients were allocated to nail debridement only or debridement plus application of a topical antifungal nail lacquer. After about 10 months, statistically, patients in the antifungal nail debridement-only group and exhibited a 76.7% rate of mycological cure compared to the 37.9% rate in the control group. After about 10 months, statistically, patients in the antifungal nail debridement-only group and exhibited a 76.7% rate of mycological cure compared to the 37.9% rate in the control group.

Another article involved patients with diabetes and summarized that onychomycosis potentially can cause severe complications in these patients and should be promptly treated. The selection of an appropriate regimen may be complicated due to the existence of comorbid conditions and the potential for drug-drug interactions. Terbinafine is an excellent choice to use in patients with diabetes, as it has a low risk of drug-drug interactions and proven efficacy against the typical pathogens causing onychomycosis. Itraconazole, while effective, is not a first-choice therapy due to its black-box cardiac warning and numerous drug interactions.

The conclusion from another study is that once-weekly miconazole cream applied to the toenail and webspace of the foot is effective in preventing long-term relapsing tinea unguum.

### Dosage Forms Used and Their Application

Numerous dosage forms are used in the topical treatment of these superficial fungal infections, including creams, liquids, gels, ointments, lacquers, and others. The treatment of athlete's foot and ringworm can easily be accomplished with creams, liquids, gels, and ointments.

**Penetration Enhancing Vehicles for Transporting the Antifungal Agents**

Antifungal agents are commonly incorporated in various dosage forms containing different solvents for delivery vehicles. Penetration enhancers that may be a part of a dosage form include propylene glycol, glycerin, dimethyl sulfoxide, polyethylene glycol 100, and alcohol, and others. Flexible collodion can assist in enhancing efficacy by prolonging contact time of the antifungal agent with the affected area. Upon evaporation of the solvent system as flexible collodion, the active agent is kept in direct and prolonged contact with the skin within the "plastic" film.

### References


**COMPOUNDED FORMULAS FOR THE TREATMENT OF FUNGAL INFECTIONS**

- **Rx** Ciclopirox 8% Topical Gel
- **Rx** Fluconazole in DMSO Topical Liquid
- **Rx** Fluconazole 10% Topical Cream
- **Rx** Itraconazole in DMSO Nail Liquid
- **Rx** Iodochlorhydroxyquin 3% Ointment
- **Rx** Iodochlorhydroxyquin 3% Cream
- **Rx** Ketoconazole 1% Topical Solution
- **Rx** Miconazole 2% Topical Cream
- **Rx** Miconazole 2% and Tolnaftate 1% Topical Liquid
- **Rx** Terbinafine 1% in DMSO Nail Liquid
- **Rx** Tolnaftate 1% Cream
- **Rx** Triacetin 25% Topical Liquid
- **Rx** Triacetin 25% Ointment
- **Rx** Undecylenic Acid 10% Topical Liquid
- **Rx** Compound Undecylenic Acid Ointment