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Dermatophytosis: Clinical Manifestation, Diagnosis, and Considerations for Antifungal use

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Dermatophytosis is a fungal infection of the keratinized tissues of the skin, hair, and nails caused by dermatophytes or other fungi. *Epidermophyton*, *Microsporum*, and *Trichophyton* are the three genera of dermatophytes that cause skin infections. In Korea, *Trichophyton rubrum* is the most common dermatophytes. Dermatophytosis can be classified into anthropophilic, zoophilic, and geophilic, and most fungal infections encountered by dermatologists are tinea, dermatophytosis. This study attempted to provide a brief discussion about the clinical manifestation, diagnosis, and considerations for antifungal use in the treatment of dermatophytosis.

Key Words: Dermatophytes, Dermatophytosis, Superficial fungal infection, Superficial mycosis, Onychomycosis, Tinea

INTRODUCTION

Mycosis is a fungal infection caused by various fungi and can be classified into superficial, subcutaneous, deep, and systemic mycoses. Superficial mycoses refer to infections of the keratinized tissues of the skin, hair, and nails caused by dermatophytes; however, infections caused by fungi other than dermatophytes are also included in this definition. Dermatophytes that cause skin infections are classified into three genera: *Epidermophyton*, *Microsporum*, and *Trichophyton*[1]. *Trichophyton rubrum*, *Trichophyton mentagrophytes*, *Trichophyton verrucosum*, and *Trichophyton tonsurans* are the most common dermatophytes in Korea, and *Microsporum canis* was reported in small numbers[2]. *Candida* or *Malassezia* infections that cause superficial fungal infections are separately defined as superficial yeast infections. Fungi can be classified taxonomically into anthropophilic, zoophilic, and geophilic. Anthropophilic fungi are characterized by the absence or presence of mild inflammation because they have adapted to humans as hosts for a long time. Zoophilic and geophilic fungi are characterized by severe inflammation because they do not primarily infect humans as hosts. Among zoophilic fungi in Korea, *M. canis* is a representative fungus that mainly infects dogs and cats[3]. As a dermatologist, most of the fungal infections encountered by dermatologists are superficial mycoses. Therefore, this manuscript will cover superficial mycoses, including nail infections.

CLINICAL MANIFESTATIONS

Tinea capitis

Tinea capitis is typically more common in children aged 3~14 years, and its incidence decreases during adolescence when sebum secretion increases. This is thought to be caused

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Fig. 1. Tinea manuus with prominent scales observed on the palms

by fatty acids in the sebum that have bacteriostatic activity against fungi. In Korea, the incidence of tinea capitis has decreased over time; however, some patients in whom infection developed after menopause may still visit hospitals because of hair loss. The most reported causative fungi in cases of tinea capitis in Korea is *M. canis*, which often causes severe inflammation[2,3]. The second most common causative fungi is *T. rubrum*, which is characterized by the presence of numerous scalp scales. *T. tonsurans*, which forms arthroconinia within the hair shaft (endothrix), is the predominant species in the United States, and it often presents as a pattern of clustered, broken hairs[4]. On the contrary, *M. canis* and *T. rubrum* often do not exhibit broken hairs as the main form because they form arthroconinia outside the hair (ectothrix)[5].

If severe inflammation of the scalp is present, permanent scarring of the scalp may remain after treatment[6]. Therefore, tinea capitis should be orally treated with antifungal agents, and depending on the severity of inflammation, systemic steroids can be appropriately added. Even if alopecia occurs immediately after treatment, some degree of recovery can be expected, except in very severe areas[7]. Thus, the potassium hydroxide (KOH) test, as a diagnostic method, should be performed[8]. Fungus culture can identify the causative fungi. In cases caused by *M. canis*, yellow-green fluorescence can be observed with Wood's lamp.

Superficial mycoses of the skin other than the scalp

Tinea barbae is a specific term used when superficial mycosis occurs in bearded areas. Tinea barbae occurring in sites other than bearded areas, such as the face, trunk, groin, and hand/feet, is called tinea faciale, tinea corporis, tinea cruris, and tinea manuus/pedis, respectively[9] (Fig. 1). While differences in characteristics depending on the body part, the diagnosis and treatment are generally similar. Typically, the clinical manifestation involves lesions with abundant scales and without significant inflammation. They often appear as circular or annular rash that spreads peripherally and can be diagnosed through the KOH test. Superficial mycoses in closed areas require caution because they may be accompanied by secondary infection. Severe dermatitis accompanied by the primary lesion can often cause an id reaction, resulting in the spread of the rash to other body areas. If a rash spreads to other body parts, patients who may be concerned about systemic fungal infections must be reassured, as it does not involve any fungal hyphae or spores.

Fig. 2. (A) Distal-lateral subungual onychomycosis (B) Proximal subungual onychomycosis (C) White superficial onychomycosis (D) White superficial onychomycosis, rapid improvement with topical efinaconazole for 10 days, and (E) Total dystrophic onychomycosis

Tinea unguium

Tinea unguium is a nail infection caused by dermatophytes, and onychomycosis is used to describe all fungal infections of the nails, including those caused by non-dermatophyte fungi. In most cases, it is caused by dermatophyte infections; thus, the two terms are often used interchangeably. Onychomycosis is classified as distal-lateral subungual, proximal subungual, white superficial, and total dystrophic onychomycoses (Fig. 2A-2E)[10]. The distal-lateral subungual type is the most common form of onychomycosis, while the proximal subungual type is rare and indicate the need for screening for human immunodeficiency virus infection[11]. The diagnosis of onychomycosis involves KOH tests and fungus culture on the suspected lesion. Additionally, diagnostic tests such as KOH-treated nail clipping stained with periodic acid-Schiff (KONCPA) and tinea unguium rapid antigen test can also be helpful in the diagnosis[12,13].

TREATMENT OF SUPERFICIAL MYCOSES

Superficial mycoses, excluding tinea capitis and onychomycosis, are usually easy to treat, and management focuses more on preventing recurrence than on treatment. As fungi generally thrive in humid environments, the infected area must be kept dry. In cases of excessive sweating, aluminum chloride solutions may be used to regulate perspiration. When applying topical antifungal agents, it is recommended to apply the medication to the surrounding area within 6 centimeters, twice a day. The treatment period ranges from 2 weeks to 6 weeks until the suspected lesion is completely resolved, and as the duration of treatment increases, the success rate also increases[14]. For foot infections, patients should be educated to apply the medication thoroughly, including areas between the toes. To prevent reinfection from contaminated dead scales, socks should be turned inside out when laundering. Soaking clothes in a diluted solution of water and bleach can also be effective; however, care should be taken to avoid damaging the fabric with the bleach. Topical imidazole antifungal agents are commonly used for treating superficial mycoses. Amorolfine, a morpholine antifungal agent, is also widely used. Failed treatments are often related to external factors such as incorrect application or reinfection rather than inadequate drug efficacy. To increase the treatment success rates and prevent a recurrence, the use of an antifungal shampoo is also effective when washing the infected area, in addition to applying topical antifungal agents[15].

Tinea capitis and moderate-to-severe onychomycosis should be treated with oral antifungal therapy, and in dermatophyte infections, terbinafine was reported to have higher success rates than azole drugs[16]. Drug-induced liver injury (DILI) is a well-known adverse reaction to oral antifungal agents. In a large cohort study of 69,830 patients treated with oral antifungal agents, DILI occurs in 134.1 per 100,000 person-months for ketoconazole, 10.4 for itraconazole, and 2.5 for terbinafine, presenting that terbinafine has the lowest risk of DILI[17]. Itraconazole is well known for its contraindication with statins (HMG-CoA reductase inhibitors), which are commonly used as cholesterol-lowering drugs. Therefore, it is often difficult to use in middle-aged and older age groups, and it cannot be used in patients with congestive heart failure and ventricular dysfunction[18,19]. Although no absolute contraindications were established for terbinafine in terms of drug interactions, the dose should be halved in patients with acute or chronic kidney diseases with a creatinine clearance of $\leq$50 mL/min[20]. Based on these considerations, terbinafine is the first-line choice because of its excellent efficacy, minimal drug interactions, and low frequency of adverse drug reactions. Itraconazole and fluconazole are the second- and third-line drugs, respectively[16]. However, in patients with superficial mycoses other than dermatophytes, itraconazole and fluconazole, which are broad-spectrum drugs, are preferred. Recently developed drugs, such as oteseconazole and fosravuconazole, have shown good efficacy in patients with onychomycosis[21,22]. However, a previous study reported that fosravuconazole can cause mild elevation of liver enzymes; thus, further large-scale studies are needed[22].

The use of topical agents is an important treatment option for patients with onychomycosis who cannot take antifungal agents orally. When applied topically for 48 weeks, efinaconazole has demonstrated good efficacy and similar therapeutic effects as taking itraconazole orally for 12 weeks[23]. Other options such as ciclopirox and amorolfine nail lacquer are also available in Korea. Physical treatments such as the application of urea ointment or nail avulsion may be considered when topical agents are not effective. In a recent meta-analysis, combination therapy of topical antifungal agents and laser therapy was reported to be more effective than topical antifungal agents alone[24].

CONCLUSION

This brief review focuses on the clinical manifestation, diagnosis, and treatment of superficial mycoses, which have

a high prevalence and commonly relapse. Therefore, it is crucial to not only focus on the diagnosis and treatment but also on preventing recurrence.

CONFLICT OF INTEREST

In relation to this article, we declare that there is no conflict of interest.

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PATIENT CONSENT STATEMENT

The patient provided written informed consent for the publication and the use of his or her images.

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