Dermatology Practical & Conceptual

Evaluation of Clinical Studies of Patients With Dermatophyte Infections Caused by Trichophyton indotineae: Treatment Response and Resistance to Antifungal Medications

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ABSTRACT

Introduction: Dermatophytoses are the most frequent fungal infections of the skin. It has been reported that dermatophyte infections resistant to antifungal medications have increased in recent years. Therefore, superficial fungal skin infections that are difficult to treat have become a major health problem worldwide. *Trichophyton indotineae* is a newly described dermatophyte species that has been mainly isolated from patients with dermatophytosis characterized by widespread skin lesions and resistance to antifungal treatment and that causes outbreaks. *T. indotineae* leads to a pruritic rash that affects the large areas of the body surface such as the trunk, groin, and extremities, even in immunocompetent patients. Moreover, these patients usually do not respond to systemic terbinafine, which is the first-line treatment for dermatophyte infections and has fungicidal effects.

Objectives: Our aim was to determine the body sites affected by *T. indotineae* infection, the types of tinea caused by *T. indotineae*, the drugs to which it is particularly resistant, and the treatment regimens to which it responds.

Methods: Articles in the PubMed database published between December 2020 and September 2024 were investigated by searching the word *"Trichophyton indotineae"*.

Results: We reviewed 39 studies in the PubMed database that reported patients with *T. indotineae* infection to identify treatment regimens to which it is resistant or responsive.

Conclusion: Treatment guidelines should be established to select the appropriate alternative antifungal medication and determine the adequate drug dose and duration in treatment-resistant fungal skin infections caused by *T. indotineae*. Nevertheless, the data required to develop standard treatment regimens are insufficient.

Introduction

Trichophyton indotineae is a newly described dermatophyte species that is frequently isolated in patients with dermatophyte infections characterized by extensive skin lesions and antifungal treatment resistance [1-3]. Patients are usually unresponsive to systemic terbinafine, which is the first-line treatment for dermatophyte infections. In addition, topical or systemic administration of steroids due to misdiagnoses worsens *T. indotineae* infection. It has been reported that clinicians' awareness of treatment-resistant fungal infections caused by *Trichophyton indotineae* is inadequate and needs to be increased [2]. Moreover, treatment guidelines should be established to select the appropriate alternative antifungal medication and determine the adequate drug dose and duration in terbinafine-resistant skin infections caused by *T. indotineae*. Nevertheless, the data required to develop standard treatment regimens are insufficient [4].

Objectives

We evaluated articles reporting patients with dermatophytosis caused by *T. indotineae* to determine the body sites affected by the infection, the types of tinea caused by *Tindotineae*, and, in particular, the drugs to which it is resistant and the treatment regimens to which it responds.

Methods

The articles in the PubMed database published between December 2020 and September 2024 were investigated by searching the word "*Trichophyton indotineae*". After reviewing the titles and abstracts, human studies reporting patients with dermatophytosis caused by *T. indotineae* were included. Articles for which the full text was not available, non-English articles, laboratory studies without patient involvement, reviews, meta-analyses, in vitro studies, and animal studies were excluded from this review.

Results

The search steps are outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Figure 1) [5]. The initial PubMed search identified 98 articles; of these, 39 met the inclusion criteria and were further reviewed.

Studies on Patients with T. indotineae *Infections*

Original Articles

Kano et al. reported two patients with tinea corporis who had traveled to Nepal and India (Table 1). The patients had previously been treated with terbinafine but had not shown any clinical response. After performing internal transcribed spacer (ITS) region sequences analysis, *T. indotineae* was detected in skin lesions. Both patients recovered completely with itraconazole and fosravuconazole treatment [6].

Khurana et al. reported 40 patients with tinea corporis and tinea cruris caused by *T. indotineae*. Among these patients, 12 had previously used systemic antifungals, 24 had previously used topical antifungals, and 24 had used topical steroids. Patients were treated with itraconazole at different doses of 100 mg, 200 mg, or 400 mg daily. Complete clinical response was observed in 37 patients; treatment failure occurred in three patients. Khurana et al. stated that serum itraconazole levels lower than 0.2 µg/ml were associated with treatment failure, while successful treatment could be achieved with values above this level [7].

Pashootan et al. investigated the antifungal susceptibility of *T. indotineae* detected in samples obtained from five patients with tinea cruris, three patients with tinea pedis, and two patients with tinea corporis. Among the antifungals such as itraconazole, terbinafine, voriconazole, ketoconazole, fluconazole, posaconazole, and amphotericin B, terbinafine was reported to have the highest effect against *T. indotineae* [8].

Moreno-Sabater et al. evaluated the frequency of *T. indotineae* as an etiological agent and terbinafine resistance in patients with dermatophyte infections. Among the 580 samples, terbinafine resistance was observed in three samples, and *T. indotineae* was detected as the causative agent in one of them. This patient reportedly had traveled to India, had been diagnosed with tinea corporis, and had been treated with itraconazole 200 mg daily. On the other hand, *T. indotineae* was detected in a total of six specimens. *T. indotineae* was particularly characterized by inflammatory skin lesions and was detected in patients with tinea cruris and tinea corporis. However, in two patients, it was also associated with onychomycosis of the fingernails and tinea pedis [9].

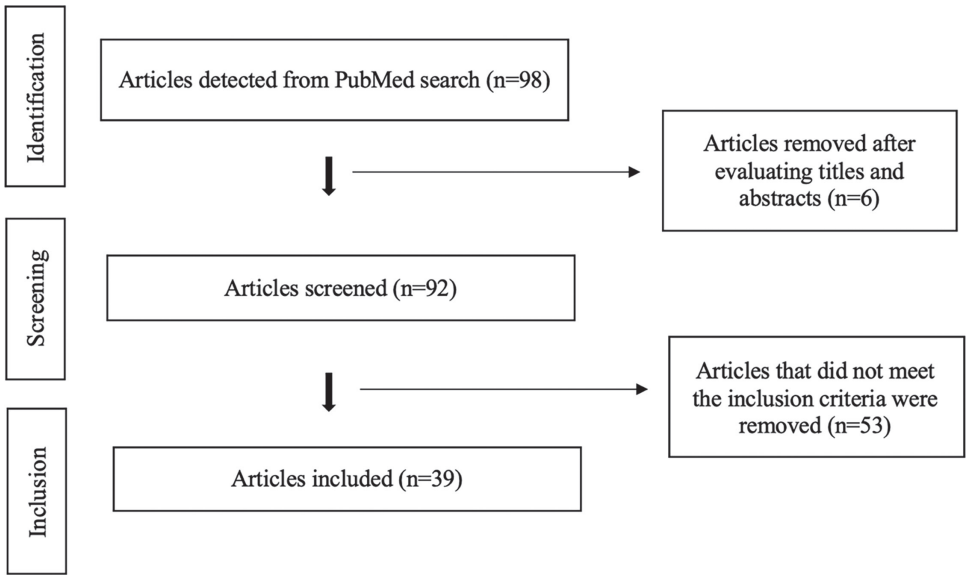

Figure 1. The search process for the articles is stated in the flow diagram.

Table 1. Articles Reporting Patients with Dermatophyte infections caused by *Trichophyton indotineae*.

Author	Infection	Treatment resistance	Effective treatment	Treatment duration
Kano et al.[6]	Tinea corporis	Terbinafine	Itraconazole, fosravuconazole	Not specified
Khurana et al.[7]	Tinea corporis, tinea cruris	Systemic terbinafine, griseofulvin, itraconazole, fluconazole, topical antifungals	Itraconazole	Until cure
Pashootan et al.[8]	Tinea corporis, tinea cruris, tinea pedis	Not specified	Not specified	Not specified
Moreno-Sabater et al.[9]	Tinea corporis, tinea cruris, tinea pedis, fingernail onychomycosis	Not specified	Oral itraconazole	1-3 months
Astvad et al.[10]	Not specified	Not specified	Not specified	Not specified
Posso-De Los Rios et al.[11]	Tinea corporis, tinea faciei Tinea corporis Tinea corporis Tinea corporis, tinea faciei Tinea corporis Tinea corporis, tinea faciei Tinea corporis, tinea pedis Tinea corporis	Oral terbinafine, fluconazole Clotrimazole cream, oral terbinafine Clotrimazole cream Terbinafine cream, ciclopirox cream, oral itraconazole Ketoconazole cream, oral fluconazole Oral terbinafine, itraconazole, topical terbinafine and ketoconazole Topical antifungal Clotrimazole cream	Referred to infectious disease department Oral itraconazole Ketoconazole cream Oral fluconazole* Referred to infectious disease department Referred to infectious disease department Oral fluconazole*, topical clotrimazole Ciclopirox cream*	Not specified 4 weeks Lost to follow-up 12 weeks Not specified Not specified 12 weeks Not specified

Table1 continues

Table 1. Articles Reporting Patients with Dermatophyte infections caused by *Trichophyton indotineae*. *(continued)*

Author	Infection	Treatment resistance	Effective treatment	Treatment duration
Jia et al.[12]	Tinea corporis, tinea cruris, tinea faciei	Oral fluconazole, miconazole nitrate cream	Oral itraconazole, bifonazole cream, ketoconazole lotion	4 weeks
Bortoluzzi et al.[13]	Tinea corporis, tinea cruris	Systemic and topical terbinafine	Oral itraconazole	14 days
Kong et al.[14]	Tinea corporis, tinea cruris	Oral itraconazole, terbinafine, topical terbinafine, econazole and ketoconazole	Oral itraconazole+ and topical naftifine hydrochloride/ ketoconazole Itraconazole pulse therapy	3 weeks 5 weeks
Tamimi et al.[15]	Tinea corporis, tinea cruris	Oral terbinafine, itraconazole	Oral terbinafine, itraconazole, voriconazole, topical clotrimazole	Not specified
Caplan et al.[16]	Tinea corporis, tinea cruris, tinea faciei	Oral terbinafine, fluconazole, griseofulvin, voriconazole, topical antifungal medication	Oral fluconazole, griseofulvin, itraconazole	2 weeks-2 months
Ngo et al.[17]	Tinea corporis, tinea cruris, tinea pedis	Not specified	Not specified	Not specified
Hiruma et al.[18]	Tinea corporis	Not specified	Not specified	Not specified
Dellière et al.[19]	Tinea corporis Tinea corporis Tinea corporis Tinea corporis, tinea faciei Tinea corporis Tinea corporis Tinea corporis	Oral terbinafine, griseofulvine Oral terbinafine Oral terbinafine Oral terbinafine None None Oral terbinafine, topical bifonazole	Oral itraconazole+ Oral itraconazole+ Oral itraconazole Oral itraconazole Oral terbinafine, topical ciclopirox Oral fluconazole+, topical terbinafine Oral terbinafine+	12 weeks 12 weeks 8 weeks 12 weeks Lost to follow-up 16 weeks 8 weeks
Jabet et al.[20]	Tinea corporis, tinea cruris	None None None Terbinafine, griseofulvin, econazole Terbinafine None None None None Terbinafine, griseofulvin	Oral and topical terbinafine Terbinafine Terbinafine None None Ciclopirox olamine Terbinafine, bifonazole+ Omoconazole, miconazole Terbinafine Itraconazole	1 month 1 month 2 months Lost to follow-up Lost to follow-up 1 month 6 weeks 2 months 1 month 2 months
Ngo et al.[21]	Tinea corporis	None	Oral itraconazole Topical ketoconazole	1 week 2 weeks
Durdu et al.[22]	Tinea cruris Tinea corporis	Oral terbinafine, itraconazole, topical antifungals Oral and topical terbinafine, resveratrol	Oral fluconazole+ Resveratrol tablet Oral itraconazole+ Oral itraconazole	Not specified 4 weeks 2 months

Table 1. Articles Reporting Patients with Dermatophyte infections caused by *Trichophyton indotineae*. *(continued)*

Author	Infection	Treatment resistance	Effective treatment	Treatment duration
Caplan et al.[23]	Tinea corporis, tinea cruris Tinea corporis, tinea cruris	Oral terbinafine Oral terbinafine, clotrimazole and terbinafine cream	Oral itraconazole Griseofulvin	4 weeks 4 weeks
Russo et al.[24]	Tinea corporis Tinea corporis, tinea cruris	Topical econazole, ketoconazole lotion None	None Oral terbinafine, topical ketoconazole	Lost to follow-up 4 months
Dashti et al.[25]	Tinea corporis, tinea cruris, tinea faciei	Oral terbinafine, griseofulvin, itraconazole, topical terbinafine, miconazole	Oral voriconazole	3 months
Messina et al.[26]	Tinea corporis	Oral fluconazole, terbinafine, topical antifungals	SUBA itraconazole	4 weeks
Crotti et al.[27]	Tinea corporis, tinea cruris, tinea faciei, tinea manuum, onychomycosis	Oral fluconazole, topical ketoconazole	Oral terbinafine, topical ciclopirox nail solution	12 weeks
Thakur et al.[28]	Tinea universalis	None	Oral itraconazole, topical luliconazole	2 months
Pavlović et al.[29]	Tinea corporis, tinea cruris, tinea faciei	Oral terbinafine, fluconazole, topical terbinafine	Oral itraconazole	8 weeks
Teo et al.[30]	Tinea cruris Tinea cruris	Not specified Topical miconazole	Not specified Oral itraconazole, topical terbinafine, ketoconazole	Not specified Under follow-up
Fukada et al.[31]	Tinea faciei	Topical ketoconazole	Oral itraconazole	5 weeks
Spivack et al.[32]	Tinea genitalis	Oral terbinafine, fluconazole, topical econazole and ketoconazole	Oral itraconazole	8 weeks
Tamimi et al.[33]	Tinea incognito Tinea incognito Tinea incognito Tinea incognito	Terbinafine Terbinafine Terbinafine Terbinafine, topical clotrimazol	Not specified	Not specified
Madarasingha et al.[34]	Extensive dermatophytosis	None Oral terbinafine None Oral terbinafine None	Oral itraconazole^{+} Oral itraconazole^{+} Oral itraconazole^{+} Oral itraconazole^{+} Oral itraconazole^{+}	6 weeks 4 weeks 8 weeks 6 weeks 10 weeks
Chua et al.[35]	Tinea cruris	Oral fluconazole, topical terbinafine, clotrimazole	Oral itraconazole	8 weeks

Table1 continues

Table 1. Articles Reporting Patients with Dermatophyte infections caused by *Trichophyton indotineae*. *(continued)*

Author	Infection	Treatment resistance	Effective treatment	Treatment duration
Smith et al.[36]	Tinea corporis	Oral fluconazole, terbinafine, itraconazole, griseofulvin, topical terbinafine, topical ketoconazole, nystatin	Not specified	Not specified
Mochizuki et al.[37]	Tinea corporis	Topical luliconazole	Oral itraconazole, topical lanoconazole[+]	1 month
Tan et al.[38]	Tinea cruris	None	Oral itraconazole, topical sertaconazole	4 weeks
Carroll et al.[39]	Tinea cruris, tinea faciei, tinea capitis	Oral terbinafine, itraconazole, topical antifungals	Topical griseofulvin	6 weeks
Gueneau et al.[40]	Tinea corporis	Systemic terbinafine and griseofulvin, topical terbinafine, econazole and bifonazole	Voriconazole cream	6 months
Villa-Gonzalez et al.[41]	Tinea corporis	Oral terbinafine	Oral itraconazole	6 months
Xie et al.[42]	Tinea corporis, tinea cruris, tinea faciei	Oral voriconazole, terbinafine	Oral itraconazole	1-8 weeks
Abdolrasouli et al.[43]	Tinea corporis, tinea cruris	Betamethasone dipropionate/ clotrimazole cream, terbinafine cream	Oral itraconazole	2 months
Bui et al.[44]	Tinea corporis, tinea cruris	Oral terbinafine, griseofulvin, fluconazole, topical clotrimazole	Oral itraconazole, topical ketoconazole	7 weeks

SUBA: Super bioavailable. [*] Treatment response was still being monitored. [+] Relapse was observed after treatment.

Astvad et al. examined the susceptibility tests performed on samples taken from patients with dermatophyte infection. *T. indotineae* was detected in six of the 59 patients. Terbinafine resistance was observed in all specimens obtained from these patients [10].

Posso-De Los Rios et al. evaluated eight Canadian patients with fungal skin infections due to *T. indotineae* who had traveled to India. All patients had previously used oral or topical antifungal medications without a complete clinical response. Three patients were started on oral itraconazole or fluconazole treatment, two patients were started on only topical antifungal treatment, and three patients were referred to the infectious diseases department [11].

Jia et al. reported the first case of *T. indotineae*-associated dermatophytosis in China. After four weeks of treatment with oral itraconazole 200 mg/day, bifonazole 1% cream twice daily, and ketoconazole 2% lotion, the lesions healed completely, leaving post-inflammatory hyperpigmentation [12].

Bortoluzzi et al. investigated five patients infected with *T.* species who were unresponsive to terbinafine treatment. ITS region sequences analysis identified *T. rubrum* in one patient and *T. indotineae* in four patients. They recovered with 14 days of oral itraconazole treatment, and the lesions did not recur during the 12-week follow-up [13].

Kong et al. described complete healing in a patient with *T. indotineae* infection three weeks after treatment with oral itraconazole 200 mg/day and naftifine hydrochloride/ ketoconazole cream. Nevertheless, the lesions recurred two weeks after discontinuation of the medications. The patient was initiated itraconazole pulse therapy (200 mg twice daily) for five weeks. The lesions did not recur at the 3-month follow-up [14].

Tamimi et al. evaluated 72 patients with tinea corporis and tinea cruris; *T. indotineae* was the causative agent in 53 patients. Of all patients, 47 had treatment-resistant infection, 42 of whom were infected with *T. indotineae*. Thirty patients with *T. indotineae* infection were unresponsive to terbinafine, 20 to itraconazole, and eight to both itraconazole and terbinafine. Refractory cases were treated with oral terbinafine, itraconazole, and voriconazole alone or in combination, with or without topical antifungal drugs such as clotrimazole [15].

Caplan et al. evaluated the characteristics of 11 patients infected with *T. indotineae*. All patients except two had traveled to Bangladesh. None of the patients responded to topical antifungals. Seven patients received oral terbinafine, and two received voriconazole, without a complete response. Four patients received oral fluconazole; two improved, and two were unresponsive to treatment. Of the five patients who received griseofulvin, two showed a clinical response to treatment, while three did not respond. Of the seven patients who received oral itraconazole, five responded to treatment, one was lost to follow-up, and one discontinued treatment due to side effects [16].

In a study by Ngo et al., *T. indotineae* was the causative agent in four of 114 patients with dermatophytosis. In vitro, *T. indotineae* was susceptible to itraconazole and voriconazole in all patients, while resistance to terbinafine was detected in half of them [17].

Short Reports

In a study by Hiruma et al., *T. indotineae* was detected in two patients with tinea corporis in Japan. In addition to terbinafine resistance, *T. indotineae* was found to be resistant to eficonazole and luliconazole [18].

Case Series

Dellière et al. reported seven patients with tinea corporis who were generally started on itraconazole due to terbinafine resistance. However, relapse was observed five months after treatment in one patient and one year after treatment in three patients [19]. Jabet et al. described 10 patients with *T. indotineae* infections; most were treated with oral terbinafine. Complete clinical response was observed only in three patients; two patients did not respond to antifungal therapy. One of the patients who showed clinical improvement had a relapse, while three were lost to long-term follow-up [20].

Case Reports

Ngo et al. reported a male patient with a 2-month history of tinea corporis due to *T. indotineae*. After one week of 200 mg/day of oral itraconazole and two weeks of topical ketoconazole treatment, almost complete improvement was observed in the lesion [21]. Durdu et al. described two patients with *T. indotineae* infection. As the first patient was unresponsive to oral terbinafine and itraconazole, oral fluconazole 200 mg/day treatment was started. Although the patient healed completely, the lesions recurred when itraconazole was stopped. The patient was started on resveratrol tablet, and the lesions regressed without the need for antifungal treatment. The other patient was a female with terbinafine-resistant tinea corporis. She recovered completely with oral itraconazole 200 mg/day for four weeks; however, the lesions recurred one month after the treatment was discontinued. She was started on resveratrol; however, unlike the first patient, there was no clinical response. The patient was started on oral itraconazole again, and no recurrence was observed after two months of treatment [22].

Caplan et al. reported two patients; the first was a female with a terbinafine-resistant but itraconazole-sensitive *T. indotineae* infection that began during pregnancy. The other patient had a *T. indotineae* infection that started while she was in Bangladesh, and most of the lesions resolved after one month of griseofulvin treatment [23].

Russo et al. described two patients with tinea corporis and tinea cruris. The first was a breastfeeding female and was therefore able to use only topical therapy such as ketoconazole. However, there was no response to treatment. The second patient was treated with oral terbinafine and topical ketoconazole; oral terbinafine treatment was extended to four months, and a complete clinical response was achieved [24].

Dashti et al. presented a dermatology nurse with disseminated dermatophytosis which was unresponsive to terbinafine, griseofulvin, and itraconazole. The patient was successfully treated with oral voriconazole. Voriconazole was given at a dose of 800 mg for the first two days, then was reduced to 400 mg per day for three months [25].

Messina et al. reported rapid, complete clinical response to super bioavailable (SUBA) itraconazole treatment in a patient with tinea corporis caused by *T. indotineae* which was unresponsive to systemic fluconazole and terbinafine treatment. SUBA itraconazole was preferred because it allows rapid attainment of therapeutic blood levels and was given at a dose of 50 mg twice a day for four weeks [26].

Crotti et al. reported a dermatophyte infection with skin and nail involvement due to *T. indotineae* in an Indian immigrant. Since the lesions were unresponsive to oral fluconazole, the patient was initiated on oral terbinafine and ciclopirox nail solution, and the lesions regressed after 12 weeks [27]. Thakur et al. reported a disseminated dermatophyte infection due to *T. indotineae*. The cure was achieved in two months with oral itraconazole 200 mg/day and topical 1% luliconazole [28].

Pavlović et al. presented a case of a treatment-resistant tinea cruris associated with *T. indotineae* that spread to the

face, trunk, and extremities. Skin lesions improved in eight weeks with oral itraconazole 200 mg/day and topical clotrimazole treatment [29]. Teo et al. investigated the antifungal resistance of *T. indotineae* obtained from the skin samples of two patients with tinea cruris. While no detailed clinical information was given about the female patient in the study, it was stated that the male patient's lesions recurred after topical miconazole treatment and that he was followed up with systemic itraconazole, topical terbinafine, and ketoconazole treatment [30].

Fukada et al. described a case of tinea faciei caused by *T. indotineae* that may have been facilitated by topical steroid use. Although the patient recovered completely after four weeks of treatment with oral itraconazole 100 mg/day, the lesions recurred after treatment. The infection was controlled with itraconazole 400 mg/day for another week. Fukada et al. stated that *T. indotineae* was not a terbinafine-resistant strain. Although the minimal inhibitory concentration (MIC) for terbinafine was low, they recommended itraconazole to the patient since the MIC does not always correlate with clinical response [31].

Spivack et al. presented a female who developed dermatophytosis due to *T. indotineae* in the genital area after sexual intercourse with a person with similar complaints. The patient had not responded to multiple systemic and topical antifungal treatments. Moreover, the topical steroids she had used with the misdiagnosis of dermatitis exacerbated the lesions. The patient transmitted the disease to her new partner after sexual intercourse. She was started itraconazole at a dose of 400 mg/day. After eight weeks of treatment, skin lesions completely regressed, and no recurrence was observed [32]. Tamimi et al. presented four females with tinea incognito who were misdiagnosed as having dermatitis and had used topical steroids. The causative agent was *T. indotineae* and showed resistance to terbinafine both in vivo and in vitro [33].

Madarasingha et al. presented five patients with extensive dermatophyte infection caused by *T. indotineae*; two patients were started on oral terbinafine. However, they were switched to itraconazole due to inadequate response. The remaining patients were treated with itraconazole; however, they still required systemic antifungal therapy for up to 10 weeks. However, relapse was observed in all patients. Terbinafine and fluconazole resistance was detected in skin samples obtained from all patients, whereas the MIC value for itraconazole was low except for one patient [34].

Chua et al. reported treatment-resistant tinea cruris in an Afghan patient living in Australia. *T. indotineae* was detected by ITS region sequences analysis, and antifungal susceptibility test revealed low MIC levels for itraconazole. The patient responded to eight weeks of oral itraconazole treatment. The authors also noted that they had detected *T. indotineae* in another patient from Sri Lanka who had yet to commence treatment [35]. Smith et al. presented a case of tinea corporis that developed after travel to India. The patient did not respond to systemic terbinafine, fluconazole, itraconazole, or griseofulvin. The lesion progressed even after increasing the dose of itraconazole to 400 mg/day [36].

Mochizuki et al. reported *T. indotineae* infection in a Vietnamese patient working in Japan. The patient was started on oral itraconazole 100 mg daily and lanoconazole cream and recovered completely after four weeks of treatment. The lesions recurred eight weeks after the cessation of medications. Therefore, the patient was started on the same treatment again [37].

Letters to the Editor

Tan et al. described a female with extensive dermatophytosis who was treated with oral itraconazole and sertaconazole cream. The clinical response was good in the first month. Terbinafine-resistant *T. indotineae* was identified as the etiological agent, which also revealed low MIC levels of itraconazole, posaconazole, and voriconazole and high MIC levels of fluconazole [38].

Carroll et al. reported *T. indotineae* infection in a Bangladeshi patient residing in Ireland. The patient was unresponsive to itraconazole and terbinafine. Although the patient was prescribed liquid griseofulvin to be taken orally, the patient mistakenly applied griseofulvin topically to the skin lesions. Nevertheless, the patient recovered after six weeks of treatment [39].

Gueneau et al. described a patient with treatment-resistant tinea corporis who was initiated on voriconazole 1% cream once daily. The lesions regressed with six months of treatment; however, they recurred six months after discontinuation of the treatment. Voriconazole cream was restarted, and the cure was achieved after two months of treatment [40].

Villa-Gonzalez et al. presented a Bangladeshi female in Spain who developed tinea corporis unresponsive to oral terbinafine. The patient recovered completely with three months of itraconazole 200 mg/day treatment. The lesions recurred one week after the treatment was stopped. The patient was given 100 mg of itraconazole daily for three more months, and no new lesion was observed afterwards [41].

Xie et al. described 14 patients with *T. indotineae* infection. Clinical and mycological cure was achieved in two patients who received oral itraconazole and topical antifungal medication. In addition, skin lesions improved in five patients with oral itraconazole. Recurrence was observed in two patients after itraconazole treatment. None of the seven patients who received oral terbinafine adequately responded to treatment. Two patients received oral voriconazole, but

treatment was discontinued due to poor response and side effects [42].

Abdolrasouli et al. described a patient with tinea corporis who had recently traveled to Central and South America and who did not adequately respond to topical antifungal medications. However, he was successfully treated with oral itraconazole 200 mg/day for two months [43].

Bui et al. reported a case of an extensive *T. indotineae* infection which was unresponsive to terbinafine, griseofulvin, and fluconazole. The patient was initially started on oral itraconazole 200 mg twice a day and topical 2% ketoconazole. After four days, the evening dose of itraconazole was adjusted to 300 mg to increase its trough level [44].

Discussion

T. indotineae is a novel dermatophyte species, first described in 2020 in India. Thereafter, *T. indotineae* infections spread rapidly outside India and were observed throughout the world, including in Europe and North America [45, 46]. Although isolating *T. indotineae* and determining the antifungal medication to which it is sensitive is crucial for effective treatment, performing laboratory tests for this purpose routinely and widely remains challenging [46]. *T. indotineae* is highly resistant to terbinafine, and this resistance is gradually increasing. Patients who are resistant to terbinafine are usually started on oral itraconazole therapy [45]. However, it has recently been shown that *T. indotineae* is also frequently resistant to azole antifungal drugs such as itraconazole and fluconazole [47]. On the other hand, experience in the usefulness of combination treatments containing different systemic antifungal medications for the management of *T. indotineae* infections is insufficient [45].

Conclusion

In the medical literature, articles on *T. indotineae* infection have been published from different countries all over the world. However, the number of clinical studies involving human participants is limited, and they are usually in the form of case reports describing one or a few patients. Within this review, we evaluated 39 clinical studies including 12 original articles, one short report, two case series, 17 case reports, and seven letters which described patients with different types of tinea caused by *T. indotineae*. In these publications, the most common dermatophyte infections detected in patients were tinea corporis and tinea cruris. Besides widespread skin involvement, the infection was usually resistant to treatment, and some patients required receiving various topical and systemic antifungal treatments, either in combination, at increased doses, or for prolonged periods, to achieve complete healing. Although *T. indotineae* has been reported to be resistant to terbinafine treatment, cases that respond to oral terbinafine have also been revealed. Further comprehensive clinical studies are required to determine the appropriate antifungal medications as the first-line treatment and treatment steps for superficial fungal skin infections caused by *T. indotineae* as well as the effective dose and duration of the treatment and the sufficient follow-up time to establish treatment guidelines.

References

1. Liang G, Li X, Li R, et al. Chinese expert consensus on management of antifungal-resistant dermatophytoses (2024 edition). *Mycoses*. 2024;67(9):e13785. DOI: 10.1111/myc.13785. PMID: 39245647.
2. Gold JAW, Benedict K, Lockhart SR, et al. Recognition of antifungal-resistant dermatophytosis by infectious diseases specialists, United States. *Emerg Infect Dis*. 2024;30(9):1978-1980. DOI: 10.3201/eid3009.240118. PMID: 39174019.
3. Uhrlaß S, Verma SB, Gräser Y, et al. Trichophyton indotineae-an emerging pathogen causing recalcitrant dermatophytoses in India and worldwide-a multidimensional perspective. *J Fungi (Basel)*. 2022;8(7):757. DOI: 10.3390/jof8070757. PMID: 35887512.
4. Ferreira CB, Lisboa C. A systematic review on the emergence of terbinafine-resistant Trichophyton indotineae in Europe: time to act? *J Eur Acad Dermatol Venereol*. 2024. Published online. DOI: 10.1111/jdv.20270. PMID: 39082800.
5. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. DOI: 10.1136/bmj.n71. PMID: 33782057.
6. Kano R, Kimura U, Kakurai M, et al. Trichophyton indotineae sp. nov.: a new highly terbinafine-resistant anthropophilic dermatophyte species. *Mycopathologia*. 2020;185(6):947-958. DOI: 10.1007/s11046-020-00455-8. PMID: 32449054.
7. Khurana A, Agarwal A, Singh A, et al. Predicting a therapeutic cut-off serum level of itraconazole in recalcitrant tinea corporis and cruris-a prospective trial. *Mycoses*. 2021;64(12):1480-1488. DOI: 10.1111/myc.13367. PMID: 34532888.
8. Pashootan N, Shams-Ghahfarokhi M, Chaichi Nusrati A, Salehi Z, Asmar M, Razzaghi-Abyaneh M. Phylogeny, antifungal susceptibility, and point mutations of SQLE gene in major pathogenic dermatophytes isolated from clinical dermatophytosis. *Front Cell Infect Microbiol*. 2022;12:851769. DOI: 10.3389/fcimb.2022.851769. PMID: 35372131.
9. Moreno-Sabater A, Normand AC, Bidaud AL, et al. Terbinafine resistance in dermatophytes: a French multicenter prospective study. *J Fungi (Basel)*. 2022;8(3):220. DOI: 10.3390/jof8030220. PMID: 35330222.
10. Astvad KMT, Hare RK, Jørgensen KM, Saunte DML, Thomsen PK, Arendrup MC. Increasing terbinafine resistance in danish Trichophyton isolates 2019-2020. *J Fungi (Basel)*. 2022;8:801. DOI: 10.3390/jof8020150. PMID: 35205904.
11. Posso-De Los Rios CJ, Tadros E, Summerbell RC, Scott JA. Terbinafine resistant Trichophyton indotineae isolated in patients with superficial dermatophyte infection in Canadian patients. *J Cutan Med Surg*. 2022;26(4):371-376. DOI: 10.1177/12034754221077891. PMID: 35144480.

12. Jia S, Long X, Hu W, et al. The epidemic of the multiresistant dermatophyte Trichophyton indotineae has reached China. *Front Immunol*. 2022;13:1113065.DOI: 10.3389/fimmu.2022.1113065. PMID: 36874152.
13. Bortoluzzi P, Prigitano A, Sechi A, et al. Report of terbinafine resistant Trichophyton spp. in Italy: clinical presentations, molecular identification, antifungal susceptibility testing and mutations in the squalene epoxidase gene. *Mycoses*. 2023;66(8):680-687. DOI: 10.1111/myc.13597. PMID: 37139949.
14. Kong X, Song G, Mei H, et al. The domestic isolation of terbinafine- and itraconazole-resistant Trichophyton indotineae in Chinese Mainland. *Mycopathologia*. 2023;188(4):383-393. DOI: 10.1007/s11046-023-00761-x. PMID: 37335400.
15. Tamimi P, Fattahi M, Firooz A, et al. Recalcitrant dermatophyte infections: identification and risk factors. *Int J Dermatol*. 2024;63(10):1398-1403. DOI: 10.1111/ijd.17145. PMID: 38712801.
16. Caplan AS, Todd GC, Zhu Y, et al. Clinical course, antifungal susceptibility, and genomic sequencing of Trichophyton indotineae. *JAMA Dermatol*. 2024;160(7):701-709. DOI: 10.1001/jamadermatol.2024.1126. PMID: 38748419.
17. Ngo TMC, Santona A, Ton Nu PA, et al. Detection of terbinafine-resistant Trichophyton indotineae isolates within the Trichophyton mentagrophytes species complex isolated from patients in Hue City, Vietnam: a comprehensive analysis. *Med Mycol*. 2024;62(8):myae088. DOI: 10.1093/mmy/myae088. PMID: 39174488.
18. Hiruma J, Kimura U, Noguchi H, Hiruma M, Harada K, Kano R. In vitro azole susceptibility testing of Japanese isolates of terbinafine-resistant Trichophyton indotineae and Trichophyton rubrum. *Med Mycol J*. 2023;64(1):23-5. DOI: 10.3314/mmj.22-00021. PMID: 36858630.
19. Dellière S, Joannard B, Benderdouche M, et al. Emergence of difficult-to-treat tinea corporis caused by Trichophyton mentagrophytes complex isolates, Paris, France. *Emerg Infect Dis*. 2022;28(1):224-228. DOI: 10.3201/eid2801.210810. PMID: 34932462.
20. Jabet A, Brun S, Normand AC, et al. Extensive dermatophytosis caused by terbinafine-resistant Trichophyton indotineae, France. *Emerg Infect Dis*. 2022;28(1):229-233. DOI: 10.3201/eid2801.210883. PMID: 34932456.
21. Ngo TMC, Ton Nu PA, Le CC, Ha TNT, Do TBT, Tran Thi G. First detection of Trichophyton indotineae causing tinea corporis in Central Vietnam. *Med Mycol Case Rep*. 2022;36:37-41. DOI: 10.1016/j.mmcr.2022.05.004. PMID: 35620657.
22. Durdu M, Kandemir H, Karakoyun AS, Ilkit M, Tang C, de Hoog S. First terbinafine-resistant Trichophyton indotineae isolates with Phe(397)Leu and/or Thr(414)His mutations in Turkey. *Mycopathologia*. 2023;188(1):2.DOI: 10.1007/s11046-023-00708-2. PMID: 36656402.
23. Caplan AS, Chaturvedi S, Zhu Y, et al. Notes from the field: first reported U.S. cases of tinea caused by Trichophyton indotineae-New York City, December 2021-March 2023. *MMWR Morb Mortal Wkly Rep*. 2023;72(19):536-537. DOI: 10.15585/mmwr.mm7219a4. PMID: 37167192.
24. Russo G, Toutous Trellu L, Fontao L, Ninet B. Towards an early clinical and biological resistance detection in dermatophytosis: about 2 cases of Trichophyton indotineae. *J Fungi (Basel)*. 2023;9(7):733. DOI: 10.3390/jof9070733. PMID: 37504722.
25. Dashti Y, Alobaid K, Al-Rashidi S, et al. Autochthonous case of Trichophyton indotineae in Kuwait. *J Mycol Med*. 2023;33(4):101432. DOI: 10.1016/j.mycmed.2023.101432. PMID: 37666031.
26. Messina F, Santiso G, Romero M, Bonifaz A, Fernandez M, Marin E. First case report of tinea corporis caused by Trichophyton indotineae in Latin America. *Med Mycol Case Rep*. 2023;41:48-51. DOI: 10.1016/j.mmcr.2023.08.004. PMID: 37706043.
27. Crotti S, Cruciani D, Spina S, et al. A terbinafine sensitive Trichophyton indotineae strain in Italy: the first clinical case of tinea corporis and onychomycosis. *J Fungi (Basel)*. 2023;9(9):865. DOI: 10.3390/jof9090865. PMID: 37754973.
28. Thakur R, Kushwaha P, Kalsi AS. Tinea universalis due to Trichophyton indotineae in an adult male. *Indian J Med Microbiol*. 2023;46:100476. DOI: 10.1016/j.ijmmb.2023.100476. PMID: 37806168.
29. Pavlović MD, Marzouk S, Bećiri L. Widespread dermatophytosis in a healthy adolescent: the first report of multidrug-resistant Trichophyton indotineae infection in the UAE. *Acta Dermatovenerol Alp Pannonica Adriat*. 2024;33(1):53-55. DOI: 10.15570/actaapa.2024.4. PMID: 38347717.
30. Teo JWP, Cheng JWS, Chew KL, Lin RTP. Whole genome characterization of Trichophyton indotineae isolated in Singapore. *Med Mycol*. 2024;62(2):myae012. DOI: 10.1093/mmy/myae012. PMID: 38366631.
31. Fukada N, Kobayashi H, Nakazono M, et al. A case of tinea faciei due to Trichophyton indotineae with steroid rosacea related to topical over-the-counter drugs purchased outside of Japan. *Med Mycol J*. 2024;65(1):23-26. DOI: 10.3314/mmj.23-00014. PMID: 38417884.
32. Spivack S, Gold JAW, Lockhart SR, et al. Potential sexual transmission of antifungal-resistant Trichophyton indotineae. *Emerg Infect Dis*. 2024;30(4):807-809. DOI: 10.3201/eid3004.240115. PMID: 38437706.
33. Tamimi P, Fattahi M, Ghaderi A, et al. Terbinafine-resistant T. indotineae due to F397L/L393S or F397L/L393F mutation among corticoid-related tinea incognita patients. *J Dtsch Dermatol Ges*. 2024;22(7):922-934. DOI: 10.1111/ddg.15440. PMID: 38924688.
34. Madarasingha NP, Thabrew H, Uhrlass S, et al. Dermatophytosis caused by Trichophyton indotineae (Trichophyton mentagrophytes ITS Genotype VIII) in Sri Lanka. *Am J Trop Med Hyg*. 2024;111(3):575-577. DOI: 10.4269/ajtmh.24-0027. PMID: 38981494.
35. Chua KY, Halliday CL, Chen SC, et al. Treatment-resistant tinea caused by Trichophyton indotineae in Australia. *Med J Aust*. 2024;221(4):192-194. DOI: 10.5694/mja2.52386. PMID: 39013435.
36. Smith A, Wong-O'Brien B, Lieberman JA, Cookson BT, Grinager E, Truong TT. The brief case: a case of tinea corporis caused by drug-resistant Trichophyton indotineae identified by broad-range fungal DNA sequencing. *J Clin Microbiol*. 2024;62(8):e0023424. DOI: 10.1128/jcm.00234-24. PMID: 39140757.
37. Mochizuki T, Anzawa K, Bernales-Mendoza AM, Shimizu A. Case of tinea corporis caused by a terbinafine-sensitive Trichophyton indotineae strain in a Vietnamese worker in Japan. *J Dermatol*. 2024. Published online. DOI: 10.1111/1346-8138.17463. PMID: 39269204.
38. Tan TY, Wang YS, Wong XYA, et al. First reported case of Trichophyton indotineae dermatophytosis in Singapore. *Pathology*.

2024;56(6):909-913. DOI: 10.1016/j.pathol.2024.04.003. PMID: 38937185.

39. Carroll E, Leahy M, Stanciu M, Laing M. Trichophyton indotineae: first case in Ireland and response to topical griseofulvin. *Clin Exp Dermatol*. 2024;49(12):1707-1708. DOI: 10.1093/ced/llae264. PMID: 39005069.
40. Gueneau R, Joannard B, Haddad N, et al. Extensive dermatophytosis caused by terbinafine-resistant Trichophyton indotineae, successfully treated with topical voriconazole. *Int J Antimicrob Agents*. 2022;60(5-6):106677. DOI: 10.1016/j.ijantimicag.2022.106677. PMID: 36184016.
41. Villa-Gonzalez JM, Pascual Ares M, López-Soria LM, Gonzalez-Hermosa MR, Gardeazabal García J, Lasa Elgezua O. Extensive tinea corporis caused by Trichophyton indotineae: report of a case in Spain. *J Eur Acad Dermatol Venereol*. 2024;38(1):e22-23. DOI: 10.1111/jdv.19404. PMID: 37556851.
42. Xie W, Kong X, Zheng H, et al. Rapid emergence of recalcitrant dermatophytosis caused by a cluster of multidrug-resistant Trichophyton indotineae in China. *Br J Dermatol*. 2024;190(4):585-587. DOI: 10.1093/bjd/ljae009. PMID: 38180270.
43. Abdolrasouli A, Borman AM, Johnson EM, Hay RJ, Arias M. Terbinafine-resistant Trichophyton indotineae causing extensive dermatophytosis in a returning traveller, London, UK. *Clin Exp Dermatol*. 2024;49(6):635-637. DOI: 10.1093/ced/llae042. PMID: 38320217.
44. Bui TS, Chan JB, Katz KA. Extensive multidrug-resistant dermatophytosis from Trichophyton indotineae. *Cutis*. 2024;113(6):E20-23. DOI: 10.12788/cutis.1050. PMID: 39082990.
45. Sonego B, Corio A, Mazzoletti V, et al. Trichophyton indotineae, an emerging drug-resistant dermatophyte: a review of the treatment options. *J Clin Med*. 2024;13(12):3558. DOI: 10.3390/jcm13123558. PMID: 38930086.
46. Jabet A, Normand AC, Brun S, et al. Trichophyton indotineae, from epidemiology to therapeutic. *J Mycol Med*. 2023;33(3):101383. DOI: 10.1016/j.mycmed.2023.101383. PMID: 37031652.
47. Hui ST, Gifford H, Rhodes J. Emerging antifungal resistance in fungal pathogens. *Curr Clin Microbiol Rep*. 2024;11(2):43-50. DOI: 10.1007/s40588-024-00219-8. PMID: 38725545.