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ORIGINAL RESEARCH

High *Trichophyton violaceum*-Induced Tinea Capitis with Isolation of Many Non-Dermatophyte Molds in Scalp Scrapings in Patients Referred to a Dermatology Clinic in Addis Ababa, Ethiopia

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Objective: This work aimed to determine the magnitude of tinea capitis, the diversity and species composition of fungi, and the predominant dermatophytes implicated in causing tinea capitis.

Methods: A prospective, cross-sectional study was conducted at a dermatology clinic. Scalp scrapings were collected and cultured, and dermatophyte and non-dermatophyte molds were identified.

Results: Of 364 scalp scrapings, fungi were recovered from 301 (82.7%) clinical samples. About 60.7% of the samples were collected from women, while 39.3% were collected from male study subjects. The association between the magnitude of scalp ringworm and gender was not statistically significant ($P = 0.105$). Two hundred eighty study subjects were less than 15 years of age, of which 254 were culture positive. The association of tinea capitis and the age of patients was statistically significant ($P = 0$). Three hundred forty-nine fungal isolates were isolated, of which 54.2% were dermatophytes, while 45.8% were non-dermatophyte molds. The occurrence of dermatophytes in their decreasing order was *T. violaceum* (138; 73%), *Trichophyton mentagrophytes* (18; 9.5%), *Trichophyton tonsurans* (16; 8.5%), *Trichophyton verrucosum* (8; 4.5%), *Microsporum audouinii* (7; 3.7%), *Trichophyton schoenleinii* (1; 0.5%), and *Trichophyton soudanense* (1; 0.5%).

Conclusion: A high prevalence rate of *T. violaceum*-induced tinea capitis was reported. The magnitude of scalp ringworm in adults was remarkably high. Therefore, conducting a nationwide epidemiological survey on tinea capitis regardless of age is suggested. The isolation of many non-dermatophyte molds in the current study may shade questions about the perception that tinea capitis is caused by dermatophytes only. Therefore, studies on their potential pathogenic role on skin and skin-related (nail and the scalp) infections appear to be an active field of research.

Keywords: scalp ringworm, superficial mycosis, dermatophytosis, *Trichophyton violaceum*, Ethiopia

Introduction

Dermatophytosis is fungal infection of the keratinized tissue of the skin, the hair, and the nails that are rich in keratin, the substrate of keratinophilic fungi. The infection is caused by a group of mycelial fungi known as dermatophytes or ringworm fungi. According to Emmons[1] and despite recent major changes in classification, there are about 40 species of ringworm fungi grouped into three major anamorphic genera: *Microsporum, Trichophyton*, and *Epidermophyton*. Ecologically, dermatophytes have been grouped into anthropophilic (prefer keratin of man), zoophilic (prefer keratin of animals), and geophilic (prefer keratin found in the soil).[2]

The reaction to tinea capitis may vary from mild to severe inflammation and the severity of the disease depends on the metabolic products of the fungus, the anatomical location of the infection, the host response to the etiological agent, the virulence factor of the infecting species, and the local environmental factors.[2,3] While the dermatophytosis is believed to

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be a trivial disease, the psychological effect of the disease is highly substantial and because of its high morbidity, it is a costly disease in terms of loss of working days and treatment cost.[3]

Based on the site of infection, dermatophytosis has been classified into many clinical categories, in which tinea capitis is defined to be an infection of the scalp and the hair shaft. The signs and symptoms of ringworm of the scalp may differ, but pustules, kerion, single or multiple scaly patches of circular alopecia, and black dots are the major ones. Dermatophytosis of the scalp is a highly contagious infection. The usual routes of infection of tinea capitis include chiefly animal-to-human and human-to-human transition and are usually enhanced by poor hygiene, overcrowding, lower socioeconomic status, and sharing contaminated fomites such as hats, brushes, pillows, and other inanimate objects.[2,3]

Although tinea capitis affects predominantly pre-adolescent children with a peak occurrence between 3 and 7 years of age,[4–7] a study conducted by Ziegler et al[8] demonstrated a high prevalence rate of scalp ringworm in adults and the elderly.

The disease is more prevalent among individuals living in poor socioeconomic status, densely populated areas, and among those with poor health and hygiene, characteristically found in low-income countries such as developing sub-Saharan countries in which Ethiopia is one of them.[9,10] As, studies conducted on tinea capitis in Ethiopia are few,[11,12] the true burden of the disease is lacking. An understanding of the changing epidemiology of tinea capitis and the diversity and species composition of the etiological agents of ringworm is vital in determining proper treatment and preventive mechanisms.[13] Against this background, the purposes of the present study are to assess the magnitude of tinea capitis across different age groups, to determine the diversity and species composition of fungi associated with tinea capitis, and determine the predominant dermatophytes implicated in causing tinea capitis among clinically identified individuals with tinea capitis referred to dermatology clinic in Addis Ababa, Ethiopia.

Materials and Methods

Study Area and Design

This prospective, cross-sectional study was conducted from October 2018 to June 2019. The study was conducted at Rank Higher Specialized Dermatology Clinic, Addis Ababa, Ethiopia.

Population

Source of Population

Persons with nail, scalp, and skin infections seeking health services at the study site.

Study Population

Clinically confirmed tinea capitis patients.

Inclusion and Exclusion Criteria

Persons that display clinical characteristics of ringworm. People with other types of nails, skin, and, scalp infections and individuals that have already started antifungal therapy are excepted from the study.

Sample Size Determination

The number of study subjects involved in the present study was 364. The sample size was calculated using the following formula: $n = Z^2_{1-\alpha/2} P(1 - P) d2$

where

n = the minimum size required

Z = standard normal value corresponding to 95% confidence interval for a two-sided test, which is equal to 1.96

P = prevalence of tinea capitis (18.0%) from a previous study conducted in Ethiopia[14]

D = margin of error, which is equal to 5%; substituting these into the formula.

Data Collection Procedure

Demographic Data

Laboratory request forms completed by dermatologists were used as a proforma to collect socio-demographic data (age, gender) as well as a history of earlier antifungal treatment of patients.

Quality Control

All the laboratory activities were carried out following standard procedures. The performance of all equipment, reagents, and the quality of culture medium were evaluated as per standard procedures before they are used. Collection, transportation, and processing of scalp scrapings were carried out following an aseptic technique. Inoculation of scalp scrapings onto culture media was done under a level II safety cabinet. The reliability of the findings was guaranteed by applying quality control procedures such as pre-analytical, analytical, and post-analytical throughout the whole processes of the laboratory work.

Statistical Analysis

Data were studied by means of SPSS statistical software version 20.

Ethics Approval and Consent to Participate

Ethical approval of this study was found from the Internal Review Board (IRB) of the Department of Medical Laboratory Science, College of Health Sciences, Addis Ababa University (Protocol number: DRERC/403/19/MLS/2019). Our study was carried out in compliance with the declaration of Helsinki. We would like to confirm all participants, and a parent or legal guardian of participants under 18 years of age provided informed consent.

Laboratory Activities

Sample Collection Transportation and Inoculation

Samples were collected by rubbing the edge of the lesion with a sterile scalp following cleaning of lesion with 70% (v/v) ethanol. Then, samples were transferred into plastic petri-dish and were then transported to the Department of Medical Laboratory Sciences following standard procedure.

Direct Microscopy Examination

Part of each scalp scraping was transferred onto a slide to which 20% potassium hydroxide (KOH) supplemented with 5% glycerol solution was added. After digesting the specimen with KOH for 5–10 minutes, the specimen was investigated for the presence of fungal elements microscopically using 10 and 40 magnification power objective lenses.

Inoculation and Incubation

The remaining part of each scalp scraping was inoculated onto duplicate Sabouraud's Dextrose Agar (SDA) plates supplemented with chloramphenicol ($100\mu gml^{-1}$), gentamycin ($50\ \mu gml^{-1}$), and cycloheximide ($100\mu gml^{-1}$). One of the duplicates of SDA plates was without cycloheximide. Chloramphenicol, gentamycin SDA, and cycloheximide are products of Oxoid, Basingstoke, Hampshire, England. Inoculated plates were incubated at 25° C aerobically for up to 4 weeks and were recorded as negative after 4 weeks of incubation.

Identification

Macroscopic Characteristics of Fungal Culture

Pigmentation of the front and the reverse side, texture, topography, and rate of growth of each culture were studied with naked eye.

Microscopic Characteristics of Fungal Culture

Microscopic features of fungal culture were examined by a lactophenol cotton blue (LPCB) staining method. Briefly, a drop of LPCB stain was placed on a slide. A piece of fungal culture was transferred to slides containing LPCB. Stained slides were then examined for their microscopic characteristics. Laboratory texts, mycology atlases, and manuals were used as reference materials in the process of identification.[15–17]

Results

Gender and Age Profile of Study Participants

As shown in Table 1, clinical samples were collected from 364 outpatient study subjects where the number of females enrolled (228; 62.6%) was much greater than that of males (136; 37.4%). The age of the patients varied from 1 to 64 years. The number of study participants regarding age was variable in that the age group of 1–14 years was the highest (280; 76.9%) followed by age groups of 25–44 (55; 15.1%).

Out of 364 scalp scrapings cultured, fungal species were recovered from 301 (82.7%) samples. Of 301 culture-positive samples, 60.7% (183/364) and 39.3% (118/364) were obtained from female and male patients, respectively (Table 2). Accordingly, the isolation rate of fungi was higher in females than in males. Yet, there was no statistically significant correlation among the magnitude of the infection and the sex of patients (P=0. 105). Culture positivity rate per age group demonstrated that patients in the age group of 1–14 were more affected than the other age groups. Among 364 study participants enrolled in the study 280 participants were in 1–14 years of age of which 84.4% (254/301) were culture positive. The correlation between tinea capitis and the age of study participants was statistically significant (P=0).

Profile of Fungal Isolates

In the present study, of a total of 364 scalp scrapings cultured, 301 were positive for fungal species of which 44 samples gave more than one species (mixed culture). A total of 349 fungi were recorded and among the fungi, 54.2% (189/349) were dermatophytes while 45.8% (160/349) were found out to be non-dermatophytes molds. The occurrence of dermatophytes in their decreasing order was *T. violaceum* (138; 73%), *T. mentagrophytes* (18:9.5%), *T. tonsurans* (16; 8.5%), *T. verrucosum* (8; 0.4.5%), *M. audouinii* (7; 3.7%), *T. schoenleinii* (1.0.5%), and *T. soudanense* (1:0.5%). Among 189 dermatophyte isolates 163 (86.2%) were anthropophilic. Species of *Aspergillus*, (64; 40), *Cladosporium* (21; 13.1%), *Alternaria* (19; 11.9%), *Fusarium*, (18; 11.3%), *Curvularia* (9; 5.6%), and *Penicillium* (7; 4.4%) were found out to be the main isolates as far as non-dermatophyte molds was considered (Table 3).

As far as fungal diagnosis is considered culturing was more efficient than direct microscopic investigation. Fungal species were seen in 225 (61.8%) scalp samples by direct microscopic examination while fungi grew in 301 (82.7%)

Table 1 Age and Gender Profile of Study Participants (n=364)

Age Group	Female	Male	Total	%
1–14	169	111	280	76.9
15–24	16	3	19	5.2
25–44	37	18	55	15.1
45–64	6	4	10	2.8
Total	228 (62.6%)	136 (37.4%)	364	100

Table 2 Frequency of Culture-Positive Samples in Relation to Gender and Age (N= 364)

Variables	Age and Sex Categories	Culture Positive Sample (%)	Total Number of Samples Tested (%)	P-value
Age group	1–14	254 (84.4)	280 (77.0)	0.000
	15–24	10 (3.4)	19 (5.2)	
	25–44	30 (10)	55 (15.0)	
	45–64	7 (2.3)	10 (2.8)	
Gender	Female	183 (60.7)	228 (62.6)	0.105
	Male	118 (39.3)	136 (37.4)	
Total		301	364 (100)	

Note: Statistical association as determined by X^2 test.

Table 3 A Spectrum of Fungal Isolates in Patients with Clinically Confirmed Tinea Capitis (n =364)

Fungal Species	Single (Pure) Isolates	Mixed with Other Fungi	Total Isolates
Dermatophytes			
T. violaceum	117	21	138
T. mentagrophytes	8	10	18
T. tonsurans	4	12	16
T. verrucosum	4	4	8
M. audouinii	3	4	7
T. schoenleinii	-	1	1
T. soudanense	-	1	1
Dermatophytes Sub-total	**136**	**53**	**189**
Non-dermatophytes			
Acremonium spp.	1	-	1
Alternaria spp.	15	4	19
Aspergillus flavus	7	3	10
Aspergillus fumigatus	11	6	17
Aspergillus niger	24	2	26
Other Aspergillus spp.	1	3	4
Aspergillus terreus	7	-	7
Bipolaris spp.	2	-	2
Cladosporium spp.	14	7	21
Curvularia spp.	9	-	9
Epicoccum spp.	1	-	1
Exophiala jeanselmei	2	-	2
Exserohilum spp.	1	-	1
Fonsecaea pedrosoi	1	1	2
Fusarium spp.	13	5	18
Mucor spp.	1	-	1
Penicillium spp.	5	2	7
Rhizopus spp.	3	-	3
Scopulariopsis spp.	2	1	3
Aureobasidium spp.	-	1	1
Phialophora spp.	-	2	2
Scytalidium dimidiatum	1	1	2
Ulocladium spp.	-	1	1
Non-dermatophytes Sub-total	**121**	**39**	**160**
T. violaceum + *A. fumigatus*		5	5
T. violaceum + *Aspergillus spp.* + *Penicillium* spp.		1	1
T. violaceum + *Aspergillus spp.* + *Aureobasidium spp.*		1	1
T. violaceum + *Cladosporium* spp.		2	2
T. verrucosum + *Cladosporium* spp.		2	2
T. verrucosum + *Phialophora* spp.		1	1
T. verrucosum + *T. tonsurans* + *Cladosporium* spp.		1	1
Cladosporium spp. + *T. mentagrophytes*		1	1
Cladosporium spp. + *T. violaceum* + *T. soudanense*		1	1
T. mentagrophytes + *Scopulariopsis* spp. + *Phialophora* spp.		1	1
M. audouinii + *Fusarium* spp.		1	1
Cladosporium spp. + *T. violaceum* + *Fusarium* spp.		1	1
T. mentagrophytes + *Scytalidium dimidiatum*		1	1

(*Continued*)

Table 3 (Continued).

Fungal Species	Single (Pure) Isolates	Mixed with Other Fungi	Total Isolates
Cladosporium spp. + T. violaceum		1	1
T. mentagrophytes + Aspergillus flavus		2	2
T. mentagrophytes + T. tonsurans		3	3
T. mentagrophytes + M. audouinii		1	1
T. tonsurans + T. violaceum		1	1
Alternaria spp. + *T. schoenleinii*		1	1
Alternaria spp. + *T. violaceum*		2	2
Alternaria spp. + *T. violaceum* + *Fusarium* spp.		1	1
A. fumigatus + M. audouinii		1	1
T. mentagrophytes + Fonsecaea pedrosoi		1	1
T. violaceum + A. niger		2	2
Fusarium spp. + *Ulocladium* spp.		1	1
T. tonsurans + Aspergillus spp.		2	2
T. tonsurans + Pencillium spp.		1	1
Fusarium Sp. + T. violaceum		1	1
T. tonsurans + T. violaceum		2	2
T. tonsurans + A. flavus		1	1
T. tonsurans + M. audouinii		1	1
Total no. of samples with a mixed culture		**44**	**44**

scalp samples. Out of 364 samples, 214 (58.7%) were positive both in culture and by direct microscopic examination. Eleven (3%) samples were positive by direct microscopic examination but culture negative. Eighty-seven (23.9) samples that were negative by direct microscopic examination were found out to be culture-positive. Fifty-two (14.4%) samples were turned out to be negative both in culture and by direct microscopic examination (Table 4).

The Distribution of Fungal Species According to Gender

Out of 189 dermatophytes, 119 were obtained from females, while 70 dermatophytes were obtained from males. Correspondingly, of 160 non-dermatophyte molds, 115 were recovered from females, whereas 45 fungi were found from males (Table 5).

The Distribution of Fungal Isolates According to the Age

Out of a total of 349 fungi, 274 were found in the age group of 1–14 of which 177 were dermatophytes and 97 were non-dermatophyte molds. Among dermatophytes, *T. violaceum* was the dominant species consisting of 135 isolates, whereas among non-dermatophyte molds *Cladosporium, Fusarium*, and *Alternaria* species were the dominant isolates in this age group (Table 6).

Table 4 Correlation of Direct Microscopy with Culture

Test Procedure	Number	Percentage
Direct microscopy positive	225	61.8
Culture positive	301	82.7
Culture and microscopy positive	214	58.7
Microscopy positive but culturenegative	11	3.0
Microscopy negative but culture positive	87	23.9
Both microscopy and culturenegative	52	14.4

Table 5 Distribution of Fungal Isolates According to Gender (n=349)

Species	Female	Male	Total
Dermatophytes			
T. violaceum	85	53	138
T. mentagrophytes	12	6	18
T. tonsurans	12	4	16
M. audouinii	4	4	8
T. verrucosum	4	3	7
T. schoenleinii	1		1
T. soudanense	1	-	1
Dermatophytes Sub-total	**119**	**70**	**189**
Non-dermatophytes			
Acremonium spp.	1	-	1
Alternaria spp.	15	4	19
A. flavus	7	3	10
A. fumigatus	11	6	17
A. niger	20	6	26
Other Aspergillus spp.	3	1	4
A. terreus	7	-	7
Bipolaris spp.	2	-	2
Cladosporium spp.	14	7	21
Curvularia spp.	6	3	9
Epicoccum spp.	1	-	1
Exophiala jeanselmei	1	1	2
Exserohilum spp.	1	-	1
Fonsecaea pedrosoi	1	1	2
Fusarium spp.	11	7	18
Mucor spp.	1	-	1
Penicillium spp.	5	2	7
Rhizopus spp.	2	1	3
Scopulariopsis spp.	2	1	3
Aureobasidium spp.	1	-	1
Phialophora spp.	1	1	2
Scytalidium dimidiatum	1	1	2
Ulocladium spp.	1	-	1
Non-dermatophytes Sub-total	**115**	**45**	**160**

Discussion

Precise identification of tinea capitis is indispensable for its effective treatment. Accurate diagnosis of ringworm of the scalp before starting antifungal treatment is vital to minimize the cost and the long period of the treatment, the risk of developing adverse drug reactions, and potential interactions with associated medications. In Ethiopia, like most developing countries, antifungal treatment of patients with tinea capitis is based solely on clinical information.

In the present study, 364 scalp scrapings were investigated nevertheless fungi were detected in 225 (61.8%) samples by direct microscopic examination, whereas fungi grew in 301 (82.7%) samples. Our finding, therefore, demonstrated that treating tinea capitis with antifungal drugs based on clinical diagnosis alone is often problematic and demands confirmation of clinical diagnosis at least microbiologically.

Table 6 Distribution of Fungal Isolates According to Age Group (n=364)

Species	Age Group				
Dermatophytes	**1–14**	**15–24**	**25–44**	**45–64**	**Total**
T. violaceum	135	2	1		138
T. mentagrophytes	15	2	1		18
T. tonsurans	14	2	–	–	16
T. verrucosum	6	–	1	1	8
M. audouinii	6	1			7
T. schoenleinii		1			1
T. soudanense	1				1
Dermatophytes Sub-total	**177**	**8**	**3**	**1**	**189**
Non-dermatophytes					
Acremonium spp.				1	1
Alternaria spp.	14	1	3	1	19
A. flavus	6	–	3	1	10
A. fumigatus	13	–	3	1	17
A. niger	11	2	9	4	26
Other Aspergillus spp.	2	1		1	4
A. terreus	4	1	1	1	7
Bipolaris spp.	1			1	2
Cladosporium spp.	18	1	1	1	21
Curvularia spp.	5	1	2	1	9
Epicoccum				1	1
Exophiala jeanselmei		1		1	2
Exserohilum spp.				1	1
Fonsecaea pedrosoi			1	1	
Fusarium spp.	14		3	1	18
Mucor spp.			1		1
Penicillium spp.	4	1	2		7
Rhizopus spp.			2	1	3
Scopulariopsis spp.	2		1		3
Aureobasidium spp.			1		1
Phialophora spp.	1		1		2
Scytalidium dimidiatum	1				1
Ulocladium spp.	1			1	2
Non-dermatophytes Sub-total	**97**	**9**	**36**	**18**	**160**
Total Isolates/age group	**274**	**17**	**39**	**19**	**349**
Positive culture/age group	**254**	**10**	**30**	**7**	**301**

The magnitude of ringworm of the scalp was more in individuals with an age group of 1–14 years (254 of 301; 84.4%) than in individuals with an age group above 14 years (47 of 301; 15.6% patients). A high prevalence rate of ringworm of the scalp in humans under puberty with a declining frequency in adults and the elderly has been demonstrated by several related studies.[18–21] Presumably, a higher prevalence rate of tinea capitis in children than in adults and the elderly is associated with insufficient production of sebum, which brings a reduction in fatty acid production and increased pH of the scalp, znd conditions that facilitate dermatophyte colonization and subsequent infection.[22] Our finding of a 15.6% prevalence rate of tinea capitis in individuals above puberty was consistent with the findings of Zeigler et al[8] that demonstrated a 16% prevalence rate of scalp ringworm in adults. The significance of the

high magnitude of scalp dermatophytosis in adults in the present study could be explained with caution that all individuals with scalp lesions should be screened for disease regardless of their age.

There are contradictory reports on the prevalence rate of tinea capitis concerning gender. Ringworm of the scalp in the present study was found to be more prevalent in females compared to male study subjects, the female–male ratio being 1.6:1. Our finding was similar to a study conducted in China[23] and Alexandria[24] but contrary to studies conducted in children of West African,[25] North Africa,[26] Central Africa,[27] and southern African countries.[28,29] In contrast to these trends in children, the frequency of tinea capitis was significantly greater in adult females than in adult males.[25] The lower magnitude of tinea capitis in males than females in our study, unlike to most studies conducted in Africa, could be explained that samples were collected from both children and adults in our study.

As far as the spectrum and species composition of the fungi is considered, 349 fungi were identified. Among the fungi, 54.2% (189/349) were dermatophytes that fall into seven species, while 45.8% (160/349) were non-dermatophyte mycelial fungi that fall into 14 genera. Of 189 isolates of dermatophytes, 138 (73%) were represented by the anthropophilic species of *T. violaceum* demonstrating that the frequency of *T. violaceum*-induced scalp dermatophytosis was the most predominant in the present study. Among 138 isolates of *T. violaceum* 135 were isolated in persons with an age group of 1–14 years. Our result also revealed that the zoophilic *T. mentagrophytes* and *T. verrucosum* and the anthropophilic species *T. tonsurans*-induced tinea capitis stood second, third, and fourth, respectively. In contrast to our finding, a recent study conducted on the mycological profile of tinea capitis in school children in rural southern Ethiopia[12] revealed that the zoophilic species *T. verrucosum*-induced tinea capitis was the most prevalent accounting for 33.0%. This was followed by *T. tonsurans* and *T. mentagrophytes*-induced tinea capitis. *Trichophyton violaceum*-induced tinea capitis was as low as 2.3%. According to Ameen,[2] *T. violaceum* has been reported as one of the endemic fungi in the horn of Africa and Asia. Globally, the dominant dermatophytes accountable for scalp dermatophytosis exhibit a variable geographic distribution; thus whereas *T. tonsurans* continues to be the most frequent causative agent of tinea capitis in the USA, the United Kingdom, and part of Europe, *T. verrucosum* is the most frequent causative agent of tinea capitis in Central and South Asia, *Microsporum canis* is the most frequent cause of tinea capitis in South America, *T. violaceum* predominates in North Africa and Asia. A very high incidence of *T. violaceum* tinea capitis in the present study than *T. schoenleinii, T. tonsurans*, and *M. audouinii*-induced tinea capitis that is generally considered to be the most important cause of tinea capitis[3] is unclear. Geographical area, both between and within countries, a temporal shift in pathogens, and epidemiology have been identified for the variation in the dominant dermatophyte species causing tinea capitis in the different regions.[8,30]

Although tinea capitis is defined to be an infection of the scalp and hair caused by species of *Epidermophyton, Microsporum*, and *Trichophyton*, isolation of non-dermatophyte molds in skin-related mycosis that is reported to be normal flora and/or laboratory contaminants have been documented as pathogens in many earlier publications[31–41] either in the form of pure or mixed culture. Nevertheless, the degree to which non-dermatophyte molds cause scalp infections is still a subject of argument. Two recent publications, however, demonstrated that tinea capitis is caused by *A. niger* with a different clinical presentation[42] and kerion-type scalp infection caused by *Aspergillus protuberus*.[43]

Sustaining of patients by drugs, chemicals, and mechanical processes debilitate physical barriers to infection, overpowers immune mechanisms, or upsets the balance of normal flora; the emergence of various chronic debilitating diseases following an increase in the life expectancy of human; and an increase in underlying diseases that overwhelm host immunity have made human to be more susceptible not only to pathogenic fungi (dermatophytes) but also to all fungi (non-dermatophyte mycelial fungi) that were once considered to be normal flora and/or laboratory contaminants.[44] These could be some of the possible reasons for the recovery of many of the non-dermatophyte fungi associated with ringworm in our study. Hence, the isolation of many species of non-dermatophyte molds in the current study may shade questions about the perception that tinea capitis is caused by dermatophytes only. Furthermore, the isolation of dermatophytes relatively in good number in adults in our study subjects may also shade questions in the notion that tinea capitis is a disease of school children.

Conclusions

A high prevalence rate of *T. violaceum-induced* tinea capitis was reported. The magnitude of scalp ringworm in adults was remarkably high. Therefore, conducting a nationwide epidemiological survey on tinea capitis regardless of age is suggested. The isolation of many non-dermatophyte molds in the current study may shade questions about the perception that tinea capitis is caused by dermatophytes only. Therefore, studies on their potential pathogenic role on skin and skin-related (nail and scalp) infections appear to be an active field of research.

Limitations of the Study

As a result of an increase in the number of immune-compromised hosts, fungal infections have become more serious now than in the past. This may indicate that studies involving fungal infections should consider the immune status of study subjects. The lack of information about the immune status of our study subjects in the present study was, therefore, one of the major limitations of the study. Due to a lack of facilities and resources, we were unable to determine the antifungal susceptibility profile of the isolates in the present study. This was another limitation of the study. Mechanisms of differentiating fungal colonization from fungal infection are not well established, and hence the subject remains a serious challenge. However, it has been suggested that the isolation of a certain fungus repetitively in a given sample may qualify the isolate as a pathogen. In this study, we were unable to do this, because our study was not a cohort so unable to get our patients, again and again, which was another limitation.

Abbreviations

LPCB, lactophenol cotton blue; KOH, potassium hydroxide; SAD, Sabouraud's dextrose agar.

Data Sharing Statement

Raw data is available upon reasonable request from the corresponding author.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare no financial and non-financial competing interests in the manuscript.

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