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REVIEW ARTICLE

Tinea capitis: An update

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Abstract

Tinea capitis is an important superficial infection and affects children globally. A literature review was conducted to identify recent findings and the current understanding of this fungal infection. Here, we highlight updates on important aspects of tinea capitis including advances in dermatophyte detection and diagnosis and comparing these new methods to more traditional techniques. Additionally, aspects of treating tinea capitis are discussed, including the importance of mycological confirmation and current means of treatment, and the treatment of asymptomatic carriers are reviewed. This review also examines the subject of laboratory monitoring of patients undergoing treatment with systemic antifungals; we discuss the opinions of prominent researchers and currently accepted guidelines. Lastly, we provide answers to several common questions that practitioners may encounter when treating a child with tinea capitis.

KEYWORDS
dermatophyte, fungal infection, ringworm, tinea capitis

1 | INTRODUCTION

Tinea capitis is the most infectious dermatophytosis in children.[1] Changing trends in the epidemiology of this condition and the emergence of antifungal resistance have been documented and recently reviewed elsewhere.[2] Here, we discuss recent advances in tinea capitis related to diagnosis and management of this condition.

2 | DIAGNOSIS

The appropriate treatment of tinea capitis rests on the correct identification of the causal agent.[1] Traditionally, clinical manifestations of tinea capitis and microscopy with culture all contribute to identification of the causal organism.[1] The gold standard for mycological diagnosis is fungal culture; unfortunately, results can be delayed as it may take 4 weeks or more for colonies to form and manifest identifiable morphological features. This technique also requires years of experience to accurately interpret the morphological features.[1,3] While highly specific, fungal culture is susceptible to contamination which could result in a non-dermatophyte being isolated, further complicating dermatophyte identification.[3] Other tests, such as the potassium hydroxide (KOH) evaluation, are non-specific and do not identify the dermatophyte species. The use of a Wood's lamp is not suitable for definitive species identification. This technique is primarily useful for observing fluorescence in ectothrix infection caused by *Microsporum spp.* with the exception of *T. schoenleinii*[4]; otherwise, *Trichophyton spp.* which cause endothrix infections do not fluoresce.[5]

The practice of trichoscopy has increased in popularity as this technique is simple, non-invasive, and relatively inexpensive. While trichoscopy can reveal features associated with endothrix and ectothrix infections (such as barcode, corkscrew, and comma hairs), which may allow a practitioner to decide on an antifungal regimen, it does not allow for dermatophyte identification at either the genus or species level.[5] Nonetheless, trichoscopy is a useful test for distinguishing between dermatophyte infections and other causes of hair abnormalities, including alopecia areata and trichotillomania. Given that prolonged systemic therapy is required, and other disorders such as seborrheic dermatitis, psoriasis, trichotillomania, and alopecia areata are possibilities, the authors recommend utilising all available diagnostic tools to confirm the presence of fungal infection.

Polymerase chain reaction (PCR) is a sensitive technique used for dermatophyte identification at both genus and species levels.[6]

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Common target sequences for PCR include the ribosomal internal transcribed spacer (ITS) and translation elongation factor 1-α (EF1-α).[6,7] Conserved sequences (i.e. ITS) are ideal PCR targets for broad dermatophyte detection; however, greater specificity is achieved when less conserved sequences, such as EF1-α, are targeted.[7,8] One caveat of this technique is that PCR does not provide information regarding the viability of the organism.

The use of matrix-assisted laser desorption ionization: time of flight mass spectrometry (MALDI-TOF/MS) has also become more popular for dermatophyte identification. This technique relies on *in silico* matching of dermatophyte mass spectra to spectra maintained in publicly available or in-house developed databases.[6] Previously, inabilities to differentiate *Trichophyton spp*. have been reported; however, updated databases allow for increased specificity.[9] Recently, Sacheli et al. reported that MALDI-TOF/MS correctly identified 78% of dermatophyte isolates at the species level after only 3 days of incubation on culture media, demonstrating that this technique combines speed with a reasonably high level of accuracy.[10] A brief summary of diagnostic methods is presented in Table 1.

3 | LABORATORY MONITORING OF PATIENTS

The most commonly used systemic antifungals for treatment of tinea capitis are generally safe.[11] However, uncommonly used terbinafine, fluconazole, and itraconazole can be hepatotoxic.[12] Fortunately, the incidence of adverse side effects, such as liver injury, is low during treatment of tinea capitis with these antifungals.[13–16]

The recommendations of laboratory testing of patient levels undergoing treatment with systemic antifungals vary.[4,15–19] The U.S. Food and Drug Administration (FDA) recommends that baseline transaminase (ALT and AST) levels should be obtained prior to beginning a terbinafine-based treatment regimen.[16,17] The American Academy of Pediatrics (AAP) specifically states in the Red Book that laboratory testing of serum hepatic enzymes is not a requirement if a griseofulvin-based regimen does not exceed 8 weeks.[17] The AAP refers clinicians to guidelines of the U.S. FDA when terbinafine is used for treatment, while acknowledging that some clinicians omit baseline monitoring in otherwise healthy children, with some follow-up testing performed at 4–6 weeks if duration of therapy is prolonged.[17] In agreement with U.S. FDA guidelines, the Canadian Pediatric Society suggests that liver enzymes should be periodically monitored in patients being treated with terbinafine beyond 4–6 weeks.[12] The German guidelines recommend that baseline AST, ALT, and GGT levels should be determined and measured after 2–4 weeks of systemic antifungal treatment only in patients with history of or current comorbidities that may contribute to impaired liver function.[18] Although the majority of recommendations address adults and children who have a decreased incidence of hepatic disorders and alcohol use and less likelihood of taking other systemic medications and have a lower likelihood of developing adverse effects from these drugs. Wang and Lipner reviewed the laboratory results of over 100 children who had taken terbinafine; only 4% had any lab abnormalities, and all were minor (Grade 1).[15]

Recommendations voiced by practitioners also vary on the topic of laboratory monitoring. Some argue against baseline and periodic monitoring levels.[14] Others suggest that because abnormal monitoring laboratory test results are infrequent in terbinafine-treated pediatric patients, monitoring in otherwise healthy children may be unnecessary. However, if there is concern about pre-existing hematologic or hepatic liver disease, then such tests should be performed.[15] Patel et al.[13] indicate that asymptomatic elevations in serum aminotransferases occur in less than one percent of patients, and these typically self-resolve without discontinuing therapy. They recommend baseline transaminase monitoring but feel that routine monitoring during systemic therapy of 12 weeks or less in healthy children may be unnecessary.

The most recent review of pediatric dermatology practitioner practices relating to onychomycosis revealed that most practitioners obtained baseline fungal cultures, but the majority did not perform monitoring tests.[19] In summary, there are differences of opinion regarding the need for laboratory monitoring in otherwise healthy children.

The authors recommend that parents be involved in the decision-making process regarding this issue in otherwise healthy children who are not on other systemic medications. Many families, after being made aware that adverse drug effects are possible, still prefer not to have their child exposed to venipuncture. If a family defers laboratory monitoring, it should be documented that they were informed of the risk, albeit very low, inherent in taking systemic terbinafine. In summary, we recommend that fungal culture be obtained in all patients prior to therapy and that all children who have other health problems, or who are taking other systemic drugs, undergo baseline and follow-up laboratory monitoring.

4 | TREATMENT/MANAGEMENT

Several official guidelines addressing the treatment of tinea capitis are available from various organizations.[4,12,17,18,20] Among these guidelines, the common recommendation is the use of systemic antifungals as first-line treatment for tinea capitis, with the use of a topical agent as an adjuvant to prevent the spread of fungal spores.[4,12,18,20]

Since its introduction in 1958, griseofulvin has served as a commonly used treatment for tinea capitis, especially when the causative organism is *M. canis*. However, griseofulvin (U.S. FDA-approved for patients >2 years of age) is no longer available in several countries.[11] There has been a shift in treatment practices with terbinafine (U.S. FDA approved for patients >4 years of age) now often considered as first-line therapy, especially for *Trichophyton* species.[18,21]

Concerns regarding drug resistance have been raised as terbinafine-resistant dermatophytes have been identified in both *Microsporum spp*. and *Trichophyton spp*. and is associated with mutations in genes encoding the squalene epoxidase enzyme.[22] The

TABLE 1 Techniques for diagnosis of tinea capitis

Test	Mechanism of action	Speed[a]	Sensitivity[a]	Specificity[a]	Advantages	Disadvantages	References
Fungal culture[b]	Fungi is grown on enrichment media, and morphology is examined for identification	Slow	Low	High	Evaluates viability of fungi contained in the sample	Susceptible to contamination; Requires years of experience for identification	1,3
Microscopy	Sample is visualised after KOH or PAS stain	Fast	Moderate	Low	Rapid	Cannot identify species or provide information on viability	1,3,18
Wood's lamp	UV light causes majority of ectothrix dermatophytes to fluoresce	Fast	Moderate	Moderate	Rapid; Inexpensive; Performed in a clinical environment	Few species (predominantly *Microsporum*) will fluoresce	4,5
Trichoscopy	Features of dermatophyte infection observed with a dermoscope	Fast	Moderate	Low	Rapid; Inexpensive; Performed in a clinical environment	Does not allow for dermatophyte identification at the genus or species level	5
PCR	Specific regions of fungal genomes amplified using molecular probes	Fast	High	High	Samples can be tested with variety of probes for detection or identification	Does not address viability of fungi; Requires laboratory setting and specialised equipment; Susceptible to false positives	6,7,8
MALDI-TOF/MS	Mass spectra of samples are compared to curated databases for identification	Moderate	High	High	Requires only short incubation time	Requires viable culture for testing; Relies on integrity of curated mass spectra databases; Requires laboratory setting and specialised equipment; Expensive	6,9,10

[a]Speed, sensitivity, and specificity of described diagnostic techniques are ranked relative to each other.

[b]Currently the gold standard for mycological diagnosis of tinea capitis.

emergence of resistant dermatophytes has been attributed to the limited availability of antifungals and failure of patients to adhere to lengthy treatment courses.[22,23] While there is less information about fluconazole and itraconazole, and their off-label use to treat tinea capitis, there is a growing body of evidence showing the effectiveness of these agents.[11,24] However, at least one large randomized double-blinded placebo-controlled trial utilising fluconazole for treating tinea capitis showed suboptimal cure rates with this drug.[25] If there is a poor or incomplete response to oral antifungal therapy, then the presumed diagnosis of tinea capitis should be reconfirmed by performing a KOH analysis if possible and taking a repeat sample for mycology. If possible, the minimum inhibitory concentration (MIC) of the causative agent against available antifungal agents should be performed in order to provide guidance regarding the best antifungal therapy to use.[21,22]

While the use of systemic antifungals is safe, as previously stated, there is a potential for hepatotoxicity especially when a patient has an underlying hepatic condition or other comorbidities.[1,12] Laboratory monitoring is recommended in any patients who have significantly prolonged or multiple therapies. In some cases, practitioners may want to avoid the use of systemic antifungals for treatment of tinea capitis.

An alternative treatment to systemic antifungals may be the off-label use of photodynamic therapy (PDT) alone or in combination with a topical adjuvant. A 2-year-old patient was cured of *T. mentagrophyte*–caused kerion using aminolevulinic acid–amended PDT.[26] Aspiroz et al. describe the case of a 10-year-old patient diagnosed with *M. canis*–caused tinea capitis being cured after a course consisting of methylaminolevulinate-activated daylight PDT therapy and 2% ketoconazole shampoo.[27] Despite the promise of PDT documented in these reports, thoroughly conducted, large clinical trials are needed to determine the efficacy and safety of PDT for treatment of tinea capitis.

5 | CARRIER STATE

Most guidelines advocate use of topical therapy to reduce spore carriage and possible transmission of infection, as well as reducing the risk of development of overt clinical tinea capitis.[4,12,18,20] Several guidelines make reference to 'spore loads' in their recommendations, restricting topical therapy to 'low' loads, while suggesting that oral therapy would be justified with 'high' loads.[4,18] However, most routine fungal testing will not provide a spore load that can be used for treatment determination. From a safety perspective, topical treatment is more prudent and effective at reducing fungal detection, allowing patients to safely return to activities between follow-ups until negative cultures are achieved.[4,18,20] In a recent review, Aharaz et al.[28] evaluated the evidence for treatment of asymptomatic carriers as conventional treatments for tinea capitis are costly and have well-known side effects. Unfortunately, only a small number of studies (n = 10) met the criteria of Aharaz et al., and the diversity of these studies made meta-analysis impossible. The authors acknowledged the discrepancy between the individual patient and written guidelines as many asymptomatic carriers were mycologically cured without intervention; however, the use of topical shampoos containing povidone-iodine or ketoconazole offered a higher rate of mycological cure (94% and 100%, respectively), which better serves the general population.[28] Given the paucity of data, the authors recommend topical antifungal shampoos as a treatment that possesses an acceptable risk–benefit ratio.

Frequently asked questions by parents:
Q: "When can my child return to the classroom?"
Most guidelines state children on a combination of both systemic and topical treatments can return to the classroom immediately if there is no draining present and the causal agent of tinea capitis is a zoophilic dermatophyte.[17] Some guidelines suggest delaying return to the classroom for one week if infection is caused by an anthropophilic dermatophyte.[4,18] In contrast, the AAP guidelines are not influenced by the causal dermatophyte, and children should not be excluded from school once appropriate therapy has begun.[17]
Q: "Should my child wear a hat?"
The use of headwear to prevent transmission of dermatophytes is generally considered unnecessary if tinea capitis is being treated with systemic and topical therapeutics.[18]
Q: "Should I shave my child's head?"
Some suggest that head shaving may allow for the removal of some infectious hairs during treatment for tinea capitis.[29] More recent guidelines state that a combined regimen of systemic and topical antifungals is sufficient; head shaving is unnecessary.[18]
Q: "What measures should I implement in my home?"
Viable spores of anthropophilic dermatophytes have been found on items such as hairbrushes and hairdressing tools.[30] Guidelines unanimously recommend these and other potential fomites (such as household linens and curtains) be treated by boiling for five minutes or by using a strong disinfectant, such as bleach, a solution of sodium hypochlorite (2%) and salt (16%), or one of many commercially available disinfectants.[4,30] Additionally, if tinea capitis is caused by a zoophilic dermatophyte, household pets and other contacts through outside farm animals or pets of friends should be examined, if possible by a qualified veterinarian, since even if pets are asymptomatic, they could be carriers of dermatophytes.[18] In addition, all family members and contacts should be queried regarding symptoms, and anyone who is symptomatic should be evaluated.[17]

6 | CONCLUSION

We present recent advances in methods which provide more rapid and specific diagnosis of tinea capitis and dermatophyte identification than traditional methods. We also discuss treatment of tinea capitis with the need to confirm diagnosis prior to starting oral antifungal therapy. If there is poor or no response to the oral antifungal therapy, the scalp should be resampled to confirm the mycological diagnosis and when available, the MIC of the causative organism against available antifungal agents available will help guide the choice of antifungal agent to use. The management of asymptomatic carriers is also reviewed. Finally, the answers to several common questions which may be posed to practitioners are presented.

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CONFLICT OF INTEREST

AKG, SFF, and AJS have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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