Tinea capitis et barbae caused by *Trichophyton tonsurans*: A retrospective cohort study of an infection chain after shavings in barber shops

Valentina Laura Müller¹,² | Korina Kappa-Markovi¹ | Julia Hyun¹ | Dimitrios Georgas¹ | Gabriel Silberfarb³ | Uwe Paasch² | Silke Uhrlaß⁴ | Pietro Nenoff⁴ | Jörg Schaller⁵

¹Klinik für Dermatologie, Allergologie und Phlebologie, Helios Klinikum Duisburg, Duisburg, Germany
²Klinik und Poliklinik für Dermatologie, Venerologie und Allergologie, Universitätsklinikum Leipzig, Leipzig, Germany
³Hautarztpraxis, Berlin, Germany
⁴Labor für Medizinische Mikrobiologie, Partnerschaft Prof. P. Nenoff und Dr. C. Krüger, Rötha OT Mölbis, Germany
⁵Dermatopathologie Duisburg, Prof. J. Schaller und Dr. C. Hendricks, Duisburg, Germany

Correspondence
Valentina Laura Müller, Klinik für Dermatologie, Allergologie und Phlebologie, Helios Klinikum Duisburg, Duisburg, Germany.
Email: va.mueller@gmx.de

Present address
Korina Kappa-Markovi, Privatpraxis Dr. Hilton und Partner, Düsseldorf, Germany
Dimitrios Georgas, Dyaderm, Dermatologie und Ästhetik Düsseldorf, Düsseldorf, Germany

Abstract

**Background:** Tinea capitis is a highly contagious infectious disease caused by dermatophytes. In Central Europe, it is mainly caused by zoophilic dermatophytes, as, for example *Microsporum (M) canis* or *Trichophyton (T) mentagrophytes* and increasingly by anthropophilic fungi. *T tonsurans* was commonly related to the Tinea gladiatorum, where transmission occurred between infected persons or via contaminated floors.

**Objective:** Reporting the transmission of this highly contagious dermatophyte for the first time via beard shaving and hairdressing in barber shops in Germany.

**Patients and methods:** 18 young male patients developed tinea capitis and/or barbae shortly after shavings of the beard and/or hair in a barber shop. Native, cultural and molecular diagnostics as well as tissue biopsies and resistance tests were performed of skin and hair samples.

**Results:** In all samples, *T tonsurans* could be identified. The medical history and the clinical picture suggest a transmission through contaminated hairdressing tools. The patients were treated with terbinafine or itraconazole in combination with or exclusively with topical antimycotics.

**Conclusion:** The transmission and a resulting increase in the incidence of infections with *T tonsurans* may be due to shavings with direct skin contact of insufficiently disinfected hairdressing tools. This path of infection has already been observed in Africa and is now being described for the first time in Germany. Knowledge of the pathogen and its transmission ways are essential to interrupt the chain of infection.

**KEYWORDS**
barber shop, dermatophyte carriage, dermatophytosis, infection chain, tinea barbae, tinea capitis
1 | INTRODUCTION

Infections with the anthropophilic dermatophyte *Trichophyton* (*T*) *tonsurans* have been described worldwide, mainly in the context of martial arts and other contact sports which require proximity between the athletes. Here, the pathogen regularly triggers local and supra-regional outbreaks of tinea corporis in sports clubs but also during competitions, which is why the disease caused by this dermatophyte is also called ‘Tinea gladiatorum’.2,3 Originally, *T tonsurans* was native to South East Asia and Australia. In the colonial period, it expanded to Central and South America, and from there, through both migration and international combat sports competitions, to Europe and the United States.4 In the USA, Iran and Turkey, the prevalence of the ‘Tinea gladiatorum’ among wrestlers varies from 2.4% to 90.62% (average 34.29%).5 As a trigger of tinea capitis, *T tonsurans* initially played a rather minor role in Europe, while in the USA, the Caribbean and, later, also in Great Britain, the pathogen has become the main cause of tinea capitis in children.6,7

During the last decades, a decrease of the formerly prevalent pathogens *Microsporum* (*M*) *canis* and *M audouinii* in favour of *T tonsurans* was observed in Central Europe. An increase in infections with *T tonsurans* has been described, particularly in patients with a West African migration background, although *T tonsurans* is not the predominant cause of tinea capitis in West Africa.5 This led to the assumption that an infection must have taken place outside the home countries.

However, it is still not conclusively clarified, why the overall prevalence of *T tonsurans* is increasing. One reason could be the therapeutic possibilities. As griseofulvin is the only approved systemic antifungal drug in childhood, it is commonly used to treat all forms of tinea capitis. Nevertheless, griseofulvin is more efficient in the treatment of infections with *Microsporum* species than *Trichophyton* species. It is possible that consequently an inadequate therapy led to the spread of *T tonsurans*. In addition, the niche could be occupied by the decreasing number of *Microsporum* species. To what extent mutations of the pathogen with increased virulence are present is yet to be proven.8,9

The present work describes a new route of infection in our regions by a possible transmission of *T tonsurans* through contaminated hair cutting tools. Shaving with high potential for microtrauma could serve as an entry for the pathogen and, if the equipment is contaminated, could lead to an increased incidence of tinea capitis or barbae. Next to an accurate diagnostic and therapy, the detection of the mode of infection and the interruption of the chain of infection are therefore of great importance.

2 | PATIENTS AND METHODS

2.1 | Patients

The observation period was 2 years, from April 2018 to April 2020. The study was conducted in accordance with the Helsinki Declaration; patient-relevant diagnostics and therapy strictly followed the current guidelines. The authors confirm that the ethical policies of the journal, as noted on the journal’s author guidelines page, have been adhered to.

In this period, 18 young, exclusively male patients with tinea capitis/barbae were presented dermatologically. In all cases, the skin lesions aroused a few days to a maximum of 2 weeks after receiving a haircut in a barber shop. The lesions appeared in the shaved/combed regions of the scalp, neck and beard (Figures 1-4). 16 patients were seen in the Clinic for Dermatology in Duisburg, two patients came from Berlin and were diagnosed in a dermatological practice there. The Berlin patients were close friends; one of them reported a visit to the hairdresser’s before the outbreak of the skin lesions. The second patient from Berlin, without a corresponding
haircut, was included in the study to complete the chain of infection. One patient was a Thai boxer in his spare time; there was no wrestler among them. Another patient regularly played football in a sports club. No patient had any relevant previous diseases. None of the patients underwent a systemic, antibiotic or steroid-containing therapy before the first skin lesions appeared. The median age of the cohort was 11.5 years (4–24 years). 15 patients were re-examined after about 2 weeks after initiation of antimycotic therapies. Three patients did not show up for follow-up.

3 | METHODS

3.1 | Morphological detection of the dermatophyte

Microscopic examinations of epilated hair shaft material and removed skin scales were carried out in all patients by preparation using TEAH (Tetraethylammonium hydroxide, Merck, Darmstadt, Germany). In addition, suitable skin biopsies were taken from 4 patients using a punch biopsy. Numerous serial sections were stained using PAS (periodic acid–schiff) reaction.

3.2 | Cultural detection of the dermatophyte

Intra- and perilesional, depilated hair (hair roots) and affected skin scales were taken from all patients for cultural, mycological diagnostics. The pathogens were cultivated on Sabouraud glucose agar containing gentamicin and chloramphenicol (Becton Dickinson, Heidelberg, Germany) and on Mycosel® agar (Becton Dickinson, Heidelberg, Germany).

After sufficient growth of the pathogens, adhesive tape was applied to the respective colonies and the material adhering to it was stained with lactophenol blue on a cover glass. Direct microscopy of the samples was performed.

3.3 | Molecular detection by sequencing the internal transcribed spacer (ITS) region of ribosomal DNA and the gene for the translation elongation factor (TEF) 1 α

In 14 patients, we additionally performed a PCR-ELISA (enzyme immunoassay) from the cultivated dermatophytes as a molecular culture confirmation test. It required sequencing of the internal transcribed spacer (ITS) region of the corresponding dermatophyte deoxyribonucleic acid (DNA) and the ‘Translation Elongation Factor 1 α’ (TEF 1 α) gene. For species identification, the ribosomal DNA with the target regions ITS1, 5.8S rRNA, ITS2 and TEF 1 α gene was examined using universal primers which bind to fungal-typical sequence sections (V9G and LSU 266). Subsequently, a sequence comparison of the respective strain with sequences of type strains stored in databases of the Online Dermatophyte Database of the Westerdijk Fungal Biodiversity Institute and the National Center for Biotechnology Information (NCBI) in Bethesda, Maryland, was carried out.

3.4 | Resistance testing of the dermatophyte

In order to evaluate the therapeutic possibilities of tinea capitis caused by T tonsurans, we carried out an in vitro resistance test for terbinafine on the samples of six randomly selected patients of our cohort. Thereby, we used a recently described modified breakpoint method. We filled Petri dishes with Sabouraud glucose agar, which contained 0.2 μg/ml terbinafine. The growth controls contained only Sabouraud glucose agar without antifungal agent. Each Petri dish was inoculated with three dermatophyte agar cubes of the cultivated...
fungi, each measuring 1 mm². The final evaluation of dermatophyte
growth or inhibition of dermatophyte growth was taken after 7 days.

4 RESULTS

4.1 Morphological detection of the dermatophyte

Hair and skin scales were microscopically examined after incubation
with TEAH. A highly variable number of hyphae were found in the
different samples, which did not correlate with the clinical expres-
sion. All patient samples were positive for fungi.

4.2 Cultural detection and molecular confirmation test of the dermatophyte

All samples showed the growth of flat, whitish colonies with a
granular, peripherally radiating surface after about 11–13 days. The
underside initially appeared yellowish and, as growth progressed,
turned increasingly brownish on Sabouraud agar and deep yellow
on Mycosel agar (Figure 5). Microscopically, numerous microconidia
of variable shape could be detected, which mostly were attached
laterally on the hyphae (Figure 6). Macroconidia and chlamydospores
were present in highly variable numbers. Due to the macroscopic
appearance of the colonies and the microscopic image, the human
pathogenic dermatophyte species *T. tonsurans* could be identified in
all cases.

The PCR-ELISA performed on 14 patients from the culturally cul-
tivated fungi with subsequent sequencing of the internal transcribed
spacer (ITS) region of the fungal DNA confirmed in each case the
infection with *T. tonsurans*.

4.3 Histopathology

Histopathological investigation of representative samples of the
scalp/neck showed clear evidence of fungal hyphae in one of the
patients. An abscessing perifolliculitis with detection of fungal hy-
phae within the hair shafts was found (Figure 7). The second patient
showed a perivascular and perifollicular neutrophilic inflammatory
reaction in the skin biopsy, which was also accompanied by melting
of the hair follicle epithelium. Only after numerous serial PAS slices,
a few septated hyphae could be detected in the area of a melting hair

**FIGURE 5** Cultures of *Trichophyton tonsurans* on Sabouraud Agar (A = bottom side, B = top side) and Mycosel® Agar (C = bottom side, D = top side)
follicle with small hair shaft residues. The third patient showed no hyphae in the tissue sample. However, the perivascular and perifollicular inflammatory reaction resembled a tinea profunda (Figure 7). Patient 4 showed PAS-positive spores and arthrospores in a hair follicle, but no hyphae were found in the present preparation.

### 4.4 Resistance testing

After 7 days, all growth controls showed regular growth. In contrast, no fungal growth was detectable on the agar plates impregnated with terbinafine. The examination showed a completely inhibited growth (breakpoint <0.2 µg/ml) under terbinafine in all 6 cultures, so that an in vitro sensitivity of the *T. tonsurans* isolates to terbinafine can be assumed.

### 4.5 Therapy and progress

After confirmation of the diagnosis of tinea capitis/barbae, oral antifungal therapy with terbinafine 250 mg or weight-adapted with terbinafine 125 mg once per day for at least 28 days was initiated in 15 patients. Supportive local therapy with solution, cream and/or shampoo containing ciclopirox olamine (in two patients additionally containing bifonazole) was provided. The therapy with terbinafine was carried out considering the fact that no systemic, antymycotic therapy in Germany is approved in childhood. The parents were given detailed information about use and side effects of the therapy. Two patients with a low response to terbinafine received subsequent therapy with itraconazole 100 mg for 3 days and then once a week. Three patients only received the above-mentioned topical antymycotic therapy, as they only presented once in our open emergency consultation. We recommended a systemic therapy with terbinafine in case of insufficient improvement under local therapy as well as the diagnostics and treatment of further contact persons. Unfortunately, the patients did not appear for follow-up. Probably the skin lesions already improved under local therapy or they visited another clinic.

All patients were informed about hygienic measures for infection prophylaxis (among other things one-time use of towels, disinfection of commonly used brushes).

The patients showed a moderate response with a decrease in skin lesions 2 weeks after initiation of therapy. All patients undergoing systemic therapy required at least 28 days of treatment until a significant improvement in symptoms could be achieved. In two patients, the skin lesions reappeared after therapy, so that the systemic, antymycotic therapy had to be repeated. These were children of larger families, so that a re-infection through physical contact can be assumed. Four patients already showed a highly inflammatory

FIGURE 6 Microscopic image of *Trichophyton tonsurans*

FIGURE 7 Histopathological findings of tinea capitis. (A) Spongiotic epidermis over abscessed, partly granulomatous inflammatory reaction of the entire corium with melting hair follicles (PAS × 8.7); (B) cross section through a hair follicle with preserved hair shaft interspersed with PAS-positive fungal elements (PAS × 25.8); (C) endothrix growth of PAS-positive septate hyphae (PAS × 77.2); (D) Cystic dilated hair follicle with pronounced perifollicular abscessing and granulomatous inflammatory reaction, perifollicular fibrosis and sinking hair follicles (HE × 11.3); (E) Remains of a hair shaft with PAS-positive septated hyphae centrally located in an epithelioid cell granuloma
course with superinfection of the lesions when visiting the clinic. Therefore, additional systemic antibiotics, either ampicillin/sulbactam or clindamycin, were prescribed.

One patient required almost 4 months of topical and systemic antifungal treatment. At last, a permanent regression of the foci was achieved, but with residual alopecic areas in form of a pseudopélade Brocq (Figures 3 and 4).

5  |  DISCUSSION

Anamnestically and clinically, the frequent occurrence of tinea capitis during the observation period could be related to shavings and hairdressing in barber shops. In all patients, T. tonsurans could be identified as the cause for the skin lesions. However, it should be taken into account that our patient collective has a relatively small number of cases and only patients with a clear anamnestic connection to a recent haircut were included (except of one patient, who probably developed tinea capitis due to his close contact to his infected friend). The increased incidence was found regionally especially in the region in and around Duisburg, but our Berlin patient also suspected an infection from shaving in a barber shop. Data on the prevalence in other cities are currently pending, but should be taken into account to trace and interrupt the chain of infection.

5.1  |  T. tonsurans in the course of time

As early as 1952, an increasing prevalence of tinea capitis was reported in the USA, whose main cause was considered to be T. tonsurans. In Germany, at that time, the zoophilic dermatophytes caused the majority of tinea capitis. In Southern and Western Europe (among others in England, Belgium and the Netherlands), the number of anthropophilic pathogens had already increased. In 1997, Fuller et al. declared tinea capitis caused by T. tonsurans to be a ‘major health problem’ in South East London. Thus, tinea capitis also gained more importance in Europe. Currently, the number of tinea capitis caused by anthropophilic pathogens is still increasing in Germany due to T. violaceum and T. soudanense and especially T. tonsurans.

As an anthropophilic dermatophyte, T. tonsurans usually triggers a rather low inflammatory reaction in the skin in contrast to zoophilic dermatophytes. However, the dermatophyte may sometimes lead to pustular, purulent abscessing and also hyperkeratotic lesions with the danger of secondary complications such as cicatrization (Figures 3 and 4). In its classic form, the ‘black dots’ tinea capitis, the hair is weakened by the pathogen, breaks off and appears as a black dot on the scalp. However, none of our patients presented this variant. 4 patients presented a rather untypical, highly inflammatory course. The clinical picture was similar to that of a severe folliculitis or impetigo, leading to an increased risk of misdiagnosis and consequently to an inadequate therapy. It is therefore of great importance, especially in ambiguous cases, to carry out a detailed diagnosis, which, in addition to a precise anamnesis, always requires microscopy of the native preparation, the preparation of a culture and, if necessary, the biopsy of a suitable skin lesion.

Microscopically, numerous spores can usually be detected in affected hairs; a so-called endotherix growth pattern is observed, in which an invasion of the hair shaft takes place, making the pathogen almost invisible to wood light. It is interesting to note that in our patients the number of microscopically visible spores did not correlate with the severity of the disease, so that even in pronounced foci on the scalp, sometimes only a few spores could be found.

Histopathological investigation is a helpful diagnostic supplement in special questions, diagnostically challenging and ambiguous cases as well as highly inflammatory courses to find a rapid diagnosis. Essential for the detection of fungi is the skin biopsy, taken from a suitable lesion. Sufficient hair shafts should be embedded in the biopsy so that the endotherix growth of T. tonsurans can be detected. Fresh lesions, where abscessing has not yet melted the entire tissue, are appropriate. Possibly, the removal of an unrepresentative lesion led to a missing detection of hyphae in 2 patients, although clinical and cultural findings were clearly positive for dermatophytes. For the dermatopathologists, the identification of fungal threads is challenging and often requires the help of numerous serial sections in PAS staining.

Usually, the endotherix infection of the hair with T. tonsurans is only slightly immunogenic, so that asymptomatic carriers must often be assumed within families or community institutions. Important places of transmission are kindergartens and schools, since there is close physical contact. Infection of adults is possible through physical contact in families, partnerships or even in sports. The Berlin patient, who had close contact with his friend and did not report of shavings in a barber shop, is likely to have developed tinea capitis due to his direct and close contact to an infected person. The pathogen benefits from its keratinase activity, which enables it to infect both hair and skin.

T. tonsurans is also capable of persisting on inanimate objects (including brushes, towels and pillows) and thereby being transmitted. Asymptomatic carriers display the spores on scalp or body and do not become ill themselves, but can transmit the pathogen. Due to these asymptomatic carriers, there is a risk of small outbreaks in public institutions and also during sports competitions that require close physical contact. Furthermore, only patients with clinical symptoms are treated, even if a large number of patients have a subclinical infection and act as a carrier.

All patients in our cohort were informed about an increased risk of infecting more persons, mainly within their families. Since transmission through physical contact and the use of common hair clippers and towels could not be avoided completely, patients were encouraged to use only their own hygiene products.

5.2  |  Dermatophytes on hair dressing tools

A Stockholm study showed that mostly migrants from West Africa were more likely to be affected by tinea capitis, mainly caused by
The common use of hairdressing tools, mostly combs and razors, was suspected to be a potential way of transmission. In a further study, conducted in a West African suburb, a random sampling of household combs, brushes and hair clippers showed a contamination of more than 70% with the anthropophilic dermatophytes *T. soudanense* and *M. audouinii*. Tinea capitis particularly affected school children in the village. The high prevalence of tinea capitis may also be due to the cultural use of certain hair practices (braiding, use of shared hair rubbers, shared brushes), especially among children. This correlates with the high incidence of the same pathogens within a family. Selective immune tolerance and variable sebum composition are also discussed. On the other hand, Sharma et al did not find a high incidence of *T. tonsurans* when using certain hair practices, so that this way of transmission must be regarded critically and depends on the context.

Many hairdressing salons and households worldwide have not developed a suitable routine for cleaning shared hair clippers or brushes. If dermatophytes were detected on household combs or razors, they could often be diagnosed in the hair of family members, even if the infection did not always lead to a clinically visible disease. Since spores of *Trichophyton* species are quite resistant to environmental influences, inadequate hygiene can lead to transmission of the pathogens even after months. Data on the prevalence in German hairdressing salons and barber shops are not known, but should be collected as a potential transmission route in case of frequent infections.

During hairdressing, the pathogens can penetrate the skin due to the micro-traumas caused by shaving. This danger increases if a spacer comb is not used during shaving and the shaving devices are applied with high pressure on the skin. Interestingly, both hairdressing tools and headrests in hairdressing chairs can be affected, whereas towels, probably by sufficient cleaning in the washing machine (ideally at a minimum of 60°C), are usually much less likely to contain spores.

Soyinka et al also described a path of infection related to hairdressing by the local barber of a village in Nigeria, as *M. audouinii* was detected on the heads of the groomed children as well as on the hairdressing tools. Tinea capitis occurred significantly less frequently in children, who did not receive a haircut. Girls were significantly less likely to develop a tinea capitis, as their hair usually is not shaved with a razor.

Takwale et al described a case report two older ladies who presented with tinea capitis. In the absence of contact with infected persons but with a common hairdresser whom they visited regularly, transmission during hairdressing was suspected.

In our cohort, all patients stated that they visited barber shops regularly. As spores of *T. tonsurans* can survive for several months on inanimate objects, shared hairbrushes and hair clippers can lead to recurrent infections. At this point, it should be emphasised that a detailed anamnesis usually provides important information about a potential origin of the disease.

Three patients reported a common barber, so that we randomly took samples from 2 combs and 3 hair clippers from the respective barber shop for the preparation of a mycological culture. It was not possible to grow a fungus in any culture. The barber told us that he sterilised his hair cutting utensils daily with a suitable device. The barber was also aware of the increased occurrence of fungus on the scalp in recent months. Therefore, he already paid attention to skin lesions, especially when shaving the scalp hair of children, and cleaned his equipment afterwards. Maybe the frequent occurrence of tinea capitis/barbae had thus also been noticed by hairdressers/barbers and hygiene measures had been initiated. We discussed regular disinfection of the devices as well as the signs of a tinea. Due to the high contagiousness, we advised in case of suspicion to recommend customers the dermatological presentation to interrupt the chain of infection. Further random examinations of other hairdressers/barber shops are desirable, but could not be carried out due to the closure of the hairdressers/barber shops in the course of the SARS-CoV-2 pandemic.

### 5.3 Therapy and hygiene

Only griseofulvin is approved for systemic antifungal therapy in children, but since 2018 it has no longer been available in Germany and can only be obtained from international pharmacies. However, only about half of all infections with *T. tonsurans* are successfully treated by the application of griseofulvin. Terbinafine in a weight-adapted dosage is more effective to treat infections with *T. tonsurans*. In our in vitro resistance testing, the growth of the pathogens could be completely inhibited under terbinafine; a terbinafine resistance is not detectable. This is significant regarding the increasing clinical and in vitro terbinafine resistance of Indian *T. mentagrophytes* genotype VIII strains.

It should be noted that the drug has no approval for children in Germany and can only be used in the context of an individual therapeutic trial (‘off label use’) after the parents have been informed accordingly. In order to interrupt the chain of infection, a mycological co-examination of the contact persons is urgently indicated, as well as the initiation of a topical, antifungal therapy in case of asymptomatic carriers of the fungus. In addition, adequate and consistent hygiene of commonly used hairdressing tools must be ensured.

With an adequate topical and systemic antifungal therapy, kindergarten or school attendance can take place again after about 1 week of treatment.

For washable textiles, it is usually sufficient to clean them at 60°C with commercially available all-purpose detergent. In a study by Ossowski et al., textiles contaminated with *T. rubrum*, *T. mentagrophytes*, *Candida (C) albicans* and *Scopulariopsis (S) brevicaulis* were safely decontaminated by this measure. Suitable disinfectants are available for cleaning razors and brushes, which should be used in hairdressing salons. As certain dermatophytes, as, for example *T. mentagrophytes*, are distinctly resistant to the environment and can survive for 3 months and longer under certain conditions, disinfection of used haircutting tools should become a daily routine.

It is not yet clear why the incidence of *T. tonsurans* has increased so rapidly in Europe in recent years and decades. It is assumed that
the pathogen can easily pass from one organism to another in close communities. Since asymptomatic carriers only become negative after approximately 2–12 months, the question is whether they should receive additional therapy to interrupt the chain of infection. Since tinea capitis is considered to be the most infectious form of all tinea diseases, T. tonsurans is to be classified as an ‘emerging pathogen’ due to the increasing incidence of this dermatophytosis in Europe.

6 | CONCLUSION

In our study, the affected young men and children showed clear anamnestic correlations with intensive shaving in barber shops, where the hair or beard was strongly shortened with a razor. The primary lesions were all located in the shaved areas of the scalp, the neck and the beard. The rest of the body was not affected, or only in the course of the disease.

According to our knowledge, the infection with T. tonsurans as a cause of tinea capitis has occurred for the first time in Germany after shaving in barbershops and should urgently be considered as a new path of transmission. The information of appropriate barber shops, the use of caps on hairdressing tools and sufficient disinfection are simple ways to prevent further spread.

ACKNOWLEDGEMENTS

This research received no specific grant from any funding agency in the public, commercial or not-for-profit-sectors.

CONFLICT OF INTEREST

Valentina Müller, Korina Kappa-Markovi, Julia Hyun, Dimitrios Georgas, Gabriel Silberfarb, Uwe Paasch, Silke Uhrläß and Jörg Schaller have nothing to disclose. Pietro Nenoff reports grants from Almirall Hermal, Beiersorf, Galderma and MSD outside of the submitted work. He is a member of the advisory board of Galderma.

AUTHOR CONTRIBUTIONS

Valentina Laura Müller: Conceptualization (equal); data curation (lead); formal analysis (equal); investigation (equal); methodology (equal); project administration (equal); supervision (equal); visualization (equal); writing-review & editing (equal). Korina Kappa-Markovi: Conceptualization (equal); investigation (equal); visualization (equal); writing-review & editing (equal). Julia Hyun: Conceptualization (equal); investigation (equal); supervision (supporting). Dimitrios Georgas: Conceptualization (equal); writing-review & editing (equal). Gabriel Silberfarb: Investigation (equal). Uwe Paasch: Funding acquisition (equal); project administration (equal); writing-review & editing (equal). Silke Uhrläß: Investigation (equal); methodology (equal); software (equal); validation (equal); visualization (equal). Pietro Nenoff: Conceptualization (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); supervision (equal); visualization (equal); writing-review & editing (equal).

Jörg Schaller: Conceptualization (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); supervision (equal); visualization (equal); writing-review & editing (equal).

ORCID

Valentina Laura Müller https://orcid.org/0000-0002-4990-3345
Pietro Nenoff https://orcid.org/0000-0002-6380-0529

REFERENCES

1. Kermani F, Moosazadeh M, Hedayati MT, et al. Molecular epidemiology of Tinea gladiatorum in contact sports in northern Iran. Mycoses. 2020;63(5):509-516.
2. Ziegler W, Lempert S, Goebeler M, Kolb-Mäurer A. Tinea capitis: Erregerspektrum und Epidemiologie im zeitlichen Wandel. J Dtsch Dermatol Ges. 2016;14(8):818-826.
3. Sakata Y, Ushigami T, Anzawa K, Mochizuki T. Molecular epidemiology of Trichophyton tonsurans, the causative dermatophyte of the tinea gladiatorum epidemic in Japan between 2011 and 2015. Jpn J Infect Dis. 2018;71:140-144.
4. Hiruma J, Ogawa Y, Hiruma M. Trichophyton tonsurans infections in Japan: epidemiology, clinical features, diagnosis and infection control. J Dermatol. 2015;42(3):245-249.
5. Kermani F, Moosazadeh M, Hosseini SA, et al. Tinea gladiatorum and dermatophyte contamination among wrestlers and in wrestling halls: a systematic review and meta-analysis. Curr Microbiol. 2020;77:602-611.
6. Abdel-Rahman SM, Farrand N, Schuenemann E, et al. The prevalence of infections with Trichophyton tonsurans in schoolchildren: the CAPITIS study. Pediatrics. 2010;125(5):966-973.
7. Fuller LC, Barton RC, Mohd Mustapa MF, et al. British Association of Dermatologists’ guidelines for the management of tinea capitis 2014. Br J Dermatol. 2014;171:454-463.
8. Gits-Muselli M, Benderdouche M, Hamane S, et al. Continuous increase of Trichophyton tonsurans as a cause of tinea capitis in the urban area of Paris, France: a 5-year-long study. Med Mycol. 2017;55(5):476-484.
9. Gupta AK, Mays RR, Versteeg SG, et al. Tinea capitis in children: a systematic review of management. J Eur Acad Dermatol Venereol. 2018;32(12):2264-2274.
10. Winter I, Uhrläß S, Krüger C, et al. Molekularbiologischer DirektNachweis von Dermatophyten im klinischen Material bei Verdacht auf Onychomykose und Tinea pedis - Eine prospektive Studie zum Vergleich konventioneller dermatomykologischer Diagnostik und der Polymerasekettenreaktion. Der Hautarzt. 2013;64:283-289.
11. Nenoff P, Krüger C, Schulze I, et al. Tinea capitis und Onychomykose durch Trichophyton soudanense – Erfolgreiche Behandlung mit Fluconazol – Literaturübersicht. Der Hautarzt. 2018;69(9):737-750.
12. Yamada T, Maeda M, Alshahni MM, et al. Terbinafine resistance of Trichophyton clinical isolates caused by specific point mutations in the squalene epoxidase gene. Antimicrob Agents Chemother. 2017;61(7):e00115-e00117.
13. Georg LK. Studies on Trichophyton tonsurans Ringworm – a new public health problem. Public Health Rep. 1952;67(1):53-56.
14. Tietz HJ, Czaika V, Ulbricht HM, Sterry W. Tinea capitis in Germany. A survey in 1998. Mycoses. 1999;42(Suppl. 2):73-76.
15. Fuller LC, Child FC, Higgins EM. Tinea capitis in south-east London: an outbreak of Trichophyton tonsurans infection. Br J Dermatol. 1997;136(1):139.
16. Ginter-Hanselmayr G, Wager W, Ilkit M, Smolle J. Epidemiology of tinea capitis in Europe: current state and changing patterns. Mycoses. 2007;50(Suppl. 2):6-13.
17. Nenoff P, Reinel D, Krüger C, et al. Tropen- und Reise-assoziierte Dermatomykosen. Teil 1: Dermatophytosen. Der Hautarzt. 2015;66:448-458.
18. Rudolph AH. The diagnosis and treatment of tinea capitis due to *Trichophyton tonsurans*. *Int J Dermatol*. 1985;24(7):426-431.
19. Stein LL, Adams EG, Holcomb KZ. Inflammatory tinea capitis mimicking dissecting cellulitis in a postpubertal male: a case report and review of the literature. *Mycoses*. 2013;56(5):596-600.
20. Mayser P, Nenoff P, Reinel D, et al. S1-Leitlinie Tinea capitis. *J Dtsch Dermatol Ges*. 2020;18:161-180.
21. Yo A, Yamamoto M, Nakayama T, et al. Detection and identification of *Trichophyton tonsurans* from clinical isolates and hairbrush samples by loop-mediated isothermal amplification system. *J Dermatol*. 2016;43(9):1037-1043.
22. Mayser P. Tinea capitis – diagnostische Maßnahmen in der Ausbruchsituation. *Hautarzt*. 2019;70:594-600.
23. White JML, Higgins EM, Fuller LC. Screening for asymptomatic carriage of *Trichophyton tonsurans* in household contacts of patients with tinea capitis: results of 209 patients from South London. *J Eur Acad Dermatol Venereol*. 2007;21(8):1061-1064.
24. Ilkit M, Ali Saracli M, Kürdak H, et al. Clonal outbreak of *Trichophyton tonsurans* tinea capitis gladiatorum among wrestlers in Adana, Turkey. *Med Mycol*. 2010;48(3):480-485.
25. Hällgren J, Petrini B, Wahlgren CF. Increasing tinea capitis prevalence in Stockholm reflects immigration. *Med Mycol*. 2016;44(2):505-509.
26. Coulibaly O, Thera MA, Pierroux R, Douno OK, Ranque S. High dermatophyte contamination levels in hairdressing salons of a West African suburban community. *Mycoses*. 2015;58(2):65-68.
27. Frieden IJ, Howard R. Tinea capitis: epidemiology, diagnosis, treatment, and control. *J Am Acad Dermatol*. 1994;31(3):542-546.
28. Sharma V, Silverberg NB, Howard R, et al. Do hair care practices affect the acquisition of tinea capitis? *Arch Pediatr Adolesc Med*. 2001;155(7):818-821.
29. Winge MCG, Chryssanthou E, Wahlgren C-F. Combs and hair-trimming tools as reservoirs for dermatophytes in juvenile tinea capitis. *Acta Derm Venereol*. 2009;89(5):536-537.
30. Dvorák J, Hubálek Z, Otčenášek M. Survival of dermatophytes in human skin scales. *Arch Dermatol*. 1986;98(5):540-542.
31. Uslu H, Uyanık M, Ayyıldız A. Mycological examination of the barber’s tools about sources of fungal infections. *Mycoses*. 2008;51:447-450.
32. Soyinka F. Epidemiologic study of dermatophyte infections in Nigeria (clinical survey and laboratory investigations). *Mycopathologia*. 1978;63(2):99-103.
33. Tawkawala A, Agarwal S, Holmes SC, Berth-Jones J. Tinea capitis in two elderly women: transmission at the hairdresser. *Br J Dermatol*. 2001;144(4):898-900.
34. Abdel-Rahman SM, Wright KJ, Navarre HC. Griseofulvin only modestly diminishes persistence of *Trichophyton tonsurans* on the scalp of carriers. *J Pediatr Pharmacol Ther*. 2009;14(2):94-99.
35. Ebert A, Monod M, Salamin K, et al. Alarming India-white phenomenon of antifungal resistance in dermatophytes: a multicenter study. *Mycoses*. 2020;63:717-728.
36. Ossowski B, Duchmann U. Der Einfluß des haushaltsüblichen Waschprozesses auf mykotisch kontaminierte Textilien. *Hautarzt*. 1997;48:397-401.
37. Katoh T. Dermatomycosis and environment. *Jpn J Med Mycol*. 2006;47(2):63-67.
38. Hay RJ, Robles W, Midgley G, Moore MK. Tinea capitis in Europe: new perspective on an old problem. *J Eur Acad Dermatol Venereol*. 2001;15:229-233.
39. Ilkit M, Demirhindih H. Asymptomatic dermatophyte scalp carriage: laboratory diagnosis, epidemiology and management. *Mycopathologia*. 2008;165:61-71.

---

**How to cite this article:** Müller VL, Kappa-Markovi K, Hyun J, et al. Tinea capitis et barbae caused by *Trichophyton tonsurans* – A retrospective cohort study of an infection chain after shavings in barber shops. *Mycoses*. 2021;64:428–436. [https://doi.org/10.1111/myc.13231](https://doi.org/10.1111/myc.13231)