

Etiology of toe-web disease in Al-Ain, United Arab Emirates: bacteriological and mycological studies

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سببيات أمراض وتقرات أصابع القدم في مدينة العين بالإمارات العربية المتحدة: دراسات جرثومية وفطرية
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خلاصة: فحصنا 45 مريضاً بـمَدَح وتقرات أصابع القدم، راجعوا عياده الأمراض الجلدية بمستشفى توأم بمدينة العين في الإمارات العربية المتحدة، وأخذنا منهم عينات للفحص الجرثومي والفطري. وكانت العوامل المُمرضة الرئيسية التي تم استفرادها (عزلها) تنتمي إلى جنس المبيضات (57.7%) وجنس الرشاشيات (28.8%) والزائفة الزنجارية (26.7%)، والقولونيات (24.4%). وقد بلغت نسبة الفطريات الجلدية 4.4% (الشعروية الحمراء). وكان هناك 43 مريضاً (95.5%) تقدموا بتقرن مفرط وتعطن في أصابع القدم والتوترات المصابة. إن عادات المجتمع الإماراتي في الجلوس مترتعين، تؤدي مع مضي الوقت، إلى فرط التقرن المتعطن، نتيجة للضغط، في الأشخاص المفرط ذوي الوزن. وحيث يوجد التقرن المتعطن، تزدهر الجراثيم المتواجدة في البيئة. إن الشعروية الحمراء والشعروية الذقنية نادرة الوجود في بيئة مدينة العين، وربما يفسر ذلك ندرة الفطريات الجلدية في داء مَدَح وتقرات أصابع القدم في العينة التي تمت دراستها.

ABSTRACT We examined and sampled 45 patients with toe-web intertrigo for bacteriological and mycological studies. Prominent isolated pathogens were the genus *Candida* (57.7%), genus *Aspergillus* (28.8%), *Pseudomonas aeruginosa* (26.7%) and coliforms (24.4%). Dermatophytes scored 4.4% (*Trichophyton rubrum*). There were 43 patients (95.5%) who presented with marked hyperkeratosis and maceration of the toe-webs involved. The tradition of the Emirati population of sitting cross-legged may, over time, induce in the toe-webs of overweight individuals a macerated pressure-reaction hyperkeratosis that is colonized by environmental germs. *T. rubrum* and *T. mentagrophytes* are uncommon in the Al-Ain environment and this may explain the rarity of dermatophytes in toe-web intertrigo in our study.

Etiologie de l'intertrigo interorteil à Al-Ain (Emirats arabes unis) : études bactériologiques et mycologiques

RESUME Nous avons examiné 45 patients ayant un intertrigo interorteil et effectué des prélèvements pour des études bactériologiques et mycologiques. Les agents pathogènes isolés importants étaient du genre *Candida* (57,7 %), du genre *Aspergillus* (28,8 %), *Pseudomonas aeruginosa* (26,7 %) et des coliformes (24,4 %). Il y avait 4,4 % de dermatophytes (*Trichophyton rubrum*). Quarante-trois (43) patients (95,5 %) présentaient une hyperkératose marquée avec macération des espaces interorteils. Avec le temps, la tradition des habitants des Emirats de s'asseoir en tailleur peut entraîner une hyperkératose macérée causée par la réaction à la pression dans les espaces interorteils des personnes ayant une surcharge pondérale, avec colonisation par des germes environnementaux. *T. rubrum* et *T. mentagrophytes* sont peu fréquents dans l'environnement d'Al-Ain et ceci peut expliquer la rareté des dermatophytes dans l'intertrigo interorteil dans notre étude.

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Introduction

The cause of interdigital toe-web infections, commonly called "athlete's foot", has been ascribed to dermatophyte fungi. The (generally outer) toe webs involved may present with scaling, erythema, inflammation, maceration, fissuring, erosions, thick hydrated hyperkeratosis, itching and malodour [1-3]. The clinical spectrum of toe-web infections ranges from nearly asymptomatic mild scaling, to dry, erythematosquamous, and wet, macerated, vesicobullous, white and fissured lesions. There may be tender, oozing and oedematous acute forms. Although specific clinical forms may evoke specific responsible agents, e.g. a dermatophyte, *Candida* species or bacterial superinfection [3-5], laboratory work is essential to characterize causative agents. Surveys show that dermatophytes are recovered in less than 50% of cases [1,6-8], and that responsible strains may vary with geographic location and time. For example, a shift from *Trichophyton mentagrophytes* to *T. rubrum* has been observed in the past 30 years in most European countries [9-11]. Moreover, athlete's foot incidence is constantly on the rise in Western countries, and is the commonest dermatophyte infection [4,9].

Environmental factors playing a role in the incidence include the occlusive effect of wearing shoes, socks made of synthetic material inducing excessive sweating, and the sharing of public bathing facilities. Moist conditions and subsequent maceration favour growth of fungi and damage the stratum corneum at the same time. Other predisposing conditions include diabetes mellitus, dystrophy of toes and peripheral vascular disorders [3,10]. Dermatophyte fungi, however, are not the only pathogens found in toe-web intertrigo. Various species

of *Candida* and bacteria, especially Gram-negative, and non-dermatophyte moulds may be discovered from pathologic toe-webs [1,3,4,8,12], and probably play a contributing role in toe-web infection.

Studies in Arabic-speaking countries have shown that toe-web disease is the commonest form of tinea pedis. In most cases, fungal studies have revealed the rarity of dermatophytes and the prominence of *C. albicans* [13,14]. With a view to evaluating the incidence of toe-web infections and their causative agents in a United Arab Emirates (UAE) population, we undertook a survey of patients attending the Dermatology Clinic at Tawam Hospital, Al-Ain, UAE.

Methods

The study, to ascertain whether previous findings on toe-web disease in Arab countries were applicable to the Al-Ain population, was conducted during the second half of 1997, including 3 months of hot and 3 months of cool weather. We recruited 45 patients with complaints of toe-web disease attending the Dermatology Clinic at Tawam Hospital, Al-Ain, UAE. Informed consent was obtained. Patient data recorded included age, sex, type of footwear, and signs and symptoms of the disease. A physical examination included weight and total body mass, toe-web inspection, smell of the toe-web area and other dermatological status of the feet. History of other medical conditions, particularly diabetes and vascular disease, was recorded. Patients who had received antifungal or antibiotic treatment in the previous 3 months were excluded.

Laboratory specimens were obtained from each patient for bacterial and fungal cultures. For the bacteriological culture, a swab was moistened in the transport medium and vigorously rubbed on the affected

toe-web area. This specimen was treated as a wound swab and cultured onto sheep blood agar, cysteine lactose electrolyte-deficient (CLED) agar and Sabouraud agar. The culture plates were incubated at 37° C and read at 24 hours and 48 hours. All significant isolates were identified according to standard laboratory procedures. In the case of mixed growth, if one organism was clearly predominant, a full work-up was performed on the predominant organism only, it being reported as "mixed growth with predominant growth of...".

A limited identification work-up was performed in the presence of coagulase-negative staphylococci, diphtheroids (an uncommon finding), viridans group streptococci and *Bacillus* species that were reported as normal skin flora (NSF).

Skin scrapings, obtained by curetting of the affected webs, were used for mycological study. For technical reasons, potassium hydroxide preparation was not performed in all patients. Sabouraud dextrose agar (SDA) was used for all specimens. SDA with 0.005% chloramphenicol to inhibit bacterial contamination and 0.05% cycloheximide to inhibit contaminating fungi was used for selective isolation of dermatophytes (Mycosel agar). SDA without cycloheximide was also used to grow non-dermatophyte fungi that are commonly considered saprophytes or contaminants but that can act as opportunistic pathogens. Potato dextrose agar was used to promote conidiation/sporulation in some cases. With the aid of a straight needle, small fragments of skin were placed on the surface of the agar in Petri dishes containing 40 mL of culture medium and pressed onto the surface to make a good contact. The samples were adjusted in four different areas on each Petri dish, or at least in two spots in the

case of a scanty sample. Petri dishes were surrounded by paraffin seal to prevent dehydration and incubated at 30 °C for 4 weeks before being considered negative for fungus. Media were examined every 3–4 days for growth of fungus. Plates overgrown with contaminants growing from Petri dish edges were eliminated. Media were examined macroscopically and, when applicable, the texture and surface colour of the colony, as well as any pigment diffusing into the medium, were carefully noted. The colour of the reverse of the colony was also recorded. An adhesive tape strip was applied onto the surface of the colony, then mounted in a drop of lactophenol cotton blue stain. The microscopic features were then examined directly through the back of the tape. Standard germ tube test was used for identification of *C. albicans*. Biochemical procedures were used to further identify *Candida* species. Moulds forming at least two colonies on two separate plates were fully identified.

Data were entered and processed using SPSS. Data are expressed as mean and standard deviation unless otherwise stated. The Student *t*-test was used to ascertain the significance of differences between mean values of two continuous variables, and the Mann-Whitney test was used for non-parametric distribution. Chi-squared analysis was applied to test for differences in proportions of categorical variables between two or more groups. In 2 × 2 tables, the Fisher exact test (two-tailed) was used instead of the chi-squared, in particular when sample size was small. One-way analysis of variance (ANOVA) was employed for comparison of several group means and to determine the presence of significant differences between group means. Multiple regression analysis was



Figure 1 Toe-web intertrigo: macerated hyperkeratosis. The blue colour is due to the presence of *Pseudomonas aeruginosa*.

used to ascertain the best predictor of the diagnosis as a dependant variable. $P < 0.05$ was considered significant.

Results

The 45 patients (24 male, 21 female) were UAE nationals living in the Al-Ain area of Abu Dhabi. Mean age of patients was 45.76 ± 18.07 years (range: 15–87 years) and mean duration of disease was 5.62 ± 3.87 years. Mean body mass index (BMI) was 28.73 ± 5.40 kg/m² (range: 17.99–40.57 kg/m²), i.e. the group was in the overweight category (26 kg/m² < BMI < 30 kg/m²), which is in line with anecdotal ob-

servations on the UAE population at large. There were 13 patients (28.9%) (4 males, 9 females) with well-controlled type 2 diabetes mellitus, which is in accordance with the incidence of type 2 diabetes mellitus in the general UAE population [15]. No patient had advanced peripheral vascular or cardiac disease, venous stasis or leg ulcer. Female patients were housewives, except for two students; men had various occupations. Only 4 male and the 2 female patients wore shoes on a regular basis (during working hours). The rest of the time they wore sandals, as does most of the UAE population all year round. There were 33 patients who had been

Table 1 Results of bacteriology studies of toe-web disease

Species	No. of isolates	Prevalence (%) in the studied sample (n = 45)
<i>Pseudomonas aeruginosa</i>	12	26.7
Mixed growth with predominant coliforms	11	24.4
<i>Klebsiella pneumoniae</i>	4	8.9
β -haemolytic streptococcus	3	6.7
<i>Citrobacter</i>	2	4.4
<i>Proteus mirabilis</i>	1	2.2
<i>Enterobacter agglomerans</i>	1	2.2
<i>Serratia</i> spp.	1	2.2
<i>Streptomyces</i> spp.	1	2.2
Total number of isolates	36	

There were no growth and normal skin flora in 6 and 14 patients respectively. Nine different bacterial species were isolated. There were 1 isolate in 18 patients, 2 isolates in 4 patients, 3 isolates in 2 patients and 4 isolates in 1 patient.

treated with various topical antifungals more than 3 months prior to recruitment. These treatments had been unsuccessful or of limited value. In all, 13 patients (9 males, 4 females) had only one foot involved (right foot: 5 patients; left foot: 8). In all patients, a fourth toe-web was always involved. A third web was also involved in 25 patients and in that group, 8 patients also had involvement of a second toe-web.

Marked macerated hyperkeratosis of the involved toe clefts was found in 43 patients (95.5%). The colour of the macerated lesions was bluish-green (Figure

1) in 5 patients, and white in the other 38. No patient presented with erythema, inflammation or noticeable foul smell. Most of the time, the lesions induced a moderate discomfort only.

Mycological and bacteriological studies were available in all patients. Results are summarized in Tables 1–3.

There were 7 patients (6 males, 1 female) with no fungal growth, and in two of the men with no fungal growth there was no bacterial growth. In the 5 patients with

Table 2 Results of fungal studies in toe-web disease

Species	No. of isolates	Prevalence (%) in the studied sample (n = 45)
<i>Trichophyton rubrum</i>	2	4.4
<i>Candida albicans</i>	15	33.3
<i>Candida</i> spp.	10	22.2
<i>C. krusei</i>	1	2.2
<i>Aspergillus niger</i>	11	24.4
<i>Fusarium</i> spp.	5	11.1
<i>A. flavus</i>	2	4.4
<i>Acremonium</i> spp.	1	2.2
<i>Alternaria</i> spp.	1	2.2
<i>Aspergillus</i> spp.	1	2.2
<i>Bipolaris</i>	1	2.2
<i>Cladosporium</i> spp.	1	2.2
<i>Cryptococcus laurenti</i>	1	2.2
<i>Penicillium</i> spp.	1	2.2
<i>Saccharomyces cerevisiae</i>	1	2.2
<i>Trichosporon cutaneum</i>	1	2.2
Total number of isolates	55	

A total of 38 patients had a positive fungal culture and 16 different fungal species were isolated. There were 1 isolate in 24 patients, 2 isolates in 11 patients and 3 isolates in 3 patients.

Table 3 Association of isolates

Results	No. of patients (n = 45)	%
Positive mycology and negative bacteriology (or normal flora)	18	40.0
Positive bacteriology and NFG	5	11.1
Negative bacteriology (or normal flora) and NFG	2	4.4
Positive bacteriology and positive mycology	20	44.4

NFG = no fungal growth.

bluish-green hue in the toe clefts, *Pseudomonas aeruginosa* growth was observed. *P. aeruginosa* also grew in 7 patients with white macerated hyperkeratosis. A dermatophyte (*T. rubrum*) was found in 2 men only, who also presented with toenail onychomycosis due to the same fungus. A 44-year-old clerk had non-macerated scaly toe clefts, and a 46-year-old policeman, bluish macerated hyperkeratosis, from which *P. aeruginosa* also grew. There were 13 patients (28.9%) (7 males, 6 females) who also presented with other lesions of fungal origin: lesions of fingernails with paronychia in 8 patients (4 males, 4 females); tinea cruris incognito in 1 man; tinea versicolour in 1 woman; dystrophic toenails in both men with *T. rubrum*; and intertrigo due to *C. albicans* in the third right finger-web of 1 woman.

Yeasts were more frequently found in female than male patients ($P < 0.004$). We performed multiple logistic regression analysis to determine the best predictor of toe-web disease. None of the independent variables (sex, age, BMI, footwear, diabetes mellitus) contributed significantly as a predictor.

Discussion

Our survey disclosed that dermatophytes were rarely isolated (4.4%) from pathologic toe-webs in the study population. Conversely, yeasts of the genus *Candida* (57.7%), bacteria such as *P. aeruginosa* (26.7%), and coliforms (24.4%) were the predominant pathogens isolated in the patients. Diabetes mellitus and peripheral vascular disorders did not influence the results. Incidentally, varicose veins and venous stasis ulcer are not a morbid feature of the UAE population.

We reviewed the results of fungal cultures of toe-web scrapings obtained from Tawam Hospital employees and their dependants during the year 1998. This sample consisted of various non-UAE nationalities who had in common the wearing of socks and shoes instead of sandals. We sampled 14 females and 16 males. We found a dermatophyte in 9 females and 5 males: 5 with *T. rubrum*; 8 with *T. mentagrophytes* var. interdigitale, 8; and 1 with *T. tonsurans*. In this sample of healthcare providers, many had already used self-prescribed topical antifungals.

The UAE patients we studied had several common characteristics. Most wore sandals without socks all year round. Certain occupations (police, military) required that some patients wore shoes during the course of their work, but they resumed the bare feet/sandals custom as soon as possible afterwards.

As Muslims, UAE nationals pray five times per day. Each prayer is preceded by ritual ablutions that include washing of the feet. Generally the feet are left to dry on their own, hence the risk of residual wetness in the toe-webs. It is a custom in the UAE to sit cross-legged on a carpet or sofa, the outer aspects of the feet and ankles

bearing the body weight. That position induces the "closure" of the fourth, and even of the third, toe clefts, which after many years may lead in some people to the development of hyperkeratosis as a reaction to mechanical pressure. Overweight, resulting in stubby toes in most patients, is possibly an additional aggravating factor. Consequently hydrated hyperkeratosis in the fourth and third toe clefts may be present in some individuals.

Another characteristic of the UAE study population was the rarity of dermatophyte infections with the exception of tinea capitis in children, mostly due to *Microsporon canis* [16]. We have demonstrated that, in the UAE, onychomycosis affects mostly fingernails and is most often due to the genus *Candida* [17]. The rarity of "moccasin" tinea pedis and of tinea cruris, especially in the Al-Ain population, is possibly related to the traditional UAE dress, consisting of a large cotton robe and sandals. There is, of course, the climate itself, which is one of the driest and hottest in the world. In the past 20 years, however, there has been intense afforestation and cultivation of plants, and the once nomadic population is now living in modern air-conditioned accommodation.

To explain why, worldwide, dermatophytes have been recovered in less than 50% of patients with pathologic toe-webs, it has been postulated that the presence of bacteria and yeasts in toe-webs is a secondary phenomenon. Primary involvement by dermatophytes is always required to initiate the process, by damaging the stratum corneum. Subsequently, because of the antifungal properties of some bacteria, dermatophytes are unable to be cultured [2,6,11]. However, previous studies in other countries that share some of the UAE population's characteristics, have shown a prevalence of bacteria and *Candida* spp. over dermatophytes [13, 14,18]. A similar spectrum in toe-web intertrigo has been reported in a Muslim population living in France [19].

We suggest that, in our study population, toe-web disease is primarily a disorder related to pressure hyperkeratosis with hydration that is colonized by various germs present in the environment. The dermatophytes *T. rubrum* and *T. mentagrophytes*, most often involved in toe-cleft infection in Western countries, are not present in the Al-Ain environment.

References

1. Kates SG et al. Microbial ecology of interdigital infections of toe web spaces. *Journal of the American Academy of Dermatology*, 1990, 22:578-82.
2. Leyden JJ, Aly R. Tinea pedis. *Seminars in dermatology*, 1993, 12:280-4.
3. Grigoriu D, Delacrétaz J, Borelli D. *Medical mycology*. Roche, Basel, Switzerland, 1987:98, 103, 125, 132, 219.
4. Hay RJ, Roberts SOB, Mackenzie DWR. Mycology. In: Champion RH, Burton JL, Ebling FJG, eds. *Rook, Wilkinson, Ebling textbook of dermatology*, 5th ed. Oxford, Blackwell Scientific Publications, 1992: 1155, 1186.
5. Beurey J, Weber M, Percebois G. Etude clinique et mycologique des intertrigos des pieds. [Clinical and mycological study

- of intertrigo of the feet.] *Phlébologie*, 1969, 22(1):73-9.
6. Leyden JL. Tinea pedis pathophysiology and treatment. *Journal of the American Academy of Dermatology*, 1994, 31: S31-3.
 7. Noble WC et al. Toeweb as a source of Gram-negative bacilli. *Journal of hospital infection*, 1986, 8:248-56.
 8. Hope YM et al. Foot infection in coal miners: a reassessment. *British journal of dermatology*, 1985, 112:405-13.
 9. Svejgaard EL. Epidemiology of dermatophytes in Europe. *International journal of dermatology*, 1995, 34:525-8.
 10. Macura AB. Dermatophytes, pathogens or saprophytes. *International journal of dermatology*, 1995, 34:529-30.
 11. Aly R. Ecology and epidemiology of dermatophyte infections. *Journal of the American Academy of Dermatology*, 1994, 31:S21-5.
 12. Noble WC et al. Bacteria and fungi in severe foot infection. *Acta dermato-venereologica*, 1983, 63:158-60.
 13. Abd-Allah MA et al. Clinical and mycological study of the macerated toe web in Egypt. *Mykosen*, 1971, 14:83-8.
 14. Al-Sogair SM, Moawad MK, Al-Humaidan YM. Fungal infection as a cause of skin disease in the eastern province of Saudi Arabia: tinea pedis and tinea manuum. *Mycoses*, 1991, 34:339-44.
 15. El-Mugamer IT et al. Diabetes, obesity and hypertension in urban and rural people of Bedouin origin in the United Arab Emirates. *Journal of tropical medicine and hygiene*, 1995, 98:407-15.
 16. Lestringant GG, Qayed KI, Blayney B. Tinea capitis in the United Arab Emirates. *International journal of dermatology*, 1991, 30:127-9.
 17. Nsanze H et al. Aetiology of onychomycosis in Al Ain, United Arab Emirates. *Mycoses*, 1995, 38:421-4.
 18. Talwar P et al. Prevalence of bacteria and fungi in athlete's foot of varying severity and response to topical and antifungal therapies. *Sabouraudia*, 1985, 23:303-12.
 19. Chevallier J. Intertrigo hyperkératósique blanchâtre des pieds des musulmans. [Whitish hyperkeratotic intertrigo in the feet of Muslims.] *Nouvelles dermatologiques*, 1997, 16:132.