Clinical and Laboratory Findings in Trauma-Induced Nail Dystrophy versus Onychomycosis

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ABSTRACT

Objective: The study aims to investigate prevalence, clinical characteristics, and laboratory findings of traumatic toenails in comparison with those of onychomycosis.

Methods: This cross-sectional study included hallux valgus (HV) patients attending Foot Clinic. Descriptive statistics, Chi-square test, Student's t-test and Mann-Whitney U test were used in statistical analysis.

Results: A total of 81 patients with a mean age of 65 years old, of which 77 were females (95.1%), were enrolled. The prevalence of onychomycosis was 25.9%, whereas that of trauma-induced nail dystrophy was 55.6%. There were 18 (22.2%) patients with fungal feet infection. Among 21 patients with nail infections, three had subclinical presentation. Fifteen patients (71.4%) with onychomycosis were infected with dermatophytes (DMPs). The others were caused by nondermatophytes (NDMs), of which 14.2% were *Neoscytalidium dimidiatum*. Comparing with traumatic nail, statistical analysis revealed HV angle of greater than 30 degrees and the presence of fungal foot infection to be significantly associated with onychomycosis ($p=.011$ and $p<.001$, respectively).

Conclusion: One-fourth of HV patients had onychomycosis. Severe foot deformities and concomitant fungal foot infection were significantly associated with onychomycosis. Holistic foot and nail examination is essential for distinguishing onychomycosis and traumatic induced nail dystrophy. Subclinical presentation was common.

Keywords: Onychomycosis; trauma-induced nail dystrophy; fungal foot infection; dermatophytosis; hallux valgus (Siriraj Med J 2018;70: 490-495)

INTRODUCTION

Trauma-induced changes in toenail units have been described in many previous reports.[1-7] The correlation between fungal infection and foot deformities was either lightly discussed or neglected altogether despite reports of foot trauma and deformity being predisposing factors for onychomycosis.[8] Most importantly, onychomycosis and trauma-induced nail dystrophy (traumatic toenail) are difficult to distinguish and may occur concomitantly. Hallux valgus (HV) was the most common foot deformity.[9] Thus, this study aimed to investigate prevalence, clinical characteristics, and laboratory findings relating to nail and foot abnormalities in patients with HV. A comparison between traumatic toenail and onychomycosis was also conducted.

MATERIALS AND METHODS

This was a cross-sectional study. Patients with HV who attended the Foot Clinic, Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University from January 2015 to August 2015 (study period) were included. The protocol for this study was approved

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by the Siriraj Institutional Review Board (Si 676/2014). Patients aged at least 18 years old were enrolled in this study and consent forms were obtained. Patients with underlying diseases known to cause nail abnormality (e.g., psoriasis) were excluded. Demographic data, family history, and predisposing factors for superficial fungal infection and HV were examined. Nail, foot, total skin examination and pedograph were performed by dermatologists and a physiatrist who specialized in foot disorders. Diagnosis and severity grading of hallux valgus were determined by angular deformity.[10] Hallux valgus angle was determined by measuring the relative position between the hallux and first metatarsal (in anthropometric terms) using the line between the most medial point of the heel and forefoot and the longitudinal axis of the big toe from weight bearing foot pressure graph (Fig 1). An angle greater than 14 degrees was interpreted to be hallux valgus, while those with a Staheli arch index of over 0.77 was defined as having flat feet.[11,12]

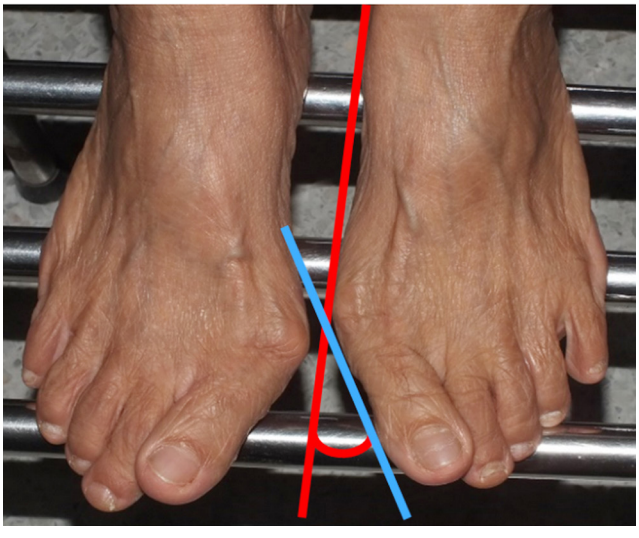

Fig 1. Hallux valgus angle
- Longitudinal axis of the big toe
- Line between the most medial point of the heel and forefoot

All toenails were evaluated for onychomycosis using Scoring Clinical Index for Onychomycosis (SCIO) score, which evaluates: (1) clinical forms of onychomycosis; (2) areas of involvement; (3) thickness of subungual hyperkeratosis; (4) locations of onychomycosis (fingernail or toenail, digit number); and, (5) age of patient. Higher SCIO score indicates increased likelihood of patients being positive for onychomycosis.[13] In each patient, nail sample was obtained from the nail with the highest SCIO score. Regarding foot involvement, specimen was collected from the foot with obvious scaly lesions. If all nails and both feet had a normal appearance, fungal culture and direct examination were performed on the right big toe and the right sole.

All nail and skin specimens were collected for microscopic examination in 20% potassium hydroxide (KOH) solution. For culture, each sample was inoculated in Sabouraud dextrose agar, with and without cyclohexylamine. Cultures were incubated at 27°C and examined every 4 days for 4 weeks. Identification of microorganisms was based on observations and descriptions of macroscopic and microscopic characteristics of colonies.

Diagnostic criteria according to a review by Gupta, *et al.*, were used for nondermatophyte molds (NDMs) onychomycosis diagnosis. Positive diagnosis was made if at least three of the following criteria were met: positive microscopic examination, positive mycological culture, at least two consistent isolations from repeated samplings, dermatophytes (DMPs) exclusion, and histology.[14] Patients with a normal clinical appearance and a positive microscopic examination and mycological culture for DMPs were diagnosed with subclinical presentation.

Statistical analysis

A sample size calculation was performed to determine the minimum requirement of a total sample size to detect the prevalence of fungal nail infection in hallux valgus patients. The prevalence of the infection (15.3%) found in Special Olympics athletes in Jenkins DW *et al.*,[15] was referenced as an anticipated population proportion. A minimum of 78 patients was necessary to provide 95% of confidence level and 0.08 of absolute precision required.

Descriptive statistics were used to describe demographic data, predisposing factors, clinical characteristics, and laboratory investigations. Descriptive data were presented as mean, median, minimum, maximum and percentages. Association between categorical variables was analyzed by v2-test or Fisher's exact test. Continuous variables with and without normal distribution were analyzed by Student's t-test and Mann-Whitney U test, respectively. A p-value ≤ .05 was considered statistically significant. All statistical analysis was performed using PASW for Windows version 18.0 (SPSS, Inc., Chicago, IL, USA).

RESULTS

A total of 81 patients with a mean age of 65 years old, of which 77 were females (95.1%), were enrolled. The prevalence of onychomycosis was 25.9%, whereas that of trauma-induced nail dystrophy was 55.6%. The remaining 15 nail specimens (20.6%) were of normal appearance and with normal fungal laboratory results. Among 21 patients with nail infection, three had subclinical presentation. Neither hematoma nor hemorrhage was

observed in any nails. Comparing with traumatic nail, statistical analysis revealed HV angle of greater than 30 degrees and the presence of fungal foot infection to be significantly associated with onychomycosis (p=.011 and p<.001, respectively). Clinical and laboratory findings were presented in Table 1 and Fig 2.

TABLE 1. Demographic data, predisposing factors for fungal infection and hallux valgus, clinical and laboratory presentations of nails in patients with hallux valgus

Factors	Onychomycosis (n=21)	Traumatic nail (n=45)	*p*-value
Sex; female	21 (100%)	41 (91.1%)	0.901
Mean age (SD; year)	67.4 (9.27)	65.9 (7.59)	0.477
Agricultural work	7 (33.3%)	13 (28.9%)	0.714
Walking barefoot	7 (33.3%)	8 (17.8%)	0.210
Poor circulation	4 (19%)	5 (11.1%)	0.450
Diabetes mellitus	4 (19%)	8 (17.8%)	1
Family history of superficial fungal infection	3 (14.3%)	6 (13.3%)	1
History of pedicure	8 (38.1%)	15 (33.3%)	0.705
Plantar hyperhidrosis	7 (33.3%)	14 (31.1%)	0.857
Family history of HV	9 (42.9%)	25 (55.6%)	0.336
Foot trauma and/or improper shoe	8 (38.1%)	18 (40%)	0.883
Median duration of HV (years)	20 (1,40)	10 (0.8, 75)	0.241
Flat feet	12 (63.2%)	19 (42.2%)	0.126
Overriding toe	11(52.4%)	13 (28.9%)	0.065
Presence of callus	17 (81%)	40 (88.9%)	0.450
Clinical nail characteristics			
Normal appearance	3 (14.35%)	0	-
Nail bed keratosis	14 (66.7%)	28 (62.2%)	0.727
Onycholysis	2 (9.5%)	7 (15.6%)	0.707
Abnormality of nail curvature	11 (52.4%)	22 (48.9%)	0.792
Discoloration	18 (85.7%)	37 (82.2%)	1
Site of toenail:			
Big toenail	8 (38.1%)	23 (51.1%)	0.324
Unilateral involvement	13 (61.9%)	36 (80%)	0.117
SCIO index (mean ± SD)	9.3 (7.69)	9.6 (7.79)	0.860
HV with angle greater than 30 degrees	18 (85.7%)	24 (53.3%)	0.011*
Fungal foot infection	14 (66.7%)	5 (11.1%)	<0.001*

*Statistical significance; p≤.05

Abbreviations: OR = odds ratio; CI = confidence interval; SD = standard deviation; SCIO = Scoring Clinical Index for Onychomycosis

Fig 2. Representative nail images of patients with hallux valgus: (a) dermatophyte onychomycosis; (b) nondermatophyte onychomycosis; (c) traumatic toenail; (d) subclinical onychomycosis.

Of 21 cases with onychomycosis, 15 (71.4%) were infected with DMPs. Ten were *Trichophyton mentagrophytes* and four were *Trichophyton rubrum*. Six nails were infected with nondermatophytes (NDMs), of which three (14.2%) were caused by *Neoscytalidium dimidiatum*.

Regarding investigation of 81 feet, fungal infection was found in 18 (22.2%). For clinical presentation, 15 feet were moccasin-type, one foot was vesicular-type, and one foot was interdigital-type. Subclinical presentation was observed in three feet. Concerning causative agents, 17 (94.5%) were infected with DMPs. Fourteen were *T. mentagrophytes*, two were *T. rubrum*, and one was infected with *N. dimidiatum*.

DISCUSSION

Foot trauma and shoe friction due to asymmetric gait and foot deformity were found to cause toenail changes.[2,4,6,7] Asymmetric gait toenail unit syndrome (AGNUS) was reported to be the most common worldwide toenail abnormality in shoe-wearing societies and may be responsible for 70-73% of abnormal toe nails.[7] Previous studies reported the prevalence of traumatic toenail to be approximately 14.2% in the normal population.[3] Regarding patients with HV in the present study, the prevalence of trauma-induced toenail dystrophy was higher (55.6%) due to the effect of foot deformities. With regard to nail bed keratosis, abnormality of nail curvature, and onycholysis caused by pressure from shoes, these abnormalities usually started from the medial aspect of the nail, with unilateral side involvement then gradually progressing to lateral aspect and bilateral sides. Hemorrhage or hematoma may be found in traumatic onycholysis.[1,3,4] However, in this study, neither hemorrhage nor hematoma was observed in patients with HV. Early recognition of traumatic toenail is essential for avoiding or minimizing nail abnormalities.

Foot and nail traumas and/or deformities were found to be important predisposing factors for onychomycosis.[6,8] Onychomycosis and traumatic toenails are often not clinically distinguishable. Nail bed keratosis, onycholysis, and abnormality of nail curvature can be found in both conditions. Furthermore, onychomycosis and traumatic toenail may occur concomitantly.[1] In the present study, there were two clinical characteristics that were significantly related to onychomycosis. First, the presence of fungal foot infection was meaningfully associated with onychomycosis. Many previous studies have supported association between fungal foot infection and onychomycosis. The spread of infection to adjacent tissues should raise awareness of the need for whole skin examination in patients with fungal infection.[3,6,14,16,17] Second, HV angle of greater than 30 degrees was associated with fungal infection. Patients with severe hallux valgus typically presented with overriding toes, particularly the first and second toes. In patients with overriding toes, fungal infection was normally observed in the moist inter-web spaces. These clinical findings may help clinicians identify patients potentially prone to fungal infection. However, mycological laboratory investigation was required for a definite diagnosis, and decisions regarding antifungal therapy, and evaluation of mycological cure. Correction of the deformity will be helpful to reduce risk of infection. While patients are waiting for a surgical correction, treatment for superficial fungal infection is beneficial to prevent widespread infection and superimposed bacterial infections.

Notably, a normal appearance did not indicate that the patient was free of fungal infection. Subclinical infection was frequently found. Previous studies reported 17.0% and 1.5% of population with and without tinea pedis had subclinical onychomycosis as proven by nail histology.[16] Similar to this study, the prevalence of subclinical onychomycosis was 14.3%. Among those with foot infection, 16.7% also had subclinical foot infection. Subclinical infection was important for detecting reservoir of fungus that could lead to spread of infection to adjacent skin and nail. Subclinical infection can also cause reinfection if treatment is not appropriate. For example, topical antifungal agents that were normally applied to treat tinea pedis did not affect onychomycosis. The use of oral antifungal therapies in patients with recurrent tinea pedis in the treatment of subclinical nail infection requires further study. However, holistic skin and nail examination in patients with tinea pedis or onychomycosis was absolutely necessary. Laboratory investigation should be considered in patients with clinical suspicion of superficial fungal infection.

Nail changes are not always caused by fungus or trauma. Many diseases appear similar to onychomycosis, such as psoriasis and lichen planus. It is advisable to perform laboratory investigation for a definitive diagnosis of fungal infection before initiating any antifungal therapy. Direct examination by KOH preparation and fungal culture remain gold standard methods for diagnosis. Misdiagnosed onychomycosis may lead to unnecessary use of systemic antifungal agents, resulting in medication-related side effects and no improvement in condition. Patients with onychomycosis may also develop concomitant traumatic toenails. It is for this reason that clinical cure may not look completely normal, even though the patient received effective antifungal therapy.[1,2] Once again, mycological examination played a critical role in evaluating mycological cure and completion of treatment.

Regarding NDMs infection in traumatic toenails, colonization or true pathogen is still under debate. NDMs onychomycosis in this study was diagnosed according to a minimum of three of the following criteria: positive microscopic examination, positive mycological culture, at least two consistent isolations from repeated samplings, and DMPs exclusion.[14] Histology was not performed in this study to confirm nail involvement. One third of NDMs onychomycosis patients had foot infection with the same NDMs agents, which may be transmitted from the ground and may serve as a reservoir for spreading infection to nails. Moreover, alteration of toenail unit anatomy caused by onycholysis, nail bed keratosis, and superficial nail plate damage in patients with AGNUS and foot deformities were essential predisposing factors for NDMs onychomycosis.[6] Therefore, NDMs onychomycosis in this study may be the true pathogens. Follow-up clinical and laboratory findings to evaluate improvement after treatment may be another key to determining the true pathogen.

Several limitations were present in this study. First, the majority of patients were female. This may be due to the fact that hallux valgus was found predominantly in female. Moreover, female patients were more concerned about their feet and thus more enthusiastic to participate in the study. Second, this study focused only on patients with HV, which has been the most common foot deformity. Further studies may be conducted with patients with other types of foot deformities and/or those without foot deformities.

CONCLUSION

In conclusion, this study revealed that one-fourth of HV patients had onychomycosis. Severe foot deformities and concomitant fungal foot infection were significantly associated with onychomycosis. Holistic foot and nail examination is essential to distinguish onychomycosis and traumatic induced nail dystrophy. Subclinical presentation was common.

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