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ORIGINAL ARTICLE

A comparative study of onychomycosis and traumatic toenail onychodystrophy dermoscopic patterns

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Abstract

Background Onychomycosis (OM) and traumatic onychodystrophy (OD) are common causes of toenail changes. A clinical diagnosis is often impossible without mycology. Dermoscopy is helpful in this setting but yet underexplored. Prospective comparative studies between OM and OD onychoscopic findings have not been previously performed.

Objectives We sought to determine distinguishing dermoscopic presentations of OM and traumatic OD.

Methods We performed a prospective, observational study including patients presenting with ≥1 toenail onychodystrophy. All underwent onychoscopy, clinical and mycological examination. Based on these results, patients received a final diagnosis of OM or OD. Dermoscopic presentations of OM and OD patients were classified in patterns and compared.

Results In all, 110 cases of OM and 82 of traumatic OD were compared. Statistical analyses revealed that the distal pulverized and the irregular spiked macular dermoscopic patterns were predictors of an OM diagnosis. The regular macular, the non-classifiable, the total and partial homogeneous background dermoscopic patterns correlated with traumatic OD diagnosis.

Conclusions We demonstrated that OM and traumatic OD have distinctive onychoscopic presentations. Dermoscopy may be an important ancillary tool to guide their differential.

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Conflicts of interest

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Introduction

Onychomycosis (OM) and chronic trauma are common causes of toenail dystrophy.[1,2] Traumatic onychodystrophy (OD) usually consists on chronic nail malformations, arising mainly from repetitive exogenous traumatic injuries, and includes several changes on nail morphology, colour and nail plate adhesion, that do not fit the usual clinical features of OM, but may, nevertheless, give the appearance of such a diagnosis. In fact, OM and traumatic OD may share similar symptoms, location and clinical signs, such as subungual hyperkeratosis and onycholysis, hampering the differential diagnosis.

Accurate diagnosis relies on mycological examination with direct microscopy and culture,[2,3] which are time-consuming, have low sensitivity and specificity, and are not widely available.[3,4] Sometimes, a punch biopsy or nail clipping for histology is needed.[3,5]

Since treatment of toenail OM is different from managing traumatic OD, accurate diagnosis is crucial.

Except for melanonychia,[6–14] dermoscopy use in nail disorders is poorly established. However, application of this simple non-invasive tool to improve the diagnostic accuracy of OM should be explored.

Three major onychoscopic features associated with OM have been described: longitudinal striae, 'jagged edge' with spikes and 'ruin appearance'.[1,15–19] Former studies were mostly retrospective, had a small number of cases and lacked a control group.

Here, we compared dermoscopy of OM and traumatic OD to determine distinguishing characteristics and propose a clinical-onychoscopic-based algorithm for their differential.

Materials and methods

Study design

This was an observational, prospective study carried out at the Dermatology Department of Centro Hospitalar Lisboa Central, from April 2016 to October 2016, after approval by the institution's ethics committee. All patients provided consent.

A convenient non-randomized sample was obtained out of outpatient attendees presenting with onychodystrophy of at least one toenail. Criteria for exclusion were having received: topical or systemic antifungals in the past 1 or 12 months, respectively; or a presumed diagnosis of an inflammatory onychopathy (e.g. psoriasis).

A detailed medical history and examination were performed. Toenail signs, foot skin changes (e.g. tinea pedis, calluses) and feet/toe deformities (e.g. hallux valgus, claw toes) were recorded, including photographic documentation of dermoscopy (including nail plate and free edge) with a DermLiteDL4 dermatoscope (3Gen San Juan Capistrano, USA).

Standard mycological examination of subungual scraping specimens, including direct microscopy with KOH 40% and culture, was systematically performed. Histology of nail clippings (including PAS stain) was randomly performed in a limited number of patients, due to economic restrictions.

Table 1 Criteria used to establish onychomycosis (OM) and traumatic onychodystrophy (OD) diagnosis

Onychomycosis diagnosis
• Direct microscopy KOH 40% positive for septate hyphae or yeasts* **and/or** • Culture-positive for dermatophytes or yeasts* **and/or** • PAS-positive showing nail plate invading hyphae†
Traumatic onychodystrophy diagnosis
• Changes in nail morphology, colour or nail plate adhesion caused by injuries directed to the nail matrix, plate, bed and proximal nail fold **and** • Negative fungal examinations (KOH; culture and PAS) **and** • History of exogenous traumatic injury or evidence of chronic microtraumatisms in patients with or without podiatric deformity

*KOH and culture-positive for yeasts were only considered diagnostic criteria for OM if both positive or associated with positive histology and if associated with clinical features consistent with OM diagnosis.

†Isolated yeast forms on PAS were not considered sufficient for OM diagnosis.

The final diagnosis rested on history, physical and mycological testing and therefore labelled as:

1 OM definitive diagnosis (findings confirmed by any fungal test), Table 1;
2 Traumatic OD definitive diagnosis (clinical suspicion supported by negative fungal tests).

All patients with positive fungal tests, independently of having or not a predamaged nail, were included in the OM group.

Analysis of dermoscopy

Patients were examined by two clinicians and clinical and onychoscopic images were analysed by a separate senior nail specialist, blinded to the diagnosis. When changes were present in more than one nail, the single most dystrophic nail was selected for pattern classification. All images obtained were grouped in patterns according to overlapping features. If more than one pattern was present, the predominant was recorded. Finally, dermoscopic patterns were correlated with mycology and final diagnosis.

Statistical analysis

Data are expressed as mean ± SD for continuous variables, and *n* (%) for categorical variables. Associations between dermoscopic patterns and final diagnosis were calculated using chi-square test or Fisher's exact test, when applicable. When an association was verified, the analysis of the standardized residuals was applied to ascertain the trend between dermoscopic patterns and final diagnosis. Odds ratios were calculated using univariate and multivariate logistic regression analysis to understand the influence of a dermoscopic pattern in the final diagnosis (identification of predictors of a diagnosis). Sensitivity and specificity were calculated as the conditional probability of observing a pattern given a diagnosis. Statistical analysis was performed with SPSS-software 23.0, IBM Corp. P values < 0.05 were considered statistically significant.

Results

Demographic and clinical data

Of 205 patients examined for toenail abnormalities, 13 met exclusion criteria: 8 received recent antifungal therapy and five had an inflammatory onychopathy.

The remaining 192 patients were included (99 male; 93 female with a mean age of 59.0 ± 16.0). A diagnosis of OM was demonstrated in 110 patients [49.1% (n = 54) were KOH + culture-positive; 31.8% (n = 35) were KOH + histology-positive; 11.8% (n = 13) were culture + histology-positive and 7.3% (n = 8) had positive histology]. Another 82 were diagnosed as OD (Table 2).

Demographic data including sex and age were not significantly different between the two groups.

Table 2 Final diagnosis and results of mycology: direct microscopy with potassium hydroxide (KOH) 40% and cultural examination.

Mycological results	Onychomycosis *n* = 110, *n* (%)	Onychodystrophy *n* = 82, *n* (%)
Positive direct microscopy KOH 40%	89 (80.9)	0 (0)
Positive fungal culture	67 (60.9) • *T. rubrum 45 (40.9)* • *T. mentagrophytes 9 (8.2)* • *Scopulariopsis brevicaulis 6 (5.5)* • *Candida* spp. *7 (6.4)*	0 (0)
Positive nail clippings histology* (including PAS stain)	53 (51.5)	0 (0)

*Histology of nail clippings was randomly performed in a limited number of patients (*n* = 103).

Patients with OM more frequently showed: concomitant tinea pedis ($P < 0.001$) and worsening of nail changes in the last year ($P < 0.001$). Patients with OD diagnosis more frequently had toenail injury history ($P < 0.001$) and exhibited symmetric nail findings ($P < 0.001$); Table 3.

Dermoscopy patterns

Patterns were classified based on similarity (Fig. 1; Table 4): (i) Irregular macular (IMa) pattern; (ii) Irregular pattern with greyish border; (iii) Focal macular pattern; (iv) Longitudinal line (LL) pattern; (v) Distal pulverized (DP) or distal crumbling pattern;[15,18] (vi) Regular macular or onycholysis pattern; (vii) Distal fine line (DFL) pattern; (viii) Total hazy homogeneous background (THHB); (ix) Partial hazy homogeneous background (PHHB); and (x) Non-classifiable group.

The detailed analysis of each dermoscopic pattern, based on causes, is summarized in Table 4. Among the two groups, all patterns were significantly different, except for the LL, the focal macular and the irregular pattern with greyish border, implying that distinctive characteristics exist among the groups.

Patterns more commonly observed in OM were IMa (53.6%, $n = 59$), DP (13.6%, $n = 15$) and LL (11.8%, $n = 13$). Traumatic OD most commonly showed: onycholysis (22.0%, $n = 18$), THHB (20.7%, $n = 17$), DFL (18.3%, $n = 15$) and PHHB (14.6%, $n = 12$) patterns.

Results of the multivariate analysis showed 2 OM associated patterns: IMa ($P < 0.001$) and DP ($P < 0.001$) patterns. The onycholysis ($P < 0.001$), the THHB ($P < 0.001$), the PHHB ($P < 0.001$) and the non-classifiable ($P < 0.001$) groups were significantly associated with traumatic OD (Table 5). For these dermoscopic patterns, we calculated their sensitivity and specificity for the correspondent diagnosis (Table 5). IMa and DP patterns showed a high specificity (>96%) for OM diagnosis. In contrast, the onycholysis, the THHB, the PHHB and the non-classifiable patterns were more than 95% specific for OD diagnosis.

No statistical association was found for the irregular pattern with greyish border or the focal macular pattern. However, both were exclusively observed in OM, so they may be highly specific, yet uncommon presentations. Similarly, the DFL pattern was present only in traumatic OD, although a statistical association was not supported by the regression analysis.

We did not separately consider a dermoscopic pattern that included solely the presence of haemorrhage although we found that subungual haematoma and splinter haemorrhages were slightly more common in patients with a final diagnosis of OD (18.3% of OD patients vs. 9.1% of OM patients and 8.4% vs. 2.7%, respectively).

Discussion/conclusions

Comparing to previous studies,[1,15–19] our findings were concordant, demonstrating two patterns systematically associated with OM: IMa and DP patterns.[1,15–18] Their presence increased the likelihood for OM diagnosis, by about 43-fold and 33-fold, respectively (Table 5). Although the specificity of both patterns

Table 3 Frequency of demographic and clinical variables in onychomycosis and traumatic onychodystrophy patients

Demographic and clinical characteristics	Onychomycosis *n* = 110, *n* (%)	Onychodystrophy *n* = 82, *n* (%)	*P*-value significantly different*
Mean age	59.6 ± 15.9	57.9 ± 16.2	0.765
Male gender	61 (55.5)	38 (46.3)	0.210
Podiatric deformity (any of hallux valgus or erectus; claw, hammer or mallet toes; calluses)	73 (66.4)	75 (91.5)	<**0.001***
Symmetrical nail changes	25 (22.7)	57 (69.5)	<**0.001***
Tinea pedis	76 (69.1)	15 (18.3)	<**0.001***
History of nail injury*	15 (13.6)	39 (47.6)	<**0.001***
Worsening of nail findings in the last year	92 (83.6)	30 (36.6)	<**0.001***

*Nail injury was defined as a history of perceived/known acute nail injury.

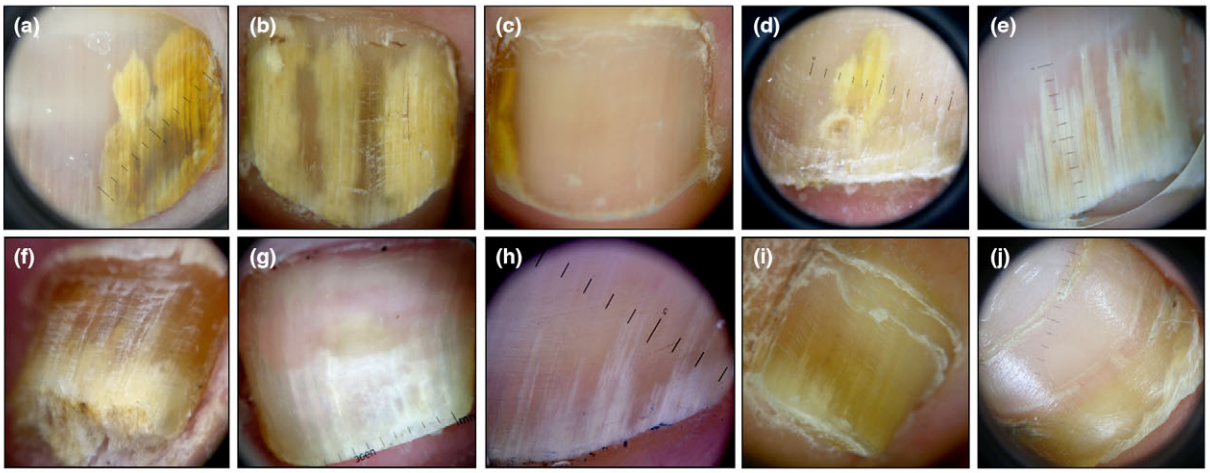

Figure 1 Main dermoscopic patterns on onychoscopy. (a). Irregular macular pattern; (b). Irregular macular pattern; (c). Irregular pattern with greyish border; (d). Focal macular pattern; (e). Longitudinal line pattern; (f). Distal pulverized pattern; (g). Regular macular or onycholysis pattern; (h). Distal fine line pattern; (i). Total hazy homogeneous background; (j). Partial hazy homogeneous background.

for OM diagnosis was high (>96%), we did not find a 100% specificity as previously reported,[1,16] perhaps because we included a larger sample and we did not restrict our inclusion criteria to a specific subtype of OM (distal subungual onychomycosis). The IMa ('jagged edged with spikes') pattern results from distal-to-proximal invasion of dermatophytes.[1,17,18] It is associated with a clearly defined matte discoloration obtained directly from the colour of invading fungal colonies and, indirectly, from inflammatory scaling and subungual debris accumulation.[1,15] In our study, this was the most frequent presentation of OM (53.6%, $n = 59$). Distal nail plate thickening, with debris accumulation from the nail bed and periungual folds, represents a reactive process to infection. This allows the appearance of the DP pattern, previously reported as subungual hyperkeratosis or 'ruin appearance',[15,17,18] sometimes leading to partial exposure of the nail bed.

Longitudinal lines were reported as predictive findings of OM.[1,15,16,18] In our study, we did not find them statistically associated with OM, which might be explained by differences between studies. In fact, we evaluated a predominant global pattern and not isolated findings. We hypothesize that longitudinal lines as isolated features are insufficient to confidently suggest OM. This finding may even be confused with the DFL pattern, more commonly observed in OD, and may be absent in dystrophic OM, as the level of fungal invasion advances.[17]

Finally, two presentations were exclusively present in OM, the focal macular (dermatophytoma) and the irregular pattern with greyish border, but did not show statistical significance. This may be related to a low patient number of these probably very specific, yet uncommon, patterns of OM.

Concerning traumatic OD-associated patterns, the onycholysis, the THHB, the PHHB and the non-classifiable patterns were considered positive discriminators for this diagnosis, increasing the possibility of OD by about 15-, 14-, 16- and 14-fold, respectively (Table 5). Additionally, their specificity for OD diagnosis was higher than 95%. The onycholysis pattern shows a regular line of traumatic detachment of the nail plate.[20] The THHB and the PHHB patterns, showing out of focus toenail yellowing, represent nail thickening with or without onycholysis. All these changes contrast with the matte discoloration or the spiked proximal border of fungal invasion.

The association of traumatic OD with specific dermoscopic patterns is unique to this study. Except for the onycholysis pattern, no other patterns have been previously associated with traumatic OD.

We found an association between OD and changes that were non-classifiable ($P < 0.001$); therefore, we believe that when changes suggestive of a specific pattern are absent, an OD diagnosis may be favoured.

Again, the DFL pattern was exclusively present in OD patients but did not show a statistical significant association with this diagnosis, probably due to our low number of patients. DFL appearance probably results from repetitive trauma to the toenail edge, induced by the tip of the shoe.

We demonstrated that OM and traumatic OD are distinct in dermoscopy. We propose a dermoscopy-based algorithm to their differential. First, the overall pattern should be determined. If an IMa, a DP, an irregular macular with greyish border or a focal macular pattern is identified, clinicians may strengthen their presumed OM clinical diagnosis. With the following dermoscopic presentations: onycholysis, DFL, THHB and PHHB,

Table 4 Frequency of dermoscopic patterns and their association (*P*-value) with final diagnosis of onychomycosis or traumatic onychodystrophy

	Dermoscopic pattern	Dermoscopic features	Frequency *n* = 192, *n* (%)	*P*-value significantly different*		Dermoscopic pattern	Dermoscopic features	Frequency *n* = 192, *n* (%)	*P*-value significantly different*
Onychomycosis	Irregular macular pattern with spikes (IMa)	• in focus yellow or white patches • irregular proximal borders • ≈ 'jagged edged with spikes' appearance[1]	62 (32.3%)	<0.001*	Onychodystrophy	Regular macular or onycholysis pattern	• in focus colour change • regular proximal border	23 (12.0%)	<0.001*
	Irregular pattern with greyish border	• ≈ to irregular macular pattern • + accompanying melanonychia	4 (2.1%)	0.137		Distal fine line pattern (DFL)	• distal leuconychia striate (sometimes yellow) • short, thin lines starting from the distal nail edge	15 (7.8%)	<0.001*
	Focal macular	• in focus yellow roundish macules in the nail plate, separated from distal edge	2 (1.0%)	0.508		Total homogeneous background (THHB)	• out of focus, complete yellowing of the nail	22 (20.0%)	0.001*
	Longitudinal line pattern (LL)	• in focus irregular lines • haphazard distribution • lines of variable breadth and length	16 (8.3%)	0.063		Partial background (PHHB)	• out of focus, partial yellowing of the nail	15 (11.5%)	0.003*
	Distal pulverized or distal crumbling pattern (DP)	• distal breakage and crumbling of the nail edge • prominent subungual hyperkeratosis • ≈ 'ruin appearance' or ' distal subungual hyperkeratosis' patterns[15,18]	16 (8.3%)	0.002*		Non-classifiable pattern	• changes could not be ascribed to any pattern, or grouped together	17 (8.9%)	0.004*

*Statistically significant difference.

Table 5 Results of multivariate analysis between OM (n = 110) and OD (n = 82) final diagnosis: dermoscopic predictors of OM and OD (A), and their estimated diagnostic specificity and sensitivity (B)

A. Dermoscopic predictors of onychomycosis and onychodystrophy		
Dermoscopic pattern	**Odds Ratio**	***P*-value significantly different***
Positive discriminators for OM		
Irregular macular pattern with spikes	42.61	**<0.001 ***
Distal pulverized pattern	32.50	**<0.001 ***
Positive discriminators for OD		
Regular macular pattern	15.22	**<0.001***
Total homogeneous background	14.372	**<0.001***
Partial homogeneous background	16.91	**<0.001***
Non-classifiable pattern	13.74	**0.001***

B. Diagnostic specificity and sensitivity of each dermoscopic pattern		
Dermoscopic pattern	**Specificity (95% confidence interval)**	**Sensitivity (95% confidence interval)**
Onychomycosis		
Irregular macular pattern with spikes	96.3 (93.7–99.0)	53.6 (46.6–60.7)
Distal pulverized pattern	98.8 (97.2–100)	13.6 (8.8–18.5)
Onychodystrophy		
Regular macular pattern	95.5 (92.5–98.4)	21.95 (16.1–27.8)
Total homogeneous background	95.5 (92.5–98.4)	20.7 (14.9–26.5)
Partial homogeneous background	97.3 (95.0–99.6)	14.6 (9.6–19.6)
Non-classifiable pattern	96.4 (93.7–99.0)	15.9 (10.7–21.0)

especially in patients with history of toenail injury and appropriate podiatric deformities, a traumatic OD diagnosis can be inferred. Discordant mycological results, with an onychoscopy-supported diagnosis, can be further reappraised by repeating mycology or performing histology.

Nevertheless, our study has some limitations. Firstly, OM subtypes were not separately analysed. Secondly, our limited population size precluded us from clarifying the role of some uncommon, but seemingly OM- and OD-specific patterns (such as the focal macular (dermatophytoma) or the DFL pattern, respectively). Additionally, longitudinal evaluation of nail changes after targeted treatment could have provided further useful information. Finally, histology was performed only in selected cases. Still, this study includes a control group of patients with traumatic OD and is the largest prospective study comparing OM dermoscopic features with those of traumatic OD. To our knowledge, these features are unique to our study. Finally, we used for the first time an onychoscopic global pattern-based approach. New onychoscopic observations can further help reappraise and reconsider diagnosis, when clinicians are faced with the limitations of fungal tests.

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