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Dermoscopic Features of Onychomycosis Identified by Image Analysis Using a Decision Tree Algorithm

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ABSTRACT

Introduction: Onychomycosis is a common fungal nail infection characterized by diverse dermoscopic patterns that vary depending on clinical and demographic factors. Accurate diagnosis is critical to differentiate onychomycosis from other nail conditions. Traditional diagnostic methods such as fungal culture are time-consuming and cost-effective, highlighting the need for innovative approaches.

Objective: This study aimed to describe and analyze the dermoscopic features of onychomycosis and to investigate associations between specific onychomycosis patterns and various patient-related factors using machine learning techniques to enhance diagnostic accuracy and improve treatment strategies.

Methodology: A total of 130 patients diagnosed with onychomycosis were prospectively enrolled. Dermoscopy served as a noninvasive tool for classifying nail patterns accurately. Decision tree analysis was applied to examine relationships between nail condition patterns and clinical variables such as age, duration of the disease, diabetes status, and occupation.

Results: The main dermoscopic features of onychomycosis were longitudinal striae, ruin appearance, aurora, spikes, jagged borders, and distal pulverized edges. Notably, spikes and jagged borders were identified in 70% of cases, strongly correlating with onychomycosis and highlighting their diagnostic relevance. Furthermore, analysis indicated that demographic and clinical factors significantly influence specific nail disorder manifestations.

Conclusion: The study revealed significant dermoscopic signs, which may serve as essential markers for identifying onychomycosis. In addition, the study explored essential relationships between nail condition patterns and various patient-related factors. Despite limitations from the small dataset, this study establishes a promising foundation for future work to confirm and expand upon these findings, further integrating machine learning in dermatological diagnostics.

Introduction

Onychomycosis (OM) is a persistent fungal infection of the nail caused by dermatophytes, yeasts, or nondermatophytic molds. It represents the most common nail disease in adults, accounting for approximately 50% of all nail disorders and 30% of superficial fungal infections [1]. The predominant causative agents include Trichophyton rubrum and, less frequently, Trichophyton mentagrophytes variant interdigitale. While onychomycosis can often be clinically suspected based on physical examination and patient history, definitive diagnosis typically requires direct microscopic examination and fungal culture. However, culture results can take a minimum of three weeks, making them time-consuming and sometimes impractical in clinical practice [2,3].

Differential diagnosis of onychomycosis includes various inflammatory and systemic conditions such as psoriasis, lupus erythematosus, pityriasis rubra pilaris, amyloidosis, diabetes mellitus, porphyria, and dysthyroidism. It must also be differentiated from other infectious and traumatic nail conditions including viral warts, chronic paronychia, cosmetic trauma (e.g., from manicures or pedicures), and tumors of the nail apparatus such as squamous cell carcinoma, melanoma, and digital fibromas [4,5].

Managing onychomycosis is often challenging due to diagnostic limitations, slow nail growth, prolonged treatment duration, possible resistance to systemic antifungals, and frequent recurrence. Previous studies have identified characteristic dermoscopic features associated with OM, such as jagged edges with spikes, longitudinal striae, distal irregular terminations, linear edges, and the so-called “ruin appearance.” Although these features aid early diagnosis and facilitate treatment decisions, the literature validating dermoscopic findings against standard mycological methods such as potassium hydroxide (KOH) testing and fungal culture remains limited [1]. Accurate diagnosis is critical, as systemic antifungal treatments usually last two to three months and can lead to liver toxicity. Misdiagnosis may not only expose patients to unnecessary side effects but also impose economic burdens on healthcare systems [6].

With advancements in medical technology, new diagnostic methods continue to emerge [7]. Onychoscopy, the dermoscopic examination of the nail unit, has gained attention as a bridge between clinical examination and histopathological assessment. This noninvasive tool minimizes the need for nail biopsies [8]. Originally used to assess pigmented skin lesions, dermoscopy has found expanding applications in dermatology and now proves especially useful in evaluating nail disorders [9]. It enables an immediate and magnified view of the nail plate and subungual structures, offering significant advantages over traditional diagnostic methods such as KOH examination and fungal culture [5].

Although not life-threatening, onychomycosis can negatively impact quality of life by causing discomfort and cosmetic concerns during daily activities [10]. Fingernails are more susceptible than toenails to trauma and environmental exposure such as water and detergents. These factors can exacerbate onycholysis and reduce subungual keratosis in fingernail infections [11].

Epidemiological data suggest that the prevalence of onychomycosis is expected to increase in the coming years [5]. The condition occurs more frequently in individuals aged 40–60 and is rarely observed before puberty. This distribution is likely due to contributing factors such as reduced peripheral circulation, impaired immune function, diabetes, larger or distorted nail surfaces, and slower nail growth in older adults [12].

Distal lateral onychomycosis in particular can pose diagnostic challenges as it may mimic distal lateral onycholysis caused by psoriasis. Given the limited sensitivity of conventional KOH mounts and fungal cultures, it becomes essential to explore reliable noninvasive diagnostic methods. Dermoscopy has emerged as a practical and effective approach for differentiating OM from similar nail disorders [13].

Dermoscopic evaluation was conducted by B. M. Piraccini [14] A of 57 patients and identified three distinctive features. Two of these, jagged proximal edges with spikes and longitudinal striae, were specific to distal subungual onychomycosis, while a linear edge without spikes was seen only in traumatic onycholysis. Similarly, E. Kaynak [15] examined 97 patients using both clinical and dermoscopic photography. Logistic regression analysis confirmed the statistical significance of patterns such as ruin appearance, homogeneous leukonychia, punctate leukonychia, and black discoloration in diagnosing OM.

In another study, 60 nails with onychomycosis were evaluated. The disease duration ranged from six weeks to 24 months. The great toe was the most frequently affected, followed by the thumb; dermoscopic examination revealed longitudinal striae, jagged edges, intermittent spiked patterns, chromonychia, and distal irregular terminations [10].

Analysis of 60 KOH-confirmed OM cases showed a male predominance of 78.3%. Most patients were aged between 21 and 30 years. Their dermoscopic findings included jagged edges with spikes in 65.5%, longitudinal striae in 77.6%, a ruin pattern in 82.7%, and chromonychia in 62.1% of cases [8].

A systematic review by Litaiem [16] further confirmed that dermoscopic signs such as ruin appearance, longitudinal striae, and spikes on the proximal margin of the onycholytic area had high specificity: 99.38%, 83.78%, and 85.64%, respectively. Interestingly, the “aurora borealis” sign demonstrated the highest overall sensitivity and specificity, making it a potentially valuable diagnostic marker.

Objectives

This research aimed to employ machine learning, specifically the decision tree algorithm, for the classification of different dermoscopic features based on image analysis and their relationship with various patient-related features. The utilization of decision trees provides an interpretable and transparent model, aiding clinicians in understanding the diagnostic process [17].

Materials and Methods

This was an analytical cross-sectional study. Onychoscopy with a DermLite DL4 dermatoscope was performed, giving a magnification of 10x. Polarizing and non-polarizing modes were used as needed, and ultrasound gel was used as the interface medium [18].

A total of 130 patients who were clinically diagnosed as OM and who underwent nail clipping and KOH examination which were positive for fungal elements were initially included in the current study. Verbal consent was obtained from all participants. A comprehensive medical history was taken for each participant. Patients were studied in the Dermatology Department of Azadi Hospital in Duhok City in Kurdistan Region of Iraq. The data collection lasted for 8 months, from January 2024 until August 2024. Data were analyzed with the Python Desktop (V3) program. Decision tree (DT) test was applied. Further model validation was performed.

Six dermoscopic feature categories were evaluated in patients presenting with varying factors. Through a comprehensive analysis conducted using Python software, four categories were selected for further examination—spikes, aurora, longitudinal striae, and ruin appearance—based on their significant relationships. The decision tree method was employed to analyze these categories, revealing substantial associations between aurora and spikes as well as between longitudinal striae and ruin appearance. The subsequent chapter section provides a detailed discussion of these findings and their implications.

The data were coded and entered into Microsoft Excel, shown in Table 1. They were then analyzed for percentages, rates, proportions, and association using the Python program, where the result was considered significant. The "score()" method from the Python "sklearn" library was used to evaluate the accuracy of the DT analysis, which resulted in a score of around 80%. This outcome fell within the range of the values reported in other studies where classification techniques were applied with similar objectives [12,13].

Table 1 provides a comprehensive overview of the variables within the dataset, detailing their descriptions and categorical coding.

Table 1. The variables of the dataset and their descriptions.

Variable	Description
Age	Age groups:1= Less than 18; 2= 18–40; 3=41–65; 4=Older than 65
Sex	1= Male; 2= Female
Occupation Residence	1= Athletes; 2= Military; 3= Restaurant worker; 4= Hairdresser;5= Housewife; 6= Others 1= City; 2= Rural area
Chief complaint	1= Asymptomatic; 2= Itching 3= Pain
Duration	In months: 1= (1–3); 2= (4–6); 3= (7–9); 4= (10–12); 5= More than one year
History of trauma	1= Yes; 2= No
Diabetes	1= Yes; 2= No
Surgical nail removal	1= Yes; 2= No
Site	1= Hand; 2= foot
Number of nails	1= Single; 2= Multiple
Paronychia	1= Yes; 2= No
Target Variables	
Target 1	0= Longitudinal striae; 1= Ruin appearance
Target 2	0 = Aurora 1 = Spikes

Results and Discussion

Onychoscopy has proven to be a valuable tool for diagnosing onychomycosis by identifying distinct nail patterns linked to fungal infections. By analyzing the percentage of patients showing these features, we gain a better understanding of their diagnostic importance.

Table 2 presents a detailed summary of the key features within the dataset, including the minimum, maximum, mean, and standard deviation (SD) values for each variable.

- Sex: The minimum value is 1, the maximum is 2, with a mean of 1.53 and a standard deviation of 0.50, indicating a fairly balanced distribution between male and female participants.
- Age: The age categories range from 1 to 4, with a mean of 2.78 and a standard deviation of 0.73, suggesting a higher concentration of participants in the middle-aged group.
- Occupation: This variable ranges from 1 to 6, with a mean of 5.16 and a standard deviation of 1.51, indicating a diverse range of occupations among the participants.
- Address: The address variable has a minimum of 1 and a maximum of 2, with a mean of 1.25 and a standard

Table 2. Individual-related factors.

Variable	Min	Max	Mean	SD
Sex	1	2	1.53	0.50
Age	1	4	2.78	0.73
Occupation	1	6	5.16	1.51
Address	1	2	1.25	0.43
Chief complaint	1	3	1.36	0.77
Duration months	1	4	3.88	1.46
History of trauma	1	2	1.96	0.19
Diabetes	1	2	1.79	0.40
Surgical nail removal	1	2	1.96	0.19
Site	1	2	1.76	0.42
Number nails	1	2	1.82	0.38
Paronychia	1	2	1.88	0.32

deviation of 0.43, showing a predominance of participants from urban areas.

- Chief complaint: Ranges from 1 to 3, with a mean of 1.36 and a standard deviation of 0.77, suggesting that most participants are asymptomatic.
- Duration in months: The duration ranges from 1 to 4, with a mean of 3.88 and a standard deviation of 1.46, indicating longer durations of the condition among participants.
- History of trauma: This variable has a minimum of 1 and a maximum of 2, with a mean of 1.96 and a standard deviation of 0.19, suggesting a low incidence of trauma history.
- Diabetes: The diabetes variable ranges from 1 to 2, with a mean of 1.79 and a standard deviation of 0.40, indicating a moderate prevalence of diabetes among participants.
- Surgical nail removal: The minimum value is 1, the maximum is 2, with a mean of 1.96 and a standard deviation of 0.19, showing that surgical nail removal is infrequent.
- Site: This variable ranges from 1 to 2, with a mean of 1.76 and a standard deviation of 0.42, suggesting that foot infections are more common.
- Number of Nails: The number of nails affected ranges from 1 to 2, with a mean of 1.82 and a standard deviation of 0.38, indicating that multiple nail involvement is more frequent.
- Paronychia: The paronychia variable has a minimum of 1 and a maximum of 2, with a mean of 1.88 and a standard deviation of 0.32, suggesting a low occurrence of paronychia among participants.

In the following sections, each feature will be identified in detail and its frequency of occurrence among patients with onychomycosis wil be explored [1-3].

1. Spikes (Figure 1): sharp structures causing indentations of the onycholytic border. This feature was present in 70% of the cases, indicating its strong association with onychomycosis.
2. Longitudinal striae (Figure 2): linear streaks on the nail plate. This feature was observed in about two thirds of the cases (65.46%).
3. Jagged border (Figure 3): irregular border of the onycholytic area. This feature was present in 70% of the cases, indicating its strong association with onychomycosis.
4. Distal irregular termination (Figure 4): the distal pulverization of the nail plate. Nearly half of the diagnosed cases exhibited distal pulverization (47.69%), pointing to this feature as a frequent manifestation in onychomycosis.
5. Aurora discoloration (Figure 5): irregular pigmentation of the nail plate distributed in horizontal striae giving an overall impression of “aurora borealis”. This feature was noted in approximately one quarter of the cases (24.61%), suggesting that, while it is not the most common finding, it still appears in a significant subset of onychomycosis patients.
6. Ruin appearance (Figure 6): irregular and crumbly ending of the thickened nail plate with subungual scales. This was the least common feature among the categories (23.76%), appearing in just under a quarter of the cases. The lower prevalence suggests that, while it is a relevant characteristic, it may not be as prominent as others for onychomycosis diagnosis.

These percentages (Figure 7) reflect the distribution of dermoscopic features in the studied cases and emphasize the variability in onychomycosis presentation, which can aid clinicians in identifying and differentiating the condition based on characteristic patterns observed through dermoscopy.

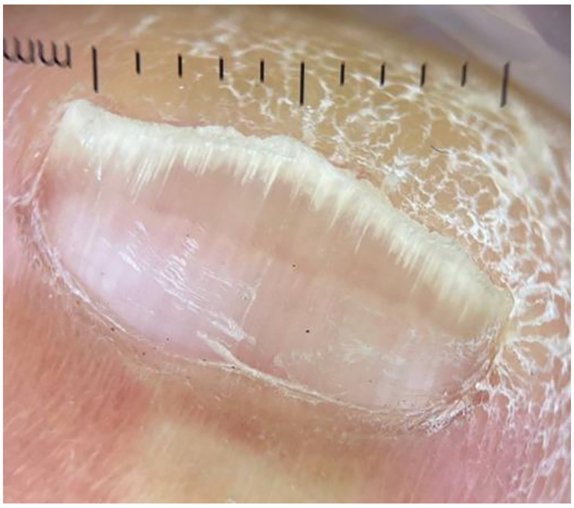

Figure 1. Spikes.

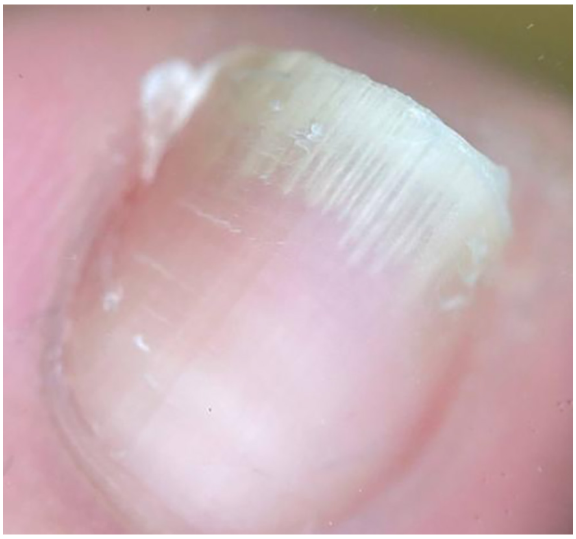

Figure 2. Longitudinal striae.

Figure 3. Jagged proximal edge**.**

Figure 4. Distal pulverized edge**.**

Figure 5. Aurora discoloration.

Figure 6. Ruin appearance.

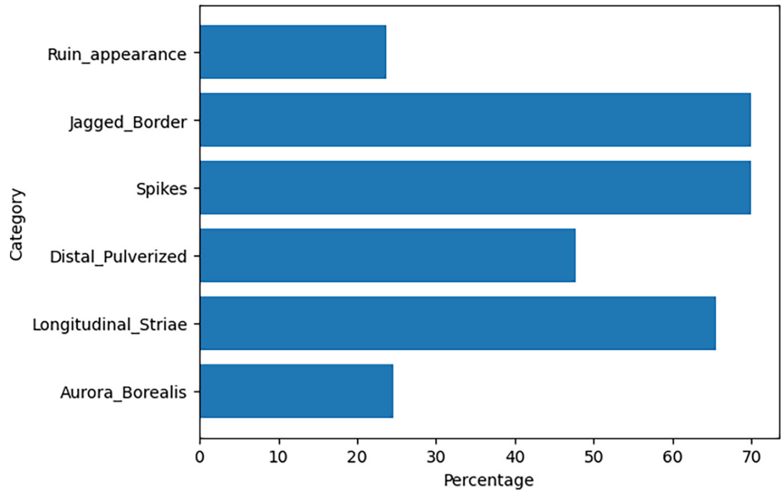

Figure 7. Percentage Distribution of Dermoscopic Features in Onychomycosis

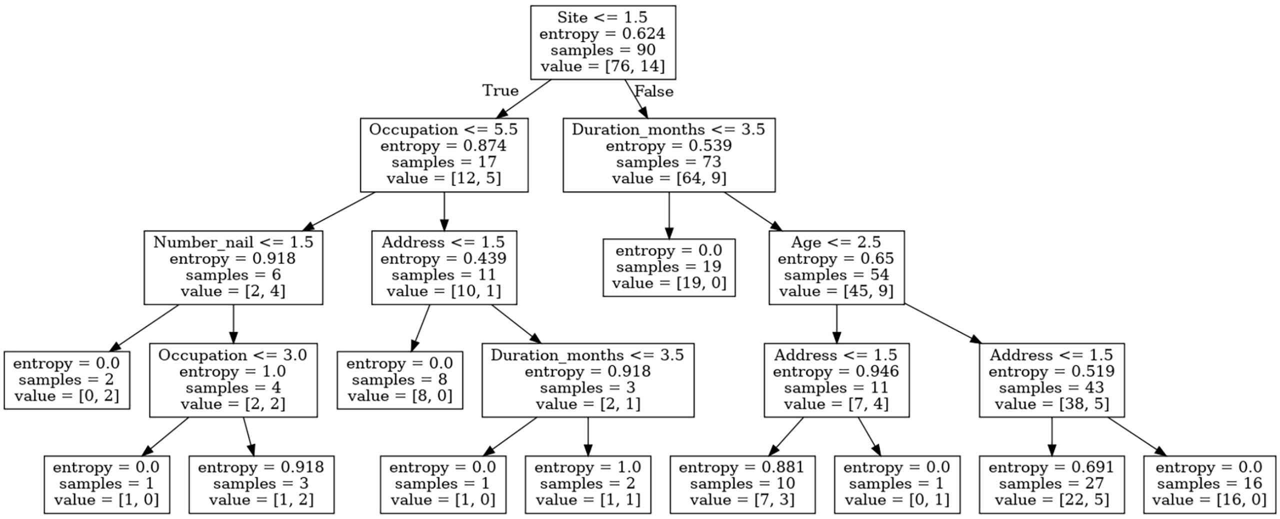

Figure 8. The results of the decision tree (DT) method, illustrating the relationship between the target variables (longitudinal striae and ruin appearance) and the associated factors.

Figure 8 illustrates the output of the decision tree (DT) analysis generated by the software, depicting the relationship between the target variables—longitudinal striae and ruin appearance—and the related factors outlined in Table 1. This relationship was identified as one of the most significant findings in this study. The hierarchical structure of the figure reveals these relationships in detail.

At the root node of the DT, the learning dataset consisted of 90 observations. The value array indicates the distribution of respondents based on their onychomycosis patterns, with the first value representing patients who reported longitudinal striae and the second value representing patients with ruin appearance of the nail for each criterion. Specifically, the root node shows that, within the collected data, 76 individuals with longitudinal striae, while 14 individuals exhibited ruin appearance.

At the subsequent level in the DT hierarchy, the analysis revealed that 73 individuals with onychomycosis in their feet fell to the right side of the graph. Among these individuals, approximately 25% who had experienced the condition for 1–9 months had all been diagnosed with longitudinal striae. Conversely, of those with a case duration of 10 months or more, 83% had longitudinal striae and 17% had ruin appearance. Further analysis of patients with a case duration of 10 months or more, particularly those aged less than 40 years living in urban areas, indicated that 70% had longitudinal striae, while 30% had ruin appearance. In contrast, among older patients aged 41 to over 65 years, 80% of onychomycosis cases had been reported in the feet, with a duration of 10 months or more. Of these cases, approximately 65% were patients living in urban areas, with 80% presenting with longitudinal striae and 20% with ruin appearance.

The left branch of the decision tree represents patients with onychomycosis on their hands. Among these patients, those with normal occupations, particularly those living in urban areas, all exhibited longitudinal striae. In contrast, individuals in high-risk occupations such as athletes, military personnel, restaurant workers, hairdressers, and housewives, showed a distribution of 65% with ruin appearance and 35% with longitudinal striae. Additionally, patients with multiple hand nails affected had an equal distribution of ruin appearance (50%) and longitudinal striae (50%). Conversely, 100% of patients with a single affected hand nail exhibited ruin appearance.

From the tree shown in Figure 8 we can highlight the following points:

- The majority of individuals in the dataset had longitudinal striae, while a smaller group showed ruin appearance of the nail.
- Among those with onychomycosis on their feet, shorter durations were exclusively linked to longitudinal striae, while longer durations showed a mix of both patterns, with longitudinal striae being more common.
- Younger individuals in urban areas tended to have longitudinal striae, while older individuals showed a stronger tendency towards longitudinal striae, though some had ruin appearance.
- On the hands, individuals in regular occupations, especially in urban areas, all presented with longitudinal striae, while ruin appearance was more frequently observed in those in high-risk occupations.
- Patients with a single affected hand nail exclusively showed ruin appearance, while those with multiple nails affected showed a more even distribution of both patterns.

Figure 9 presents the output of the decision tree (DT) analysis generated by the software, illustrating the relationships between the target variables, aurora and spikes, and the associated factors listed in Table 1. This relationship represents one of the most significant findings of the study. The hierarchical structure of the figure demonstrates these relationships in detail. At the root node, the dataset used for learning was made up of a total of 105 observations. The value array reflects the distribution of participants based on their onychomycosis patterns, where the first value corresponds to patients who reported aurora and the second value represents those with spikes in the nail, according to each criterion. Specifically, the root node indicates that out of the collected data, 23 individuals experienced aurora, while 82 displayed spikes.

At the next level of the DT hierarchy, the analysis identified 44 individuals with onychomycosis for less than one year, located on the left side of the graph. Among these, approximately 75% resided in urban areas, with over 90% of this group had been diagnosed with spikes affecting multiple nails. In contrast, of the remaining 25% who lived in rural areas, 30% had been diagnosed with aurora, while 70% exhibited spikes. Additionally, within the younger age group, all cases reported spikes, whereas in older age groups, 60% were diagnosed with aurora.

The right branch of the DT output represents 61 patients who had had onychomycosis for more than one year. Among these individuals, the majority, covering a range of occupations, had been affected on their feet, with over 85% falling into this category, and approximately 70% displaying spikes. Additionally, within the diabetic group, 60% exhibited spikes, while 40% were diagnosed with aurora. Furthermore, all patients with onychomycosis affecting multiple nails of their hands were found to have spikes.

From the tree shown in Figure 9 we can highlight the following points:

- The dataset shows a clear predominance of spikes over aurora, with most individuals displaying spikes in their nails.
- Among those with onychomycosis for less than one year, urban residents were more likely to have spikes. In contrast, rural residents had a more even split between aurora and spikes.

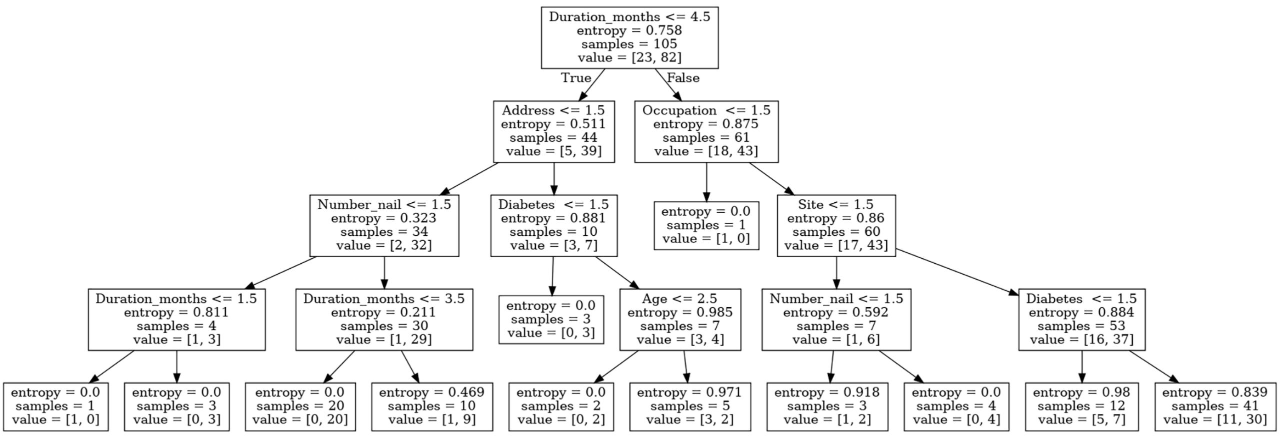

Figure 9. The results of the decision tree (DT) method, illustrating the relationship between the target variables (aurora and spikes) and the associated factors.

- Younger individuals were exclusively diagnosed with spikes, whereas older individuals showed a stronger association with aurora.
- Diabetic individuals tended to show a higher prevalence of spikes, though a significant proportion still had aurora.

For the medical community, the use of machine learning techniques such as decision trees can streamline diagnostic processes, potentially reducing reliance on time-consuming and less accurate traditional methods. Additionally, incorporating noninvasive tools such as dermoscopy into routine clinical practice could minimize the need for more invasive procedures, thus improving patient care.

However, this study is not without limitations. The primary constraint is the relatively small dataset used, which may limit the generalizability of the findings. The study focused on specific types of nail conditions and targeted particular diagnostic patterns. Furthermore, the dataset's size may have constrained the ability to detect more nuanced relationships among the variables.

In addition, while dermoscopy enhances the clinical diagnosis of onychomycosis by revealing characteristic features such as longitudinal striae, spikes, and color changes, it does not allow for the identification of the specific causative pathogen (e.g., dermatophytes, non-dermatophyte molds, or yeasts). Therefore, dermoscopy should be considered a complementary tool rather than a substitute for microbiological or molecular testing, which remains essential for definitive pathogen identification and guiding targeted antifungal therapy.

These limitations highlight the need for future research with larger and more diverse datasets to validate the findings and expand the understanding of onychomycosis.

Future research should aim to address these limitations by incorporating a more extensive dataset that includes a broader spectrum of nail conditions and patient. Additionally, integrating other machine learning methods and combining them with traditional clinical assessments could further enhance diagnostic accuracy. Longitudinal studies investigating the progression of onychomycosis over time and its response to different treatments could also provide valuable insights. Ultimately, a multidisciplinary approach that combines advanced data analytics with clinical expertise may significantly improve the management and outcomes of patients with onychomycosis.

Conclusion

This study identified key dermoscopic features associated with onychomycosis, including longitudinal striae, ruin appearance, aurora, spikes, jagged borders, and distal pulverization. Among these, spikes and jagged borders were observed in 70% of the cases, demonstrating a strong correlation with onychomycosis and underscoring their significance as diagnostic markers. Furthermore, the analysis highlighted how specific clinical factors such as age, diabetes status, and the duration of the disease affect the manifestation of distinct nail conditions. These insights enhance our understanding of onychomycosis presentations and provide valuable guidance for healthcare practitioners in tailoring diagnostic and treatment strategies more effectively. By integrating machine learning techniques with noninvasive dermoscopic methods, this approach offers a more rapid, accurate, and data-driven diagnostic process compared to traditional methodologies.

Overall, this study establishes a strong foundation for future investigations aimed at validating and expanding upon these findings. Advocating for the integration of advanced analytical methods into clinical practice paves the way for more personalized and efficient management of onychomycosis, ultimately improving patient outcomes and promoting further exploration in dermatological researches.

References

1. Glanz K, Rimer BK, Viswanath K. *Health Behavior: Theory, Research, and Practice*. 5th ed. Wiley; 2015.
2. Starace M, Milan E, Summa G, et al. Onychoscopic characteristics of Trichophyton rubrum and Trichophyton interdigitalis fungal infections: a multicentric study. *Mycoses*. 2024;67(1):e13673. DOI:10.1111/myc.13673. PMID:37966016.
3. Kaya Islamoğlu ZG. Nail digital dermoscopy in onychomycosis: correlation with clinical type, gender and culture examination. *Erciyes Med J*. 2019;41(4):386-392. DOI:10.14744/etd.2019.94210. PMID:31815159.
4. Jesús-Silva MA, Fernández-Martínez R, Roldán-Marín R, Arenas R. Dermoscopic patterns in patients with a clinical diagnosis of onychomycosis—results of a prospective study including potassium hydroxide and culture examination. *Dermatol Pract Concept*. 2015;5(2):39-44. DOI:10.5826/dpc.0502a05. PMID:26090200.
5. Yorulmaz A, Yalcin B. Prevalence and risk factors of onychomycosis in Turkey. *Acta Dermatovenerol Alp Pannonica Adriat*. 2018;27(1):11-14. DOI:10.15570/actaapa.2018.3. PMID:29658917.
6. Lim SS, Hui L, Ohn J, et al. Diagnostic accuracy of dermoscopy for onychomycosis: a systematic review. *Front Med*. 2022;9:1048913. DOI:10.3389/fmed.2022.1048913. PMID:36312692.
7. Ma Y, Wang J, Sun Y, et al. Assessment of the clinical diagnosis of onychomycosis by dermoscopy. *Front Surg*. 2022;9:854632. DOI:10.3389/fsurg.2022.854632. PMID:35386841.
8. Hazarika N, Chauhan P, Divyalakshmi C, et al. Onychoscopy: a quick and effective tool for diagnosing onychomycosis in a resource-poor setting. *Acta Dermatovenerol Alp Pannonica Adriat*. 2021;30(1):11-15. DOI:10.15570/actaapa.2021.3. PMID:33742954.
9. Maatouk I, Haber R, Benmehidi N. Onychoscopic evaluation of distal and lateral subungual onychomycosis: a cross-sectional study. *Clin Med Mycol*. 2019;5(2):19-25. DOI:10.18502/cmm.5.2.1161.

10. Nargis T, Pinto M, Shenoy MM, Hegde S. Dermoscopic features of distal lateral subungual onychomycosis. *Indian Dermatol Online J*. 2018;9(1):16-19. DOI:10.4103/idoj.IDOJ_40_17. PMID:29491643.
11. Iorizzo M, Starace M, Piraccini BM, et al. Clinical and onychoscopy patterns in fingernail onychomycosis: a study by the International Dermoscopy Society. *Dermatol Pract Concept*. 2025;15(1):e4887. DOI:10.5826/dpc.1501a4887.
12. Abdallah NA, Said M, Mahmoud MT, Omar MA. Onychomycosis: correlation between dermoscopic patterns and fungal culture. *J Cosmet Dermatol*. 2020;19(5):1196-1204. DOI:10.1111/jocd.13144. PMID:31875442.
13. Yadav T, Khopkar U. White streaks: dermoscopic sign of distal lateral subungual onychomycosis. *Indian J Dermatol*. 2016;61(1):123. DOI:10.4103/0019-5154.174151. PMID:26955113.
14. Piraccini BM, Balestri R, Starace M, Rech G. Nail digital dermoscopy (onychoscopy) in the diagnosis of onychomycosis. *J Eur Acad Dermatol Venereol*. 2013;27(4):509-513. DOI:10.1111/j.1468-3083.2011.04323.x. PMID:22040510.
15. Kaynak E, Gökdemir G, Ozturk G, et al. The role of dermoscopy in the diagnosis of distal lateral subungual onychomycosis. *Arch Dermatol Res*. 2018;310(1):57-69. DOI:10.1007/s00403-017-1796-2. PMID:29147801.
16. Litaiem N, Mnif E, Zeglaoui F. Dermoscopy of onychomycosis: a systematic review. *Dermatol Pract Concept*. 2023;13(1):e2023072. DOI:10.5826/dpc.1301a72. PMID:36618618.
17. Tu MC, Shin D, Shin D. A comparative study of medical data classification methods based on decision tree and bagging algorithms. In: Proceedings of the 2009 IEEE International Conference on Dependable, Autonomic and Secure Computing. IEEE; 2009:183-187. DOI:10.1109/DASC.2009.40.
18. Kayarkatte M, Singal A, Pandhi D, et al. Nail dermoscopy findings in the diagnosis of primary onychomycosis: a cross-sectional study. *Indian J Dermatol Venereol Leprol*. 2020;86(4):341-346. DOI:10.4103/ijdvl.IJDVL_100_19. PMID:32643725.
19. Abdullah P, Sipos T. Exploring the factors influencing traffic accidents: an analysis of black spots and decision tree for injury severity. *Period Polytech Transp Eng*. 2023. DOI:10.3311/PPtr.22392.

20. Abdullah P, Sipos T. Drivers' behavior and traffic accident analysis using decision tree method. *Sustainability*. 2022;14(18):11339. DOI:10.3390/su141811339.