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Comparison of the effectiveness of blacklight blue lamp and wood lamp in the screening of tinea capitis

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ABSTRACT

Background: Tinea capitis is a common fungal infection of the scalp in children. Most cases are caused by *Microsporum canis* or Trichophyton mentagrophyte. Wood lamps screen for tinea capitis by detecting green-yellow fluorescence produced by tryptophan metabolites. Because wood lamps are expensive and replacement parts are difficult to find during maintenance, we have developed a blacklight blue lamp device with a similar wavelength that is cheaper than wood lamps.

Objective: To evaluate the BLB lamp device for screening tinea capitis by determining the sensitivity, specificity, and accuracy compared to fungus culture (gold standard).

Materials and methods: One hundred seventy-five patients with suspected tinea capitis were tested using KOH examination, fungal culture, a Wood lamp, and a blacklight blue lamp device. The research data obtained will be used to analyze the sensitivity, specificity, and accuracy of the blacklight blue lamp device by comparing it using various methods.

Results: The analysis assessed the sensitivity, specificity, and accuracy of the blacklight blue lamp device, Wood lamp, and KOH preparation when comparing fungal culture as the standard method for diagnosing tinea capitis. The sensitivity was 99.39%, 100%, and 100%, specificity was 100%, 90.91%, and 100%, and accuracy was 99.43%, 99.43%, and 100%, respectively. The p-value for the three methods' differences was 0.723 for sensitivity, 0.735 for specificity, and 0.676 for accuracy. These results show that the differences between the two methods' sensitivity, specificity, and accuracy were not statistically significant.

Conclusion: The blacklight blue lamp device effectively screened tinea capitis with a sensitivity, specificity, and accuracy that were not significantly different from the wood lamp. It may be an inexpensive tool used as a substitute in the health service system.

Introduction

Tinea capitis is most observed in children between 3 and 14 years old.[1] The fungistatic effect of fatty acids in sebum may help to explain the sharp decrease in incidence after puberty. The overall prevalence of the carrier state is approximately 4% in the United States, with a peak prevalence of roughly 13% in girls of sub-Saharan African American descent. The fungistatic effect of fatty acids in sebum may help to decrease incidence after puberty.[2]

The Southern Regional Hospital of Tropical Dermatology in Trang Province reports that, on average, 24,873 individuals are seen annually, with 227 having tinea capitis on their scalps.[3] Therefore, fungal-related skin diseases are common in tropical regions, particularly

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in southern Thailand. At the hospital in the study, dermatologists request laboratory tests for fungus 2,551 times a year on average using the KOH technique for diagnosis and treatment and 363 times a year on average for the kind of fungal infection to be identified using fungal culture on agar, which is the gold standard.

Alternatively, fungi from the *Microsporum* group may be made to glow green-blue due to the chemical pteridine. This approach has the advantage of speeding up the identification of the condition. Wood light is a piece of equipment that the hospital uses 107 times a year on average.[4] This apparatus aids in diagnosing skin conditions in patients and facilitates the appropriate collection of illness samples. The UVA bulb for the Wood lamp requires replacement after being used for more than 20 years due to deterioration. However, because new bulbs are either too costly or have been discontinued, it is not feasible to replace them.

However, there are currently affordable blacklight blue bulbs on the market. Both bulbs produce bright purple light with the same maximum wavelength of 365 nm. The glass light bulb, which is blue-purple, has a visible light range of 365 nm. It does not appear blue or black but filters off visible blue light. Wood lamp generates ultraviolet light using a glass filter of 9% nickel oxide and barium silicate, with a wavelength of 365 nanometers (320-400 nanometers, or UVA).[5,6] The wood lamp and blacklight blue lamp device have been compared in previous R2R (routine to research) investigations for differential diagnosis of tinea versicolor and erythrasma. The results showed that the lamp eliminated other wavelengths of light, leaving only blue-white light. The study's findings revealed that the two approaches' respective sensitivity, specificity, and accuracy were 82.05, 97.62, and 90.12 percent. In this example, the blacklight blue lamp device and the wood lamp produced the same diagnostic results.[7-10] Thus, a machine was conceived to substitute the wood lamp with the blacklight blue lamp device. Furthermore, the blacklight blue device can be linked to a computer or smartphone and can capture still photographs while observing the lesion or from the sample, such as skin or hair. The blue-green hue of pteridine in the diseased region may be seen by shining the blacklight blue lamp device directly at the lesion in tinea capitis infected with *Microsporum* canis.[11]

At the time of this study, a comparison of the blacklight blue lamp device and wood lamp does not appear in the research on tinea capitis screening in humans. Since blacklight blue can be used to diagnose or screen for tinea capitis, it would no doubt be beneficial for treating the condition and can be practically implemented in the healthcare system. For this reason, the research team decided to examine the efficacy of the blacklight blue lamp device in screening for tinea capitis by considering both analytical sensitivity and specificity.

Materials and methods

Study population

The study focused on patients suspected of having tinea capitis and was conducted at the Southern Regional Hospital of Tropical Dermatology in Trang Province, Thailand, from October 2022 to September 2024. Participants were eligible if they were aged 3 to 15 years, attended their first consultation at the hospital, had a confirmed diagnosis of tinea capitis, provided informed consent, and demonstrated proficiency in reading, writing, speaking, and understanding Thai. Patients were excluded if they had used topical treatments, oral antifungal medications, or antifungal shampoos for tinea capitis within 60 days before they visited the physician.

Collection

Data were obtained from 175 people with confirmed or suspected tinea capitis at Southern Regional Hospital of Tropical Dermatology, Trang Province, Thailand. Three separate parts made up the questionnaire used to gather data for this study: Part 1 consists of general personal data such as age, gender, occupation, history of using antifungal medications, and chronic disease; Part 2 consists of skin disease diagnosis, including clinical characteristics, location, and diagnosis; and Part 3 consists of laboratory examination with data collection based on laboratory test results and skin disease diagnosis. Utilizing Diagnostic Test statistics, the data results were examined to determine the sensitivity, specificity, and accuracy of the wood lamp, blacklight blue lamp device, and KOH preparation test in comparison to fungal culture, the gold standard for diagnosing tinea capitis.

The following is the research protocol: Using a wood Lamp and blacklight blue lamp device, the dermatologist confirmed the diagnosis of suspected tinea capitis and checked for fluorescence in the lesion.

The sample was taken for the types of specimens using a skin or scalp scrape in the same area as the fluorescence observation. The fungus was grown on Sabouraud dextrose agar containing chloramphenicol and cycloheximide, and the causative fungal species was identified within 28 days. Afterward, enough specimens were collected by dividing the fresh specimens into 10-30% potassium hydroxide (KOH) solution for microscopic examination. A preliminary exam examined the fluorescence from a wood lamp and a blacklight blue lamp device. The results were presented to the doctor for treatment, along with the location of the lesion and its fluorescent hue. The laboratory staff were provided a consent form and invited the patients to participate in the experiment. A dermatologist diagnosed the individuals with fungus.

Screening using the wood lamp and blacklight blue (BLB) lamp device

The screening process utilized the wood and blacklight blue (BLB) lamps. The wood lamp, specifically the UVGL-58 Handheld UV Lamp /P/2 95-0007-06, was employed for ultraviolet examination. The BLB lamp device, developed and patented by the Southern Regional Hospital of Tropical Dermatology in Trang Province (Patent No. 1903002609), was also utilized, as illustrated in Figure 1.

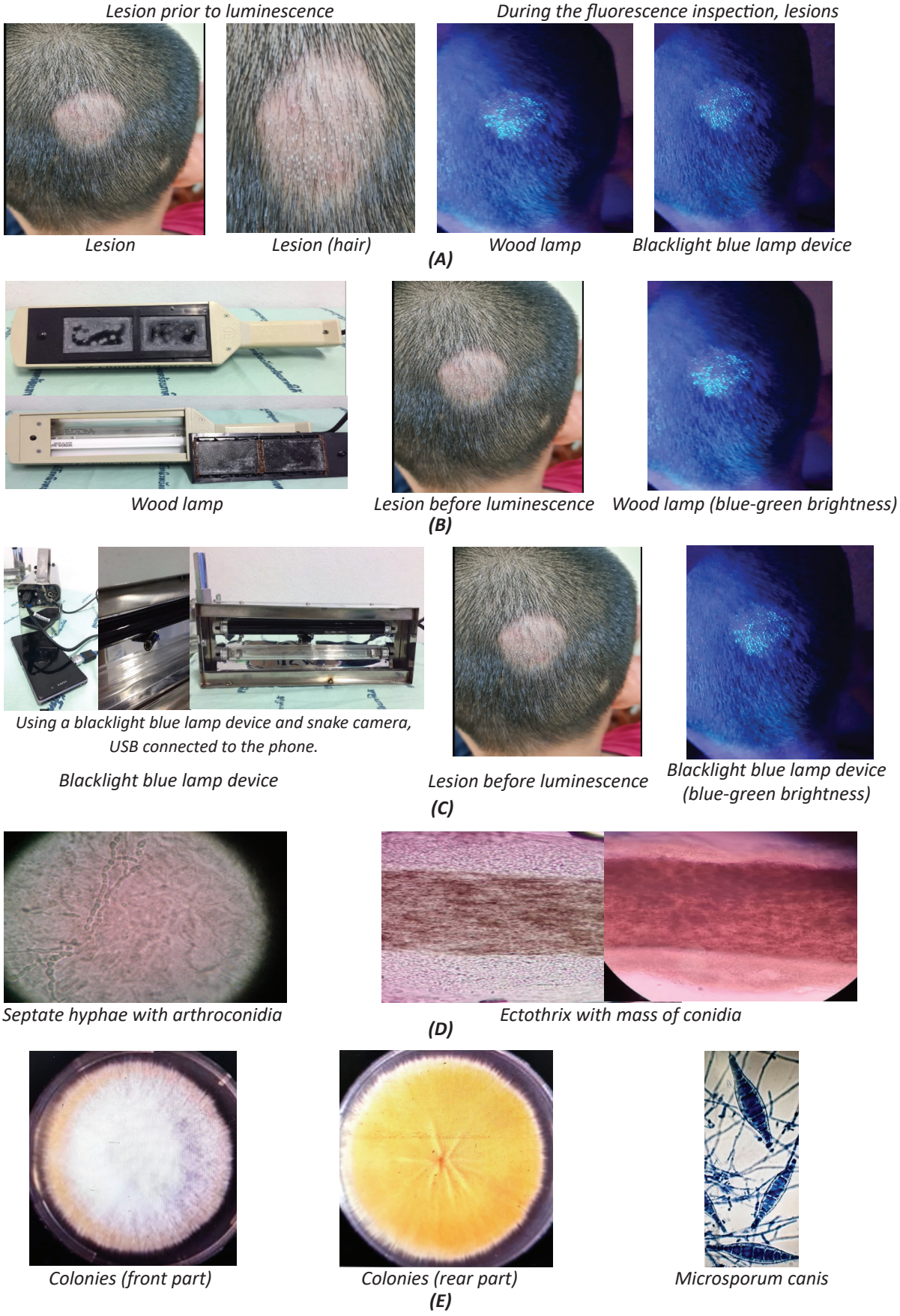

Figure 1. *Investigation on fungal culture, blacklight blue lamp device, wood lamp, and KOH preparation for diagnosing tinea capitis.* ***A****: a comparison of lesions observed before fluorescence and after fluorescence using a wood lamp and a blacklight blue lamp device,* ***B****: lesions observed before and after fluorescence using a wood lamp,* ***C****: lesions observed before and after fluorescence using a blacklight blue lamp,* ***D****: KOH Preparation,* ***E****: a cultured fungus (gold standard).*

Laboratory examination

The fungus was grown on Sabouraud dextrose agar containing chloramphenicol and cycloheximide, and the causative fungal species was identified within 28 days. Afterward, enough specimens were collected by dividing the fresh specimens into 10-30% potassium hydroxide (KOH) solution for microscopic examination. A preliminary exam examined the fluorescence from a wood lamp and a blacklight blue lamp device by laboratory staff trained in the result fluorescence. The results were presented to the doctor for treatment, along with the location of the lesion and its fluorescent hue. The laboratory staff were provided a consent form and invited the patients to participate in the experiment. A dermatologist diagnosed the individuals with fungus.

Statistical analysis

Data analysis was conducted using statistical software and diagnostic test statistics. Categorical data are presented by comparing the blacklight blue lamp device, wood lamp, and KOH preparation of fungal culture as the gold standard for diagnosing tinea capitis to reveal these methods' sensitivity, specificity, and accuracy. The formula diagnostic test statistics calculated the sample size using the n4Studies application,[12-15] with Se of 0.9, 1-Se of 1-0.9, d^2 of 0.1^2, and proportion (p) of 0.2. The sample size calculated from the formula was 175. The sensitivity, specificity, and accuracy of the blacklight blue lamp device, wood lamp, and KOH preparation tests were compared to fungal culture using Pearson's chi-squared test for statistical analyses.

Ethical approval

The complete study was conducted according to the Declaration of Helsinki and approved by the Institute of Dermatology, Bangkok, Thailand Human Ethics Committee (approval number: IRB/IEC 019/2564).

Results

Data on general information and skin disorder diagnosis were used to classify the number and percentage of responders. As shown in Table 1, a total of 175 volunteers participated in the study, of which 114 were male (65.14%) and 61 were female (34.86%). There were 133 (76.00%) children aged 3-9 years and 24 (24.00%) children aged 10 to 15 years, respectively, with a mean age of 8.85 years (SD=3.77). Of the participants, 164 individuals, or 93.71 percent, had no underlying disorders, whereas 11 individuals, or 6.29 percent, did. Tinea capitis affected 175 persons, or 100% of the sample. The head and hair affected 165 individuals, or 94.29 percent of the sample, while the head only affected 4 people, or 2.29 percent, followed by the hair with 6 people, or 3.43%.

Grey patches on the scalp were the most prevalent clinical symptoms, affecting 120 patients or 68.57 percent. These were followed by partial hair loss in 51 patients, 29.14 percent, and diffuse pustular in 4 patients, or 2.29 percent.

Table 1. Data on general information and skin disorder diagnosis were used to classify the number and percentage of responders. (N=175).

Data	Number (N=175)	Percentage
Gender		
Male	114	65.14
Female	61	34.86
Age (years) (Mean=8.85, SD=3.77)		
Pre-existing long-term medical conditions		
No underlying disease	164	93.71
Underlying disease	11	6.29
Provisional diagnosis		
Tinea capitis	175	100
Location		
Scalp	4	2.29
Hairs	6	3.43
Scalp and hairs	165	94.29
Clinical manifestation		
Diffuse pustular	4	2.29
Partial hair loss	51	29.14
Grey patches	120	68.57

Table 2 shows the blacklight blue lamp device analytical findings for sensitivity, specificity, and accuracy compared to a cultured fungus, using the gold standard for determining tinea capitis diagnosis. By screening 175 patients with a blacklight blue lamp device light examination and 175 samples of cultured fungus, it was discovered that 175 individuals had been diagnosed with tinea capitis. It was found that A total of 164 True Positive samples, or 99.39 percent, were screened using a blacklight blue lamp device to search for fluorescence. The lesion region had a blue-green fluorescence, indicating the pathogen entering the hair.

Table 2. Blacklight blue lamp device analytical findings for sensitivity, specificity, and accuracy compared to a cultured fungus.

Result	Culture fungus (gold standard)	N	%	Indication
Blacklight blue lamp device				
Fluorescent detection (+)	Positive	164	99.39	True positive
	Negative	1	0.61	False positive
No fluorescent detection (-)	Positive	0	0	False negative
	Negative	10	100	True negative
Total results		175		
Sensitivity			99.39	
Specificity			100	
Accuracy			99.43	

Pteridine is the luminous material (pyrimidine-4,5, 2,3-pyrazine). The colonies' smooth surface, like silk or cat hair, is a culture characteristic with a possible groove in the middle of the colony where the yellow edges meet. Under a microscope, the yellow colonies beneath the microconidia seem to be solitary, oval cells that are sparsely protruding from the edges of the fungal stalk. Macroconidia are large, like shuttles, with solid walls, spines, and a pointy tip that curves. *Microsporum canis* is present within, where 6-15 cells develop from the peduncle. The result of fungal culture was positive in about 165 patients with the morphology of colony and microscopic identification that were shown *Microsporum canis* all 165 colonies as shown in Figure 1, a cultured fungus (gold standard) (E).

Ten true negative samples, or 100 percent, revealed that neither the fungal culture nor the screening using the blacklight blue lamp device's fluorescence revealed any fungal growth in the lesion region.

Table 3 shows the study's findings of the wood lamp's sensitivity, specificity, and accuracy compared to the cultured fungus (gold standard) technique. It shows that 175 patients were diagnosed with the condition, 175 underwent a light examination, and 175 underwent fungal culture.

Table 3. Wood lamp analytical findings for sensitivity, specificity, and accuracy compared to a cultured fungus.

Result	Culture fungus (gold standard)	N	%	Indication
Wood lamp				
Fluorescent detection (+)	Positive	164	100	True positive
	Negative	0	0	False positive
No fluorescent detection (-)	Positive	1	9.09	False negative
	Negative	10	90.91	True negative
Total results		175		
Sensitivity			100	
Specificity			90.91	
Accuracy			99.43	

True positive results of 164 samples, or 100% (from fungal culture is *M. canis*), revealed that the fungal culture had the appearance of a colony with a smooth surface like silk or cat's fur, the yellow edge possibly having a groove at the center of the colony, and the screening by looking at the wood lamp fluorescence in the lesion area showed a blue-green fluorescence of pteridine in the pathological area. Under a microscope, the yellow colony shows large macroconidia resembling shuttles, thick walls and thorns, a curved pointed tip, and 6-15 cells growing from the peduncle, identified as *Microsporum canis*. The microconidia are single oval cells that grow out from the side of the fungal stalk in small numbers.

Ten samples presented the true negative result. It revealed that no fungus (90.91% of the total) was discovered in the fungal culture and that no fluorescence

was detected in the lesion region using the wood lamp fluorescence screening.

Table 4 presents the findings of examining the KOH Preparation test's sensitivity, specificity, and accuracy compared to the culture technique, considered the gold standard. The analysis reveals that 175 patients were diagnosed with the condition, 175 underwent the KOH Preparation test, and 175 underwent culture.

Table 4. Results of comparing the KOH preparation test with a culture of fungus in terms of sensitivity, specificity, and accuracy.

Result	Culture fungus (gold standard)	N	%
KOH preparation			
	Positive	165	94.29
	Negative	10	5.71
Total results		175	
Sensitivity			100
Specificity			100
Accuracy			100

Note: The culture fungus had to be compared with the 95% confidence interval, CI.

The KOH preparation test, as shown in Figure 1, indicated ectothrix with a mass of conidia and septate hyphae with arthroconidia, and ectothrix with a mass of conidia and culture showed growth of *Microsporum canis*, according to true positive findings of 165 samples. Furthermore, the true negative findings of ten samples demonstrated that neither fungal growth nor the KOH Preparation test could identify the fungus.

The data was analyzed using diagnostic test statistics, and the findings show that the data had 100% accuracy, 100% specificity, and 100% sensitivity.

When compared to fungal culture, the gold standard for diagnosing tinea capitis, Table 5 shows sensitivity, specificity, and accuracy analysis of the blacklight blue lamp device, wood lamp, and KOH preparation test was 99.39%, 100%, and 100% for sensitivity, 100%, 90.91%, and 100% for specificity, and 94.43%, 100%, and 99.43% for accuracy, respectively. A comparison of the three methods revealed the differences in sensitivity values and no statistically significant differences in sensitivity, specificity, or accuracy; the *p* value was 0.723, the methods' specificity was 0.735, and their accuracy was 0.676.

Table 5 The sensitivity, specificity, and accuracy analysis of the blacklight blue lamp device, wood lamp, and KOH preparation tests compared with the fungal culture.

Test	%		
	Sensitivity	Specificity	Accuracy
Blacklight blue lamp device	99.39	100	99.43
Lamp	100	90.91	99.43
KOH Preparation	100	100	100
p-value	0.723	0.735	0.676

Note: the cultured fungus had to be compared with the p-value.

Diagnostic Test statistics were used to analyze the data, and the findings showed that the accuracy, sensitivity, and specificity were, respectively, 99.43 percent, 100 percent, and 99.39 percent.

Under a microscope, microconidia are single, oval cells that grow from the side of the fungal stalk and are few. Macroconidia are large, resembling a shuttle, with a pointed and curved tip, thick wall, and thorns. Inside are 6-15 cells growing from the peduncle, confirmed to be *Microsporum canis*. Tinea capitis of the scalp, wood lamp, and blacklight blue lamp device show a blue-green color. Lastly, the KOH preparation test reveals septate hyphae with arthroconidia or ectothrix with a mass of conidia.

Under a microscope, microconidia are single, oval cells that grow from the side of the fungal stalk and are few. Macroconidia are large, resembling a shuttle, with a pointed and curved tip, thick wall, and thorns. Inside are 6-15 cells growing from the peduncle, confirmed to be *Microsporum canis*. Tinea capitis of the scalp, wood lamp, and blacklight blue lamp device show a blue-green color. Lastly, the KOH preparation test reveals septate hyphae with arthroconidia or ectothrix with a mass of conidia.

Discussion

Microsporum canis infection is the cause of tinea capitis. A long-used instrument known as a Wood light was formerly present in the hospital unit, but its degradation impacted the service. As a result, patients and physicians who made laboratory diagnoses did not receive the appropriate care. Market analysis showed that blacklight

blue lamps are less costly, have a visible light range of 365 nanometers, have the same maximum wavelength (365 nm), and have light purple characteristics. The wood lamp, on the other hand, is a device that produces ultraviolet light with a wavelength of 365 nanometers (320-400 nanometers, or UVA) by blocking out other wavelengths and leaving only blue-white light behind. The filter glass is made of barium silicate, and 9% nickel oxide.[5,6,11] Blacklight blue's look is comparable to a wood desktop lamp and needs to be plugged in. The lamp has a switch for three modes: light purple, bright blue, and adjustable blacklight blue.

In this study, 175 individuals with a history of tinea capitis were tested for KOH preparation, and 175 samples of fungal cultures were collected. Ten of the samples were actual negatives, and 165 were true positives. One sample had a false positive rate of 00.61%. It was discovered that the fluorescence of contaminants such as cotton swabs, gauze, flour, or the use of certain medications before visiting a doctor could be the cause of a false positive in a blacklight blue machine screening. As for fungal culture, it could have been caused by microorganisms present during sample collection, laboratory examinations, contamination of culture media, local organisms in the sample, or even pathogenic fungi from other samples examined in the lab.

False Negative is not detected, although the blacklight blue lamp device can detect it. It might be brought on by using ointments on the lesion before visiting a physician or by reducing microorganisms because of treatment. The fungal culture could be the consequence of the patient receiving antifungal medication, where the drug buildup in the hair is high enough to prevent the growth of microbes on the culture medium, or it could come from the scalp and hair samples used for testing that were taken from the ends of the hair that have dead fungi or are unable to multiply. While incidents are rare, false positive findings might occur using wood lamp screening. They might be brought on by using ointments on the lesion before visiting a physician or by the treatment-induced reduction of organisms. The fungal culture might be obtained from the tested scalp and hair samples, from hair ends that contain inactive or dead fungi, or from patients who are receiving antifungal medication and have enough drug build-up in their hair to prevent the organism from growing on the culture medium.

The false negative findings (one sample, 9.09%) suggest that wood lamp screening might have been ointments applied to the lesion before consultation with a physician or a reduction in the number of microorganisms because of therapy. The fungal culture could have originated from the scalp and hair samples used in the examination, taken from hair ends containing dead fungi or incapable of increasing, or from patients whose hair had a high enough concentration of antifungal medication to prevent the growth of microorganisms on the culture medium.

In the case of the KOH preparation test and fungal culture, the wood lamp and blacklight blue lamp devices both aid in properly collecting specimens in the right location, complying with the guidelines, and enough. Nevertheless, the KOH preparation method may yield false negative results, which could arise from the fact that the hair and scalp samples used in the test were taken from hair ends that contained dead fungi or were unable to multiply or from patients whose drug accumulation was high enough to prevent the fungi on the culture medium from growing. The data was assessed using diagnostic test statistics with a 95% CI.[16-19] The results showed 100% accuracy, 100% specificity, and 100% sensitivity. While KOH preparation has a high sensitivity for fungal detection in samples, it cannot identify or categorize the kind of fungal species present in the samples.[17] Tomotaka Sato *et al*. found that the wood lamp is helpful for the diagnosis of onychomycosis and for monitoring the course of treatment of the disease.[20] It is a simple and quick method for looking at the pathological characteristics of the lesion margin and the destruction of the nail caused by fungus. On the other hand, the blacklight blue lamp device is an easy-to-use, rapid-acting instrument consistent with the study results. The tool checks for skin conditions in doctor's examining rooms, including erythrasma, tinea capitis, and tinea versicolor. The light blue lamp device was developed at a cost of under 5,000 Baht by the Southern Regional Hospital of Tropical Dermatology Trang Province. Nevertheless, the wood Lamp costs under 20,000 Baht.

This developed device represented various features during the medical procedure with the sample or lesions, e.g., photo recording, simulating imaging, and connecting to computer or mobile devices. This supports physicians in identifying illnesses quickly, accurately, and efficiently, enhancing the quality of life for those who receive services.

Limitation

Using a wood lamp or blacklight blue lamp device alone might not be enough for a precise diagnosis. It should be combined with other laboratory tests like direct examination or culture to confirm the diagnosis. Both tools are useful for preliminary screening; however, each has limitations: 1) Since other chemicals may be responsible for the luminous material, the type of fungus causing the sickness cannot be recognized, 2) Research in other communities, and 3) Examine the outcomes of therapy fluorescence and other populations.

Conclusion

Using a comparison of fungal culture, the gold standard for diagnosing tinea capitis, the sensitivity, specificity, and accuracy analysis of the blacklight blue lamp device, wood lamp, and KOH preparation test was assessed. It is practical, easy to use, and time-saving for medical professionals in diagnosing and treating patients. A wood or blacklight blue lamp device alone may not diagnose definitively. For confirmation, it is recommended to combine it with other laboratory techniques, such as direct examination or culture testing.

Conflict of interest

None declared.

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