

## The Diagnostic Accuracy of Potassium Hydroxide Test in Dermatophytosis

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### Abstract

Superficial and cutaneous fungal infections have high prevalence all over the world. Dermatophytosis is the most prevalent and important cutaneous fungal infection. Because of the requirement of long-course anti-fungal therapy, precise diagnosis of dermatophytosis is necessary before starting treatment. Currently, the routine laboratory studies are direct microscopic examination with potassium chloride (KOH) preparation and fungal culture. However, fungal culture is relatively expensive and time-consuming in comparison to KOH test. In this study, the accuracy of KOH test in the diagnosis of dermatophytosis was evaluated in 489 patients who were suspected for superficial fungal infections from March 2011 to March 2014. The samples were taken from the suspicious lesions, and the diagnosis was made by fungal culture and/or KOH test. Fungal culture was considered as the gold standard for diagnosis. The results showed that, of the 489 cases, 147 (30.1%) had positive KOH test and 100 (20.5%) had positive culture. For dermatophytes, the diagnostic sensitivity, specificity, positive predictive value, and negative predictive value of KOH test were 91.9%, 91%, 61.9%, and 98.6%, respectively. We concluded that KOH test was simple, fast and cheap, and there was no need for fungal culture to diagnose the superficial fungal infections, especially for those caused by the dermatophytes due to the high sensitivity of KOH test.

**Keywords:** Diagnosis, KOH test, fungal culture, dermatophytes

### Introduction

Based on the forms of colonies, fungi can be divided into two categories: yeast and molds or filamentous fungi, as well as the fungi that are capable of producing both forms (dimorphic). According to the locations, fungal infections can be divided into four categories: superficial, cutaneous, subcutaneous, and systemic or visceral (1, 2).

Cutaneous and superficial fungal infections are skin diseases caused by fungi such as dermatophytes and some opportunistic fungi (*Malassezia*, *Candida*, *Aspergillus*, etc.). The prevalence and characteristics of these diseases are related to the environmental conditions, life styles, characteristics of common immigration, etc. (3). Dermatophytosis is one of the most important cutaneous fungal diseases (4). Animals are an important source of fungal

infection in both urban and rural communities (5). Pathological changes of these infections occur as a result of host immune system response to fungi and their metabolic products. So far, more than 40 species of dermatophytes have been detected, which are classified into three generations: *Microsporum*, *Trichophyton* and *Epidermophyton* (6). Only 11 species of these 40 dermatophyte species are common causes of tinea capitis in humans and their sources can be from human, animal or soil (4).

Dermatophytosis has multiple clinical forms that can be classified according to the involved sites: body ringworm (*T. corporis*), tinea capitis (*T. capitis*), beard ringworm (*T. barba*), tinea of face (*T. faciei*), tinea pedis (*T. pedis*), hand ringworm (*T. manum*), jock itch (*T. cruris*), and onychomycosis (*T. unguium*) (6).

Because fungal culture is a high-cost, time-consuming process and considering the high prevalence of fungal infection, it is necessary to develop a definitive diagnosis of dermatophyte infection before starting antifungal therapy. Because it is difficult to clinically differentiate dermatophytosis from other fungal dermatoses, laboratory studies (direct microscopic examination and fungal culture) are necessary for definitive diagnosis (7). Currently, the routine laboratory tests are direct microscopic examination with potassium hydroxide (KOH) preparation and fungal culture (8). KOH test is an easy, fast and inexpensive method that is commonly used in the diagnosis of cutaneous fungal infections (9). However, KOH test and fungal culture have often produced conflicting results due to different methods used for collection and preparation of samples (8). Doctors use a combination of these two tests to increase their diagnostic sensitivity (10). Since the fungal culture is a costly and time-consuming method in comparison with KOH test, and also because of the high prevalence of fungal infections, quick and efficient diagnosis and treatment are necessary. Therefore, this study was done to evaluate the diagnostic value of KOH test in dermatophytosis to understand whether it was necessary and important for conducting both KOH test and fungal culture in diagnosis of suspicious lesions.

### Materials and Methods

From March 2011 to February 2014, there were a total of 2,203 patients who had skin lesions suspected for superficial fungal infection and were examined in Yazd Central Laboratory of Mycology. Of them, 1,714 patients had KOH test alone and were excluded from the studies. The remaining 489 patients had both KOH test and fungal culture, and were analyzed.

The samples were collected from the suspicious lesions with clean and sterile plates. The skin and nail samples were first treated with 10% KOH, and the hair samples were treated with lactophenol solution for 30-60 min. The samples were then

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examined under light microscopy. The sample smear was considered as positive if hyphae, mycelium, arthroconidia, spores, yeast, pseudohyphae, or budding cells were observed under the microscopy. For cultivation of the samples, sabouraud dextrose agar medium containing chloramphenicol and cyclohexamide was used. The medium was kept at room temperature and evaluated for fungal growth 2-3 times every week. The culture was considered as negative if fungal growth was absent after four weeks' culture.

The information that was recorded in a pre-designed table included patient's gender, lesion location, smear test result, fungus cultivation result, and type of growing species. The results were presented in the form of frequency tables and required indexes.

## Results

From March 2011 to February 2014, 2,203 patients were referred to the Central Laboratory with 489 patients having both KOH smear and fungal culture.

Of the 489 patients, 242 were male (49.5%) and 247 were female (50.5%). In terms of the sampling location, 39.9%, 7.2%, 19.2%, 11.9%, 9.6% and 12.3% of the samples were acquired from nail, head, body, groin, hand, and foot, respectively. The most complaints of patients had been from the nail and the least complaints of patients had been from the head region. Regarding the season, 134 patients (27.4%) were tested in the winter and 107 patients (21.9%) in the summer.

Table 1 shows the KOH test results of the 489 patients and of them, 342 (69.9%) were negative and 147 (30.1%) were positive. Of the positive diagnosis, dermatophyte had the highest frequency. Table 2 shows the fungal culture results of the 489 patients and of them, 389 (79.5%) were negative, 100 (20.5%) were positive, and dermatophytosis had the highest frequency (62%) in the positive culture. The most common dermatophyte was *Trichophyton verrucosum* (22 cases) and the least was *Trichophyton violaceum* (2 cases).

Table 1: Results of the KOH tests

Results	Number	Percentage (%)
Negative	342	69.9
Positive		
Dermatophytes	92	18.8
Candidiasis	36	7.4
Erythrasma	18	3.7
T. versicolor	1	0.2
Total	489	100

Table 2: Results of the fungal culture

Type of fungi	Number	Percentage
Dermatophytes		
<i>T. mentagrophytes</i>	19	19
<i>T. verrucosum</i>	22	22
<i>T. tonsourans</i>	5	5
<i>T. violaceum</i>	2	2
<i>Epidermophyton floccosum</i>	11	11
<i>Microsporum canis</i>	3	3
Candida	33	33
Aspergillus	5	5
Total	100	100

Table 3: The diagnostic consistency between KOH tests and fungal culture

Culture	KOH test				
	Negative	Dermatophyte	T. versicolor	Candida	Erythrasma
Negative	328	35	7	18	1
Positive	14	57	29	0	0
Total	342	92	36	18	1

Table 3 shows the diagnostic consistency for between KOH test and fungal culture. Of the 342 cases with negative KOH test, 328 cases were also negative by culture, but 14 cases were positive by culture. Of the 14 cases with negative KOH test and positive culture, 5 cases were dermatophytes, 5 were aspergillus, and 4 were candidiasis.

Of the 92 cases with dermatophytes by KOH test, majority (57 cases) were also positive by fungal culture, but 35 cases had negative culture. To determine the sensitivity and specificity of KOH test in the diagnosis of dermatophytosis, fungal culture was taken as the gold standard test. As shown in table 4, the sensitivity, specificity, positive predictive value, and negative predictive value of KOH tests were 91.9%, 91%, 61.9%, and 98.6%, respectively.

Table 4: The diagnostic value of KOH test for dermatophytosis

Negative predictive value	Positive predictive value	Specificity	Sensitivity
98.6%	61.9%	91%	91.9%

## Discussion

The annual death tolls of healthcare-associated infections (bacterial and fungal infections) are estimated to be more than 60,000 in the U.S. (11). In the present study, the most common infectious disease was dermatophytosis among the superficial and cutaneous fungal infections. The studies by Azizi and Jivad (4), and Jafari *et al.* in Yazd (2), Nasrollahi Omran *et al.* in Tehran (3), Khazaei *et al.* in Arak (12), etc. in Iran have shown that dermatophytosis has the highest prevalence among superficial and cutaneous fungal infections. The studies in Turkey and in Japan on the prevalence of superficial fungal infections have also demonstrated that the dermatophytosis is the most common infectious disease (13, 14).

Of the 489 cases requested culture in this study, 100 (20.5%) had positive culture. Dermatophyte was the most frequently isolated fungi (62 cases). Regarding the species of dermatophytes, *T. verrucosum*, a type of zoophilic fungi, was most commonly observed (22 cases). *T. mentagrophytes* was the second (19 cases). In the studies by Jafari *et al.* and by Azizi and Jivad in Yazd, the most common species have been reported to be *T. verrucosum* and *T. violaceum*, respectively (2, 4).

Based on the study by Edalatkhah *et al.*, the most common species is *T. verrucosum* (14). In the present studies, this species was the second. The most common isolated fungus is *T. mentagrophytes* in the studies by Nasrollahi Omran *et al.* (3), and by Baghestani *et al.* (15). Based on the study by Aghamirian *et al.* (5), the most common cause is *Epidermophyton floccosum* that was the third in the present studies. In the studies in Japan (14), Mexico (16), and Turkey (13), the most common fungal species has been reported to be *Trichophyton rubrum*, while in our study, there was no reported isolation for this species.

The difference in the most common infection species for dermatophytosis among the studies may be due to the difference in weather condition, sampling time and location, travels and immigrations, customs and people's social practices in different regions, presence or absence of animals in human life, and sanitation.

Different results are acquired from KOH test and fungal culture in various studies. Many physicians ask both of the tests to increase the diagnostic sensitivity, but the fungal culture is a highly costing and time-consuming method. To determine the sensitivity and specificity of KOH test, a gold standard is necessary. Clinical

assessment alone cannot be considered as the gold standard because various non-dermatophytosis diseases can have similar symptoms to dermatophytosis. In various studies on KOH test, fungal culture is considered as the gold standard for evaluation of the diagnostic value of KOH test (9, 18, 19).

Ecemis *et al.* investigated the necessity of culture for recognition of *T. pedis* (17). The KOH test and fungal culture were done for 2,427 suspected patients. The fungal culture is regarded as the gold standard. The results of their studies have shown 95.7% and 69.6% for the sensitivity and specificity of KOH test, respectively. In the studies by Miller and Hodgson, the sensitivity and specificity of KOH test and fungal culture for detection of *T. pedis* were examined in 333 suspected cases with culture being used as the gold standard (9). The results have shown that the sensitivity and specificity of KOH test are 77% and 62%, respectively. Haldane *et al.* compared the different laboratory tests in the diagnosis of superficial fungal infections (19). In this study, fungal culture was used as the gold standard and 207 samples from patients were studied. The results have shown that the KOH test for dermatophytes has 88% sensitivity, 95% specificity, 73% positive predictive value, and 98% negative predictive value.

The present study was done to determine the diagnostic value of KOH test in dermatophytosis in patients referred to Yazd Central Laboratory in 2011-2014. The KOH test sensitivity and specificity were 91.9% and 91%, respectively. In comparison with other studies, our data showed a higher sensitivity and specificity in some cases and a lower sensitivity and specificity in other cases.

As shown in table 4, the false negative and false positive values of KOH test for detection of dermatophytes were 8% and 9%, respectively. The studies by Ecemis *et al.* have shown the false positive and false negative values of KOH test are 30.4% and 3.4%, respectively (17). The false negative results of KOH test may be due to the low fungal elements in the samples or less experience of the laboratory technicians, while the false positive results can be caused due to improper sampling, artifacts, or dead fungal organism.

## Conclusion

Combination of KOH test and fungal culture can increase the diagnostic sensitivity. Considering the high sensitivity and specificity of KOH test, it alone is enough for detection of fungal infections if this technique is done by an expert and in a well-equipped laboratory. Because of time-consuming of fungal culture as well as additional costs, there is no need to request culture and treatment can be started in most cases if the clinical signs are in favor of dermatophytosis and the KOH test result is positive.

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