ORIGINAL ARTICLE

Evaluation of an Artificial Intelligence Technology for the Diagnosis of Pigmented Skin Lesions in Egyptian Patients

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Abstract

Background: ***Pigmented skin lesions are that lesions which cause colored spots and may classified to Benign or malignant lesions. It is very important to differentiate between them to develop a suitable treatment. Previous literature reported a new technology that could be used to diagnosis the pigmented skin lesion based on artificial intelligence(AI).***

Aim and objectives: ***To assess the efficacy of artificial intelligence-based tools for the evaluation of pigmented skin lesions, both malignant and benign, and their ability to predict possible differential diagnoses.***

Subjects and methods: ***This cross-sectional study was carried out on 200 participants with different pigmented skin lesions who underwent skin biopsy after taking a photo session of lesions. The photograph was assessed by AI tools, and the results were compared with the results of the biopsy. The result of AI tools was evaluated depending on two aspects: the ability to differentiate between benign and malignant lesions, and the ability to predict the correct diagnosis within the predicted differential diagnosis.***

Results: ***Biopsy results revealed 50% benign and 50% malignant lesions, with seborrheic keratosis(48%) and basal cell carcinoma(51%) being the most common. All AI tools showed strong agreement with histopathology(k-values ranging between 0.64-0.89), particularly in identifying pigmented skin lesion.***

Conclusion: ***AI tools for screening pigmented skin lesions improve diagnostic accuracy, helping healthcare providers, especially those with less experience, to achieve expert-level assessments. They are transforming dermatology by enhancing diagnostic precision and improving patient outcomes through timely interventions and efficient care.***

Keywords: Pigmented skin lesions; Artificial intelligence

1. Introduction

Pigmented skin lesions(PSLs) are spots on the skin, usually brown, black, or blue, caused by melanin, blood, or external pigments like tattoos. They can be melanocytic or non-melanocytic, with non-melanocytic lesions including keratinocyte, vascular, or reactive lesions.[1]

The causes of PSLs are varied, including hormonal changes, genetics, age, skin trauma, inflammation, sun exposure, medications, and various diseases. Distinguishing between benign and malignant lesions is crucial for formulating an appropriate treatment plan.[2]

Clinical evaluation of PSLs is crucial to monitor changes in size, shape, color, border, diameter, or asymmetry, which may suggest malignancy. Early skin cancer detection improves outcomes, requiring an expert dermatologist's assessment. Additional tests, like swabs, nail clippings, blood samples, and biopsies, may also be requested when necessary.[3,4]

A skin biopsy involves removing a small skin sample for testing to diagnose diseases and stage tumors for appropriate treatment, especially in cases of malignancy. It requires time, resources, and medical staff, so accurately assessing suspicious PSLs is essential to distinguish between benign and potentially malignant lesions before biopsy.[5,6]

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Artificial intelligence(AI) aims to replicate human cognitive functions, primarily simulating human reasoning. Machine learning, a subset of AI, uses algorithms to detect patterns and make predictions from data.[7,8]

The aim of this study was to assess the efficacy of AI-based tools for the evaluation of pigmented skin lesions, both malignant and benign, and their ability to predict possible differential diagnoses.

2. Patients and methods

This cross-sectional study was carried out on 200-participants from November 2023 to December 2024 in which, one hundred patients with benign pigmented skin lesions including(48-cases of seborrheic keratosis, 40-cases of melanocytic nevus, and 12-cases of actinic keratosis) and the remaining 100-patients with malignant pigmented skin lesions including(51-cases of basal cell carcinoma, 37-cases of squamous cell carcinoma, and 12-cases of malignant melanoma) underwent lesion photo analysis by AI tool then skin biopsy(as baseline) which is compared to the result of AI tools. The selection of 100-benign and 100-malignant biopsy-confirmed cases ensured a balanced distribution in the study. This approach was taken to evaluate the AI tool's performance without bias toward either class, allowing for a more accurate assessment of its diagnostic capabilities.

Ethical consideration:

Informed consent was obtained from all subjects before study enrollment and after approval from the Al-Azhar Medical Research Ethics Committee.

Inclusion criterion:

Participants were recruited from Al-Azhar University Hospitals' Dermatology Outpatient Clinics. The study included both sexes, aged 10-60, with a single type of pigmented skin lesion on visible areas of the body, excluding areas where the lesions were unclear such as that mentioned in exclusion criteria.

Exclusion criteria:

Patients with multiple different skin lesions, patients with skin lesions contain foreign objects such as(marker, tattoo, sunscreen and powder), patients with skin lesion area is under the nail, with sunburn skin or very dark skin(type V on Fitzpatrick scale), with skin lesion in skin fold, with Skin lesion on the surface of mucous membrane, with skin lesions in heavy hairy areas to avoid possible factors that may obscure the visibility of the skin lesions and complicate image interpretation, and patients who fail to fulfill the inclusion criteria.

Sample size:

A total of 200 cases were included to ensure statistical reliability and meaningful results. The sample size was determined based on a power analysis, considering factors such as the prevalence of pigmented skin lesions, the diagnostic accuracy of artificial intelligence-based tools, and a 95% confidence level with 80% power. This number is expected to provide sufficient data to evaluate the effectiveness of AI in distinguishing between benign and malignant lesions and predicting differential diagnoses. Additionally, a margin was considered to account for potential data loss or incomplete cases, ensuring the robustness of the study.

Methods:

All members of the study were subjected to the following:

History taking: including age, sex, occupation, duration, medical history, and history of drugs. Clinical assessment and examination: This is done to determine the possible clinical diagnosis of the pigmented skin lesion and then analyze it with the biopsy result. Photo session for lesions: This will be used in evaluation by an AI-based tool.

AI tools:

Model Dermatology:

Model dermatology is an advanced tool designed for healthcare seekers. It uses machine learning algorithms to identify and analyze skin lesions. It examines user-uploaded images, offering a preliminary skin condition assessment.

Action: The application uses a trained classification model to categorize lesions and predict whether they are benign or malignant, offering a ranked list of potential diagnoses but cannot definitively diagnose skin conditions.

Advantages: Free, user-friendly, available on both web and mobile platforms, and developed based on academic research and input from dermatology experts, ensuring scientific accuracy.

Disadvantages: Serves only as a screening tool; it cannot provide a definitive diagnosis or recommend treatments.

Skinive MD:

Skinive MD is a version of the Skinive platform designed for healthcare providers, using AI and computer vision to identify skin diseases.

Action: The application analyzes skin images with a trained AI model, comparing them to a large database to assess malignancy risk and provide likelihood percentages for each condition.

Advantages: User-friendly, detects a wide range of skin lesions, offers continuous support from a dedicated team, and is updated regularly.

Disadvantages: Paid application(with a one-month free trial), only available as a mobile application, which may not suit all users.

Tibot:

Tibot is an AI-powered tool available as a web

and mobile application for healthcare seekers, designed to raise awareness about skin conditions and encourage users to seek medical advice.

Action: It categorizes benign and malignant skin lesions using its AI-based classification system.

Advantages: Free, easy to use, accessible on multiple platforms, and helps raise awareness about skin health.

Disadvantages: It cannot definitively diagnose cancerous lesions or suggest treatment, limiting its clinical decision-making capability.

Fundamentals and basics of AI programs for classifying lesions as benign or malignant:

AI is a simulation of human intelligence and way of thinking. The ability of an AI application to classify skin lesions is determined by its training process during its development and creation phase.

AI tools learn to differentiate between benign and malignant skin lesions through a technical process called supervised learning, where they are trained on a large dataset of labeled images. The training process involves: dataset processing, feature extraction, and evaluation.

Datasets:

A large, organized collection of dermatological and clinical images of skin lesions is used to train AI models. These images are labeled by dermatologists or histopathology reports into categories such as: Benign: Normal moles, seborrheic keratosis, actinic keratosis; Malignant: Melanoma, basal cell carcinoma(BCC), squamous cell carcinoma(SCC).

Learning and Feature Extraction

The AI application is fed with this dataset, where each image is checked to detect specific lesion characteristics, such as: Shape & Asymmetry-Malignant lesions are often irregular in shape; Border Irregularity-Benign lesions have smooth edges, while malignant ones have uneven borders; Color Variation-Benign lesions tend to have uniform color, whereas malignant lesions may contain multiple colors(brown, black, red, blue, white); Texture & Patterns-AI detects surface textures and patterns that indicate malignancy.

The image passes through multiple levels of analysis:First level-Detect basic features(edges, lines); Middle level-Identify complex patterns (shapes, borders); Final level-Make classification decisions(benign vs. malignant).

Evaluation & Validation:

During training, the AI model is exposed to thousands of labeled images. After training, it is tested using new, unlabeled images to assess whether it can correctly extract features and predict lesion classification. The AI's predictions are then compared with actual diagnoses made by dermatologists or histopathology specialists to ensure accuracy and reliability.

Statistical analysis:

Data were analyzed using Statistics Package for Social Sciences(SPSS) version 25. Qualitative data were expressed as frequency and percentage. Continuous quantitative data were expressed as mean±standard deviation(Mean±SD). Mean(average): the central value of a discrete set of numbers, specifically the sum of values divided by the number of values. Standard deviation(SD) is the measure of dispersion of a set of values. A low SD indicates that the values tend to be close to the mean of the set, while a high SD indicates that the values are spread out over a wider range. Probability(P-value): P-value<0.05 was considered significant, P-value<0.001 was considered highly significant, and P-value>0.05 was considered insignificant.

The following tests were done:

Kappa test(k) was done to measure the agreement between the studied test and the gold standard test. Kappa interpretation: K<0.2 means poor agreement, K=0.2-0.4 means fair agreement, K=0.4- 0.6 means moderate agreement, K=0.6- 0.8 means good agreement, and K=0.8-1.0 means very good agreement.

AI Applications Interface:

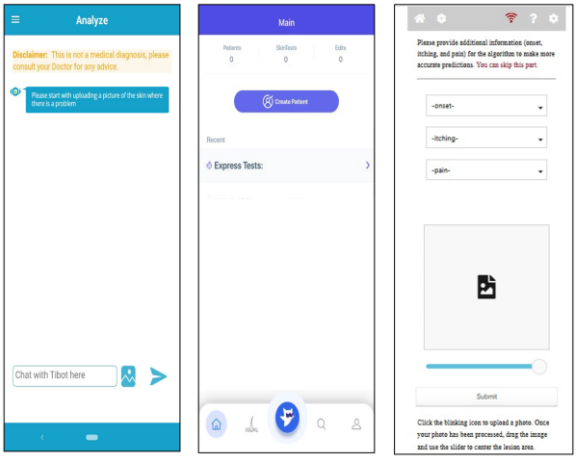


Figure 1. (A): Tibot tool, (B): Skinive MD tool, (C): Model Dermatology tool.

3. Results

Table 1. Description of biopsy results in all studied patients.

BIOPSY RESULTS		ALL PATIENTS (N=200)	
TYPE OF TUMOR	Benign	100	50.0%
	Malignant	100	50.0%
BENIGN LESIONS (N=100)			
SEBORRHEIC KERATOSIS		48	48.0%
MELANOCYTIC NEVUS		40	40.0%
ACTINIC KERATOSIS		12	12.0%
MALIGNANT LESIONS (N=100)			
BASAL CELL CARCINOMA (BCC)		51	51.0%
SQUAMOUS CELL CARCINOMA (SCC)		37	37.0%
MALIGNANT MELANOMA		12	12.0%

Biopsy results showed 100-patients (50%) with

benign lesions and 100-patients (50%) with malignant lesions. Among benign lesions, 48-patients (48%) had seborrheic keratosis, 40-patients (40%) had melanocytic nevus, and 12-patients (12%) had actinic keratosis. Among malignant lesions, 51-patients (51%) had basal cell carcinoma, 37-patients (37%) had squamous cell carcinoma, and 12-patients (12%) had malignant melanoma.

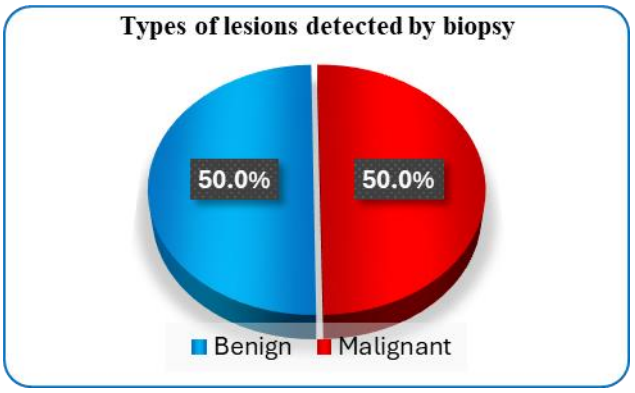


Figure 2. Type of tumor detected by biopsy in all studied patients.

Table 2. Clinical utility of clinician decision in categorization of pigmented skin lesions into benign or malignant in all studied patients

CLINICAL UTILITY				
SENSITIVITY	Specificity	PPV	NPV	Accuracy
95%	90%	90.5%	94.7%	92.5%

Clinician decision has the sensitivity of 95%, specificity of 90%, PPV of 90.5%, NPV of 94.7% and accuracy of 92.5% in categorization of pigmented skin lesions into benign and malignant when compared with biopsy.

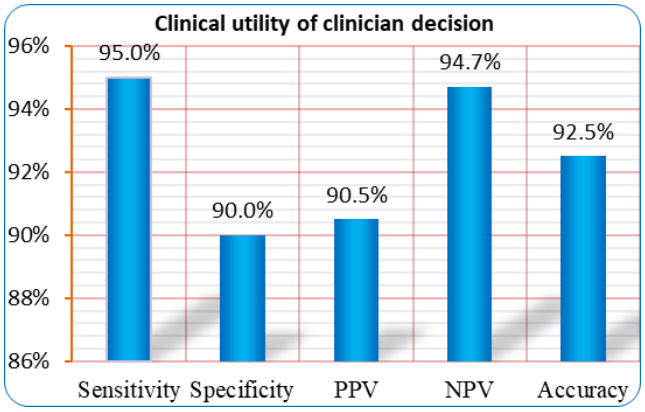


Figure 3. Clinical utility of clinician decision in categorization of pigmented skin lesions into benign and malignant when compared with biopsy in all studied patients.

Table 3. Clinical utility of tibot in categorization of pigmented skin lesions into benign or malignant in all studied patients.

CLINICAL UTILITY				
SENSITIVITY	Specificity	PPV	NPV	Accuracy
95%	69%	75.4%	93.2%	82%

Tibot has the sensitivity of 95%, specificity of 69%, PPV of 75.4%, NPV of 93.2% and accuracy of 82% in categorization of pigmented skin lesions into benign and malignant when compared with biopsy.

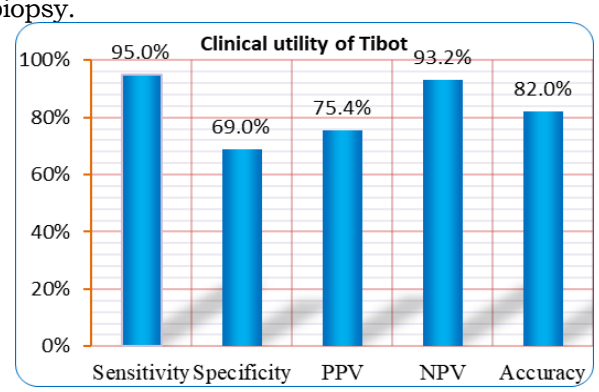


Figure 4. Clinical utility of tibot in categorization of pigmented skin lesions into benign and malignant when compared with biopsy in all studied patients.

Table 4. Clinical utility of model dermatology in categorization of pigmented skin lesions into benign or malignant in all studied patients.

CLINICAL UTILITY				
SENSITIVITY	Specificity	PPV	NPV	Accuracy
94%	95%	94.9%	94.1%	94.5%

Model dermatology has the sensitivity of 94%, specificity of 95%, PPV of 94.9%, NPV of 94.1% and accuracy of 94.5% in categorization of pigmented skin lesions into benign and malignant when compared with biopsy.

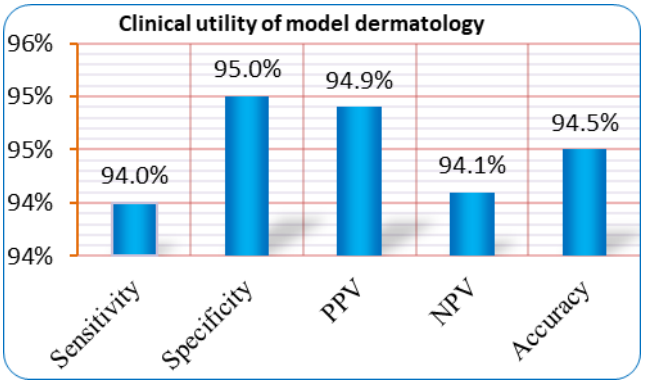


Figure 5. Clinical utility of model dermatology in categorization of pigmented skin lesions into benign or malignant when compared with biopsy in all studied patients.

Table 5. Clinical utility of skinive MD in categorization of pigmented skin lesions into benign or malignant in all studied patients.

CLINICAL UTILITY				
SENSITIVITY	Specificity	PPV	NPV	Accuracy
94%	92%	92.2%	93.9%	93%

Skinive MD has the sensitivity of 94%, specificity of 92%, PPV of 92.2%, NPV of 93.9% and accuracy of 93% in categorization of pigmented skin lesions into benign and malignant when compared with biopsy.

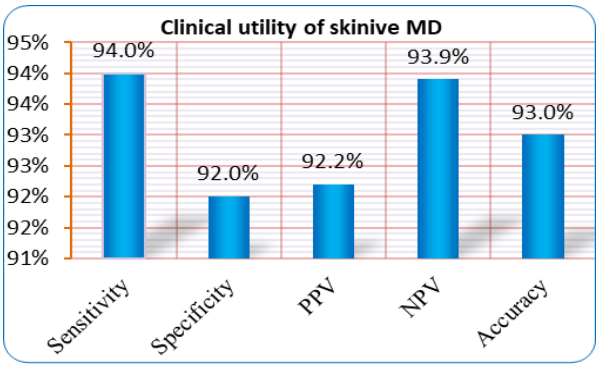


Figure 6. Clinical utility of skinive MD in categorization of pigmented skin lesions into benign or malignant when compared with biopsy in all studied patients.

Table 6. Description of correct rank of diagnosis by(clinician decision-model dermatology-skinive MD) among different lesions revealed by biopsy in all studied patients.

RANK	BCC		SCC		MALIGNANT MELANOMA		SEBORRHEIC KERATOSIS		MELANOCYTIC NEVUS		ACTINIC KERATOSIS	
CLINICIAN DECISION												
FAILURE TO PREDICT THE CORRECT DIAGNOSIS	1	2.0%	10	27.0%	0	0.0%	3	6.3%	5	12.5%	2	16.7%
RANK-1	47	92.2%	15	40.5%	10	83.3%	25	52.1%	31	77.5%	8	66.7%
RANK-2	3	5.9%	10	27.0%	1	8.3%	15	31.3%	3	7.5%	2	16.7%
RANK-3	0	0.0%	2	5.4%	1	8.3%	5	10.4%	1	2.5%	0	0.0%
MODEL DERMATOLOGY												
FAILURE TO PREDICT THE CORRECT DIAGNOSIS	3	5.9%	0	0.0%	1	8.3%	2	4.2%	0	0.0%	0	0.0%
RANK-1	42	82.4%	27	73.0%	8	66.7%	31	64.6%	32	80.0%	7	58.3%
RANK-2	3	5.9%	7	18.9%	2	16.7%	8	16.7%	5	12.5%	4	33.3%
RANK-3	3	5.9%	3	8.1%	1	8.3%	7	14.6%	3	7.5%	1	8.3%
SKINIVE MD												
FAILURE TO PREDICT THE CORRECT DIAGNOSIS	1	2.0%	0	0.0%	0	0.0%	0	0.0%	3	7.5%	3	25.0%
RANK-1	43	84.3%	30	81.1%	10	83.3%	41	85.4%	30	75.0%	7	58.3%
RANK-2	7	13.7%	4	10.8%	1	8.3%	6	12.5%	5	12.5%	1	8.3%
RANK-3	0	0.0%	3	8.1%	1	8.3%	1	2.1%	2	5.0%	1	8.3%

Clinician's diagnosis:

For BCC, the clinician correctly predicted the diagnosis in rank-1 for 92.2% of patients, rank-2 for 5.9%, and failed in 2%. In SCC, the correct diagnosis was made in rank-1 for 40.5%, rank-2 for 27%, and rank-3 for 5.4%, with a failure rate of 27%. For malignant melanoma, the correct diagnosis was made in rank-1 for 83.3%, and 8.3% for both rank-2 and rank-3, with no failure. In seborrheic keratosis, the correct diagnosis was made in rank-1 for 52.1%, rank-2 for 31.3%, rank-3 for 10.4%, and failed in 6.3%. For melanocytic nevus, the diagnosis was correct in rank-1 for 77.5%, rank-2 for 7.5%, rank-3 for 2.5%, and failed in 12.5%. In actinic keratosis, the diagnosis was correct in rank-1 for 66.7%, rank-2 for 16.7%, and failed in 16.7%.

Model dermatology diagnosis:

For BCC, model dermatology correctly predicted the diagnosis in rank-1 for 82.4%, rank-2 for 5.9%, and rank-3 for 5.9%, with a failure rate of 5.9%. In SCC, the correct diagnosis was made in rank-1 for 73%, rank-2 for 18.9%, and rank-3 for 8.1%, with no failure. For malignant melanoma, the diagnosis was correct in rank-1 for 66.7%, rank-2 for 16.7%, and rank-3 for 8.3%, with a failure rate of 8.3%. In seborrheic keratosis, the correct diagnosis was made in rank-1 for 64.6%, rank-2 for 16.7%, and rank-3 for 14.6%, with a failure rate of 4.2%. For melanocytic nevus, the diagnosis was correct in rank-1 for 80%, rank-2 for 12.5%, and rank-3 for 7.5%, with no failure. In actinic keratosis, the diagnosis was correct in rank-1 for 58.3%, rank-2 for 33.3%, and rank-3 for 8.3%, with no failure.

Skinive MD diagnosis:

For BCC, skinive MD correctly predicted the diagnosis in rank-1 for 84.3%, and rank-2 for 13.7%, with a failure rate of 2%. In SCC, the correct diagnosis was made in rank-1 for 81.1%, rank-2 for 10.8%, and rank-3 for 8.1%, with no failure. For malignant melanoma, the diagnosis was correct in rank-1 for 83.3%, and 8.3% for both rank-2 and rank-3, with no failure. In seborrheic keratosis, the correct diagnosis was made in rank-1 for 85.4%, rank-2 for 12.5%, and

rank-3 for 2.1%, with no failure. For melanocytic nevus, the diagnosis was correct in rank-1 for 75%, rank-2 for 12.5%, and rank-3 for 5%, with a failure rate of 7.5%. In actinic keratosis, the correct diagnosis was made in rank-1 for 58.3%, and 8.3% for both rank-2 and rank-3, with a failure rate of 25%.

Case presentation:

Case one:

Melanocytic Nevus Case

Male patient, aged 34-years old, worked as a driver, complain of asymptomatic skin lesion at the back of 6-month duration. Clinical examination showed well defined hypo pigmented patch on the back with central hyper pigmented nodule.

Clinicians' differential diagnosis:

Halo nevus, malignant melanoma, and nevus depigmentosus, biopsy result: halo nevus

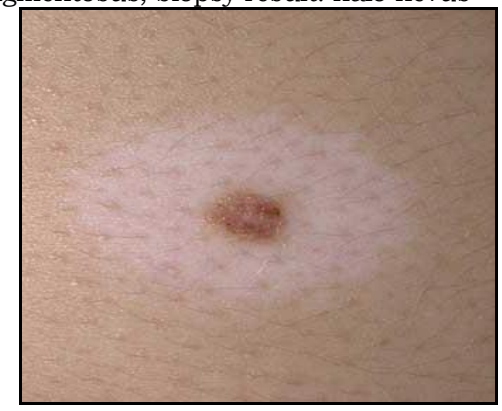
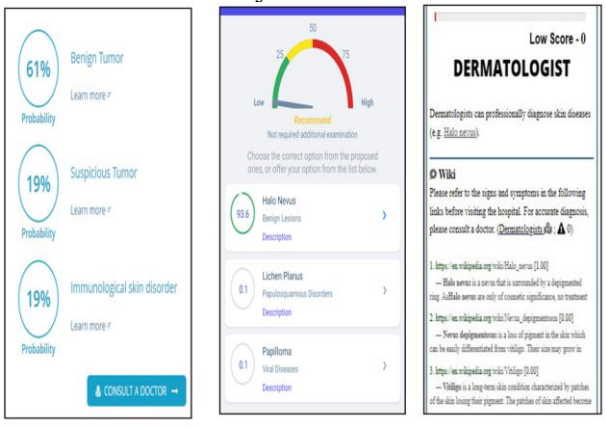


Figure 7. Lesion image.

Ai tools lesion analysis:



A B C

Figure 8. Melanocytic Nevus case analysis:(A):Tibot tool, (B):Skinive MD tool, (C):Model Dermatology tool.

Tibot: benign, model dermatology: low risk of malignancy, halo nevus at rank-1. Skinive MD: low-risk of malignancy, halo nevus at rank-1.

Case two:

Malignant Lesion

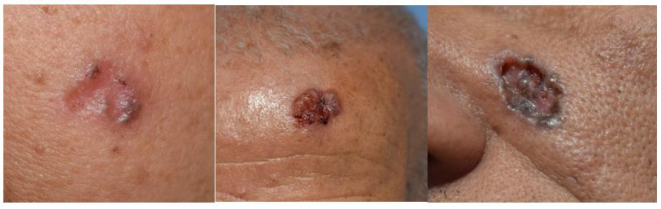


Figure 9. BCC Cases

Clinicians: Malignant, BCC at rank 1

Ai tools results:

Tibot: Malignant, model dermatology: High risk of malignancy, BCC at rank-1. Skinive MD: High risk of malignancy, BCC at rank-1.

Benign Lesion:

Figure 10. Seborrheic Keratosis cases.

Clinicians: benign, Seborrheic Keratosis at rank-1

Ai tools results:

Tibot: benign, model dermatology: low-risk of malignancy, Seborrheic Keratosis at rank-1. Skinive MD: low-risk of malignancy, Seborrheic Keratosis at rank-1.

Fundamentals and mechanism of medical analysis process of lesion:

Figure 11. Lesion detection during AI image analysis, along with lesion feature identification and labeling using 36-code and F9-code, corresponds to familiar information the AI has learned and stored from its training dataset, assisting in the final decision-making process.

4. Discussion

This study demonstrated that clinician performance in categorizing pigmented skin lesions achieved an accuracy of 92.5% across all study cases, while the AI software(namely Tibot in our study) had an accuracy of 82%. Clinicians could predict benign pigmented skin lesions with approximately 90% accuracy and malignant pigmented skin lesions with about 95% accuracy. In contrast, Tibot could predict benign pigmented skin lesions with about 69% accuracy and malignant pigmented skin lesions with about 95% accuracy. Both clinicians and Tibot showed the highest accuracy in predicting malignant lesions(95%), meaning they performed equally well in identifying malignant lesions. Tibot exhibited the lowest performance in predicting benign lesions(69%), suggesting that the AI algorithm faces more difficulty in identifying benign cases compared to others. Top of FormBottom of Form

This study also demonstrated that the AI software(namely Model Dermatology in our study) achieved an accuracy of 94.5% in categorizing pigmented skin lesions across all study cases. It could predict benign pigmented skin lesions with about 95% accuracy and malignant pigmented skin lesions with about 94% accuracy. This shows that the Model Dermatology AI tool has the highest accuracy in predicting benign lesions(95%) and a slightly lower accuracy(94%) in predicting malignant lesions.

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Clarifying the failure rate in this study, clinicians have the highest failure rate in SCC(27%) and melanocytic nevus (12.5%). However, the clinician has a 0% failure rate for malignant melanoma, which is impressive. While Model Dermatology has no failure in SCC, Actinic Keratosis, and Melanocytic Nevus, it is highly reliable for those lesions.

Clinician has the highest rank 1 detection rate for BCC(92.2%) and Malignant Melanoma (83.3%), indicating strong performance in these cases while Model Dermatology shows reliable performance for Melanocytic Nevus(80%).

Model Dermatology shows a relatively higher Rank-3 rate for Seborrheic Keratosis(14.6%), suggesting that it is less confident in this diagnosis, which may require more refinement. Clinician Rank-3 detection is generally lower compared to AI, indicating that clinicians typically rank cases higher in their diagnosis list, potentially reflecting a more nuanced understanding.

This study also demonstrated that the AI software(namely SkinIve in our study) achieved an accuracy of 93% in categorizing pigmented skin lesions across all study cases. It could predict benign pigmented skin lesions with about 92% accuracy and malignant pigmented skin lesions with about 94% accuracy. This indicates that Model Dermatology is slightly outperforming. Both Model Dermatology and SkinIve show promising performance with benign lesions(95% and 92%, respectively), making them strong tools when used in combination with clinicians. The study also revealed that SkinIve had higher failure rates in diagnosing Actinic Keratosis(25%), while it showed a perfect 0% failure rate for Seborrheic Keratosis, squamous cell carcinoma, and malignant melanoma. SkinIve also demonstrated excellent performance for Seborrheic Keratosis(85.4%) and squamous cell carcinoma(81.1%) at rank 1, which was the highest among all models and clinicians. Additionally, SkinIve had the lowest rank three detection rate for Seborrheic Keratosis(2.1%) compared to Model Dermatology(14.6%) and the clinician(10.4% Form

AI tools in diagnosing pigmented skin lesions have great potential to enhance clinical decision-making, but must be certified, regularly updated, and responsibly integrated into practice. Continuous improvements, access to larger datasets, and frequent updates improve AI performance. While helpful, these tools should never replace clinical judgment.

The study was in agreement with Sokolov et al.,[9] which use the Skinive neural network as machine-learning algorithm to calculate the risk rating of skin pathologies. It shows for all skin neoplasms 95.3% sensitivity and 93.5% Specificity. This shows nearly similar Sensitivity and Specificity.

Also, it was in agreement with Han et al.,[10] which use Model Dermatology for diagnosing several types of skin neoplasms. Agreement In using clinical information integrated with image analysis process help Ai tools to achieve accurate predictive diagnoses with high accuracy comparable to clinical expert but the study differed with respect of the work of Han et al.,10 that the result without integrated clinical information didn't be tested.

On the other hand, Patil et al.,[11] used Tibot AI Application to predict the diagnosis of benign condition with an accuracy of 71.4% which differs from this study, where the accuracy of the diagnosing benign condition was 82% that may be due to significant sample size difference between the two studies as well as the fact that the work of Patil et al.,[11] focused on predicting benign lesions only, while this study involved in the prediction of both benign and malignant skin lesions.

4. Conclusion

AI tools for screening pigmented skin lesions enhance diagnostic accuracy, assisting healthcare providers, particularly those with less experience, in making expert-level assessments. These certified tools streamline workflows, guide referrals, and reduce unnecessary procedures, improving dermatology by enhancing diagnostic precision and patient outcomes.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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