Diagnostic Approaches of Skin Cancer and Artificial Intelligence Applications

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ABSTRACT

Skin cancer is one of the most common cancers around the world and its rate is increasing. Exposure to sunlight for long periods of time is classified as one of the main causes. Therefore, understanding the disease and using innovative, effective, diagnostic methods may help in the eradication of the disease and improving the patients' quality of life. In this review, the main etiological factors, the most common diagnostic approaches and the application of artificial intelligence in the detection of skin cancer are discussed. Currently, there are several diagnostic techniques to detect skin cancer, however each technique has advantages and disadvantages that can affect the efficiency of diagnosis. Artificial intelligence (AI) is a promising tool in the detection and treatment of skin cancers. AI is expected to play a key role in several aspects in the field of battling skin cancer in integration with other technologies. This role may be represented by several applications, including aiding in diagnosis and treatment, analysing images, enhancing diagnostic accuracy, and having applications for initial self-diagnosis. As these tools are expected to play an even bigger role in the future, there is a need for more studies on these applications, both in terms of pros and cons.

Keywords: Skin cancer , Artificial intelligence (AI) , Diagnostic techniques

INTRODUCTION

Skin cancer incidence and mortality rates are constantly increasing, thus making it one of the most common cancers in the world, and notably in regions with higher numbers of white-skinned people[1]. From the perspective of patient health and the cost of healthcare, the diagnosis and treatment of neoplasms is considered a noteworthy problem. Treatment options like surgical excision, chemotherapy and radiation for example are very costly. However, since skin cancers are repeatedly found in the most sun-exposed areas of the body, the head and neck regions. Thus, prolonged sun protection plays a key role in preventing skin cancers especially in these highly vulnerable areas[2].

The incidence of melanoma is on the rise globally, especially in the most vulnerable groups. Melanoma skin cancer is the most deadly compared to other types of skin cancer[3]. To date, the treatment of advanced melanoma cases, especially metastases, is still a challenge, especially with the lack of desired results from treatment[3]. Most skin cancer cases occurred in countries with a majority of fair-skinned inhabitants and expose to excessive levels of sunlight[1,4,5]. Skin cancers are particularly prominent in light-skinned individuals across the continents of North America, Oceania, and Europe, where most of the population is light-skinned[1].

It is therefore important to know the causes of skin cancer and the diagnostic methods used in order to detect it and to battle these types of cancers that cause harm to humanity.

MAIN CAUSES OF SKIN CANCERS

Sunlight and indoor tanning : Nearly 80% of skin cancer cases are caused by exposure to ultraviolet in sunlight[6]. Types of radiation in sunlight play a role in triggering the development of skin cancer[2,7]. In addition, damage to DNA caused by ultraviolet radiation may lead to genetic mutations and may supress the immune system, affecting its ability to recognize and eliminate cancer cells. Thus, this may lead to an increase in the cancer development[8]. Additionally, consuming these high amounts of radiation over long periods of time in indoor tanning machines, has been observed as a fundamental cause to developing skin cancers including melanoma and non-melanoma[3,9].

Immunogenic morbidity: There are several causes affecting the immunity system which may contribute to the development of skin cancers. These include Immunosuppression which may be one of the causes of non-melanoma skin cancers[10].

Aging: Another factor that causes skin cancer is aging. It is one of the causes associated with the development of skin cancer compared to younger age groups. The aging process is considered the peak of all the changes that occur in people's life, including physiological, psychological, and social change[11]. Aging is one of the utmost common causes of most diseases, including cancers. In aging, cells are more probable to have undergone somatic mutations after going through so many replications, which may result in an inability to check cell growth process[11]. As an example of the correlation between age and disease incidence, a study showed a linear increase in the number of cases of Basal cell carcinoma (BCC) for the over 40 year age group[12].

Viruses: Some viruses have been found to be associated with the formation of certain types of skin cancers. For example, HPV5&8 has been associated with certain cases of cutaneous squamous cell carcinoma. Therefore, studying these cases of viruses and how they work can help prevent their role in the development of skin cancer in the future[13]. Figure 1 represents the main causes of skin cancers. Understanding the role of these main causes may contribute in early detection and prevention of skin cancer.

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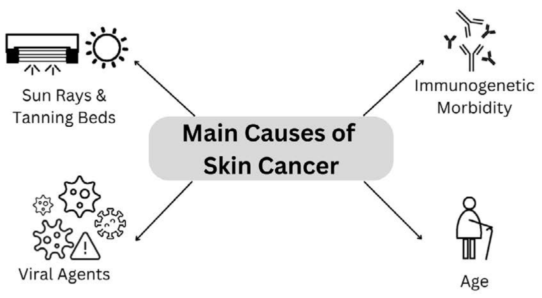

Figure 1. Main causes of skin cancer

Early detection of lesions and cases contributes greatly to the efficiency of treatment. Thus, early diagnosis is essential to contribute to a success of therapeutic plan as well as to minimize mortality rate from the disease[14]. Moreover, avoiding the triggers can help minimize the incidence of skin cancers. Beside the clinical examination, diagnostic techniques and approaches play an important role in the definitive diagnosis and therapeutic plan of such cases.

DIAGNOSTIC APPROACHES

Clinical examination is an essential first step in the inspection of skin lesions that are suspected to be malignant. Other methods are then used to assist in the diagnosis, such as the use of Dermoscopy and the use of biopsies of skin lesion to assess the characteristics of malignant changes in skin lesion by histopathology, which may be a milestone in the diagnostic process of skin cancer[15].

1-The Skin Biopsy Method and Cytology

Skin biopsy: In the evaluation of many dermatologic diseases the technique of skin biopsies can provide clinicians with important information. This information is useful to diagnose skin diseases and skin cancers as the prevalence of these diseases. The punch, shave, excisional, and incisional biopsies are considered as common biopsy techniques. Using one of these types depends on many factors including disease's pathology and location of lesion. The favourable technique for patients and clinicians is one which can be described as time-saving and cost-effective techniques. Innovated techniques have been used in the last decades which are easy, cheap and have a short procedure time [16].

In skin cancer, to confirm a diagnosis of BCC and identify its histologic species, skin biopsies are often necessary[17]. An excisional or punch biopsy is necessary especially when dealing with suspected melanoma, and especially if it appears as a shallow pigmented lesion. This is because distinguishing between melanoma and pigmented BCC can be challenging in such cases[18].While superficial biopsies that include the dermis are usually sufficient for BCC diagnosis, there is a risk of overlooking tumours if they are deeply embedded[19].

Moreover, in dermatology, skin biopsies are crucial for accurate diagnosis and therapeutic treatment planning. Several biopsy techniques exist, including shaving, incisional, and excisional biopsy, where the entire lesion is removed. Excisional biopsies are effective for assessing skin tumours, inflammatory conditions, and dermal lesions[16,18]. Although complications are rare, proper patient evaluation and meticulous technique are essential to minimize risks. While these biopsies provide valuable tissue for histological analysis, a comprehensive understanding of the clinical presentation is imperative for a definitive diagnosis[18].

Additionally, another technique in the cases of skin cancer diagnosis is sentinel lymph node biopsy (SLNB). The first lymph nodes to receive lymph fluid from primary cancer are Sentinel lymph nodes. Thus, SLNB can detect the spread of cancer to these nodes, even when it is not visible. It may also help control the spread of cancer regionally. While SLNB was initially used for melanoma, it is now applied to other skin cancers. Studies in melanoma have shown potential prognostic benefits from SLNB[20]. However, its impact on the prognosis of non-melanoma skin cancers is less clear, although it provides valuable information about lymph node involvement. Since SLNB carries potential risks like infection, lymphedema, and nerve damage, it is not routinely recommended for all skin cancer patients[20].

Cytology: Histological confirmation is crucial for diagnosing basal cell carcinoma BCC, especially in areas like the eyelid. This is typically achieved through excisional biopsies (punch or shave). These biopsies provide detailed information about the specific type of BCC. Cytology, while a faster option, may offer a preliminary diagnosis during the initial visit[21]. Although its accuracy in detecting BCC of the eyelid is still under debate, it is generally considered reliable. However, its sensitivity for pre-operative surgical planning may be insufficient[21].

Research by Barton et al. showed that cytology followed by excisional biopsy yielded a 92% sensitivity and 75% predictive accuracy for BCC diagnosis. This was compared to a group that underwent incisional biopsy and subsequent histological confirmation. The latter group demonstrated 100% sensitivity and 96% predictive accuracy for BCC diagnosis[22].

2-Dermatoscopy: Dermatoscopy is defined as a non-invasive microscopic technique that allows dermatologists to visualize structures below the skin surface including epidermis and dermis layers which are not observable by the naked eye[23]. Many researches have shown that the sensitivity and specificity for the detection of skin cancers are increased by using dermoscopy in comparison with naked eye evaluation. Moreover, it is observed that thinner and smaller cancers can be detected using dermoscopy[24].

Thus, dermoscopy is a valuable means for diagnosing skin lesions which require removal, and especially in distinguishing between benign and malignant ones, through the presence or absence of certain dermoscopic structures. By visualizing these identifiable structures, clinicians or dermatologists can predict histologic findings and select appropriate treatment and management for different skin cancer types[24]. In addition, one of the advantages of dermoscopy that its can be used in ex vivo specimens. It can be beneficial as it further enhances diagnostic accuracy by guiding targeted tissue sampling and identifying areas with potential genetic impact[24]. Thus, after detecting the potential relevant mutations, this technique can help in an appropriate therapeutic plan[24].

Over the last two decades, dermoscopic examination has been used as a non-invasive technique for diagnosing skin tumours that include melanoma and BCC[25]. Furthermore, dermoscopy is considered a helpful tool in diagnosing both melanoma and non-melanoma skin cancers especially since the diagnosis of non-melanocytic tumours has been previously done using this technique[25]. In addition, studies have shown that this technique has contributed to increasing the specificity and sensitivity in the diagnosis of melanoma, in addition to contributing to the detection of early stages of this disease. It has also shown a role in assisting in the detection of some cases of BCC[26].

Dermoscopy assists in diagnosing skin cancers, both melanoma and non-melanoma, however, it is not conclusive. Clinical history, age, and visual appearance are also utilized in the diagnosis of cancer. When a clear diagnosis is uncertain with dermoscopy, it is suggested that a biopsy should be performed[25].

3-Total body photography (TBP): Total body photography (TBP) is considered one of the promising approaches for evaluating skin lesion, this works by monitoring changes in records of all existing lesions over time. In TBP, a photographic record, which can be either 2-D or 3-D TBP, is provided by using clinical photography of the patients' skin surface. 2-D images of the skin are commonly collected and composed to body map in 2-D TBP. On the other hand, 3-D TBP comprises creating a 3-D picture of the patient's surface which is then partly linked with images of dermascopy. For that reason, using 3-D TBP may predominantly assist in the localization of lesions for follow-up[27,28].

Recently, 3D-TBP is used in patients at high risk of melanoma to assist with skin examination, mainly to monitor melanocytic lesions. According to a study by Gellrich et al., which compares clinical skin examinations with dermoscopy and 3D-TBP, overall, using 3D-TBP alone has lower sensitivity for the diagnosis of BCC, squamous cell carcinoma (SCC) and invasive skin tumours[29].

Furthermore, the effectiveness of 3D-TBP was not influenced by the skin tumour location. 3D-TBP can often detect advanced skin tumours with a greater tumour thickness or a higher infiltration level. So, while advanced non melanomas may be detected using 3D-TBP, this study noticed that the accuracy of traditional skin examination with dermoscopy is higher than using 3D-TBP alone. Also, further investigation is essential to know if additional photographs of poorly visible areas of the body or digital dermoscopy can improve the accuracy of 3D-TBP in the diagnosis[29].

4-Raman spectroscopy: In recent years, Raman spectroscopy has emerged as an innovative skin imaging technique with a wide range of applications in skin cancer diagnostics, including the assessment of melanoma and non-melanoma (SCC and BCC)[30-32].

Raman spectroscopy is considered a unique potential non-invasive technique that analyses molecular vibrations, promising advancement in skin cancer diagnosis[32]. By illuminating a sample and examining the scattered light, Raman spectroscopy generates a molecular fingerprint unique to different skin cancer types, including melanoma and non-melanoma skin cancers[32]. In the future, technology improvement of Raman spectroscopy technique may enhance the efficiency and accuracy of diagnosis, especially via increasing the sensitivity, resolution, and the acquisition of real-time data[32,33].

Furthermore, improvements in imaging techniques, combined with Raman spectroscopy, are expected to lead to earlier detection and diagnosis of skin tumours. This combination will provide a deeper understanding and analysis of both benign and malignant skin tissues[32]. Nowadays, there is a focus on using of Raman spectroscopy to monitor disease progression or responses to therapy by longitudinal monitoring of skin lesions. Moreover, another focus of Raman spectroscopy is on the area of developing patient-specific analyses and diagnostic approaches[32].

Based on research that assessed the advantages and disadvantages of using several non-invasive techniques to detect the presence of skin cancer. The study showed that the Raman spectroscopy technique has a high accuracy in diagnosing skin cancer[34]. The study suggested that the development of this technique as a future technology may play a major role in finding accurate and effective therapeutic plans for the disease. However, the study suggested that there is a need for further study regarding the diagnostic accuracy of this technique[34].

5-Liquid biopsy: Recently, a technique known as liquid biopsy has been used to assist in detecting diseases, including cancers. It is a non-invasive diagnostic or monitoring technique that examines body fluids such as blood, urine, or cord fluid to analyse several biomarkers, including for example, circulating tumour cells, cell-free DNA, nucleic acids and proteins[35].
The concept of this technology is based on the understanding that tumours shed some substances in the blood stream or body fluids, and these substances carry some important information that may indicate the occurrence of mutations and genetic changes in addition to the tumour molecular characteristics[35]. This information is analysed by experts such as physicians and researchers, and the results of the analysis helps to detect cancers and find out their genetic makeup[35].

This innovative technology is one of the most promising techniques for the early detection of melanoma through non-invasive procedures[36]. In addition, liquid biopsy is a novel technique that contributes to monitoring the treatment response of the cancer disease as well as predicting of cancer metastasis[36]. Moreover, according to Boerlin et al., cell-free DNA which is a liquid biopsy technique, may play an important role in the diagnosis, monitoring, and treatment response of diseases, as well as an important role in contributing to the detection of genetic variants specific to the type of tumour[37]. However, more studies are needed on the possibility of using cell-free DNA as a diagnostic tool, as well as to investigate the limitations and challenges that the technology may face in its use[37]. In the near future, the efficiency of liquid biopsy is expected to be enhanced by integrating it with other techniques that help in the ease of use and quality[38].

ARTIFICIAL INTELLIGENCE AND SKIN CANCER DIAGNOSIS

Skin cancer is considered one of the most common types of cancer. Some of the challenges that face traditional skin cancer diagnostic techniques are high cost, the need for a professional expert physician, and high time-consumption. Therefore, artificial intelligence tools are being used to help in diagnosing skin cancer. This tool includes the methodologies of shallow and deep machine learning-based that are trained to detect and classify skin cancer by using computer algorithms and deep neural networks[39]. Artificial intelligence is designed to help in different areas including screening and diagnosis of skin cancer as it is a disruptive and assistive technology. Artificial intelligence is a promising powerful tool that can be used by physicians to diagnose and treat skin cancer[40]. Recently, artificial intelligence has been used to analyze images to predict the most common types of skin cancers, including melanoma and non-melanoma[40,41].

Moreover, RNA dataset markers have been developed for use in predicting skin cancers and skin lesion prognosis. Thus, to minimize the incidence rate of skin cancer, many of these technologies have the potential to be easy and effective to use for different target groups such as patients, primary care physicians, and dermatologists[40]. As previously mentioned, AI may be useful to aid in skin cancer diagnosis and treatment. An example of AI-based technologies that have been designed to detect and classify skin cancer are convolutional neural network (CNN) and deep convolutional neural network (DCNN)[41].

Many researchers looked at the accuracy of skin cancer diagnosis using AI-based algorithms. A study mentioned that different skin lesions can be accurately classified depending on their potential danger using AI-approaches (CNN and DCNN) via analysis of categorize photos[42].

Another research focused on the tests needed during a routine visit to primary care or tests that patients carryout themselves, by creating an analysis system of suspicious pigmented lesion utilizing DCNNs to detect skin lesions that needed more examination. However, using AI-based algorithms in therapy plans is still controversial[43].

A research study was conducted to investigate the role of artificial intelligence in assessing skin cancer cases by several non-dermatologist physicians. The study showed that artificial intelligence contributed to helping these non-specialized physicians in detecting cancers with a result comparable to dermatologists[40]. This outcome may help the dermatology expert to focus on the detection of malignancy cases in early stage by discriminative benign patient cases from the primary care physicians. Thus, may help the specialized clinician to reach the malignancies in a timely manner[40].

Moreover, the large number of diagnoses in dermatology including rare aggressive cases such a Merkel cell carcinoma and angiosarcoma is one of the challenges in training of AI models. Thus, the suggested solutions are through training programs between the collaborated academic multicentre, especially those who have expertise in this field, or by shared information from the central data bank[40].

It is expected that in the near future, AI will be used by dermatologists and primary care physicians as well as patients, especially after training on several multimodal datasets.

There are also some issues and challenges facing some of the existing models related to training and the reason behind this is the large number of skin disease cases. These may include rare cases but aggressive malignancy conditions such as a Merkel cell carcinoma and angiosarcom. It also includes rare chronic malignancies that have the potential to develop aggressively, for example cutaneous T cell lymphoma[40].

To solve these challenges, it is proposed to establish training programs in academic centres that specialize in these skin cases, in addition to establishing a central data bank. These solutions, in turn, contribute to raising the competence of those treating these cases, whether a primary care physician or a specialized dermatologist, through specialized training or sharing important diagnostic information through a central data bank[40].

Recently, one of the main tools used to allow documentation and follow-up of the entire skin surface is total body photography. Also, using AI-based systems to automate lesion detection and diagnosis are growing in the field[44].

Moreover, a study was conducted in several specialized centres around the world in which skin cancer cases were examined by specialized dermatologists. These dermatologists classified cases of clinically relevant melanocytic lesions (CRML) that require follow-up or removal by specialists for example[44]. In addition, some patients were given 2D automated total body mapping (ATBM) using AI- automated lesion detection known as (ATBM master, Fotofinder Systems GmbH). The study aimed to determine the efficiency of the system in detecting CRML cases, in addition to detecting any new or changed ulcers during the follow-up phase[44].

The study revealed that the majority of clinically relevant melanocytic lesions and new or changed clinically relevant melanocytic lesions during follow-up examinations were correctly detected by ATBM with lesion detection software in a timely manner. This prospective study proves a step towards the application of an AI-assisted, time-efficient support for dermatologists to detect suspected melanoma lesions. This demonstrates the important role of detection software to correctly identify most clinically relevant lesions. This achievement may help in developing the implementation of deep learning-based algorithms for the lesion diagnosis classification[44].

Many researchers focused on the diagnosis of skin cancer which may help in early detection and aid in reducing the mortality rate for this type of cancer. Traditional methods for skin cancer diagnosis have many challenges which include being painful for patients, costly, time-consuming, and thus may lead to the spread of disease[45]. Although Dermoscopy is one of the diagnostic tools used for skin cancers, it has some limitations. Thus using AI in the developed automated detection system may help in a reduction of the limitations of traditional methods and enhance the rate of early skin cancer detection[45].

Recently, a study was conducted by Mahmoud et al, in which artificial intelligence was used in a proposed automated early detection system of skin cancer to analyse dermoscopic images. To detect and distinguish between benign and malignant lesions, this system is designed to analyse dermoscopic images in several stages, including pre-processing, segmentation methods, and classification methods[45]. In this study, two algorithm models, adaptive snake and region growing, were used for automated segmentation and the results of the models were compared to each other to see which one was more accurate and efficient. The results showed that the adaptive snake algorithm was the more efficient and accurate of the two models, with an accuracy of 96% compared to 90% for the region growing algorithms[45].

Additionally, in this proposed system, the two different algorithm models used for automated classification were compared with each other, these models were Artificial Neural Networks (ANN) and Support Vector Machine (SVM) algorithms. The results showed high accuracy (94%), precision (96%), specificity (95.83%), sensitivity (recall) (92.30%), and F1-score (0.94) when using the proposed detection system with Artificial Neural networks[45].

Another example of the potential role of AI integration with approaches used to detect skin cancers is Raman spectroscopy. The integration of Raman spectroscopy and AI identify subtle spectral markers and molecular signatures of skin cancers[32]. The integration outcomes will include accelerating the characterization of specific patient conditions and molecular changes observed over time. Thus, this will help enhance diagnostic accuracy and efficiency, aiding in early diagnosis and therapeutic plans via the identification of relevant markers and molecular signatures[32].

Based on the rapid development of medical technologies, the near future may see the use of AI applications with liquid biopsy technique in the diagnosis and prognosis of cancers. This is likely to be by providing detailed information about the spatial and functional assessment of the disease[46]. However, there may be some challenges in using AI-enabled liquid biopsy technology in clinics. These challenges include the financial and time cost of teaching AI, as well as equipping laboratories with modern devices, advanced software and data storage, and training technicians to use the technology in the laboratory[46,47].

Moreover, AI may help the patient to refer themselves for dermatologist by models that can assess regional anatomic sites for concerning lesions. This implementation can make the dermatologic care more accessible to the general population[40]. There remains a scarcity of specialized centres in remote and sprawling areas, causing delays in early detection and subsequent treatment. Therefore, the need for these applications that contribute to early detection are needed. In the near future, it can be expected that artificial intelligence in user-friendly and accessible applications that help access and evaluate anatomical areas in lesions with worrisome variable characteristics will be used. These technologies will help patients reach specialized physicians at the right time and in the cases that need to be diagnosed[40]. However, some limitations exist when trying to achieve the correct diagnostic including assessing cases out of the range which may mislead physicians when decision-making. Thus, using developed models including confidence estimates together with diagnostic predictions is required to avoid misdiagnosis[40].

Recently, the use of mobile health applications with public AI-based algorithms for skin cancer screening has already saved a lot of time[48].

Furthermore, today healthcare professionals are being challenged to evaluate moles in patients using available examination tools such as magnifying glasses or even just by using the naked eye. The decision is often based on the type of training the doctor has received or even the personal medical opinion of the doctor. Due to the raising rate of skin cancer globally, and especially in the most vulnerable groups, finding easy, non-expensive, non-invasive and accurate diagnostic tools is essential and may help in the early detection and reduction of the skin cancer rate[49,50].

Recently, skin cancer including melanoma, basal cell carcinoma, and squamous cell carcinoma can be diagnosed using DermaSensor, which is the first FDA approved AI-powered tool to diagnose skin cancer[49,50]. DermaSensor is designed to use AI-powered spectroscopy technology to non-invasively evaluate cellular and subcellular characteristics of a lesion in skin cancer. The device was designed to be used by non-dermatologist physicians to evaluate skin lesions. This tool is characterized by handled and wireless device using an FDA-cleared algorithm to provide immediate results[47,49,50].

The device has been evaluated in a study called DERM-SUCCESS, which examined more than 1,500 lesions of skin in more than 1,000 patients visiting more than 22 medical centres. The results of this study showed that the sensitivity of the device was approximately 96% compared to 83% for healthcare centre physicians. In addition, the sensitivity of the device to detect negative results was 96.6%, which was confirmed by biopsy, while 20% was the specificity percentage[51,52].

The FDA's authorization specifies that the device has been approved by them for use by healthcare physicians to contribute to the diagnosis and referral of skin cancer to specialists. A utility study was conducted to diagnose more than 10,000 skin lesions cases by 108 primary care physicians using the device. The result of the study showed a raise in management sensitivity (91.4% vs. 82%) and diagnostic sensitivity (81.7% vs. 71.1%), in addition, it showed a reduction in the number of false negative referrals by almost half. But, the study found a statistically significant reduction in specificity for less than 12%[51]. Through these pre-market studies, DermaSensor has shown the potential to aid in the early detection of skin cancers by non-dermatologist physicians, in addition to the possibility of using the device based on its characteristics in primary health care centres. Conversely, there are still some challenges, including specificity, which has also been considered as a challenge in some previous cases of device models, which represents a challenge in the use of AI in medical devices used in dermatology. These challenges could lead to unnecessary referrals to specialists, which could result in increased burden and cost[51]. Based on what has been shown, the DermaSensor is the latest device authorized for use in primary care centres and an assistant to detect skin lesions, and this device may be the milestone for the study and development of medical devices and authorization used for artificial intelligence in the medical field in the future[51].

Therefore, the use of artificial intelligence has the potential to contribute to the detection and treatment of skin cancer in several application as highlighted in Figure 2.

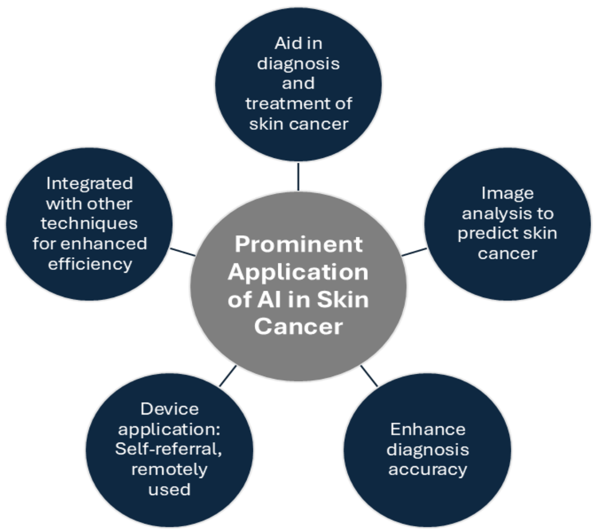

Figure 2. Prominent application of AI in Skin Cancer.

CONCLUSION AND FUTURE DIRECTION

Effective diagnostic tools play a major role in detecting and eradicating this cancer, especially advanced cases that urgently need medical response. Therefore, the use of techniques such as biopsies to confirm malignant cases are important, but it is followed by surgical procedure in addition to consuming a lot of time. Therefore, the use of advanced innovative techniques such as liquid biopsies in turn contributes to provide more molecular details about the type of cancer, in addition to being a non-invasive and less time-consuming technique. Dermoscopy or Raman spectroscopy are other techniques that belong to the non-invasive tools category which aids in the diagnosis of skin cancer. These techniques may also be improved by the integration with Artificial intelligence (AI).

AI is revolutionizing many fields, including the medical field. In the near future, there are several applications of AI that is expected to play a major role in the diagnosis of many diseases that would otherwise be a challenge in the health system. These applications include integrating with some of the technologies used to increase the accuracy of diagnosis and reduce the time of diagnosis. It also enhances technology outcomes that analyse images for diagnosis. In addition, the great role in the use of remote AI applications for patients in isolated areas to contribute to early diagnosis. Also, the use of AI to help primary health care physicians and non-specialized dermatologists to distinguish between malignant cases that require referral to specialized physicians. This will help minimize the referral of non-malignant cases, reduce cost, relieving pressure from specialists and helping to reach and treat cases in a timely manner.

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Competing Interest: None

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REFERENCE

1. Roky AH, Islam MM, Ahasan AMF, et al. Overview of skin cancer types and prevalence rates across continents. CPT 2024;2949713224000582.
2. Gruber P, Zito PM. Skin Cancer. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Dec 15]. https://www.ncbi.nlm.nih.gov/books/NBK441949/
3. Hsieh M yun, Hsu SK, Liu TY, et al. Melanoma biology and treatment: a review of novel regulated cell death-based approaches. Cancer Cell Int 2024;24(1):63.
4. Garbe C, Amaral T, Peris K, et al. European consensus-based interdisciplinary guideline for melanoma. Part 1: Diagnostics – Update 2019. Eur J Cancer 2020;126:141–58.
5. Schadendorf D, Fisher DE, Garbe C, et al. Melanoma. Nat Rev Dis Primers 2015;1(1):15003.
6. Jones OT, Ranmuthu CKI, Hall PN, et al. Recognising Skin Cancer in Primary Care. Adv Ther 2020;37(1):603–16.
7. D'Orazio J, Jarrett S, Amaro-Ortiz A, et al. UV radiation and the skin. Int J Mol Sci 2013;14(6):12222–48.
8. Narayanan DL, Saladi RN, Fox JL. Review: Ultraviolet radiation and skin cancer. Int J Dermatology 2010;49(9):978–86.
9. Schulman JM, Fisher DE. Indoor ultraviolet tanning and skin cancer: health risks and opportunities. Curr Opin Oncol 2009;21(2):144–9.
10. Hasan N, Nadaf A, Imran M, et al. Skin cancer: understanding the journey of transformation from conventional to advanced treatment approaches. Mol Cancer 2023;22(1):168.
11. Ribero S, Stucci L, Marra E, et al. Effect of Age on Melanoma Risk, Prognosis and Treatment Response. Acta Derm Venerol 2018;98(7):624–9.
12. Apalla Z, Nashan D, Weller RB, et al. Skin Cancer: Epidemiology, Disease Burden, Pathophysiology, Diagnosis, and Therapeutic Approaches. Dermatol Ther (Heidelb) 2017;7(S1):5–19.
13. Becerril S, Corchado-Cobos R, García-Sancha N, et al. Viruses and Skin Cancer. Int J Mol Sci 2021;22(10):5399.
14. Garrido AQ, Wainstein AJA, Brandão MPA, et al. Diagnosis of Cutaneous Melanoma: the Gap Between the Knowledge of General Practitioners and Dermatologists in a Brazilian Population. J Cancer Educ 2020;35(4):819–25.
15. Nataren N, Yamada M, Prow T. Molecular Skin Cancer Diagnosis. J Mol Diagn 2023;25(1):17–35.
16. Kilic A, Kilic A, Kivanc A, et al. Biopsy techniques for skin disease and skin cancer: A new approach. J Cutan Aesthet Surg 2020;13(3):251.
17. Psaty EL, Halpern AC. Current and emerging technologies in melanoma diagnosis: the state of the art. Clin Dermatol 2009;27(1):35–45.
18. Beard CJ, Ponnarasu S, Schmieder GJ. Excisional Biopsy. StatPearls Publishing; 2022.
19. Dourmishev L, Rusinova D, Botev I. Clinical variants, stages, and management of basal cell carcinoma. Indian Dermatol Online J 2013;4(1):12.
20. Ishizuki S, Nakamura Y. Role of Sentinel Lymph Node Biopsy for Skin Cancer Based on Clinical Studies. Cancers. 2023;15(13):3291.
21. Al-Abbadi MA. Basics of cytology. Avicenna J Med 2011;01(01):18–28.
22. Barton K, Curling OM, Paridaens ADA, et al. The Role of Cytology in the Diagnosis of Periocular Basal Cell Carcinomas: Ophthalmic Plast Reconstr Surg 1996;12(3):190–5.
23. Rao BK, Ahn CS. Dermatoscopy for Melanoma and Pigmented Lesions. Dermatol Clin 2012;30(3):413–34.
24. Yélamos O, Braun RP, Liopyris K, et al. Usefulness of dermoscopy to improve the clinical and histopathologic diagnosis of skin cancers. J Am Acad Dermatol. 2019;80(2):365–77.
25. Kato J, Horimoto K, Sato S, et al. Dermoscopy of Melanoma and Non-melanoma Skin Cancers. Front Med 2019;6:180.
26. Wolner ZJ, Yélamos O, Liopyris K, et al. Enhancing Skin Cancer Diagnosis with Dermoscopy. Dermatol Clin 2017;35(4):417–37.
27. Rayner JE, Laino AM, Nufer KL, et al. Clinical Perspective of 3D Total Body Photography for Early Detection and Screening of Melanoma. Front Med 2018;5:152.
28. Hornung A, Steeb T, Wessely A, et al. The Value of Total Body Photography for the Early Detection of Melanoma: A Systematic Review. Int J Environ Res Public Health 2021;18(4):1726.
29. Gellrich FF, Strunk A, Steininger J, et al. Comparison of the efficacy of skin examination using 3D total body photography to clinical and dermoscopic examination. EJC Skin Cancer 2024;2:100264.
30. Csány G, Gergely LH, Kiss N, et al. Preliminary Clinical Experience with a Novel Optical–Ultrasound Imaging Device on Various Skin Lesions. Diagnostics 2022;12(1):204.
31. Schuh S, Ruini C, Perwein MKE, et al. Line-Field Confocal Optical Coherence Tomography: A New Tool for the Differentiation between Nevi and Melanomas? Cancers 2022;14(5):1140.
32. Delrue C, Speeckaert R, Oyaert M, et al. From Vibrations to Visions: Raman Spectroscopy's Impact on Skin Cancer Diagnostics. J Clin Med 2023;12(23):7428.
33. Lui H, Zhao J, McLean D, et al. Real-time Raman Spectroscopy for *In Vivo* Skin Cancer Diagnosis. Cancer Res 2012;72(10):2491–500.
34. Jung JM, Cho JY, Lee WJ, et al. Emerging Minimally Invasive Technologies for the Detection of Skin Cancer. J Pers Med 2021;11(10):951.
35. Wang H, Zhang Y, Zhang H, et al. Liquid biopsy for human cancer: cancer screening, monitoring, and treatment. MedComm 2024;5(6):e564.
36. Slusher N, Jones N, Nonaka T. Liquid biopsy for diagnostic and prognostic evaluation of melanoma. Front Cell Dev Biol 2024;12:1420360.
37. Boerlin A, Bellini E, Turko P, et al. The Prognostic Value of a Single, Randomly Timed Circulating Tumor DNA Measurement in Patients with Metastatic Melanoma. Cancers 2022;14(17):4158.
38. Ma L, Guo H, Zhao Y, et al. Liquid biopsy in cancer current: status, challenges and future prospects. Signal Transduct Target Ther 2024;9(1):336.
39. Takiddin A, Schneider J, Yang Y, et al. Artificial Intelligence for Skin Cancer Detection: Scoping Review. J Med Internet Res 2021;23(11):e22934.
40. Wei ML, Tada M, So A, et al. Artificial intelligence and skin cancer. Front Med (Lausanne) 2024;11:1331895.
41. Esteva A, Kuprel B, Novoa RA, et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature 2017;542(7639):115–8.
42. Kränke T, Tripolt-Droschl K, Röd L, et al. New AI-algorithms on smartphones to detect skin cancer in a clinical setting-A validation study. PLoS One 2023;18(2):e0280670.
43. Soenksen LR, Kassis T, Conover ST, et al. Using deep learning for dermatologist-level detection of suspicious pigmented skin lesions from wide-field images. Sci Transl Med 2021;13(581):eabb3652.
44. Winkler JK, Kommoss KS, Toberer F, et al. Performance of an automated total body mapping algorithm to detect melanocytic lesions of clinical relevance. Eur J Cancer 2024;202:114026.

45. Mahmoud NM, Soliman AM. Early automated detection system for skin cancer diagnosis using artificial intelligent techniques. Sci Rep 2024;14(1):9749.
46. Foser S, Maiese K, Digumarthy SR, et al. Looking to the Future of Early Detection in Cancer: Liquid Biopsies, Imaging, and Artificial Intelligence. Clin Chem 2024;70(1):27–32.
47. Ignatiadis M, Sledge GW, Jeffrey SS. Liquid biopsy enters the clinic — implementation issues and future challenges. Nat Rev Clin Oncol 2021;18(5):297–312.
48. Smak Gregoor AM, Sangers TE, Bakker LJ, et al. An artificial intelligence based app for skin cancer detection evaluated in a population based setting. NPJ Digit Med 2023;6(1):90.
49. Office of the Commissioner. FDA Roundup [Internet]. FDA; 2024 Jan. Available from: https://www.fda.gov/news-events/press-announcements/fda-roundup-january-16-2024
50. FDA clearance granted for first AI-powered medical device to detect all 3 common skin cancers (melanoma, basal cell carcinoma, and squamous cell carcinoma). [Internet]. DermaSensor; 2024 Jan. Available from: https://www.dermasensor.com/fda-clearance-granted-for-first-ai-powered-medical-device-to-detect-all-three-common-skin-cancers-melanoma-basal-cell-carcinoma-and-squamous-cell-carcinoma/
51. Venkatesh KP, Kadakia KT, Gilbert S. Learnings from the first AI-enabled skin cancer device for primary care authorized by FDA. npj Digit Med 2024;7(1):156.
52. Clinical Studies [Internet]. DermaSensor; 2024. Available from: https://www.dermasensor.com/wp-content/uploads/80-0015.1-Clinical-Evidence-Three-Studies-1.pdf