Artificial Intelligence in Dermatology: Crossing the Frontier

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ABSTRACT Artificial intelligence (AI), an epic frontier in biomedical research, can potentially lead to a paradigm shift in many fields. AI is rapidly reshaping innumerable areas, including that of dermatology, both as a disruptive and assistive technological force. If used properly, AI will be grounded as an effectual tool to be leveraged by physicians in their patient care, enabling optimal diagnostic and treatment outcomes. Skin cancer is among the most prevalent cancers globally, with increasing incidence. AI-based technologies have emerged in recent times to precipitate successful diagnosis of cutaneous malignancies. Here, we review recent advances of AI in dermatology and dermatopathology, its applications in diagnosis, its impact on clinical investigations, usability limitations, and future potential.

KEYWORDS: artificial intelligence, dermatology

INTRODUCTION

Artificial intelligence (AI) has made a ginormous impact on healthcare, including dermatology, where AI is principally being developed as a tool for physicians, ideally board-certified dermatologists, or as a contrivance for the general public (1). At present smartphone apps, while widely seen in the healthcare realm, do not make decisive diagnoses and forewarn the general public that these apps cannot supplant a diagnosis by a physician. From a medicolegal standpoint, healthcare is designed that the liability is generally bore by the physician, and accordingly smartphone apps do not have a comprehensive place in ongoings. Smartphone apps do not necessarily imply better medical results and might instead lead to futile confusion and concern. Accordingly, the existing societal and medicolegal state of affairs is optimal for AI as diagnostic support for physicians, including in the area of cutaneous oncology.

The assessment of burn depth is essential to determine if an early excision and grafting is the appropriate treatment, seeking to optimize care and prevent unneeded hospitalization. An artificial neural network-based algorithm was utilized to foretell when a burn would heal, yielding a prediction accuracy of 86% (2). The clinical remission time can range in patients with chronic urticaria. However, the development of an AI predictive model using machine learning to foresee the time of clinical remission has been developed and is poised to produce improved outcomes (3). Applications of AI in cutaneous oncology have been evinced in the biomedical literature, oftentimes pivotal in early detection of skin malignancies (4). AI models have been successfully employed to aide in preventing contact dermatitis by predicting skin sensitization potential and potency of chemicals, ranging from cosmetics to pesticides (5).

A 2023 bibliometric analysis found that 72 different journals had published 406 papers on AI in dermatology (6). Moreover, its applicability in dermatopathology is likewise being explored, including concerning tissue classification. Efforts have been undertaken to interpret indirect immunofluorescence microscopies with AI to categorize bullous dermatoses (7). In Mohs surgery, AI has been used for

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the histological classification of the most common type of skin cancer, namely basal cell carcinoma (8). Vanguard technology implementing dermoscopy, augmented by AI materially improves the sensitivity, safety, and effectiveness of skin cancer recognition and consequent care. New evidence supports the valid stand-alone use of a digital dermoscopy image-based artificial intelligence algorithm device that substantially improves the detection of cutaneous malignancies by ameliorating current practices (9). A daunting challenge is training models in a full spectrum of dermatologic findings, including low incidence but dangerous malignancies. Confidence estimates coupled with diagnostic predictions have been evinced as a solution to preventing misdiagnosis (10).

AI methodologies such as machine learning, deep learning, and other tools that utilize pattern recognition are emerging as useful tools in clinical practice. Dermatology, a field that relies heavily on image analysis, is perhaps uniquely situated as a medical field that would benefit highly from the implementation of these AI tools. AI has uses in diagnosing conditions such as skin cancer, atopic dermatitis, onychomycosis, and acne vulgaris, amongst other dermatoses (11). Furthermore, AI shows promise in advancing the field of precision medicine by giving insight into treatment outcomes and drug efficacy (12,13). Many types of AI also provide a patient-forward interface that can lessen the burden associated with telemedicine messaging platforms by providing patients with timely and often accurate answers to their questions regarding dermatologic conditions (14,15).

Skin Cancer

Worldwide, both cutaneous melanoma and non-melanoma skin cancer (NMSC) rank amongst the most common cancers (16). In the U.S., specifically, rates of basal cell carcinoma and squamous cell carcinoma have been on the rise in recent years (17). Early detection is key in the treatment and prognosis of melanoma and NMSC (18), and AI presents a unique opportunity to streamline cancer diagnoses.

AI methods such as deep learning and deep neural networks (DNNs) are currently being utilized in the field of dermatology and show great promise (19). For example, one study that utilized a combination of a handwritten algorithm to detect disorder in melanocytic lesions and a convolutional neural network (CNN, a type of DNN) to differentiate between melanomas and nevi yielded a sensitivity and specificity of 86% and 82%, respectively (20). Similarly, another study utilizing DNNs found that AI models diagnosed melanocytic lesions more accurately than dermatologists and residents with AUCs of 0.87, 0.74, and 0.66, respectively (21). There are also encouraging results regarding the combination of in-vivo laser-induced plasma spectroscopy and AI. One such study found that DNNs differentiated between skin cancers and benign lesions with a sensitivity and specificity of 94.6% and 88.9%, respectively (22).

Another study that investigated the effectiveness of skin cancer diagnosing applications (SCDA) (such as AI Dermatologist, Skinner, etc.) and AI Chatbots (such as ChatGPT) yielded similar but less-promising results, reporting that combined, the technologies identified melanoma with a 67% accuracy (23). Comparably, another study found that ChatGPT was able to diagnose malignant lesions with an accuracy of 58.8% (24). Beyond simply identifying lesions, other studies have investigated the usefulness of Chatbots, like ChatGPT, in disseminating accurate and patient-facing responses to clinical questions. In a study that investigated the responses of ChatGPT to melanoma-related patient questions, dermatologists scored the response accuracy of the responses as 4.88/5 and suggested it could be useful for patients (14).

Psoriasis

Identifying and scoring psoriasis, a common skin condition, using AI could alleviate the high demand for dermatologists that sometimes delays treatment and, therefore, symptom relief. Using 100 clinical images, a recent study found that a two-stage CNN model identified psoriasis in patients with 98.1% accuracy (25). Another study showed that an artificial neural network (ANN) scored psoriasis using the PASI scale with 95.95% accuracy (26). Additionally, a similar study showed that compared to physicians, CNN models outperformed physicians in PASI scoring of psoriasis images (27).

Machine learning models have also been effective in diagnosing psoriasis, as one recent study showed that algorithm assessment of psoriasis was 90% more accurate than dermatologists (28). A different machine learning model utilized risk-factor assessment to aid in determining the best treatment for psoriasis patients. The study showed that machine learning models could be used to predict the 5-year probability of patients discontinuing biologic drugs with 85% accuracy (12).

Dermatitis

Atopic dermatitis (AD) is an inflammatory skin condition with a high global prevalence. Accuracy and efficiency in diagnosing provide patients with the best chance of symptomatic relief (15). One such

study combined CNN with reflectance confocal microscopy (RCM) to distinguish between interface dermatitis and other inflammatory skin conditions with a 94.67% accuracy (29). AI models have also been used to identify which patients are more likely to experience negative side effects associated with certain treatment types, such as persistent facial erythema in patients undergoing atopic dermatitis treatment with biologics like dupilumab (13). These predictive models have the potential to improve patient compliance and avoid subjecting patients to such side effects. Similarly to other medical conditions, AI technologies like ChatGPT can be utilized to disseminate information about AD to curious patients. A recent study showed that a panel of dermatologists graded ChatGPT as responding favorably to common AD questions (15).

Onychomycosis

Onychomycosis is a challenging diagnosis to make based on appearance alone due to its similarity to other causes of nail dystrophy(30). It thus requires confirmatory laboratory testing to make a proper diagnosis (30). AI can serve as a helpful tool to aid in distinguishing onychomycosis from other differentials. One study used six different convolutional neural networks to determine the accuracy of these platforms in identifying dermatoses by image and found the platforms had an accuracy of 99%, sensitivity of 97.9%, and specificity of 100% in diagnosing onychomycosis, suggesting AI is a useful tool in aiding in diagnosis of onychomycosis (31). Further studies looking at the ability of AI to differentiate onychomycosis from other nail disorders using dermoscopic images found that using deep learning networks allowed for 87.5% accuracy, 93.0% sensitivity, and 78.5% specificity, which yielded higher sensitivity and specificity when compared to dermatologists (32). This further indicates the use of AI in the field of dermatology to aid in distinguishing differential diagnoses.

Acne Vulgaris

Acne vulgaris is a common skin condition, yet the grading systems used in clinical practice can be subjective and time-consuming (33). AI can standardize care by providing a more objective approach to scoring acne vulgaris. Using deep learning with convolutional neural networks, AI could grade acne with a 67% accuracy (34). Another study using a deep-learning model found that their machine-learning model exhibited high levels of accuracy in determining acne grading, with an F1 score of 80%, and performed similarly to experienced dermatologists (35). Similarly, using an artificial intelligence algorithm, AI could grade acne using smartphone photographs, similar to dermatologists, with an F1 score of 84% (36). Overall, AI is a useful tool when determining grading for acne vulgaris and can potentially standardize patient care in dermatology.

Other Dermatoses

AI is emerging in diagnosing and treating many other dermatologic conditions. Machine learning is being used to evaluate clinical features of female pattern hair loss to determine which treatment method would yield the best outcome (37). Convolutional neuronal networks are being used in conjunction with reflectance confocal microscopy to more accurately diagnose congenital pigmented macules (38). Smartphone apps using deep machine learning to identify cutaneous lupus erythematosus are being developed and have been shown to have an accuracy of 90.67%, sensitivity of 92.51%, and specificity of 90.37% (39). Additionally, using multimodal deep learning systems, AI has improved dermatologists' accuracy by about 15% in diagnosing cutaneous lupus erythematosus (40). AI is a developing field in dermatology and will continue to expand to increase diagnostic accuracy and aid in choosing therapeutic interventions.

Ethical Considerations

Although AI is emerging as a useful tool in clinical practice, there are several ethical considerations dermatologists need to be aware of. One of these considerations is the presence of bias. Studies have found that AI platforms like ChatGPT-4o are significantly more accurate in diagnosing non-skin-of-color patients than skin-of-color patients (41). A study comparing the performance of AI in melanoma diagnosis of black patients versus non-black patients found a significant decrease in the performance of AI in the diagnosis of black patients (42). Furthermore, multiple systematic reviews have shown deep learning research is skewed toward lighter skin types (43,44). Thus, AI platforms may introduce new biases towards people of lighter skin tones. It is crucial that all AI platforms are properly trained with images of varying skin colors in order to decrease the gap in health disparities. On the contrary, public and free access to AI platforms like ChatGPT may help lessen the gap in health outcomes due to individuals who may not have the means to see a dermatologist being able to access care (45).

AI platforms, when accurate, can help patients seek treatment for potentially harmful dermato-

ses, thus ethically aiding in beneficence for patients (46,47). Additionally, when patients receive dermatopathology reports, AI has been shown to be a beneficial tool for translating these reports into understandable language, thus easing potential anxiety for patients and contributing to nonmaleficence in patient care (48). Yet, these platforms rely on accurate patient input, thus can make mistakes and can be inaccurate, leading to increased stress and anxiety for patients and counteract the ethical principle of nonmaleficence (46,15,49). AI platforms like ChatGPT can also present false information, which is known as artificial hallucination, contributing to potential maleficence[50]. Erroneous AI answers could additionally lead patients to question physician integrity once a proper diagnosis is provided that is not aligned with the AI diagnosis (45). Patient education is key regarding using AI platforms in conjunction with clinical practice to avoid maleficence and ensure physician integrity in the care of patients.

Additionally, one of the major concerns of using AI systems is the black box phenomenon, where there is limited access to information regarding how the AI algorithm made the diagnostic decision (51). This could hinder the ethical principle of informed consent due to the inability to inform patients about the decision-making process for their clinical care (51). Furthermore, if AI becomes the standard of care, it is unknown whether patients will be able to refuse AI use. Thus, AI could potentially infringe on patient autonomy (52).

The legal guidelines for the use of AI in dermatology are also unclear. As stated above, AI platforms can be inaccurate in their performance. If AI becomes implemented as a critical part of patient care and the physician is misled by faulty AI, it is unknown if the physician is legally at fault for the potential implications in patient care (52). Thus, it is important for the legal implications of AI use to be clearly stated for those using AI in their practice.

Patient privacy is also a concern for the use of AI in dermatology. AI platforms are trained; thus, the image of the dermatosis may be used to train the algorithm without the patient's consent (53). It is crucial to inform patients of this risk when using AI platforms in clinical practice. Overall, AI platforms are key tools that are revolutionizing clinical practice in dermatology, but it is important to be aware of the key ethical considerations that can impact both the patient and the physician.

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