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REVIEW

Teledermoscopy – An Emerging Technology for Skin Cancer Detection

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Abstract

Dermatology faces a worsening scarcity of providers, especially since the onset of the COVID-19 pandemic. With lengthening waiting periods for skin cancer screening examinations, there is a distinct need for alternatives to in-person evaluation. Delayed diagnosis is associated with poorer outcomes, especially in melanoma. Teledermatology has the potential to prevent the increased morbidity and mortality associated with late-stage diagnosis, especially when utilized with dermoscopy. In the literature, this novel field of 'teledermoscopy' has exhibited accuracy and reliability comparable to face-to-face visits, and it is a promising alternative intervention for those who require triaging or for patients who are unable to access in-person care (rural, underserved populations). Although early data are promising, formal guidelines for acquisition and interpretation of dermatoscopic images must be established before wider implementation is possible. With standardization, use at home or in primary care offices might relieve some of the pressure on an overburdened dermatologic care system and help patients requiring urgent care to be seen more expediently.

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Morbidity and mortality of melanoma and nonmelanoma skin cancers continue to rise in the United States and globally. Global melanoma cases are projected to increase to over 500,000 new cases and almost 100,000 deaths annually; in the United States, by 2040, melanoma is projected to be the second most common cancer among women and the most common cancer annually among men.[1,2]

The annual cost of treating such skin cancers in the United States is estimated at $8.1 billion.[3] A large portion of the time and expense associated with skin cancer treatment, worldwide, can be attributed to late-stage carcinomas. This is especially true in melanoma – the third most common but overall the deadliest form of skin cancer.[4,5] This review focuses on newer advances in technology-based modalities, such as teledermoscopy, to improve skin cancer detection, along with barriers and research needs to broader adoption of such modalities.[6]

Skin Cancer Prevention and Screening

Considerable research has focused on improving primary and secondary prevention strategies, such as reducing sun exposure and indoor tanning, wearing sun-protective clothing, and using sunscreens.[7–9] However, with rising cases and, subsequently, rising treatment costs, research works into early melanoma and nonmelanoma skin cancer detection interventions are crucial. Further efforts

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to decrease the morbidity and mortality of skin cancer may involve improved diagnostic accuracy of screening tools and increased access to screening exams at regular intervals.[10–12] Improved screening methods also decrease wait times for seeing providers and decrease the anxiety prevalent among patients at risk of skin cancer.

The relative scarcity of dermatology providers and the growing demand for appointments only exacerbate this issue. With 40% of the United States classified as a 'dermatology desert', the lack of physical access to dermatology specialists has resulted in significant delays for skin cancer screening.[13] This provider shortage poses a danger to patients with skin cancer, especially those facing a melanoma diagnosis. Even short delays in evaluation, diagnosis, and treatment for melanomas can impact outcomes.[14,15] For these reasons, it is vital for the healthcare system to advance and implement skin cancer screening alternatives for at-risk patients.[12,16,17]

Dermoscopy In Clinical Practice

One of the most frequently utilized non-invasive screening tools in dermatology is the dermoscope – a hand-held device that uses light and magnification to help trained clinicians examine a patient's skin.[18,19] Most dermatologists utilize dermoscopy to view moles and other skin lesions at a microscopic level. In the hands of an experienced physician, specific or characteristic findings greatly aid in diagnosis.[20] Additionally, dermoscopy allows for further discrimination of concerning features between lesions that might look similar to the unaided eye, allowing for more accurate identification among malignant lesions.[20,21]

A recent Cochrane Review demonstrated that dermoscopy in a trained user was more effective in diagnosing melanoma than simple visual inspection of the skin.[22] When used correctly, a dermoscope is an effective tool for not only dermatologists but also practitioners of multiple specialties. Studies on the feasibility and accuracy of dermoscopic use in primary care clinics demonstrate that, with proper training and education, primary care providers find dermoscopy a valuable resource in identifying skin lesions.[23] Despite a generally positive reception by family physicians in research studies, a number of obstacles remain to widely implement dermoscopic evaluation in primary care, including a need for increased access to the tool itself, improved training, and a change in perception surrounding the complexity of use.[23,24] In addition to increasing the chances of detecting skin cancer during routine physical examination, expansion of dermoscopy use into primary care offices has also prompted investigation of the possible role for dermoscopic evaluation in the telehealth setting. However, it is important to note that there is an ongoing learning curve with dermoscopy, and biopsy rates are often higher early in training. Therefore, it is important to gain sufficient experience in order to improve accuracy.

Teledermatology and Skin Cancer Detection

Teledermatology is a growing option that complements traditional in-person dermatology visits. Since the COVID-19 pandemic, significant growth has occurred in utilization of telehealth dermatology ('teledermatology').[25,26] Recent research demonstrates that dermatologists and patients are comfortable addressing many conditions remotely during video-enabled visits. Superficial infections, scars, eczema, and pigmentary disorders are all conditions where dermatologists report 'maximum' levels of confidence diagnosing and treating remotely.[27,28] General increases have also occurred in physician confidence pre- and post-intervention in teledermatology studies.[27,29] An increase in the utilization of teledermatology offers an opportunity to decrease the backlog for dermatologic care and reduce wait times for skin cancer screening appointments. This is especially important for rural and underserved patient populations, which often experience a disproportionate backlog for dermatologic care compared to their urban counterparts.[30–32] Teledermatology allows for triaging patients on order to reserve in-office care for those who truly require a face-to-face (FTF) encounter.[33]

Multiple issues arise considering teledermatology and skin cancer detection. For instance, without the use of a dermoscope, teledermatology has more limited evidence on its ability to accurately triage lesions from the initial remote visit to the office.[34] For instance, sensitivity for diagnosis of melanoma using just photo images might be as low as 59%, and specificity might also be as low as 30%. Such poor diagnostic thresholds may relate to inadequate acquisition of high-quality images from the patient to the provider.

Teledermoscopy and skin cancer detection

'Teledermoscopy' is a term that describes dual utilization of telehealth technology and virtual transmission of dermoscopic images.[35,36] The utilization of dermoscopic techniques out-of-office via telemedicine may be used to better differentiate benign lesions from more worrisome lesions that require more timely intervention to rule out cancerous growth.[37] For instance, the combination approach increases diagnostic skin cancer sensitivity to 85% and specificity to 92%.[34] When used in conjunction with video-visit and patient portal technology, teledermoscopy may support easing in scheduling burdens experienced by dermatologic providers.[10,26] Teledermoscopy appears to effectively triage 'spot checks', sending the most concerning lesions to be seen in-person quickly, while reassuring clearly benign lesions that might allow patients to avoid an in-person encounter altogether.[35–39] For those patients

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without ready access to a dermatologist due to financial or geographic limitation, teledermoscopy may afford the only opportunity for early detection of cutaneous malignancies.[40,41]

A recent study by Sangeeta et al. in 2019 compared the effectiveness of FTF workflows with teledermoscopy in the diagnosis of skin cancer. Teledermoscopy was proven superior to traditional referral for the detection of cancer. In this study (which was conducted using a dermoscope-fitted digital camera, a picture archiving and communication system, and image retrieval), teledermoscopy was associated with a 39% reduction in the need for in-person evaluation.[42] In a 2015 study by Boerve et al., 816 patients referred via smartphone-facilitated teledermoscopy were compared to 746 patients referred via the traditional paper-based system. The results demonstrated that, when surgical treatment was required, patients who had melanoma, melanoma in situ, squamous cell carcinoma, and basal cell carcinoma had significantly shorter wait times when referred via teledermoscopy compared to direct referrals. The use of teledermoscopy also increased the accuracy of triage decisions; and only 0.4% of the referrals had to be excluded due to poor image quality.[43]

Several studies have been conducted comparing the accuracy of in-person examinations to those of teledermoscopy (with subsequent physician diagnosis via images). The accuracy of diagnosis via teledermoscopy is contingent on the experience of the observer and the difficulty of characterization of a given lesion. However, studies have, for the most part, demonstrated biopsy-proven consensus between the two screening modalities.[44,45] One recent study in Denmark revealed that among 600 skin lesions evaluated by teledermoscopy and subsequently compared to FTF evaluation, the concordance between FTF and teledermoscopy, and the interobserver concordance of two separate teledermoscopy evaluations were moderate to substantial (AC1 = 0.57–0.71).[45] Piccolo et al. conducted a similar study in 2000, where histopathology was acknowledge as the gold standard in dermatologic diagnoses. Notably, however, 85% of the diagnoses reached by teledermoscopy were correct (results varied from 77 to 75%), a result similar to the accuracy of FTF diagnosis (reported to be 91%).[44]

Patient comfort and proficiency in teledermoscopic evaluation of skin lesions are also important components of teledermoscopy. In one study, both the diagnostic concordance of teledermoscopy and patient's receptiveness to the modality were investigated in short-term monitoring of nevi. The study reported 97% agreement with decisions made by clinical dermatologists, and patients were largely amenable to teledermoscopy for monitoring between in-person visits.

Challenges to Improved Skin Cancer Detection and Triage Using Teledermoscopy

Teledermoscopy faces distinct barriers in patient care compared to in-person visits. One of the most crucial constraints to teledermoscopy is effective evaluation of malignant lesions through access to dermoscopic images. Repeatedly, physicians report that their ability to remotely rule out skin cancers, especially melanoma, is dependent on a concomitant use of such dermatoscopic images.[27,29]

Patients and providers may be concerned with costs associated with the utilization of teledermoscopy in their care. While teledermoscopy may increase immediate upfront costs for patients, they may find the added expense is an acceptable trade-off for the decrease in wait time to evaluation. In an Australian study completed in 2018, although there was a slight increase in overall healthcare cost associated with the utilization of teledermoscopy in dermatologic evaluation, it was also associated with a decrease in time to intervention (mean wait time decreased by 26 days).[46]

In addition, the cost for the equipment must be considered. High-end dermatoscopes, such as DermLite DL3N ($1,500 USD), are likely beyond the acceptable price range for home-dermoscopy users.[47] Fortunately, the literature contains evidence that more affordable options might be available for both primary care providers and home-dermoscopy users. Unconventional methods, such as using clip-on mobile lenses (traditionally used to checking currency bills, and easily available online for as low as $6 USD) plus a smartphone camera may be used to capture high-quality images of cutaneous lesions. This alternative tool does lack a polarized light source, but utilization of an interface medium (such as ultrasound gel) produces similar results at very low cost.[48]

While several studies utilizing teledermoscopy report good accuracy compared to FTF visits, not all studies have demonstrated concordance between the two modalities for evaluation. Comprehensive findings on the accuracy of teledermoscopy were reported in a larger scale 2017 review by Finnane et al. The paper investigated diagnostic accuracy (defined as agreement with histopathology for excised lesions or clinical diagnosis for non-excised lesions) of FTF dermatology consultation versus teledermoscopy as reported by 21 separate studies. The review demonstrated that the accuracy of FTF consultation was higher (67 to 85% agreement with reference standard) when compared with teledermatology (51 to 85% agreement with reference standard), for the diagnosis of skin cancer.[49] The literature also includes evidence that teledermoscopy may increase the accuracy of providers who do not have dermatologic training and allow for inclusion of outside specialties in triaging patients. The accuracy and reliability of teledermoscopy versus clinical diagnosis for skin cancers by general practitioners and surgical specialists (when diagnostic algorithms were utilized) was reported in one investigation. It demonstrated a diagnostic accuracy between teledermoscopic and histopathologic diagnosis at 90.91% – an improvement compared to clinical evaluation alone (accuracy was 82.64%).

FTF visits likely result in a higher 'yield' than teledermoscopy alone. In a study by Janda et al., 42 additional lesions were noted during clinical skin examination compared to dermoscopy (20 in the intervention group and 22 in the control group), including one clinically presenting as melanoma (dysplastic nevus), two basal cell carcinomas (one confirmed in the intervention group, and one resolved before surgery in the control group), and one squamous cell carcinoma (confirmed in the intervention group). Additionally, it was noted that some areas of the body are not easily viewed by the patient and may be missed on self-examination.[50] It should be noted that while many patients are open to utilizing teledermoscopy as an additional screening tool, some patients lack confidence in their ability to identify cancerous lesions. Therefore, patient education and skill in taking accurate images are other items to consider in the teledermoscopy implementation. Rather than replacing FTF evaluation altogether, most patients state that they would prefer performing self-examinations in-between in-person visits, to monitor for change.[51]

Widespread implementation of home teledermoscopy will also benefit from standardization and guidelines for use. In a 2022 article by Camaj Deda et al., a detailed methodology is described; the goal of the article is to outline a protocol for dermatoscopic image acquisition that is reproducible and reliable. The paper contains checklists that describe lighting, background, resolution, color, and other important considerations that affect the quality of dermatoscopic store-and-forward (SAF) images. These guidelines are a promising start to address the need for standardization of teledermoscopy. However, as the authors mention, there still exists a need for validated diagnostic criteria and standardized characteristics when examining home dermoscopy images.[52] Additionally, systemic protocols must be in place for dermatoscopic images that are taken by patients at home or in the primary care setting. Once collected, reading by a trained dermatologist may be possible via direct communication with patients' charts or with remote partnerships between primary care providers and dermatologists. As new advances are made in the realm of teledermoscopy, it may also become possible for artificial intelligence (AI) software to read these dermoscopy images.

Future Directions

The utilization of AI software in the evaluation of suspicious skin lesions is an additional new development in the field of dermatology. A large 2022 study compared the accuracy of trained AI algorithms vs. 18 dermatologists in the diagnosis of skin lesions using dermatoscopic images. The algorithms performed better than experts in most categories, with the exception of actinic keratoses (similar accuracy on average) and images from categories not included in algorithmic training data.[53] Stiff et al. evaluated the advantages and challenges of AI in the detection of melanoma using dermoscopy in a 2022 review article. They concluded that AI may offer benefits beyond diagnosis; it can detect features that predict melanoma prognosis such as likelihood of response to immune checkpoint inhibitors and may be able to classify patients as 'high risk' (which coincides with a significantly decreased chance for progression-free survival).[54]

Disparities in the delivery of care to skin-of-color patients are a growing topic of conversation in the dermatologic community. The literature suggests minority patients experience delayed diagnosis and poorer outcomes compared to their Caucasian counterparts for a variety of dermatologic conditions, including melanoma.[55–58] A concerted effort must be put forth to avoid perpetuating these disparities in the development of AI software for utilization in teledermoscopic evaluation.[59] Recent studies have commented on the image collections used to train AI software, pointing out a distinct paucity in reference images containing darker skin tones.[60–62] A recent study by Daneshjou et al. pointed out the challenge of developing an unbiased and accurate data set for AI training, and the importance of fine-tuning AI models to close the performance gap between light and dark skin tones.[60] Future research and development should emphasize the importance of training AI software to recognize and accurately diagnose dermatoscopic images in patients of all skin tones.

With smartphone ownership increasing to 85% of adult Americans over the past decade, the use of smartphone-compatible dermoscopes, as well as smartphone applications specifically designed for live or SAF (Software Agent Framework) evaluation, is a growing subject of research and development. Smartphones are able to capture high-quality images, and more options for dermoscope attachments are available for purchase.[63] The integration of these smartphone attachments with SAF software, teledermatology, and even AI technology might vastly increase the opportunities for skin cancer screening in patients who otherwise lack access. However, there are several areas of concern that are critical to successful widespread implementation of home dermoscopy for skin cancer screening, including continued improvements in SAF software, standardized image acquisition, effective communication within electronic medical records, and clear guidelines for patient education and follow-up.

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Conclusions

With rising demands for dermatologic evaluation and a relative scarcity of providers, there is a clear need to implement triaging mechanisms to expand access to care. Teledermoscopy may offer such a solution; however, the intervention does have room for improvement as a screening tool when compared to traditional in-person evaluation by a dermatologist. Additionally, reviews of teledermoscopy have noted methodological limitations in many studies, indicating a need for more standardized data collection.[49] Optimization and standardization of methodologies used in future studies are crucial. Study data that accurately report the conditions under which teledermoscopy is successful will increase the likelihood of the intervention becoming a more widely used screening tool.

Many of the findings reported in these preliminary studies are promising, as they establish a possible role for teledermoscopy in bridging the care gap left by the shortage of community dermatologists, especially in rural and underserved areas. With the demand for dermatology appointments far exceeding supply, it is crucial to triage complaints and allocate in-person visits to those who truly require FTF treatment.[43] While not a replacement for FTF total body skin examinations, teledermoscopy is an attractive tool to decrease the burden of skin cancers and improve screening, especially in populations with limited access to dermatological care.[64,65] Implementation of teledermoscopy may reduce unnecessary biopsies by enabling home monitoring of suspicious lesions. It also may increase the overall cost-efficiency of dermatologic care by reducing the number of unnecessary in-person visits for clearly benign skin lesions.

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