The role of mobile teledermoscopy in skin cancer triage and management during the COVID-19 pandemic

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Abstract

The unprecedented onset of the COVID-19 crisis poses a significant challenge to all fields of medicine, including dermatology. Since the start of the coronavirus outbreak, a stark decline in new skin cancer diagnoses has been reported by countries worldwide. One of the greatest challenges during the pandemic has been the reduced access to face-to-face dermatologic evaluation and non-urgent procedures, such as biopsies or surgical excisions. Teledermatology is a well-integrated alternative when face-to-face dermatological assistance is not available. Teledermoscopy, an extension of teledermatology, comprises consulting dermoscopic images to improve the remote assessment of pigmented and non-pigmented lesions when direct visualisation of lesions is difficult. One of teledermoscopy's greatest strengths may be its utility as a triage and monitoring tool, which is critical in the early detection of skin cancer, as it can reduce the number of unnecessary referrals, wait times, and the cost of providing and receiving dermatological care. Mobile teledermoscopy may act as a communication tool between medical practitioners and patients. By using their smartphone (mobile phone) patients can monitor a suspicious skin lesion identified by their medical practitioner, or alternatively self-detect concerning lesions and forward valuable dermoscopic images for remote medical evaluation. Several mobile applications that allow users to photograph suspicious lesions with their smartphones and have them evaluated using artificial intelligence technology have recently emerged. With the growing popularity of mobile apps and consumer-involved healthcare, this will likely be a key component of skin cancer screening in the years to come. However, most of these applications apply artificial intelligence technology to assess clinical images rather than dermoscopic images, which may lead to lower diagnostic accuracy. Incorporating the direct-to-consumer mobile dermoscopy model in combination with mole-scanning artificial intelligence as a mobile app may be the future of skin cancer detection.

Key words: Dermoscopy, teledermoscopy, smartphone, COVID-19, skin cancer, melanoma

Introduction

Since March 2020, the COVID-19 pandemic continues to heavily impact all aspects of the healthcare system, forcing countries globally to adapt to changing guidelines and limited hospital occupancy. The strict "lockdown" regulations implemented by health authorities at the start of the pandemic decimated access to in-person evaluations and treatment for non-urgent medical conditions. As a result, many patients had to forego annual screenings and elective procedures for a period, delaying diagnosis and management, which has led to harm in terms of morbidity and mortality in 50% of patients.[1]

The unprecedented COVID-19 crisis poses a significant challenge to all fields of medicine, including dermatology in which one of the most notable consequences witnessed internationally has been the momentous reduction in new skin cancer diagnoses made during this time.[2] Prior to the pandemic, the incidence rate of both melanoma and non-melanoma skin cancer had been exponentially rising for many decades. This was thought to be due to increased sun exposure and improved skin cancer screening practices by providers.[3] However, since the start of the coronavirus outbreak in early 2020, a stark decline in new skin cancer diagnoses, often mirrored

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by the number of skin biopsies performed, has been reported by countries worldwide.[4–8] Studies evaluating the potential causes reported these findings as likely consequences of the challenges associated with the pandemic, suggesting that skin cancer is being underdiagnosed, and therefore untreated, rather than truly declining in prevalence.[8,9] Since early detection and management remain the most important factors affecting morbidity and mortality due to skin cancer, the delays experienced during the pandemic may be expected to increase the number of preventable skin cancer deaths.[10]

One of the greatest challenges in managing skin cancer during the era of COVID-19 has been the limited access to face-to-face dermatologic evaluation and non-urgent procedures, such as biopsies or surgical excisions. Such scarcity in appointments compounded with the growing population of undiagnosed skin cancer patients necessitates accurate triage of suspicious skin lesions to ensure these limited spaces are allocated to those with urgent need. In the absence of a diagnostic biopsy, it is difficult to ascertain the risk posed by a suspicious skin lesion based on naked-eye visualisation alone. Studies agree that including dermoscopic images in a teleconsultation, otherwise known as teledermoscopy, significantly improves the reliability of telediagnoses with increased sensitivity and specificity.[11] The clinical utility of teledermoscopy has grown since the start of the pandemic. The frequent emergence of new and more transmissible COVID-19 variants continues to render the return to pre-covid normalcy uncertain. In this scenario, teledermoscopy will continue to serve an integral role in optimising skin cancer patient outcomes while minimising the spread of SARS-CoV-2.

In this paper, we provide a narrative review focused on the critical role of teledermoscopy and its growing importance in skin cancer management during the era of COVID-19 and beyond. We conducted an extensive literature search of the PubMed (Medline) database using the query ("teledermatology" or "teledermoscopy" or "mobile dermoscopy") and ("COVID-19" or "coronavirus" or "pandemic"). Then, we conducted a manual search of the reference lists to obtain further relevant studies. All publications in English reporting the utility of teledermoscopy in skin cancer management during the COVID-19 pandemic were included.

Teledermoscopy

As one of the earliest telemedicine specialities, teledermatology is a well-integrated alternative when face-to-face dermatological assistance is not available. Teledermatology involves the transfer of medical information from a patient through virtual communication to a remote dermatologist for further evaluation. Teledermoscopy, an extension of teledermatology, consists of consulting digital dermoscopic images, to improve the remote assessment of pigmented and non-pigmented lesions when direct visualisation of lesions is difficult.[12] There are two main models through which teledermoscopy is commonly practised: "synchronous telemedicine," which involves live-interactive video consultation between the patient and provider, or "asynchronous telemedicine" in which digital dermoscopic images are stored to be referenced in future consultations. Digital dermoscopic images can be acquired through numerous digital devices including dermoscope adapters that attach to smartphones (mobile teledermoscopy), and other digital devices (digital teledermoscopy) with all-in-one systems that have image capturing, data storage and transfer capabilities.[13] Digital teledermoscopy utilises either an image-capturing digital dermoscope or a digital camera interfaced with a dermoscopic lens in order to virtually send high-definition dermoscopic images to providers via secure web-based teledermoscopy platforms. Mobile teledermoscopy (smartphone dermoscopy) is the more recent variant in which mobile devices (smartphones, tablets) capture and integrate photographic and telecommunication features of mobile devices with attachable magnifying devices in order to enhance patient's skin self-examination.[14]

Advantages of teledermoscopy

With dermoscopic patterns being well established for a wide range of dermatological conditions, especially skin malignancies, the combination of clinical teledermatology with teledermoscopy has been shown to improve the effectiveness of teledermatology consultations. One of teledermoscopy's greatest strengths may be its utility as a triage and monitoring tool, which is critical in the early detection of skin cancer, as it can reduce the number of unnecessary referrals, wait times, and the cost of providing and receiving dermatological care. According to a 2018 systematic review summarizing recent trends in teledermatology, numerous studies attest to the usefulness of mobile teledermoscopy in triage and referral by primary care providers assisting patients in remote or medically underserved locations and also in monitoring patients with chronic skin conditions.[14,15] Another major advantage of teledermoscopy, specifically mobile teledermoscopy, which enables its widespread applicability is its simplicity and user-friendly nature. Studies report that when using mobile teledermoscopy, general practitioners, dermatology staff, and patients generally are capable of capturing dermoscopic images of sufficient quality for teleconsultations.[15] Even with little to no dermoscopic experience, when provided minimal instruction, studies report that images acquired through mobile dermoscopy are of good quality, with substantial agreement observed (81-91%) between mobile dermoscopy and face-to-face diagnosis.[15] Many patients report high satisfaction with mobile teledermoscopy, despite reduced in-person evaluation, citing improved waiting times, convenience, reassurance and privacy.[16,17] In a randomised controlled trial comparing self-skin examinations with mobile teledermoscopy and clinical self-examination, skin evaluation submitted by mobile teledermoscopy was highly sensitive (82%), indicating concordance with clinical and telediagnosis 89·8% ($\kappa = 0{\cdot}74$, SE 0·04).[18]

Limitations of teledermoscopy

With mobile teledermoscopy, selection and subsequent imaging of pigmented lesions are determined by the patient or general practitioners, who often are limited in their knowledge of atypical dermoscopic features. Thus, there is a risk of overlooking skin malignancies which may have been incidentally noticed by a dermatologist during an in-person evaluation. This was demonstrated in a study that compared identification of skin cancers with mobile dermoscopy-enhanced self-skin examination and face-to-face examination, which showed that although mobile teledermoscopy has a high sensitivity (>75%) for the identification of skin cancers (9 vs 10), there was a slightly higher number of skin cancers missed compared to the face-to-face group (7.3% vs 2.4% respectively).[19] In select cases involving complex pigmented lesions with confusing dermoscopic characteristics, such as Spitz nevi, relying on teledermoscopy performed by the patient may lead to diagnostic failures which may be attributed to the lack of standardisation of image acquisition, as these are asynchronous store and forward images. In a study done by Baracaui *et al.* the diagnostic inter-observer concordance between face-to-face diagnosis and telediagnosis via asynchronous store-and-forward teledermoscopy for challenging pigmented lesions was assessed. Face-to-face diagnoses had a moderate agreement with clinical-histopathological diagnoses ($K = 0.6$) and telediagnosis had slightly lower interobserver concordance (K=0.52) which the authors justified due to the dermoscopic difficulty of the visualized lesions.[19]

The utility of mobile teledermoscopy is still limited by the patient's ability to distinguish a concerning skin lesion from a benign one. A recent Australian study showed that consumers using mobile teledermoscopy-enhanced self-skin examinations did not result in significantly higher sensitivity than those practicing normal naked-eye self-skin exams, with both groups submitting a large number of benign lesions to be further evaluated.[18] The introduction of teledermoscopy into clinical practice could lead to a large burden for telediagnostic services if its use results in people submitting many benign lesions. Nonetheless, teledermoscopy has consistently demonstrated very high cancer detection rates (sensitivity 100% and specificity 90%)[16] for patients presenting with specific skin lesions, and new technologies exploring mole-scanning artificial intelligence are being developed to optimise the selection and detection of skin cancers for the untrained eye.

Impact of COVID-19 on skin cancer

There is continued pressure for health care systems to manage essential supplies and human capital while mitigating the risk of viral transmission in the ongoing pandemic. When coronavirus cases rise to a point of overburdening hospital systems, available medical resources and personnel are reallocated to departments tackling acute medical emergencies. This negatively affects the diagnosis, management and outcomes for skin cancer patients, as has been well documented since the inception of the pandemic.

Lockdown period

In early March 2020, authorities in many nations radically modified health care guidelines by suspending all non-urgent practices and enforced strict public restrictions (lockdowns) to limit COVID-19 dissemination. In skin cancer patients these delays could worsen outcomes. One of the most notable consequences is the precipitous drop in new skin cancer diagnoses during the lockdown, which starkly contrasts with recent trends where skin cancer incidence was steadily rising for decades. A Dutch study using their National Cancer Registry reported that skin cancer diagnosis was reduced by 60%, six weeks after the first confirmed case of COVID-19 was identified in that country, while for other cancer types, this reduction was 26%.[20] The cause for such a striking decline in skin cancer diagnosis compared to other malignancies may be explained by the relaxed attitude towards skin health amongst the general population. Decreases in skin cancer referrals may also explain the drastic decline in skin cancer incidence during this time. In the United Kingdom, reductions of 56% for referrals of all skin cancers and 53% in diagnoses for skin cancers were reported.[21] Similar findings were reported from Victoria, Australia in which they estimated that about 2530 cancer diagnoses were either delayed or missed, accounted for by the reduction in skin checks performed by general practitioners in Australia during this time.[22]

Not only were routine screenings and referrals affected by the initial lockdown, but scheduled elective surgeries and procedures for skin cancer management were also postponed in many countries. A study done in Spain compared tumour burden in patients who underwent surgery for melanoma and cutaneous squamous cell carcinoma during their nationwide lockdown (March 14, 2020 - June 13, 2020) to patients treated during the same time period in 2019. Their main findings showed a significant reduction in skin tumours operated on (41% decrease for melanoma and 44% decrease for squamous cell carcinoma) and a doubling in the proportion of thicker and larger tumours operated on, which are classically poor prognostic factors for cutaneous malignancies.[23] While these findings appear to indicate that an appreciable proportion of skin cancer patients with poor prognosis received care as usual, we can expect to see an increase in cases with worse prognosis following the lockdown period due to the high number of untreated patients.

Post-lockdown period

As lockdown restrictions were lifted, many anticipated that the extensive delays imposed would translate into an increased number of advanced skin cancers seen post-lockdown. According to a study done by Tejera-Vaquerizo *et al.* which modelled tumour growth based on the kinetics of melanoma and cutaneous squamous cell carcinoma, a diagnostic delay of 2 months, which was the average lockdown period in many countries, would result in a doubling of the proportion of thick melanomas

(>4 mm) and a 60% increase in that of large squamous cell carcinomas (>40 mm).[24] Similar findings were seen in a retrospective case-control study done in Italy that reported the number of advanced skin cancers diagnosed at the end of Italy's first lockdown (May–November 2020) had more than doubled compared to the year prior (54 vs 22; odds ratio, 2.64; 95% confidence interval, 1.56–4.47; $P = 0.0003$).[25] In another retrospective cross-sectional study, Canedo *et al.* interestingly reported a decrease in the number of newly diagnosed melanomas in situ by almost half compared to the previous year (2019), but the number of melanomas with > 2-mm thickness rose almost 5-fold (39% in 2020 compared to 8% in 2019).[26] In the same direction, a study in Italy compared histopathologic features for melanomas diagnosed before and after Italy's 54-day lockdown period and observed increases in pathological features that have proven poor prognostic value such as increased tumour depth, ulceration, and nodular subtype in post-lockdown melanomas compared with pre-lockdown melanomas.[8] These findings illustrate the adverse effect the delays associated with lockdown had in advancing melanoma in patients, though further investigation is required to thoroughly characterise the associated effect it may have on long-term survival.

Although there was a significant increase in the number of advanced skin cancers being seen post-lockdown, as elective procedures and outpatient clinics reopened in the summer of 2020, many countries still experienced significant decreases in new skin cancer incidence. In a population-based cohort study performed in Canada, they observed large drops in new skin cancer diagnoses mirrored by the decreased total number of skin biopsies (15% of expected), with a differential change between keratinocyte carcinoma (18% of expected) and melanoma (27% of expected) in the 10 weeks following the end of lockdown.[10] As physical biopsy remains the gold standard for diagnosis of skin cancer, limited availability for these services, compounded with record-high wait times, inadequate triaging protocols, and the general population's continued fear of viral contagion are likely contributions to these findings. In a 2021 letter featuring the Croatian Referral Centre of the Ministry of Health for Melanoma, dermato-venereologists expressed concern after learning that a significant number of their newly diagnosed melanoma and non-melanoma skin cancer patients reported noticing a suspicious skin lesion months prior but opted out of seeking professional inspection due to the worrisome epidemiologic situation.[27] The authors hypothesised that a probable reason for this is the lack of significant symptoms with skin tumours. Unlike cardiac or pulmonary difficulties which are often perceived as life-threatening, progression of skin malignancies often presents as small changes in lesion appearance that can easily go unnoticed by patients and appear seemingly less dangerous than the threat of contracting COVID-19.

Teledermoscopy during COVID-19

Since the onset of the COVID-19 pandemic, there has been rapid integration of telehealth into care delivery motivated by the need to limit COVID-19 exposure. Dermatology has been touted as a suitable field for telemedicine due to the visual aspect of the speciality. Yet, the heavy reliance on visual clarity also proves a common hurdle, especially when evaluating a lesion concerning skin cancer. Typically, dermatologists utilize dermoscopy when evaluating a potential skin cancer, however, dermoscopic lenses and buttons were found to be contaminated with microorganisms acquired through patient contact and were suggested to be sources of COVID-19 infection.[28–30] While fear of viral transmission remains heightened, teledermoscopy could be viewed as a better option compared to face-to-face examination as it reduces unnecessary referrals and waiting times, and optimises triaging procedures, all while minimising the cross-contamination risk associated with face-to-face visits.

Provider perspective

It can be argued that health care providers are some of the most impacted by the ramifications of coronavirus. The temporary suspension of most practices led to a huge backlog of patients' post-lockdown; coupled with the nationwide medical staffing shortage associated with vaccine mandates,[31] this contributed to burnout felt by many remaining healthcare providers. Therefore, it has become pivotal that innovative strategies of triage be implemented to prevent overloading the system. Recently, teledermoscopy has played an essential role in the accurate triage of lesions suspicious for skin cancer, often utilised in referrals from primary care physicians to dermatology specialists. In a community-based United Kingdom study, Lowe *et al.* incorporated teledermoscopy into their urgent skin cancer referral pathways and were able to successfully divert 86.3% of the total number of virtually evaluated skin lesions away from needing to attend an in-person dermatology clinic.[32] Another recent study done in New Zealand compared two different teledermoscopic referral pathways, one that was entirely electronic versus one involving an additional in-person visit with general practitioners who would preemptively acquire and assess dermoscopic images post-dermoscopy training, which demonstrated a statistically significant reduction in time to dermatologist advice with electronic referrals directly from primary care providers.[33] This highlights the benefit of expanding the use of teledermoscopy by primary care physicians, and fortunately general practitioners have expressed acceptance and heightened confidence when using this advanced diagnostic tool.[34,35]

Patient perspective

With mobile teledermoscopy, patients can monitor suspicious skin lesions identified by their medical practitioner, or alternatively self-detect concerning lesions and forward dermoscopic images for remote medical evaluation. Potential benefits of consumer-performed teledermoscopy

include improved triage and management times, reduction in unnecessary referrals of benign lesions, reduced travel time, and potential cost savings.[36] High levels of satisfaction by patients using mobile teledermoscopy had already been reported prior to the pandemic,[37,38] claiming patient preference for mobile teledermoscopy for skin cancer screening over visiting a general practitioner. More recent studies citing some of the patient-reported advantages of direct-to-consumer mobile teledermoscopy include convenience, the option to avoid an in-person visit, and having a record of skin lesions to reference.[39] Other studies even highlight that incorporation of mobile teledermoscopy increased patients' motivation in performing regular self-skin exams.[20]

Teledermoscopy is limited by the quality of images that can be captured by the consumer with limited expertise .[40] Due to the shifting demand towards consumer-led image acquisition, Koh *et al.* developed a checklist tool for consumers that was adapted from the International Skin Imaging Collaboration guidelines to aid patients in obtaining consistent high-quality images to improve the accuracy of telediagnoses. This includes guidance on optimal lighting, background colour, the field of view, and image orientation.[41]

Future of teledermoscopy

Smartphone-based teledermoscopy has improved the quality of capture, storage, and transmission of dermoscopic images. There have been many recent developments in the field that involve using automated algorithms to exclude clearly benign skin lesions.

Teledermoscopy and artificial intelligence

There is some initial evidence for the effectiveness of artificial intelligence in the detection of melanoma, even demonstrating its higher accuracy compared to specialist dermatologists in several studies,[42–45] though more studies evaluating its implementation in clinical practice are required. A prospective clinical trial being conducted in Australia is one of the first to evaluate the use of artificial intelligence as a diagnostic aid for skin cancer in a real-world setting.[46] In the United States (US), companies implementing artificial intelligence dermoscopy selection of pigmented lesions (Sklip Inc., MetaOptima Technology Inc., and 3Gen Inc.) have recently been granted breakthrough device designation by the US Food and Drug Administration for the triage of concerning skin lesions based on digital dermoscopy image input, and clinical trials assessing its use in the early detection of skin cancer have already begun. Incorporating such technology with mobile teledermoscopy may expand its applicability, especially in rural communities with limited access to specialised dermatologic care. A South Korean study employed an advanced convolutional neural network to classify three different types of skin lesions (melanoma, melanocytic nevus and seborrheic keratosis) and found that the diagnostic validity of images acquired with an inexpensive smartphone dermoscope was comparable (approximately 80% accuracy) to images of the same lesions acquired by a portable dermoscope and digital camera, demonstrating how an amateur device can be compatible with this technology.[47]

Several mobile applications that allow users to photograph suspicious lesions with their smartphones and have them evaluated using artificial intelligence technology have recently emerged.[48,49] With the growing popularity of mobile apps and consumer-involved healthcare, this will likely be a key component of skin cancer screening in the years to come. However, most of these applications apply artificial intelligence technology to assess clinical images rather than dermoscopic images, which may lead to lower diagnostic accuracy.

Conclusion

Based on the findings in this review, incorporating the direct-to-consumer mobile dermoscopy model in combination with mole-scanning artificial intelligence triage in the form of a mobile app may be the future of skin cancer detection in our tech-enabled age of medicine.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflict of interest

AW and JL are the founders of Sklip Inc. a company mentioned once in the article and properly cited (48).

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