Teledermatology: its use in the detection and management of actinic keratosis

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Short title: Teledermatology and actinic keratosis
Abstract

Teledermatology can profoundly improve access to medical services for those who may have limited access to dermatology due to workforce shortages, distance to providers, or limitations in their mobility. Two common ways of teledermatology are differentiated: life synchronous, where patient and doctor communicate directly, or store and forward asynchronous methods, where the patient and doctor provide and assess the medical information independently. Teledermatology has been tested for its safety, feasibility and accuracy for a number of dermatological conditions, including the early detection of skin cancer and is usually safe, feasible and accurate. Studies reported somewhat better results for synchronous than asynchronous methods, possibly because of loss of information if no direct patient doctor contact is feasible. However asynchronous methods are easier to organize, require less sophisticated technology and are more widely accessible, and are more convenient for both patients and doctors. No study to date focused solely on teledermatology of actinic keratosis, but such lesions are typically found during teledermatology examinations for other main target lesions. In studies where such results were reported, actinic keratoses seemed to be readily identifiable for teledermatologists and adequate management and treatment can be suggested within remote consultations.
Introduction

Telemedicine

Telemedicine is often defined as medicine at a distance and can be applied to a large variety of medical applications. The first article to mention telemedicine and indexed in Pubmed was published in 1974[1]. Despite some ebbs and flows, telemedicine has grown since. A national strategy for telehealth has been proposed in Australia in 2013, the European Commission has produced a Green paper on mobile Health in 2014, and telemedicine is viewed with great anticipation in most countries of the world. A search of Pubmed using the keyword ‘telemedicine’ in April 2014 resulted in more than 17,000 citations. In recent years, due to vast improvements to wireless technology and connectivity, there has been an upsurge in interest in telemedicine. The main benefits of telemedicine are to improve access to medical services especially for underserved populations such as those living in rural or remote areas, people with limited mobility, or people with highly specialised needs where a high density of suitably trained health professionals cannot be achieved. Further advantages of telemedicine include the potential for cost reductions by saving time and travel, and reduction of unnecessary consultations. It has also been proposed that the timely application of telemedicine could prevent detrimental outcomes by minimising delays in presentations for urgent health problems [2]. To some extent this upsurge can also be seen as a response to pressures on health care systems worldwide which struggle to cope with increasing patient loads due to aging populations and chronic disease burden. Several models of telemedicine have been tested. The most commonly used categorisation distinguishes between store-and-forward or real-time consultation models [3]. Real-time consultations often use video teleconferencing or increasingly communication via online multimedia channels. Store and forward telemedicine uses various methods of linking patient and health care provider in an asynchronous fashion. Both store-and-forward or real-time consultation models are associated with advantages and disadvantages (Table 1).

Teledermatology

Dermatology is a subspecialty of medicine, mainly dealing with disease of the skin, which are commonly visible and diagnosable without requiring internal examination or imaging. Dermatology is thus well suited for telediagnosis and teletreatment applications. Teledermatology is therefore a special term for telemedicine applied to all aspects of dermatology [3]. Evidence for the utility of teledermatology is accumulating, with a recent review summarising its diagnostic reliability and accuracy, as well as clinical, patient satisfaction and economical outcomes. The review concluded that good evidence is available for the diagnostic reliability of teledermatology. For store-and-forward applications studies reported complete agreement between face-to-face and telediagnosis ranging between 41-89% and partial agreement when also considering differential diagnoses between 57-89%. For real-time teledermatology studies reported a range of 59-80% and 76-99% full or partial agreement, respectively[4]. These findings are within the bounds of agreement achieved when two or more clinic-based dermatologists assess the same cases face-to-face. The review concluded that there was little evidence for the other relevant outcome measures, with only few
studies investigating downstream clinical outcomes of patient treatment or intermediate outcomes such as time to treatment or clinic visits avoided, or whether teledermatology was cost-effective and could improve evidence-based practice. There are few studies which did found that store-and-forward technology may prevent between 18 and 31% of patients needing to come to a clinic, while 44 to 72% of visits may be spared through real-time consultation [4, 5]. Very few studies evaluated satisfaction outcomes [6], and found that while most patients were satisfied overall with teledermatology, long wait times until receiving the diagnosis and not having a personal interaction with the dermatologists were concerning for patients in store-and-forward studies. In the real-time teledermatology consultations, some patients did not like being videoed and missed having a physical examination. While dermatologists commented positively on some features of real time teledermatology, problems with technology, dislike of being videoed and preference for clinic-based diagnoses were their main concerns. In addition, economic considerations for how dermatologists should be reimbursed for their services outside the research setting are still unresolved in many health care contexts. Similarly the results of studies investigating whether providing teledermatological instead of the conventional diagnosis was more economical are inconclusive to date, with real-time consultations often more expensive than clinic care. Benefits beyond cost savings such as quality of life improvements have rarely been assessed.

Teledermoscopy

One important further subspecialisation of teledermatology that is especially relevant for skin cancer early detection and diagnosis is teledermoscopy. Dermatoscopes are now commonly used by both dermatologists and general practitioners or family doctors during clinical skin examinations for the early detection or diagnosis of skin cancers. Dermatoscopes allow non-invasive examination of skin lesions, and lead to demonstrated improvements of diagnostic accuracy by providing magnification and polarised light. These improved optics allow better visualisation of morphologic surface and bring subsurface architecture to the forefront, which are not easily detectable by the naked eye [7-9]. The range of uses of such devices has recently been enhanced by dermatoscopes which can be attached to smartphones, making them mobile devices, leading to a subspeciality of teledermoscopy. Furthermore such devices can not only be used by doctors during clinical examinations allowing a pictorial record of skin lesions which can be used in teledermatology consultations. They can also be used by patients themselves during skin self-examinations, allowing them to take and submit via email or specialised Apps photos of concerning skin lesions for a doctor’s opinion. This process is called mobile teledermoscopy (MTD) [10]. Based on studies which have shown that the quality of skin self-examinations improve if patients use photographs as a record of the original lesion presentation [11-13], mobile teledermoscopy could have immediate benefits for patients including greater accuracy in selecting suspicious skin lesions, and more broadly leading to their empowerment, and greater ownership over their health [14-16].

Mobile diagnosis using Apps

The US health resources and services administration defined mHealth Apps as those that aim to either improve health outcomes, deliver health care services or enable health research [17]. Over 10,000 Health Apps are available, and many more in development. Apps are commonly used to enhance patient self-management and health monitoring, improve communication with or between health care providers, and assist or replace some face-to-face health care encounters. However,
while many of these were developed with good intentions, often in response to a health care need, few of these Apps have been rigorously tested in their respective medical context. Interestingly the US Food and Drug Administration indicated that they would approve only Apps that serve as medical devices or accessories, whereas communication, self-management or monitoring Apps would not fall under their jurisdiction[18]. Specifically related to skin cancer, Apps are already used to provide information and behavioural motivation and instructions on sun protection, skin cancer prevention and early detection, with some offering the option to submit photographs of suspicious skin lesions for diagnostic assessment. As Stoeckler et al eloquently summarised [19], evaluations of these Apps indicate that the algorithms used by most of these Apps still need further development [20, 21], which could be facilitated by databases of dermoscopic images, with known histopathology diagnosis. Also App developers need to integrate functions which allow inclusion of the history of the lesion to allow a more accurate diagnosis.

Teledermatology and actinic keratosis

The above summary shows that the spectrum of telemedical applications in dermatology is rapidly increasing. To specifically investigate the current evidence of teledermatology for the diagnosis and management of actinic keratosis, we searched PubMed, Cochrane and Embase from inception to April 2014 for the following key words: ‘actinic keratosis OR solar keratosis OR solar cheilitis or actinic cheilitis’ AND ‘teledermatology OR teledermoscopy OR teledermatooncology’. We also searched the reference lists of any retrieved articles manually for further relevant publications. Overall, our search retrieved 391 citations, and we identified an additional 37 citations from the reference lists of the retrieved articles. Of these 428 articles, 403 were excluded as they that did not specifically report on actinic keratosis or squamous cell carcinomas separately or did not use teledermatology for their assessment. Overall, 25 articles were retained including 22 research studies and 3 reviews [22-46]. None of these specifically focussed on detecting actinic keratosis, most either assessed the value of teledermatology for diagnosing skin cancers by comparing telediagnosis to face to face clinical diagnosis or histopathology and assessed the inter-rater reliability of skin cancer telediagnoses by comparing several teledermatologists. There was also mention of actinic keratosis diagnoses in studies that assessed the accuracy of teledermatology more broadly, not specifically focussing on skin cancer. While actinic keratosis was not the main focus, they were commonly diagnosed in these studies, and the teledermatologists appeared very comfortable in diagnosing these skin lesions. An example of the incidence of actinic keratosis as part of teledermatology examination, can be provided using our recent teledermoscopy study conducted in Southeast Queensland among a population at high risk of skin cancers due to the high environmental ultraviolet radiation exposure [47]. This study aimed to assess the clinical accuracy of skin self-examination plus mobile teledermoscopy with our without detailed skin self-examination instructions compared to clinical skin examination. We provided participants with mobile teledermoscopes and asked them to perform a skin self-examination, looking for lesions that had changed or fitted the asymmetry and colour (AC) rule, with or without detailed skin self-examination instructions. Within 3 months, they underwent a clinical skin examination by a dermatologist. Participants were randomised to intervention group that received detailed instructions on how to conduct a thorough skin self-examination or control group with no specific skin self-examination instructions. Overall, 49 of 58 randomised participants completed the study, and submitted 309 lesions to the teledermatologist (156 intervention; 153 control group). Intervention group participants were more likely to submit lesions from their legs compared to
control (p=0.03), but no other differences between groups in number or site of missed lesions. Sensitivity of skin self-examination plus mobile teledermoscopy ranged from 41.9-79.4%, specificity from 56.2-89.6% depending on whether the patient or lesion was used as denominator. There was substantial agreement between telediagnoses and clinical skin examination diagnoses (Kappa =0.90) accounting for differential diagnoses. Participants photographed 21 actinic keratoses during the skin self-examinations, but also missed 13 additional ones that the dermatologist detected at the clinical skin examination. All of these actinic keratosis lesions were recommended for treatment (most commonly topic treatment or monitoring).

Summary

Many studies assessing the quality and accuracy of teledermatology or teledermoscopy have been conducted particularly over the past 10-15 years. These have shown that telemedicine is safe, effective and often already part of the usual routine, with for example doctors in training using telecommunication to confirm their diagnosis[48]. The number of studies and sophistication of methods increased in parallel with the widespread availability of digital photography, internet connectivity and multiple methods of electronic communication. None of the reviewed studies specifically focussed on actinic keratosis and such lesions were most commonly diagnosed when aiming to early diagnose melanoma or keratinocyte cancers including basal cell or squamous cell carcinomas. However, making a correct diagnosis of these lesions does not seem to place a large burden on the teledermatologists, with the vast majority of actinic keratosis telediagnoses confirmed upon clinical examination. The studies conducted to date lack a comprehensive assessment of the optimal pathways to and acceptance of teledermatology [6] both from the perspective of the clinicians or the patients, the cost-effectiveness of such services and the medical reimbursement models.

Another potential application for teledermatology in the specific field of actinic keratosis is monitoring of topical treatment in regards to side effects and their management as well as for assessing the efficacy of the treatment. The exciting new imaging world of 3D photography will most probably open up a new dimension of store-and-forward teledermatology for diagnostic and monitoring purposes and together with newly developed decision support systems has the potential to revolutionise the workflow for skin cancer screening in particular and dermatology in general[49, 50].

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Table 1: Advantages and disadvantages of store and forward compared to real-time teledermatology

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<td>Direct communication between patient and doctor</td>
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