ORIGINAL ARTICLE

Internet-based skin cancer screening using clinical images alone or in conjunction with dermoscopic images: A randomized teledermoscopy trial

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Background: Teledermoscopy involves the use of dermoscopic images for remote consultation and decision-making in skin cancer screening.

Objective: We sought to analyze the potential benefits gained from the addition of dermoscopic images to an internet-based skin cancer screening system.

Methods: A randomized clinical trial assessed the diagnostic performance and cost-effectiveness of clinical teleconsultations (CTC) and clinical with dermoscopic teleconsultations.

Results: A total of 454 patients were enrolled in the trial (n_{CTC} = 226, $n_{clinical\ with\ dermoscopic\ teleconsultation}$ = 228). Teledermoscopy improved sensitivity and specificity (92.86% and 96.24%, respectively) compared with CTC (86.57% and 72.33%, respectively). Correct decisions were made in 94.30% of patients through clinical with dermoscopic teleconsultations and in 79.20% in CTC ($P < .001$). The only variable associated with an increased likelihood of correct diagnosis was management using teledermoscopy (odds ratio 4.04; 95% confidence interval 2.02-8.09; $P < .0001$). The cost-effectiveness analysis showed teledermoscopy as the dominant strategy, with a lower cost-effectiveness ratio (65.13 vs 80.84).

Limitations: Potentially, a limitation is the establishment of an experienced dermatologist as the gold standard for the in-person evaluation.

Conclusions: The addition of dermoscopic images significantly improves the results of an internet-based skin cancer screening system, compared with screening systems based on clinical images alone. (J Am Acad Dermatol http://dx.doi.org/10.1016/j.jaad.2016.10.041.)

Key words: dermoscopy; information and communication technologies; melanoma; nonmelanoma skin cancer; pigmented lesions; seborrheic keratosis; teledermatology; teledermoscopy.

Over the past 10 years, teledermatology (TD) has become a routine procedure for skin cancer triage in many health care settings.[1-4] TD has yielded favorable results in terms of preventing referrals to face-to-face skin cancer clinics, improving diagnostic performance, and increasing

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Conflicts of interest: None declared.

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cost-effectiveness.[2,5] Teledermoscopy involves the use of dermoscopic images for remote consultation and decision-making.[6] At conventional in-person consultations, dermoscopy has notably improved the sensitivity and specificity of diagnosing cutaneous lesions.[7] However, whether the addition of dermoscopic images to clinical teleconsultations (CTC) is of interest for remote internet-based skin cancer screening remains to be assessed in experimental studies.

This study aims to analyze the potential benefits gained from the addition of dermoscopic images to an internet-based skin cancer screening system between primary care centers and the skin cancer clinic of an academic hospital.

CAPSULE SUMMARY

- Teledermatology using clinical images alone is an effective, accurate, and efficient methodology for skin cancer screening.
- In this trial dermoscopic images improved the diagnostic performance and efficacy of skin cancer screening.
- Teledermatology based on clinical and dermoscopic images is a cost-effective approach for internet-based skin cancer screening.

METHODS

A randomized clinical trial comparing the diagnostic performance, effectiveness, and efficiency of teledermoscopy with TD using clinical images for skin cancer screening was conducted between January 1, and December 31, 2015. The trial was performed at the TD Network of the Hospital Universitario Virgen Macarena, an academic hospital affiliated with the Public Health System of Andalucía (Spain).

Patients visiting 5 participating primary care centers because of concern over lesions suggestive of skin cancer were randomized after signing a consent form and ruling out the following exclusion criteria: multiple lesions, congenital lesions, and lesions on mucosal surfaces or hairy areas.

The interventions compared encompassed the internet-based consultations using clinical images alone (CTC) and teleconsultations using both clinical and dermoscopic images (teledermoscopy) (Fig 1). Dermoscopic images were taken using a DermLite Pro-II (3Gen Inc, San Juan Capistrano, CA) adapted to a J1Nikkor 10 to 30 mm (Nikon Corp, Tokyo, Japan). After evaluation of teleconsultations in both study groups by the remote dermatologist (L. F., T. O.-V., F. J. M.-G., or A. R. C.; TD experience from 5-10 years), a referral or nonreferral decision was made. All the patients were sent for in-person evaluation by an expert dermatologist (D. M.-R.; 13 years' skin cancer experience), which was considered the gold standard to classify referral decisions as correct or incorrect.

In an attempt to ensure blinding of the patients, TD operators, and remote dermatologists, the patients were initially randomized in a 2:1 ratio to a trial series and to a second nontrial series. Afterward, patients were randomized at a 1:1 ratio to the CTC and teledermoscopy groups (Fig 2).

The independent variables recorded were as follows: participant primary care center; remote dermatologist; clinical and demographic information (age, sex, anatomic location); remote dermatologist diagnosis; decision (referral vs nonreferral); diagnostic confidence level (1: uncertain diagnosis; 2: likely diagnosis; 3: confident diagnosis); in-person visit diagnosis; time dedicated by the TD operator to handle teleconsultations; and time dedicated by the remote dermatologist to evaluating teleconsultations.

For the diagnostic performance study, the definitions of true-positive, true-negative, false-positive, and false-negative results are described in Table I. Diagnostic performance was analyzed in terms of sensitivity, specificity, false-positive rate, false-negative rate, predictive values, and accuracy index or correct decisions percentage (accuracy index = [true positive + true negative]/[true positive + true negative + false positive + false-negative]). The multivariate odds ratios (ORs) of making correct decisions were also calculated.

A cost-effectiveness analysis under the health system perspective was designed by modeling a decision (Fig 3). The effectiveness end point applied was the making of a correct decision. Costs were allocated to each activity performed following an activity-based costing method (Fig 3). The technology costs were obtained by applying an amortization period of 3 years to the total acquisition cost of digital cameras (€3295.00), and digital cameras with adapted dermoscopes (€7156.65). The cost of staff activities was calculated from the Official List of Prices of the Public Health System of Andalucia.[8] At our TD network, the TD operator at the primary care center is a staff nurse with a cost of €20.88/patient in the CTC group and of €25.89/patient in teledermoscopy.[8] The cost associated with teleconsultation assessments by the remote dermatologist was adjusted to the performance rate in routine TD practice (40 teleconsultations/h), and from the time spent in assessing teleconsultations in each group.