Validation of a Handheld Elastic-Scattering Spectroscopy Device on Lesions Concerning for Melanoma

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DermaSensor

Introduction and Objectives

Skin cancer is the most common cancer worldwide and its most common types are basal cell carcinoma (BCC), squamous cell carcinoma (SCC) and melanoma [1,2]. One in five Americans will develop skin cancer by the age of 70 and more than two people die of skin cancer in the U.S. every hour [3]. The mortality rate and morbidity of melanoma are highly associated with the stage at which the cancer is detected. Self-examination and GP detection play an important role in skin cancer management, as most melanomas have been shown to be detected by patients or primary care physicians [4].

Elastic-scattering spectroscopy (ESS) is an optical tissue sampling technique that can distinguish between normal and abnormal tissue in vivo by recording photons scattered back from chromophores. A handheld ESS device measures ESS spectra of skin lesions and classifies lesions as either malignant or benign with an output of "Investigate Further" or "Monitor". The technology has been shown to have skin cancer sensitivity over 90% in various prospective, multi-centre studies [5,6,7,8]. This study aims to validate whether the use of an ESS point-of-care test can detect melanoma when dermatologists are evaluating lesions concerning for melanoma.

ESS algorithm trained and validated with over 11,000 spectral scans from over 3,500 skin lesions.

Figure 1. Handheld ESS Device

Materials & Methods

The handheld ESS device measures spectra of skin lesions and uses Convolutional Neural Networks to classify the lesion's scanned properties against those of known malignant and benign lesions. The output of the ESS classifier is "Investigate Further" or "Monitor". Additionally, for "Investigate Further" classified lesions, a score from 1 to 10 is provided which corresponds to the amount of spectral similarity a lesion has to malignant lesions in studies, with 10 representing the highest amount.

The algorithm was trained and validated with over 11,000 spectral scans from over 3,500 skin lesions, including histologically confirmed melanoma and non melanoma skin cancer (NMSC); as well as biopsied and unbiopsied benign lesions, as diagnosed by board-certified dermatologists [6,7]. The device is intended to act as an adjunctive tool for lesions that are suspicious of melanoma or NMSC.

This study consisted of ten dermatology study centers scanning lesions that they found concerning for melanoma. All dermatologists were blinded to the device results. Gold standard comparison for performance of the device and dermatologists was the biopsy result with multiple dermatopathologist review when consensus was not reached during the primary review process. High resolution digital images and the patient's clinical information, including prior skin cancer history, risk factors and physical examination results, were recorded for each case. After clinical evaluation, dermatologists reported their diagnosis and confidence level, which provided the physician comparison data. The results evaluated were sensitivity, specificity, Negative Predictive Value (NPV, and Positive Predictive Value (PPV) for melanoma, melanoma + severely atypical nevi, and all high-risk lesions. Area Under the Curve (AUC) was also calculated and modelled and compared between the study dermatologists and the device performance.

Results

A total of 311 patients with 440 biopsied lesions were evaluated by the study dermatologists, device and dermatopathology results. Most patients were male (54%), white (98%) and non-Hispanic (96%) and Fitzpatrick skin type II (53%) or III (20%). Lesions were most commonly described as flat (84%), pigmented (96%) and with a median length of 5mm.

Biopsy revealed 114 high-risk lesions with 44 melanomas, 44 severely atypical nevi (SAN) and 26 NMSC. Cancer prevalence was 26% (Number Needed to Biopsy (NNB): 4). Diagnostic sensitivity of the device was 96% (95% CI: 0.845 - 0.988) for melanoma alone, 91% for melanoma and SAN (95% CI: 0.831 - 0.953) and 93% (95% CI: 0.834 - 0.971) for all malignant lesions (Table 1). Overall device specificity was 33% (95% CI: 0.272-0.383). Dermatologist's sensitivity was 91% (95% CI: 0.806 - 0.960) for melanoma, 72% (95% CI: 0.613 - 0.800) for melanoma + SAN (Table 2).

Table 1: Concordance Between Device Output and Reference Standard - Melanoma

Device Reading	Reference Standard	
	Benign	Malignant
Benign	106/326 (32.5%)	2/44 (4.5%)
Malignant	220/326 (67.5%)	42/44 (95.5%)
Specificity (95% CI)	0.325 (0.272 - 0.383)	
Sensitivity (95% CI)	0.955 (0.845 - 0.988)	

Notes: 1. Biopsy results are used as reference standard. 2. Malignant diagnoses include lesions classified as Melanoma. 95% CI calculated accounting for the within subject correlation using the Wilson method.

Table 2: Concordance between Dermatologist and Reference Standard - Melanoma

Dermatologist Decision	Reference Standard	
	Benign	Malignant
Benign	189/326 (58%)	4/44 (9.1%)
Malignant	137/326 (42%)	40/44 (90.9%)
Specificity (95% CI)	0.580 (0.516-0.641)	
Sensitivity (95% CI)	0.909 (0.831 - 0.953)	

Notes: 1. Biopsy results are used as reference standard. 2. Malignant diagnoses include lesions classified by the Investigator as Melanoma.

Table 3: Management Sensitivity and Specificity With and Without the Device

Overall PPV	16% (0.116-0.217)
Scores 1-4	10.7% (0.068 - 0.165)
Scores 5-7	25.5% (0.146 - 0.407)
Scores 8-10	47.4% (0.249 - 0.698)

The overall NPV for a monitor result was 98.1% for melanoma. The overall PPV for a positive device result was 16%. When looking at spectral score groupings, the PPV increased for higher scores, with scores of 1-4 having a PPV of 11%, scores 5-7 with a PPV of 26% and scores of 8-10 having a PPV of 47%. (Table 3).

Table 4: NPV and PPV Across Various Cancer Prevalence Assumptions

Cancer Prevalence	NPV	PPV
3%	99.1%	4%
5%	98.5%	7%
9%	97.3%	11.8%
13%	96%	16.8%
15%	95.3%	19.2%

Notes: 1. These NPV and PPV value estimates are for melanoma only.

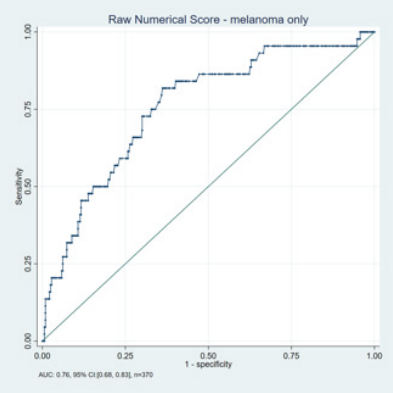

Figure 2: Receiver operating characteristic curve depicting diagnostic ability of ESS device's 0-10 score

For prevalence assumptions like those seen in general dermatology practice, the predicted NPV of the device is 97.3% with a PPV of 11.8% (Table 4).

The AUC of the ESS device for melanoma detection was 0.76 compared to the dermatologists of 0.75. Figure 2 demonstrates the AUC of the device for scores 0-10. The negative result of "Monitor" is represented by 0.

Discussion and Conclusion

The use of the handheld ESS device by physicians, in addition to clinical evaluation, may improve melanoma detection. The device was able to identify 96% of melanomas when compared to dermatopathology results. In addition, the high NPV of ~98% can provide confidence in ruling out melanoma. When presented with a high score (8-10), the PPV was 47% for melanoma which equates to a NNB of 2, meaning approximately 50% of scores 8-10 may be melanoma.

The high concordance of the handheld device with dermatopathology may help alleviate patient and dermatologist concern for benign lesions mimicking melanoma, particularly for nevi that do not merit re-excision.

When compared to other tools and the current gold standard available for visually assessing skin lesions (i.e. ABCDEs), the ESS device has AUC similar to dermatologists, high sensitivity for malignancy, and reasonable specificity for ruling out suspicious yet benign lesions biopsied by dermatologists, thereby providing important objective information to providers. While this study was conducted by melanoma specialists, given the device's similar overall performance to these specialists and its simple, non-invasive use, there is potential for the device to be used to help rule in or out lesion referrals for primary care physicians.

Adapted from Hartman R, Tepedino K, Fung, MA, McNiff, JM, Patrick G, Nguyen V, Chatha K, Grant-Kels J. Validation of a Handheld Elastic-scattering Spectroscopy Device on Lesions Suggestive of Melanoma. Poster Presentation, SDPA Fall Conference, Miami, FL, November 17-20, 2022

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Disclosures

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