

Trial of novel image-enhancement software to assist medical students in identifying dermoscopic features of melanoma

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Abstract

Background Early detection of melanoma is central to reducing the disease-related burden. The dermatoscope is used by skin cancer clinicians to help identify features of melanoma in a skin lesion. Features can be subtle and identification can be a challenge for early dermoscopists.

Objectives To investigate the utility of novel image-enhancement software as a possible aid for beginner dermoscopists in identifying melanoma features. The software had previously been developed for optometry for the diagnosis and monitoring of anterior eye conditions.

Methods Following an introductory lecture on dermoscopy, third-year medical students at James Cook University were asked to complete a 10-lesion test set of dermoscopic images on benign lesions and cutaneous melanoma (CM). Students scored the presence or absence of some melanoma-related features (asymmetry, blue-grey colour, atypical network) and made a diagnosis for a standard image and then for the matching enhanced image.

Results In total, 61 students participated. Total performance scores did not differ significantly between standard and enhanced images of the benign lesions. However, students correctly identified CM-related features (blue-grey colour $P=0.01$, atypical network $P<0.001$) and diagnosed melanoma correctly ($P=0.005$) significantly more often when observing the enhanced images of CM compared with standard images. Participants also reported a subjective improvement in diagnostic confidence when using the enhanced images.

Conclusions The image-enhancement software shows promise in assisting beginner dermoscopists in identifying some features of melanoma and could be tested with more advanced dermoscopists along with a wider range of dermoscopic features. The software could potentially be made widely and cheaply available in the form of a mobile phone application or be incorporated into an existing image-management platform.

Graphical abstract

TRIAL OF NOVEL IMAGE ENHANCEMENT SOFTWARE TO ASSIST MEDICAL STUDENTS IDENTIFY DERMOSCOPIC FEATURES OF MELANOMA.



BACKGROUND

Dermoscopy is central to diagnosing melanoma, it can be a challenge for early dermoscopists.



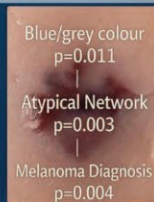
OBJECTIVE

This study trials a novel image enhancement software on dermoscopy images.



METHODS

Medical students were shown original and then enhanced melanoma images and asked to identify dermoscopic features.



RESULTS

Students identified melanoma features more accurately and made correct diagnoses at a significantly higher rate when using the enhanced images.



CONCLUSION

The software should also be trialled with skin cancer clinicians. It may have value as an education tool or as a clinical aid for dermoscopists.

What is already known about this topic?

- Early detection of melanoma is central to reducing the disease-related burden.
- The dermatoscope is used by skin cancer clinicians to help identify features of melanoma in a skin lesion.
- Features of early melanoma can be subtle and identification can be a challenge for early dermoscopists.

What does this study add?

- This study assesses the use of a novel image-enhancement software (previously used in optometry) applied to dermoscopic images.
- The study showed that medical students were able to correctly identify some dermoscopic features of melanoma and make a correct diagnosis at a significantly higher rate with the enhanced images than with standard images.
- The software should be trialled with further melanoma features and with actual skin cancer clinicians.
- The software could be made available as an educational tool or incorporated into existing image management systems to aid students or clinicians with the identification of melanoma.

Australasia has the highest incidence of cutaneous melanoma (CM) and CM-related deaths globally.¹ Early detection is a vital part of reducing this disease burden.² A substantial increase in the number of cases of CM in Australia is expected by 2030. A large proportion of these will be managed in primary care and relevant clinical training will need to be expanded to meet this service need.³

Dermoscopy, 'the stethoscope of the skin', has been shown to increase the sensitivity of detecting CM by between 9- and 15-fold compared with clinical examination using the naked eye alone.⁴ Current recommendations are that clinicians conducting skin examinations in Australasia should be proficient in dermoscopy, with training commencing early in their medical education.³ Recognizing subtle dermoscopic features may be challenging for early-career and experienced dermoscopists, potentially leading to an underdiagnosis of CM.^{5,6}

Automated serial total-body photography, with computer assessment of images along with dermoscopy, is an example of recent technological advances that can help identify CM over time.^{7,8} Using multispectral skin analysis or reflectance confocal microscopy in conjunction with dermoscopy has also been shown to improve the sensitivity and specificity for CM diagnosis.^{9,10} However, cost and accessibility are barriers to the widespread use of these expensive systems in primary care or remote settings.

In contrast, some low-cost methods for enhancing dermoscopic images have been identified. A high dynamic range (HDR) setting on mobile phone cameras made it easier to identify dermoscopic features in hypopigmented lesions.¹¹ A simple mobile phone editing application (Samsung, Seoul, South Korea) was shown to enhance the appearance of vessels and other dermoscopic structures in a mucocoele.¹² Feature-amplifying dermoscopy is an example of an image-enhancing algorithm. This technique was used by Blum *et al.* in clinical practice with the FotoFinder dermoscopy system to help evaluate melanocytic skin tumours.¹³ Blum *et al.* published a case report of feature-amplifying dermoscopy and noted that image enhancement was a potentially simple and cost-effective addition to digital dermoscopy.¹³

General image-processing tools use contrast or HDR for image enhancement, but these can saturate the image or result in loss of original data. Sparca Corporation (Fort Lauderdale, FL, USA) has developed a novel algorithm-based signal-enhancing software; this operates at an individual pixel level with no loss of data

(<https://www.sparca.com>). Commercial application of this software to date includes a platform that enables opticians to image and grade anterior eye conditions (<https://aos-hub.com>). The first author (S.F.) was presented with the opportunity to apply the image-enhancement software to dermoscopy.

S.F. informally presented enhanced dermoscopy images to work colleagues, including intermediate and expert dermoscopists. Feedback from the intermediate dermoscopists – nurse practitioners with 1–5 years of clinical experience – was the most enthusiastic for identifying CM-related features. It was then postulated that early-career dermoscopists would also find the enhancements helpful for identifying CM features. This study looked at the impact of enhanced dermoscopy images on the identification of CM features compared with standard images for novice dermoscopists in the form of third-year medical students at James Cook University, Australia.

Materials and methods

Study design

This was an experimental study with a within-participant design. An online test set was created using Google Forms consisting of standard and enhanced dermoscopic images (×10 magnification) for each of 10 flat, ambiguous and at least partially pigmented lesions. The lesions used were either lentigo/atypical melanocytic naevi or melanoma *in situ* (MIS)/early CM and were sourced from the clinical practice of the first author (S.F.) Histology had been obtained for all 10 cases. The seven cases of MIS/early CM were interspersed with the three benign cases. The presence or absence of dermoscopic features in each image was agreed upon by a group of experienced skin cancer clinicians (Skin Cancer College Australasia and NZ Skin Cancer Doctors).

Study population

The entire cohort of 196 third-year undergraduate medicine students enrolled at James Cook University in Townsville, Australia, in 2023 was sent a group message inviting the voluntary participation of interested students.

Students were taught to use the 3-point checklist to recognize lesion asymmetry, the presence of blue or white colouration, and

an atypical pigment network in dermoscopic images during a 50-min compulsory lecture conducted by J.H.^{14,15} Data collection was conducted in an adjacent room 10 min after the dermoscopy skills training lecture finished.

Sample size calculation

Informal preliminary investigations were first undertaken by S.F. with 16 colleagues with intermediate-to-advanced dermoscopy skills. Based on the results, we estimated that a sample size consisting of paired data for 52 participants (scores achieved using enhanced vs. standard images) should be sufficient to achieve a power of 80% and a significance level of 5% (two-sided) to detect an effect size of 0.4 between pairs (reasonably small effect size).

Image-enhancement software

The image-enhancement software was developed to enhance CM features, including asymmetry, atypical pigment network, blue–grey colouration, polymorphous vessels and polarized specific white lines, without altering the fundamental colours or structures within the dermoscopic images (Figures 1–3). A software prototype was made available for use by the authors.

Data collection

The students who attended data collection were instructed to open the study materials on their personal smartphone via a QR code. Following an introductory segment during which J.H. guided participants through three example lesions, the students were asked to examine the standard dermoscopy image of the first lesion in the test set on their phone (zoom function was available). They were then asked to answer three dichotomous questions about the presence (score=1) or absence (score=0) of

(i) lesion asymmetry, (ii) blue–grey colour and (iii) an atypical pigment network. They then used the 3-point checklist score to arrive at their diagnosis (scores ≤ 1 benign; scores ≥ 2 MIS/CM) for the standard image and then the enhanced image of the same lesion. For each case, participants were asked to rate how the enhanced image impacted their confidence in decision making.

The process was repeated for all 10 lesions in the test set. Feedback was provided by J.H. to the participant group between each lesion about the presence or absence of features from the three-point checklist, along with the lesion's histological diagnosis. There was also an opportunity at the end of the test set for participants to provide subjective feedback. Student responses were autopopulated in an online Microsoft Excel spreadsheet.

Statistical analysis

Numerical data were summarized as mean (SD) or median (interquartile range). Total student performance scores (maximum 40) were compared overall by image type (enhanced vs. standard) and also by lesion type (benign vs. MIS/CM) using the Student's *t*-test. ANOVA was performed to examine the effect of image enhancement on total student performance scores separately by lesion type, within the subset of seven MIS/CM lesions (maximum score 28) and then within the subset of three benign lesions (maximum score 12).

Incidence rate ratios (IRRs) with 95% confidence intervals (CIs) were calculated using Poisson regression models to assess the likelihood of correctly diagnosing the lesion type (melanoma vs. benign) based on image type (enhanced vs. standard). The model included lesion type, image type and their interaction term to examine whether the effect of image type on diagnostic accuracy differed for melanoma. The primary outcome was the number of correct diagnoses, with IRRs indicating the relative likelihood of correct readings.

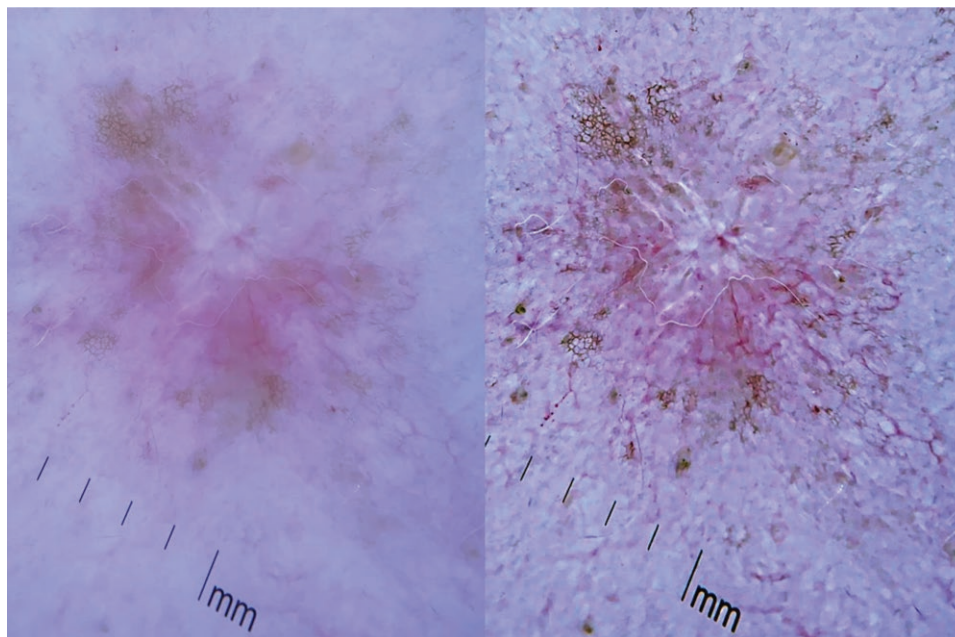


Figure 1 Dermatofibroma (benign lesion). Left: standard dermoscopic image. Right: enhanced image showing polarized specific white lines, vasculature and the pigment network more clearly.

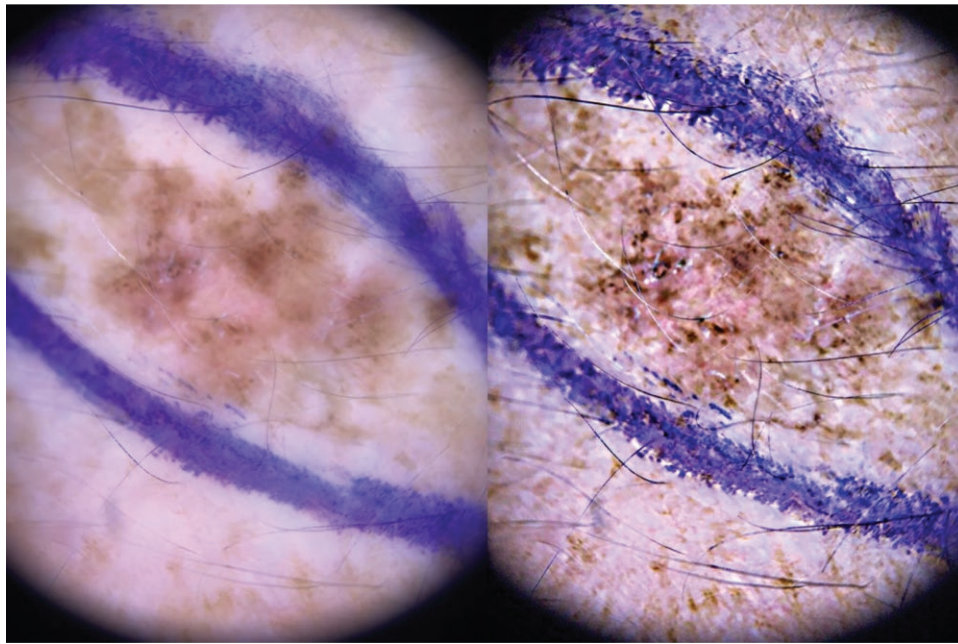


Figure 2 Melanoma *in situ*. Left: standard dermoscopic image. Right: enhanced image showing the irregular pigment distribution more clearly. Although it is unconventional to show pen markings, the sharpening of the pen lines helps demonstrate the enhancement effect.

Lastly, the numbers of true-positive, true-negative, false-positive and false-negative responses achieved were used to determine the overall sensitivity and specificity. The diagnostic odds ratio (OR; the ratio of the odds of positivity in patients with disease relative to the odds in patients without disease) was also calculated, and the ORs of the random effects model are presented together with 95% CIs.

All statistical analyses were performed in R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was assessed at a P -value threshold of <0.05 .

Results

Of the 196 third-year students invited to participate via group message, 177 attended lectures on the day of testing and 61 (34.5%) agreed to stay behind to trial the test set. Total student performance scores did not differ significantly between standard and enhanced dermoscopy images for the 10-image set [mean (SD) 15.2 (7.1) vs. 16.1 (8.1); $P = 0.36$] (Figure 4a). However, with subanalysis of benign and melanoma lesions across both image types, melanoma lesions consistently scored higher (Figure 4b),

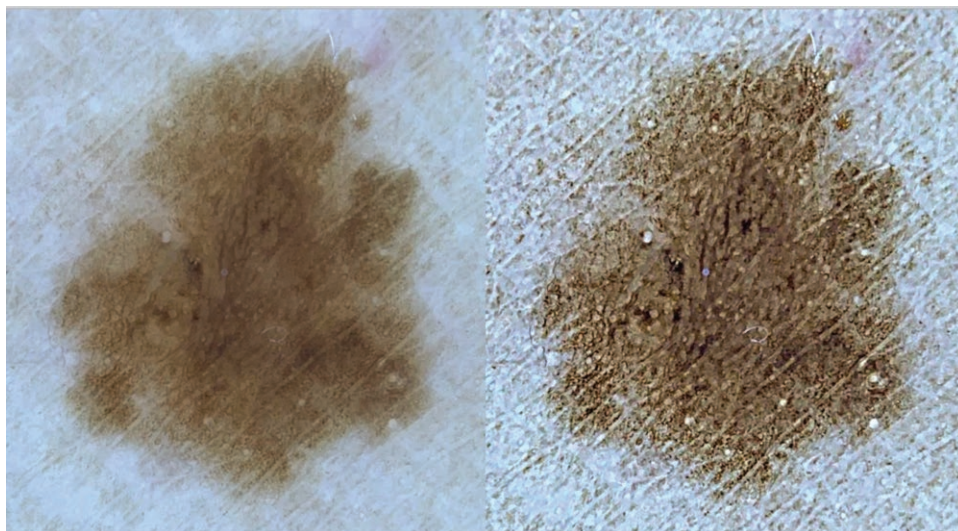


Figure 3 Benign lentigo. Left: standard dermoscopic image. Right: enhanced image. Although symmetrical, the pigment can appear more striking, with the potential for false-positive results.

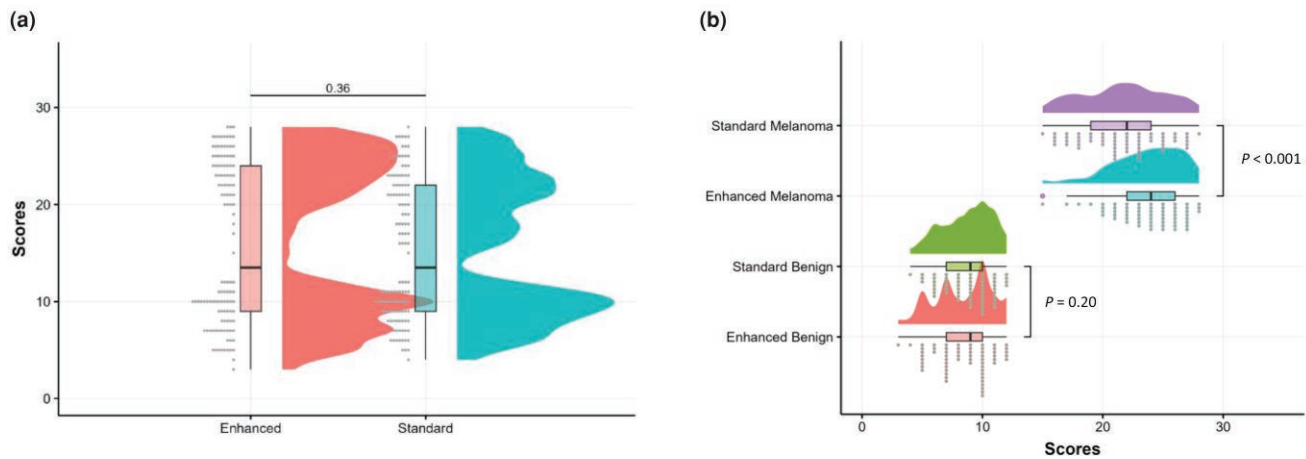


Figure 4 (a) Distribution of total student performance scores (maximum score 40) for the test set of 10 lesions. Comparison of diagnosis scores achieved using standard dermoscopy images compared with enhanced dermoscopy images. (b) Comparison of diagnosis scores for benign lesions (maximum score 12) and melanoma lesions (maximum score 28) under enhanced and standard imaging.

and image enhancement resulted in a significant improvement in score. For benign lesions, the mean (SD) score was 8.39 (2.33) for enhanced images and 8.77 (2.05) for standard images. In contrast, melanoma lesions scored a mean (SD) of 23.7 (2.85) for enhanced images and 21.7 (3.42) for standard images ($P < 0.001$).

On subanalysis of the components of the 3-point checklist (Table 1), there was no significant difference in scores between enhanced and standard images in the asymmetry category. However, scores for atypical pigment networks (mean 5.87 vs. 5.05, difference of 0.82; $P = 0.003$) and blue–grey colour (mean 5.48 vs. 4.89, difference of 0.59; $P = 0.01$) were higher in the enhanced images of MIS/CM. Consequently, students achieved significantly higher overall scores diagnosing MIS/CM using enhanced vs. standard images (mean 6.11 vs. 5.52, difference of 0.59; $P = 0.004$).

As shown in Table 2, there were no significant differences in overall diagnostic performance between standard and enhanced images, with an IRR of 1.04 (95% CI 0.93–1.18; $P = 0.48$). However, melanoma lesions were significantly more likely to be correctly diagnosed than benign lesions, with an IRR of 1.21 (95% CI 1.10–1.34; $P < 0.001$). The interaction between image type and lesion type suggested a lower diagnostic accuracy for melanoma lesions when using standard images compared with enhanced images, with an IRR of 0.87 (95% CI 0.76–1.01), although there was only weak evidence of an association ($P = 0.06$).

The overall sensitivity of this image-enhancement software in helping this sample of novice dermoscopists to correctly diagnose

early melanoma was 0.84 (95% CI 0.81–0.87), and the overall specificity was 0.80 (95% CI 0.74–0.85) (Figure 5). The diagnostic OR indicated that the odds of these students obtaining a correct diagnosis when observing histologically confirmed MIS/CM was 13.2 times higher than the odds of them obtaining a positive diagnosis when observing benign lesions (OR 13.2, 95% CI 9.73–17.9; $P < 0.001$).

Discussion

Our study examined the utility of image-enhancement software on dermoscopy images to aid the early detection of CM. The software demonstrates potential as an accessible and inexpensive tool for enhancing recognition of CM. Third-year undergraduate medical students were able to identify atypical network and blue–grey colour in the seven MIS/CM lesions in our test set at a significantly higher rate than in standard images. Consequently, their ability to diagnose melanoma also improved. The students also reported a subjective improvement in diagnostic confidence when using the enhanced images.

The enhancements did not improve scoring on identification of lesion symmetry. We postulate that humans have an innate ability to identify symmetry, and this was the feature students scored best on for original and enhanced lesions.

The digital enhancements did not improve the accuracy of diagnosis for the benign lesions. Symmetry and the absence of melanoma-specific features are the main clues that a lesion is benign. Other

Table 1 Differences in mean scores for the individual components of the 3-point checklist for cutaneous melanoma (asymmetry, colour, atypical pigment network) and the clinical diagnosis achieved by novice dermoscopists using enhanced dermoscopy images compared with standard dermoscopy images (maximum score 7 in each category)

Characteristic	Enhanced	Standard	Difference (95% CI)	P-value
Asymmetry	6.26	6.20	0.07 (–0.24 to 0.38)	0.68
Blue or grey colour	5.48	4.89	0.59 (0.14 to 1.04)	0.01
Atypical pigment network	5.87	5.05	0.82 (0.29 to 1.35)	0.003
Correct diagnosis	6.11	5.52	0.59 (0.20 to 0.98)	0.004

CI, confidence interval.

Sensitivity and Specificity of Image-Enhancement Software

Image	Proportion	(95% Confidence Interval)
Melanoma (Sensitivity)	0.875	(0.832 to 0.908)
Benign (Sensitivity)	0.801	(0.749 to 0.845)
Overall (Sensitivity)	0.844	(0.810 to 0.873)
Melanoma (Specificity)	0.774	(0.692 to 0.839)
Benign (Specificity)	0.833	(0.742 to 0.897)
Overall (Specificity)	0.803	(0.744 to 0.851)

Diagnostic Odds Ratio (DOR) for melanoma:
13.19 [9.73; 17.87], $p < 0.0001$

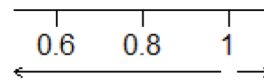


Figure 5 Sensitivity and specificity of the image-enhancement software.

than confirming a symmetrical distribution of pigment, it is not possible to digitally enhance the absence of a melanoma-specific feature. Despite the enhancements often making the lesions look more dramatic, the number of false-positive results did not increase.

Improvement in the diagnosis of melanoma lesions suggests the image-enhancement software shows sufficient promise to be studied further in terms of different groups of clinicians and types of lesions. As novice dermoscopists the medical students required some dermoscopy training prior to completing our test set; this would not be a requirement when working with more experienced dermoscopists. Alternatively, studies could be designed such that any percentage improvement from image enhancement could be determined separately from teaching benefit.

Polymorphic vessels are an important criterion for identifying difficult-to-diagnose CMs such as hypomelanotic melanoma.¹⁶ Although the 3-point checklist did not require the students to look at vessel features when reviewing our test set, our experience from piloting this tool with expert and intermediate dermoscopists is that the enhanced images are useful for highlighting blood vessels. The ability of image-enhancement software to enhance vessels has been noted previously.^{12,13} Vessel enhancement is an important part of existing Sparca software for assessing anterior eye conditions. We plan to explore this feature when trialling with more experienced

dermoscopists identifying hypomelanotic melanoma, and will make the software available for study in clinical settings.

If the enhanced dermoscopy images continue to prove useful for education or clinical decision making, then the tools could be made widely and cheaply available in the form of a mobile phone app for use in a primary care or remote setting. A further possibility is for the software to be incorporated into an existing dermoscopy image management system.

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Author contributions

Stuart Farmer (Conceptualization, Writing—original draft [lead], Data curation, Methodology, Project administration [equal]), Simone Harrison (Data curation, Methodology, Supervision, Writing—review & editing [equal]), Jeremy Hudson (Conceptualization, Investigation, Writing—review & editing [equal]), Nichole Harvey (Project administration, Resources, Writing—review & editing [supporting]), Oyelola Adegboye (Data curation, Supervision [equal], Formal analysis [lead]), and Clare Heal (Supervision, Writing—review & editing [equal])

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Conflicts of interest

The authors declare no conflicts of interest.

Data availability

The data underlying this article are stored on the Research Data James Cook University platform and can be shared on request to the corresponding author.

Table 2 Incidence rate ratios (IRRs) with 95% confidence intervals (CIs) and *P*-values for the likelihood of a correct diagnosis based on image type (standard vs. enhanced) and lesion type (benign vs. melanoma)

Characteristic	IRR (95% CI)	<i>P</i> -value
Image		
Enhanced		
Standard	1.04 (0.93–1.18)	0.48
Types		
Benign		
Melanoma	1.21 (1.10–1.34)	<0.001
Image × types (interaction term)		
Standard × melanoma	0.87 (0.76–1.01)	0.06

Ethics statement

Ethics approval was provided by the James Cook University Human Ethics Committee (approval number: H8994, 11 April 2023) before commencement of this study.

Patient consent

Not applicable.

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