

Cross-Polarized Macro Photography versus Polarized Dermoscopy in Basal Cell Carcinoma: A Blinded Paired-Image Comparison

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Background: Polarized dermoscopy (PD) is the established non-contact imaging modality for basal cell carcinoma (BCC). Cross-polarized macro photography (CPMP) applies analogous optical principles using widely available equipment, but its performance relative to PD has not been systematically evaluated.

Objective: To compare dermoscopic feature visibility, image quality, and expert modality preference between CPMP and PD in BCC using a blinded, paired-image design.

Methods: One hundred paired CPMP and PD images of histopathologically confirmed BCCs, acquired during the same clinical visit, were digitally masked to remove modality-revealing cues and reviewed in randomized side-by-side pairs. Feature visibility was assessed by three dermoscopists; image quality by a multidisciplinary panel using the DIQS-5 (a structured 5-point dermoscopic image quality scale); and modality preference by three dermatologists with varying CPMP familiarity across two blinded rounds with a washout period.

Results: Feature visibility did not differ significantly for any established BCC criterion (all $P > 0.05$). CPMP scored significantly higher for depth of field and color fidelity (both $P < 0.001$); sharpness was comparable between modalities ($P = 0.494$). CPMP captured all lesions ≥ 1 cm in a single frame, whereas 41.5% of large lesions exceeded PD's field of view. The majority of raters preferred CPMP in both evaluation rounds, with phenotype-dependent patterns: CPMP was favored for pigment-rich lesions and PD for lesions with fine vascular structures.

Conclusion: CPMP demonstrated feature visibility comparable to PD while offering measurable advantages in depth of field, field of view, and color rendering, suggesting complementary roles for these modalities in BCC imaging.

Plain Language Summary: Basal cell carcinoma is the most common skin cancer. Dermatologists usually examine these lesions with a handheld device called a dermoscope, which uses a special polarized light to reveal details beneath the skin surface. Standard dermoscopes work best when held close to the skin and cover a small area at a time, which can be challenging with larger growths. We wanted to know whether a photographic technique called cross-polarized macro photography (which uses the same type of light but works at a distance with a regular camera) could show the same information.

We studied 100 people diagnosed with basal cell carcinoma. For each person, we had two images of the same skin area: one taken with the camera technique and one with a dermoscope. Different skin specialists reviewed the paired images side by side, without knowing which technique produced each image. They recorded what they could see, scored the image quality, and chose which image they found more useful.

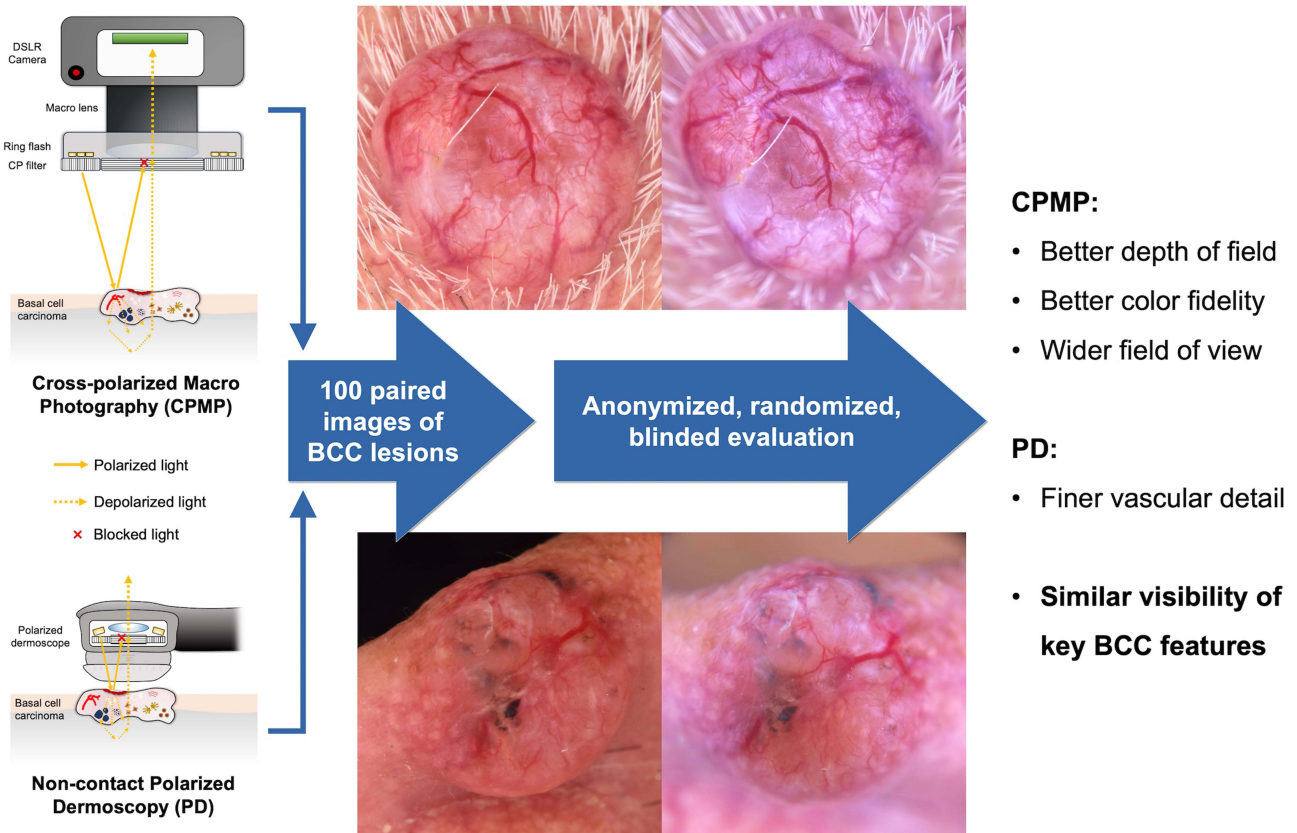
We found that both techniques showed the important visual features of basal cell carcinoma equally well. The camera technique produced sharper focus across the whole lesion, more accurate colors, and a wider view, often capturing larger growths in a single image. Dermoscopy showed fine blood vessels slightly more clearly.



These results suggest that cross-polarized macro photography can work alongside dermoscopy in everyday practice. Each technique has its own strengths, and together they may give clinicians a more complete picture when examining skin lesions.

Keywords: dermoscopic feature visibility, image quality, medical photography, non-contact imaging, skin cancer imaging, optical imaging

Graphical Abstract



Introduction

Basal cell carcinoma (BCC) is the most common skin cancer worldwide, and its rising incidence imposes a substantial burden on patients and healthcare systems.¹ Although BCC typically follows an indolent course with low metastatic potential, delayed diagnosis or untreated lesions may result in extensive local tissue destruction, functional impairment, and considerable cosmetic morbidity.² Therefore, timely and accurate diagnosis is critical not only for improving patient outcomes but also for reducing the need for complex surgical interventions and related resource use.^{3,4} While clinical examination remains the cornerstone of diagnosis, non-invasive imaging modalities are playing an increasingly central role in detection, treatment planning, and longitudinal monitoring of BCC.⁵⁻⁸

Among these modalities, approaches based on cross-polarization occupy a pivotal position. Since its introduction to dermatology by Anderson in 1991,⁹ cross-polarization has become a core optical principle in skin imaging. In contrast to non-polarized imaging, in which surface-reflected light hinders visualization of deeper structures, cross-polarization suppresses this glare through the use of two orthogonally oriented polarizing filters, thereby enhancing the visibility of deeper subsurface

features, including vascular and collagen-related structures that are imperceptible to the naked eye.¹⁰ In addition, by eliminating the need for immersion fluids and direct skin contact required in conventional non-polarized dermoscopy, this technique has evolved into a standard component of contemporary dermoscopes.^{11,12} At the other end of the spectrum, cross-polarized illumination also underpins high-end platforms such as automated total-body mapping and multimodal facial imaging systems, developed for standardized, reproducible documentation in screening and follow-up.^{13–15} However, these systems are often limited by high acquisition and maintenance costs, workflow complexity, and restricted availability.

This highlights a practical gap between readily available polarized dermoscopy (PD) and technologically sophisticated platforms that offer non-contact, cross-polarized imaging but are less widely deployable for routine use. In this setting, cross-polarized macro photography (CPMP) may provide a pragmatic bridge. CPMP can be assembled from equipment commonly available in dermatology clinics (a digital camera, macro lens, and ring flash fitted with a cross-polarizing filter) and applies optical principles analogous to PD while enabling non-contact cross-polarized imaging.^{16,17} However, whether CPMP yields comparable information to standard PD has not been systematically evaluated. Therefore, focusing on BCC, we compared CPMP and PD by assessing dermoscopic feature visibility, image quality parameters, and expert preferences using paired images of the same lesions.

Materials and Methods

Study Design and Ethics

This study was designed as a retrospective, observational, comparative imaging analysis. The study protocol adhered to the principles of the Declaration of Helsinki, and ethical approval was obtained from the institutional ethics committee prior to initiation (approval #: 2025/06-21).

Patient Selection and Dataset Creation

We retrospectively reviewed the digital image archives for images acquired between January 2023 and January 2025. The study cohort consisted of patients with histopathologically confirmed BCC for whom paired CPMP and PD images were available from the same preoperative visit. To minimize operator-dependent variability and ensure high image quality, inclusion was initially restricted to cases where at least three consecutively acquired images were available for each modality. From this pool, a single CPMP and a single PD image that best represented the lesion were selected by consensus between two authors (O.E., V.A.E). The final dataset comprised 100 image pairs, with each pair consisting of one CPMP and one PD image of the same lesion.

Image Acquisition

CPMP images were captured utilizing a Nikon D3500 DSLR camera equipped with a Nikon AF-S 60 mm f/2.8G ED Micro lens and a GODOX ML150 ring flash, combined with a custom-built cross-polarization filter as previously described.^{16,17} Camera settings were standardized in manual mode to 1/200 s exposure time, f/20 aperture, and ISO 100 sensitivity. All photographs were obtained perpendicular to the lesion at a working distance of approximately 10 ± 2 cm, with image acquisition requiring only a few seconds once the setup was established.

PD images were acquired using either a DermLite DL4 or DL5 dermoscope (3Gen, CA, USA) attached to an iPhone 13 (Apple Inc., CA, USA) via an adapter. Mobile phone camera settings remained in automatic mode to reflect routine clinical practice, while the dermoscope was operated in non-contact cross-polarized mode. All images were captured by a single experienced dermatologist (O.E.) trained in clinical photography and dermoscopic imaging to ensure consistency.

Image Preparation and Randomization

To ensure blinding and eliminate visual cues that might disclose the imaging modality, all images underwent digital pre-processing prior to evaluation. Device-specific elements, such as dermoscope rulers, vignette borders, or other modality revealing clues, were removed using cropping and object removal tools in Adobe Lightroom (version 8.3.1; Adobe Inc., CA, USA). Images were rotated as needed to facilitate side-by-side comparison and accurate anatomical matching of

structures (Figure 1). Digital post-processing was strictly limited to cropping; original resolution, brightness, contrast, and sharpness were preserved to maintain data integrity.

For each lesion, the CPMP and PD images were arranged in paired side-by-side montages. The presentation order of the lesions and the relative positioning (left vs right) of the modalities within each pair were randomized using a computer-generated sequence. To assess intra-rater consistency, the entire assessment process, including the randomized lesion order and modality positioning, was repeated after a minimum washout period of eight weeks to minimize recall bias.

Image Assessment Parameters

Clinical and Dermoscopic Features

For each lesion, anatomical location, lesion size, overall morphology (flat/slightly elevated, markedly elevated, or depressed) and skin surface contour (flat, convex, or concave) were documented. The presence of visual artifacts, including hair, hemorrhage, purulence/crusting, or suture material, was also noted.

Dermoscopic features characteristic of BCC, as defined in established literature,¹⁸ were assessed for each image pair. The presence or absence of the following structures was recorded separately for CPMP and PD images: shiny white-red structureless areas, arborising vessels, ulceration/erosions, maple leaf-like structures, concentric structures, spoke-wheel areas, blue-grey ovoid nests, blue-grey globules/dots, short fine telangiectasia, and white streaks (chrysalis lines).

Image Quality

Image quality was evaluated using a 5-point dermoscopic image quality scale (DIQS-5) specifically developed for this study to enable structured and standardized assessment. The scale comprises three domains:

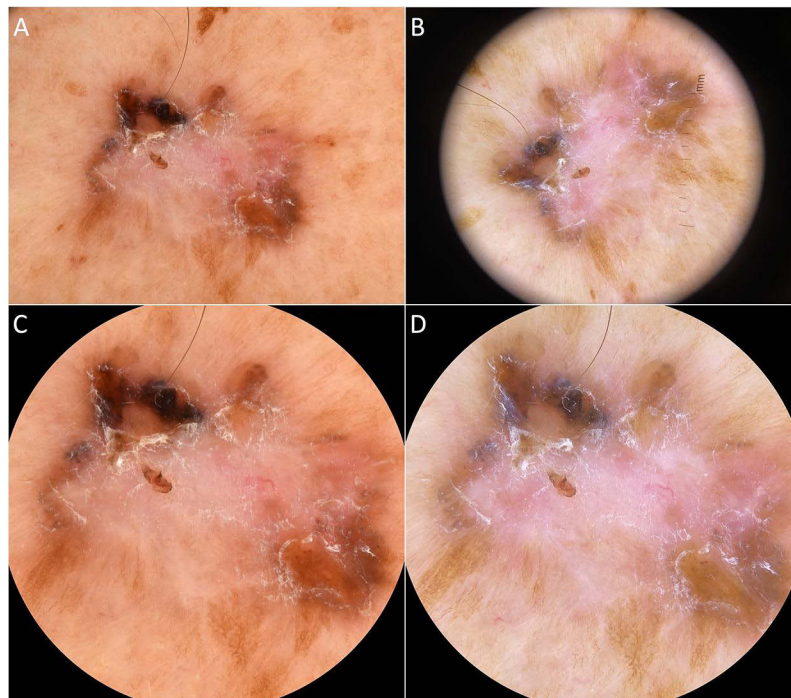


Figure 1 Image pre-processing workflow for modality-blinded evaluation. (A and B) Original cross-polarized macro photography (CPMP) and polarized dermoscopy (PD) images of the same lesion, respectively. Note the rectangular format of the raw CPMP image, and the visible millimeter scale and vignette effect in the raw PD image. (C) Processed CPMP image: A circular crop (mask) was applied to simulate the typical field of view of a dermoscope, rendering the image format indistinguishable from the PD counterpart. (D) Processed PD image: The scale bar was digitally removed, and the image was rotated to achieve anatomical alignment with the CPMP image. A standardized black background was applied to the corners of both processed images to ensure visual consistency.

1. Focus and depth of field: The extent to which the lesion is well-focused throughout, without relevant blurred or out-of-focus areas.
2. Sharpness and clarity: The visibility and definition of fine structures such as small vessels or pigmented elements.
3. Color fidelity: The perceived accuracy of color tones, saturation and contrast for dermoscopic interpretation.

Each domain was rated on a 5-point Likert scale, with higher scores indicating higher perceived image quality. An overall image quality score was calculated as the mean of the three domain scores. Descriptive criteria and representative examples for each DIQS-5 level are provided in [Supplementary Figure 1](#) and [Supplementary Table S1](#).

Modality Preference

Evaluators viewed paired CPMP and PD images side-by-side for each lesion and selected the modality they deemed superior for diagnostic assessment. This selection was based on their overall impression of diagnostic utility, reflecting a composite assessment of feature visibility, image quality, and perceived ease of interpretation.

Rater Characteristics and Blinding

To reduce potential bias, assessments were stratified across specific expert groups. Lesion characteristics were extracted by the corresponding author (O.E). Dermoscopic feature annotation was performed by consensus among three experienced dermatologists (V.A.E., A.E.K.A., S.S.E). Image quality ratings were performed in consensus by a multidisciplinary team comprising two dermatologists (B.B.D., G.G.) and one software engineer specializing in image processing and dermoscopic datasets (A.Y.), to incorporate both clinical and technical perspectives. Subjective preferences were recorded by three independent dermatologists with varying levels of familiarity with the technique: two were familiar with CPMP imaging (M.S.G., F.G.) and one had no prior exposure (EG).

To evaluate intra-rater consistency, the preference assessment was repeated after a minimum washout period of eight weeks using a fully re-randomized image set. All evaluators remained blinded to the imaging modality and patient clinical data throughout the process.

Statistical Analysis

Statistical analyses were performed utilizing R software (version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were summarized as mean \pm standard deviation (SD) or median with interquartile range (IQR), depending on the normality of distribution (assessed via Shapiro–Wilk test). Categorical variables were presented as frequencies and percentages. The visibility of dermoscopic features between paired CPMP and PD images was compared using McNemar’s test for matched pairs. Differences in DIQS-5 domain scores and overall image quality scores were analyzed using the Wilcoxon signed-rank test. To evaluate the consistency of subjective modality preferences across the three evaluators, the Chi-squared test was employed. Inter-rater reliability for feature annotation was assessed using Fleiss’ kappa, while intra-rater consistency was determined using Cohen’s kappa coefficient. A two-tailed P-value < 0.05 was considered statistically significant.

Results

Lesion Characteristics

Among the 100 evaluated BCCs, most were located on the face (39%), followed by the trunk and extremities (23%), scalp (14%), nose (12%), ear (5%), periorbital region (5%) and perioral area (2%). Lesion sizes were nearly evenly distributed, with 47% measuring < 1 cm and 53% ≥ 1 cm. The majority were flat or slightly elevated (69%), while 27% were markedly elevated and 4% were depressed. The skin surface contour was predominantly flat (73%), followed by convex (20%) and concave (7%).

Visibility of Dermoscopic Features

The comparative visibility of dermoscopic features between CPMP and PD modalities is summarized in [Table 1](#). Key diagnostic features of BCC, including shiny white-red structureless areas, arborising vessels, ulceration or multiple small

Table 1 Comparative Visibility of Dermoscopic Features Between Cross-Polarized Macro Photography (CPMP) and Polarized Dermoscopy (PD) in Basal Cell Carcinoma (n = 100)

Dermoscopic Features	CPMP (n)	PD (n)	Only in CPMP (n)	Only in PD (n)	P-value
Shiny white-red structureless areas	75	75	1	1	1.000
Arborising vessels	65	64	1	0	1.000
Ulceration or multiple small erosions	65	66	0	1	1.000
Short, fine telangiectasia	64	66	2	4	0.687
White streaks	49	52	2	5	0.453
Blue-grey globules and dots	43	41	2	0	0.500
Blue-grey ovoid nests	40	41	0	1	1.000
Maple leaf-like structures	36	36	0	0	1.000
Yellow whitish globules	20	19	1	0	1.000
Concentric structures	17	17	0	0	1.000
Spoke-wheel areas	13	13	0	0	1.000

Notes: Data represent the total number of lesions where the respective feature was detected. Discordant pairs (features visible in only one modality) were analyzed using McNemar's test.

Abbreviations: CPMP, Cross-polarized macro photography; PD, Polarized dermoscopy.

erosions, maple leaf-like structures, concentric structures, and spoke-wheel areas, were observed with identical frequencies in both CPMP and PD images (matched pairs; $P = 1.00$ for all). Minor discrepancies were noted for features such as short fine telangiectasia, white streaks (chrysalis lines), and blue-grey globules/dots; however, none of these differences reached statistical significance on McNemar's test (all $P > 0.05$).

Image Quality Analysis

Descriptive statistics for each image quality domain (DIQS-5) and overall quality scores are presented in Table 2. CPMP images achieved significantly higher scores for focus and depth of field and color fidelity compared to PD images ($P < 0.001$ for both). Although sharpness and clarity scores were slightly higher in PD images, this difference did not reach statistical significance ($P = 0.494$). Consequently, the overall mean image quality scores were significantly higher for CPMP than for PD ($P < 0.001$).

Table 2 Comparison of Image Quality Scores Between Cross-Polarized Macro Photography (CPMP) and Polarized Dermoscopy (PD) (n = 100)

Quality Features	CPMP		PD		p-value
	Mean \pm SD	Median (Q1-Q3)	Mean \pm SD	Median (Q1-Q3)	
Focus and depth of field	4.57 \pm 0.62	5.00 (4.00–5.00)	3.99 \pm 1.05	4.00 (3.00–5.00)	< 0.001
Sharpness and clarity	4.34 \pm 0.74	4.00 (4.00–5.00)	4.42 \pm 0.85	5.00 (4.00–5.00)	0.494
Color fidelity	4.87 \pm 0.37	5.00 (5.00–5.00)	4.03 \pm 0.78	4.00 (3.75–5.00)	< 0.001
Overall score	4.59 \pm 0.43	4.67 (4.33–5.00)	4.15 \pm 0.70	4.33 (3.67–4.67)	< 0.001

Notes: Data represent scores from the 5-point DIQS-5 scale. Statistical comparison was performed using the Wilcoxon signed-rank test.

Abbreviations: CPMP, Cross-polarized macro photography; PD, Polarized dermoscopy; SD, Standard deviation; Q1–Q3, Interquartile range (25th–75th percentiles).

Field-of-View Analysis

To evaluate the effective field of view, all 100 lesions were assessed to determine whether the entire tumor and its immediate surroundings could be fully captured within a single image frame. Among the 47 lesions measuring < 1 cm, 100% were completely visualized in both CPMP and PD images. In contrast, among the 53 lesions measuring ≥ 1 cm, only 31 (58.5%) could be fully contained within a single PD frame. However, the remaining 22 (41.5%) larger lesions, which exceeded the field of view of standard dermoscopy, were completely captured in a single frame using CPMP (Figure 2).

Modality Preference and Rater Consistency

In the first evaluation round, all three evaluators demonstrated a preference for CPMP, selecting it as the preferred modality in 51%, 61%, and 60% of cases (EV-1, EV-2, and EV-3, respectively; Figure 3). In the second round (after the washout period), EV-1 shifted preference towards PD (56%), whereas EV-2 and EV-3 continued to favor CPMP (59% and 57%, respectively). No statistically significant differences in preference distribution among evaluators were observed in either round ($P = 0.289$ and $P = 0.070$, respectively).

Inter-rater reliability was fair and statistically significant in both the first ($\kappa = 0.35$, $P < 0.001$) and second ($\kappa = 0.28$, $P < 0.001$) rounds. Intra-rater consistency was highest for evaluator EV-3 ($\kappa = 0.53$; 95% CI: 0.36–0.70), while EV-2 ($\kappa = 0.29$; 95% CI: 0.10–0.48) and EV-1 ($\kappa = 0.26$; 95% CI: 0.08–0.45) showed lower levels of consistency.

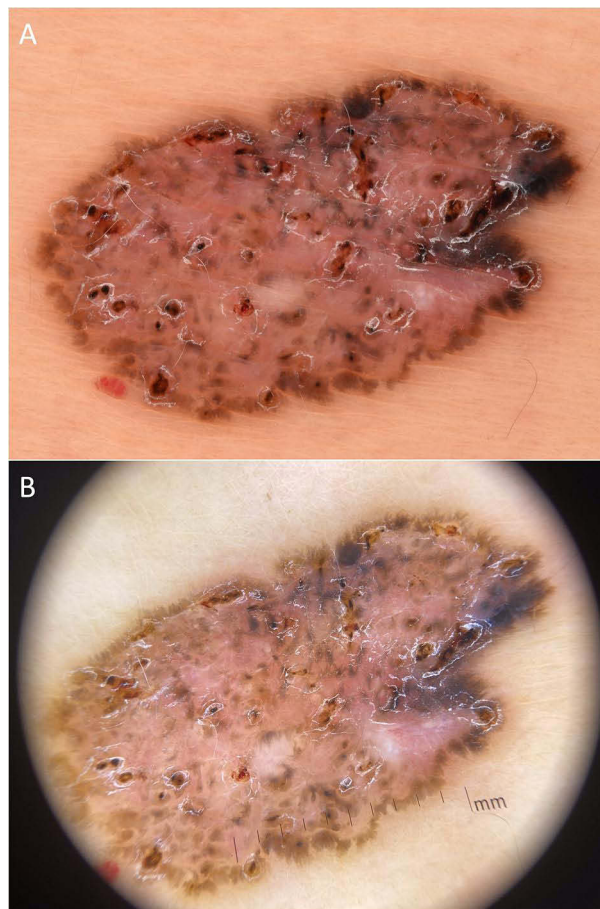


Figure 2 Representative comparison of field of view and depth of field between modalities. (A) Cross-polarized macro photography (CPMP) image capturing the entire anatomical extent of a large basal cell carcinoma within a single frame, maintaining uniform sharpness from center to periphery. (B) Polarized dermoscopy (PD) image of the same lesion; note the restricted field of view which fails to encompass the entire tumor, and the peripheral defocus (blurring) caused by the shallow depth of field inherent to standard dermoscopic optics.

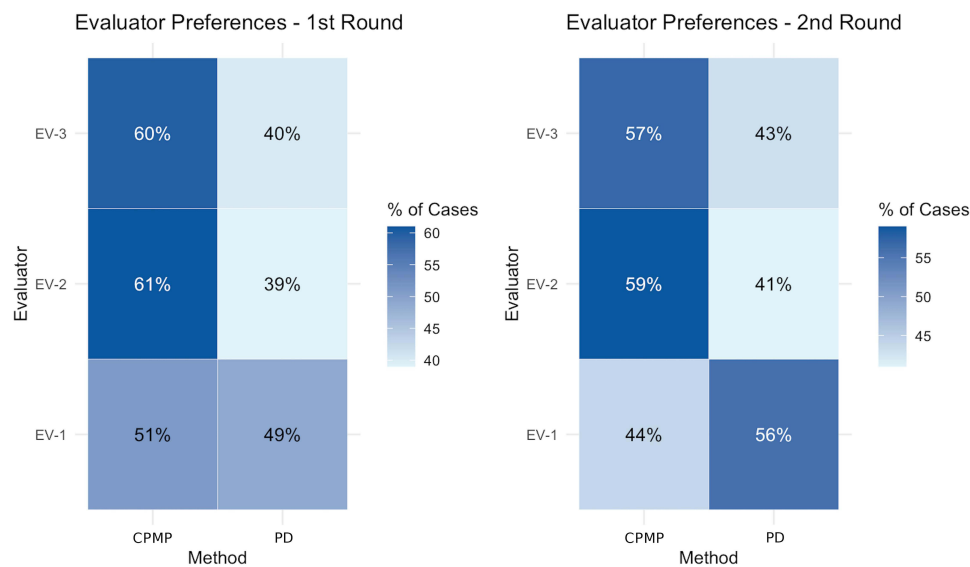


Figure 3 Heatmap illustrating subjective evaluator preferences for cross-polarized macro photography (CPMP) and polarized dermoscopy (PD) images across two evaluation rounds. Values indicate the percentage of cases in which each evaluator (EV-1 to EV-3) favored a specific modality. Left panel represents the initial assessment (Round 1), and the right panel shows preferences after the washout period (Round 2). No statistically significant differences in preference distributions were observed among evaluators in either round ($P = 0.289$ and $P = 0.070$, respectively; Chi-squared test).

Analysis of High-Consensus Cases

To identify factors influencing modality preference, we analyzed a subset of lesions with high inter-rater consistency, defined as cases where at least five of the six assessments favored the same modality ($n = 59$). Complete agreement (6/6) was observed in 24 cases (41%), and near-complete agreement (5/6) in 35 cases (59%).

Within this high-consensus subset, CPMP images were preferred in 37 cases (63%) and PD images in 22 cases (37%). Image quality differences in this subset mirrored the overall cohort: CPMP images scored significantly higher for focus and depth of field ($P = 0.029$) and color fidelity ($P < 0.001$), with no significant difference in sharpness and clarity ($P = 0.657$).

Specific dermoscopic features significantly influenced modality preference. Short fine telangiectasia were detected in 38 of the 59 cases and were significantly associated with a preference for PD (18/22 PD-preferred cases; $P = 0.031$). Conversely, blue-grey ovoid nests (present in 24 cases) were more commonly observed in CPMP-preferred lesions (20/37; $P = 0.007$). Similarly, maple leaf-like structures (present in 18 cases) were predominantly found in CPMP-preferred lesions (15/18; $P = 0.030$). Other clinical variables, including anatomical location, lesion size, morphology, surface contour, and the presence of artifacts, did not significantly influence modality selection (all $P > 0.05$). Representative high-consensus cases are illustrated in Figures 4 and 5.

Discussion

In this study, CPMP provided diagnostic information and overall image quality broadly comparable to non-contact PD for the evaluation of BCC. Across the predefined dermoscopic criteria, we did not detect statistically significant differences in feature visibility between modalities; CPMP additionally showed advantages in depth of field, field of view, and color rendering, whereas PD provided slightly crisper delineation of fine vascular structures. The modest inter- and intra-rater agreement suggests that the two modalities convey similar clinical interpretability, with individual preferences reflecting subtle perceptual differences rather than major technical disparities. Notably, evaluators showed consistent phenotype-dependent patterns, favoring CPMP in lesions rich in pigmented structures and PD in lesions dominated by fine vessels, indicating complementary strengths.

Cross-polarization has been widely adopted in visually driven specialties such as dermatology, dentistry, forensics, and ophthalmology to suppress surface glare and reveal subsurface structures.¹⁹ In dermatology, it has clinical value across diverse conditions, including inflammatory, pigmentary and vascular disorders.^{20–28} However, its use as

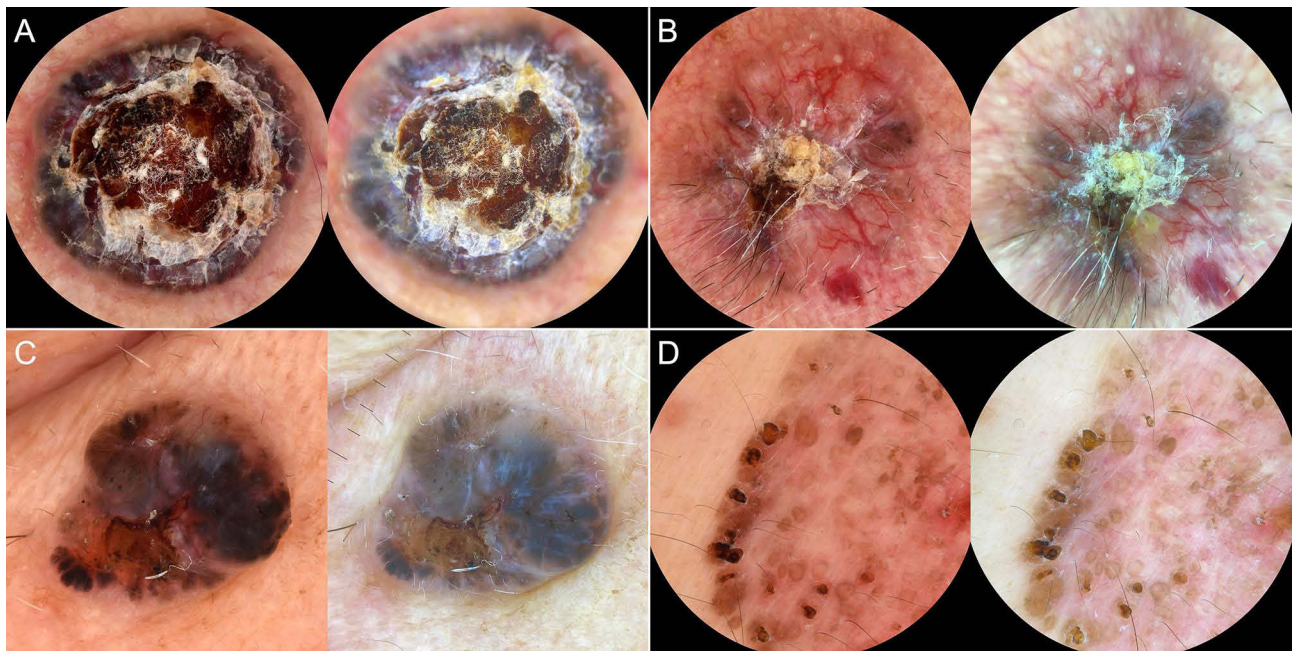


Figure 4 Representative high-consensus cases in which evaluators consistently favored cross-polarized macro photography (CPMP) (agreement $\geq 5/6$). Within each image pair, the CPMP image is shown on the left and the polarized dermoscopy (PD) image on the right for direct visual comparison (note: image presentation was randomized during the blinded evaluation). Panels (A–D) show four representative lesions from this subgroup. These cases include predominantly pigmented and/or crusted lesions, as well as lesions with convex or elevated morphology, in which the greater depth of field and color fidelity of CPMP appeared advantageous for overall lesion assessment.

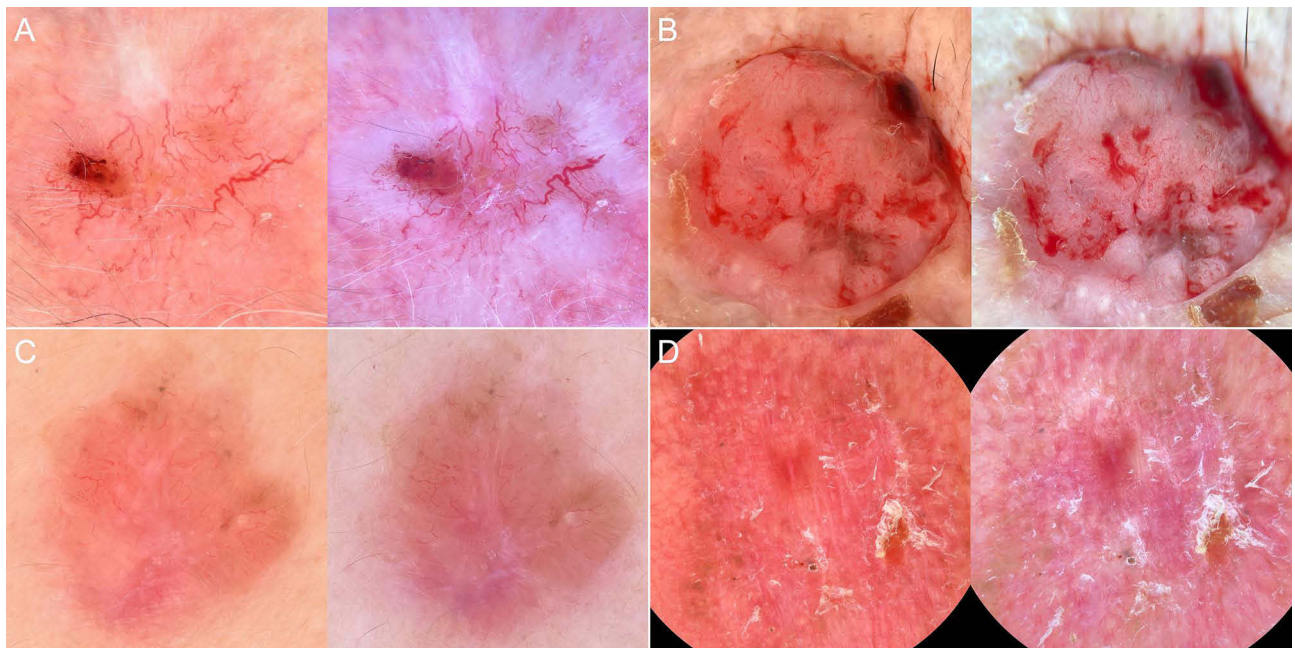


Figure 5 Representative high-consensus cases in which evaluators consistently favored polarized dermoscopy (PD) (agreement $\geq 5/6$). Within each image pair, the CPMP image is shown on the left and the PD image on the right for direct visual comparison (note: image presentation was randomized during the blinded evaluation). Panels (A–D) show four representative lesions from this subgroup. These cases were predominantly non-pigmented or hypopigmented and were characterized by fine vascular structures and/or relatively flat surface contours, in which the sharper depiction of delicate vascular detail by PD appeared advantageous.

a standalone, lesion-level approach for solitary tumors has remained limited, likely because cross-polarization was rapidly incorporated into dermoscopy devices, consolidating dermoscopy as the dominant modality for lesion-based assessment.²⁹ Practical constraints also play a role: placing polarizing filters in front of flash illumination attenuates light output and forces compromises (eg, higher ISO, wider apertures, shorter working distances) that can increase noise, reduce depth of field, and challenge autofocus.³⁰ Dermoscopes partly overcome these issues through high-intensity LEDs placed close to the skin, but non-contact operation is typically limited to a few centimeters, as their short focal length restricts the focusing range and illumination falls rapidly with increasing distance.³¹ Novel ‘remote non-contact dermoscopy’ systems have been developed to capture dermoscope-equivalent images from a greater distance using ultra-bright LED illumination and distance-assisted autofocus; however, their shallow depth of field often necessitates computational post-processing, which adds workflow complexity.^{32–35}

Our CPMP configuration occupies an intermediate position between handheld dermoscopy and remote platforms. Operating at ~10 cm, it combines a cross-polarizing filter with a powerful xenon ring flash and a macro lens, enabling small apertures ($f/20$) at base ISO to achieve deep focus and all-in-focus images in a single frame, without software-based post-processing. CPMP also captured the entire lesion and surrounding anatomical context in one high-resolution image, whereas PD may require overlapping images for larger tumors. Despite these advantages, lesion size and morphology did not significantly influence expert preference in this dataset. The absence of a significant effect of lesion size or morphology on preference may suggest that evaluators prioritized diagnostically relevant feature visibility over overall image quality. Thus, even when CPMP offered superior depth of field, preference may have depended more on the conspicuity of specific vascular or pigmented structures. The modest inter- and intra-rater consistency, despite this technical advantage, further suggests that evaluator preference was driven less by depth of field itself and more by subtle lesion-specific visual cues. Larger studies with broader panels are warranted to clarify whether these parameters affect clinician choice.

Differences in perceived color and sharpness may relate to illumination spectrum and device processing. Xenon ring-flash illumination provides a broad, near-continuous spectrum with high color-rendering performance, which may enhance chromophore separation and preserve red–brown hues. In contrast, smartphone-based PD using DermLite DL4/5 relies on phosphor-converted white LEDs with reduced red output, and automatic smartphone processing may preserve edge contrast at the expense of color saturation, rendering vascular details crisper but pigmentation less saturated.³⁶ These factors offer a plausible explanation for the stronger performance of CPMP in pigmented lesions and PD in lesions with fine vascular structures.

Beyond their technical relevance, our findings may also have practical implications. In particular, CPMP may be useful for preoperative documentation by capturing the entire lesion and its surrounding anatomical context in a single high-resolution image. Its non-contact configuration may also be advantageous for lesions in anatomically sensitive areas or in situations where direct contact is undesirable. In addition, because CPMP uses widely available photographic equipment and produces context-rich images, it may have potential value in teledermatology and longitudinal visual documentation, although these applications require dedicated prospective study.

This study has several limitations. First, CPMP images were acquired with a DSLR sensor whereas PD images used a smartphone sensor; although reflective of real-world practice, this hardware difference complicates purely optical comparisons. Future studies using a shared sensor platform would better isolate the effect of illumination modality. Second, we focused exclusively on BCC; CPMP should be evaluated in other keratinocyte carcinomas and melanocytic lesions. Third, we assessed feature visibility and image quality rather than conducting a formal diagnostic accuracy study. In addition, no formal sample size calculation was performed; although the paired sample was likely sufficient to detect moderate-to-large differences between modalities, smaller differences may have gone undetected. No formal adjustment for multiple statistical testing was applied, so the findings should be interpreted with appropriate caution, particularly for smaller or subgroup-specific differences. Furthermore, because one CPMP and one PD image judged to best represent each lesion were selected from consecutively acquired images, some degree of selection bias toward more favorable images may have been introduced. Finally, the DIQS-5 image-quality scale was developed specifically for this study and has not yet been externally validated.

Conclusions

In conclusion, CPMP provides lesion-level information broadly comparable to non-contact PD for BCC, while offering practical advantages in field of view, depth of field and color rendering. The phenotype-dependent preference patterns suggest that CPMP and PD have complementary strengths, with CPMP offering particular advantages for larger, more pigmented, or anatomically challenging lesions, as well as in settings where non-contact imaging or preoperative documentation is desirable. Given the exploratory nature of the subgroup findings and the modest inter-rater reliability observed, CPMP should be regarded as a complement to dermoscopy rather than a substitute for it. Future studies should evaluate the diagnostic accuracy of CPMP, externally validate the DIQS-5 scale, and assess its applicability in other skin cancer types.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the Istanbul Medeniyet University Institutional Review Board (approval no. 2025/06-21).

Consent for Publication

Written informed consent was obtained from all participants for the use and publication of their images.

Acknowledgment

Open access publication of this article was supported by the Turkish Dermatology Association. Abdurrahim Yilmaz has been funded by the President's PhD Scholarships at Imperial College London, which solely supported his academic studies.

Funding

This article has no funding source.

Disclosure

The authors report no conflicts of interest in this work.

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