

Ultraviolet-Induced Fluorescence Dermatoscopy (UVFD) features in Porokeratosis: Findings from a Multicenter Retrospective Study

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ABSTRACT Introduction: Porokeratosis is a group of keratinization disorders characterized by the histopathological presence of the cornoid lamella, a hallmark feature across all subtypes. The clinical diagnosis of porokeratosis can be challenging due to its similarity to other dermatological conditions. While polarized light dermatoscopy (PLD) enhances diagnostic accuracy, certain features remain difficult to identify. Ultraviolet-induced fluorescence dermatoscopy (UVFD) is a novel imaging technique that may improve the visualization of porokeratosis features, particularly the peripheral keratin rim.

Objectives: This study aimed to assess the diagnostic utility of UVFD compared with PLD in identifying the dermatoscopic features of porokeratosis.

Methods: In this retrospective study, dermatologists from five institutions in Chile, Brazil, Poland, and the United States contributed with dermatoscopic images of porokeratosis cases. Both PLD and UVFD images were obtained for each lesion. Two independent investigators evaluated each lesion in PLD and UVFD for the presence of peripheral keratin rim, rim continuity, central scaling, follicular plugs, vascular structures, and photodamaged surrounding skin. A third investigator reviewed discrepancies. Frequencies and means were calculated. McNemar's chi-square was used for comparison.

Results: A total of 136 lesions from 35 patients with biopsy-proven porokeratosis were analyzed. UVFD significantly improved the visualization of the peripheral keratin rim (95.6% vs. 66.2% in PLD; $P < 0.001$) and increased identification rates for central scaling, follicular plugs, and interrupted rims. PLD remained superior for detecting vascular structures ($P < 0.001$).

Conclusions: UVFD enhances the visualization of key dermatoscopic features of porokeratosis, particularly the peripheral keratin rim and other keratin-related structures.

Introduction

Porokeratosis (PK) is a group of hereditary or acquired epidermal keratinization disorders, classified into different clinical subtypes [1,2]. Among them, porokeratosis of Mibelli and disseminated superficial actinic porokeratosis are the most common [2]. While each subtype has distinct morphology, distribution, and clinical course, they all share a hallmark feature: the presence of the cornoid lamella, a parakeratotic column overlying an area of epidermal invagination, surrounded by dyskeratosis and hypogranulosis/agranulosis [1,3]. The diagnosis of PK can be challenging due to its clinical similarity to other entities such as actinic keratosis, squamous cell carcinoma, superficial basal cell carcinoma, or annular inflammatory conditions (e.g., guttate psoriasis, pityriasis rosea, nummular dermatitis, annular lichen planus, tinea corporis, and granuloma annulare).

Dermatoscopy has been shown to enhance the diagnostic accuracy of PK by revealing specific clues such as the peripheral keratin rim, which corresponds to the cornoid lamella, and glomerular vessels, which can aid in the diagnosis of PK [2,3]. The addition of the ink test has also shown improved recognition of the peripheral keratin rim [4]. Ultraviolet-induced fluorescence dermatoscopy (UVFD) is an emerging dermatoscopy mode that allows for the visualization of specific features that are not visible with conventional dermatoscopy (i.e. polarized and non-polarized dermatoscopy). When excited by ultraviolet (UV) light, certain chromophores in the skin emit a longer wavelength that falls within the visible light spectrum known as the Stokes shift phenomenon [5]. UVFD improves visualization of the peripheral keratin rim without requiring ink-enhanced dermatoscopy or Wood's lamp examination [4,6].

UVFD is gaining increasing clinical relevance, with multiple emerging uses having been published in the past few

years [7-14]. As UVFD becomes more widely available, it is essential to characterize the dermatoscopic features of various dermatological conditions. To date, the UVFD features of PK have been poorly characterized, with only a few single cases or small case-series published [1,9,15].

Objectives

This study aimed to analyze and compare the dermatoscopic features of PK under polarized light dermatoscopy (PLD) and UVFD, assessing their diagnostic utility and interobserver agreement.

Methods

This was an IRB-approved retrospective multicenter cross-sectional study conducted between March and December 2024. All patients and/or their legal guardians signed informed consent.

Participants

We included consecutive patients from five institutions in Chile, Brazil, Poland, and the United States with lesions clinically and histopathologically compatible with PK. Eight participants were excluded due to low-quality images. The following variables were collected for each patient: age, sex, country, and PK subtype.

Dermatoscopic Evaluation

Dermatoscopic images of each lesion were obtained using a commercially available hybrid dermatoscope (DL5, DermLite, San Juan Capistrano, CA, USA) attached to a smartphone (Samsung S23 Ultra or Samsung ZFold4, Samsung, Seoul, South Korea). Both PLD and UVFD images were captured for each lesion.

Two board-certified dermatologists and dermatoscopy experts (C.N-D., P.P.) conducted a consensus meeting to determine the key dermatoscopic features of PK to be assessed. Two independent researchers (M.C.C., F.D.) evaluated all dermatoscopic images, analyzing the following features in both PLD and UVFD: presence of a peripheral keratin rim (circular double-rim keratotic structure), rim continuity (categorized as continuous, i.e., 100% uninterrupted, vs. interrupted), presence of central scales (different from the peripheral rim), keratin plugs (hyperkeratotic follicular plugs confined within the peripheral rim), any vascular structure within the lesion, and photodamage in the surrounding skin (defined by the presence of lentigos, hypo/hyperpigmented macules, wrinkles, telangiectasias, or polarizing-specific white lines/solar elastosis). Each independent researcher rated their confidence in identifying the peripheral keratin rim on a scale from 1 to 5, with 1 indicating very low confidence and 5 indicating very high confidence.

After the initial evaluation, a third expert dermatoscopist resolved the discrepancies between the two investigators. All dermatoscopic images analyzed in this study are available as Supplementary Material (Supplemental Figure 1).

Statistical Analysis

A priori sample size was calculated using G*Power (v3.1.9.7) for a two-tailed McNemar test, assuming an expected odds ratio (OR) of 2.5, an estimated proportion of discordant pairs of 0.35, a significance level of 0.05 (α), and a statistical power of 80%. The minimum required sample size was 121 lesions evaluated under both imaging modalities.

For statistical analysis, categorical variables were described using frequency and percentage, and continuous variables were described using the mean, standard deviation, and range. A series of McNemar's chi-square tests for categorical variables was used to compare the detection of features between PLD and UVFD.

Cohen's kappa coefficient was calculated for interobserver agreement, which was interpreted as poor (≤ 0), slight (> 0 to 0.20), fair (> 0.2 to 0.4), moderate (> 0.4 to 0.6), substantial (> 0.6 to 0.8), or almost perfect (> 0.8) [16]. Wilcoxon signed-rank test was performed for the calculation of statistical significance regarding the differences in diagnostic confidence in identifying the peripheral keratin rim between the PLD and the UVFD group. A two-tailed p-value < 0.05 was considered statistically significant. All analyses were conducted using IBM SPSS Statistics software version 26.0 (IBM Corp., Armonk, NY).

Results

Patient and Lesion Characteristics

A total of 136 lesions from 35 patients with PK, confirmed clinically and histopathologically, were analyzed. The mean

age of the patients was 60 years (standard deviation (SD) 19.6; range: 1–86), and 40% (N=14) were female. Patients' lesions were categorized into the following PK variants: disseminated superficial actinic PK (N=20), disseminated superficial PK (N=7), Mibelli (N=2), disseminated superficial actinic PK and palmaris et plantaris disseminate (N=2), genitogluteal PK (N=2), PK palmaris et plantaris disseminate (N=1), and concomitant linear PK (N=1).

Dermatoscopic Features

The peripheral keratin rim was identified in 66.2% (N=90) of lesions using PLD and in 95.6% (N=130) with UVFD ($P < 0.001$). Among those lesions displaying peripheral keratin rim, 59.6% (N=51) appeared continuous under PLD compared with 66.2% (N=86) under UVFD ($P < 0.001$). Central scaling was observed in 58.1% (N=79) of lesions under PLD and in 67.6% (N=92) under UVFD ($P < 0.001$). Follicular plugs were detected in 24.3% (N=33) of lesions under PLD, whereas UVFD revealed them in 64.7% (N=88) of cases ($P < 0.001$). Vascular structures were more frequently seen with PLD (44.9%, N=61) compared with UVFD (15.4%, N=21) ($P < 0.001$). Surrounding photodamage was identified in 79.4% (N=108) of lesions under PLD and in 83.8% under UVFD, with no statistically significant difference ($P = 0.348$). Descriptive statistics of the analyzed dermatoscopic features in PLD and UVFD are summarized in Table 1, and representative examples are illustrated in Figure 1.

Interobserver Agreement

Substantial agreement was observed for the presence of scales under PLD ($\kappa = 0.718$; $P < 0.001$). Moderate interobserver agreement was noted for follicular plugs ($\kappa = 0.559$; $P < 0.001$), vascular structures ($\kappa = 0.546$; $P < 0.001$), and surrounding sun damage under PLD ($\kappa = 0.488$, $P < 0.001$), and central scales ($\kappa = 0.488$, $P < 0.001$) and follicular plugs under UVFD ($\kappa = 0.473$; $P < 0.001$). Slight interobserver agreement was seen in the detection of the peripheral keratin rim under PLD ($\kappa = 0.116$; $P = 0.004$) and under UVFD ($\kappa = 0.189$; $P < 0.001$). The mean diagnostic confidence for detection of peripheral keratin rim under PLD was 3.09 ± 1.34 , and for UVFD 4.73 ± 0.7 ($P = 0.003$).

Discussion

In this retrospective study of 136 PK lesions from 35 patients, we found that UVFD improved both the visualization of key diagnostic features and clinician confidence in their detection compared with PLD. UVFD significantly enhanced the detection of the peripheral keratin rim, a hallmark feature of porokeratosis, as well as that of central scaling and follicular plugs. The latter is particularly important as follicular plugs are often difficult to detect with PLD but were

Table 1. Comparison of dermoscopic features and interobserver agreement between polarized light dermatoscopy and ultraviolet-induced fluorescence dermatoscopy.

Dermatoscopic feature	PLD N (%)	UVFD N (%)	p-value	PLD interobserver agreement (kappa)	p-value	UVFD interobserver agreement (kappa)	p-value
Peripheral keratin rim	90 (66.2%)	130 (95.6%)	<0.001	0.116	0.004	0.189	<0.001
Rim continuity (continuous)	51 (37.5%)	86 (63.2%)	<0.001	0.189	<0.001	0.488	<0.001
Central scaling	79 (58.1%)	92 (67.6%)	0.031	0.718	<0.001	0.488	<0.001
Follicular plugs	33 (24.3%)	88 (64.7%)	<0.001	0.559	<0.001	0.473	<0.001
Vascular structures	61 (44.9%)	21 (15.4%)	<0.001	0.546	<0.001	0.548	<0.001
Photodamaged surrounding skin	108 (79.4%)	114 (83.8%)	0.21	0.488	<0.001	0.374	<0.001

Abbreviations: PLD: Polarized light dermatoscopy; UVFD: ultraviolet-induced fluorescence dermatoscopy; N: absolute frequency.

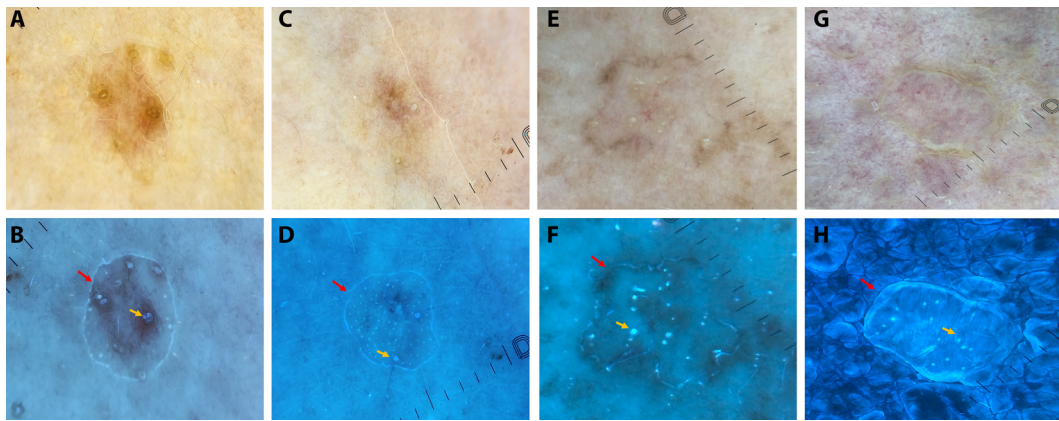


Figure 1. Porokeratosis. A, C, E, and G: Polarized light dermatoscopy showing porokeratosis lesions without an evident peripheral keratin rim and barely visible follicular plugs (original magnification 10X). B, D, F, and H: Ultraviolet-induced fluorescence dermatoscopy showing bluish-white fluorescence, enhancing the peripheral keratin rim (red arrows) and follicular plugs (yellow arrows). Original magnification 10x.

clearly visualized under UVFD. On the other hand, vascular structures were more frequently observed under PLD. Despite these improvements, interobserver agreement varied, particularly in identifying the peripheral keratin rim, where differences in evaluation criteria influenced the consistency. Our findings suggest that UVFD provides additional diagnostic clues that are not always apparent under PLD and may facilitate a more confident clinical diagnosis of dermatologic conditions [7,8,10-14].

Previous research has documented the PLD characteristics of PK [2]; however, the only case series describing the UVFD features of PK included 11 patients with a total of 54 lesions, which is smaller than our sample [15]. Our study confirms the PLD findings of prior research in a much larger sample. Additionally, other studies have mentioned the possible benefits of UVFD in PK diagnosis [1,9] or have described ink-enhanced dermatoscopy and Wood's lamp

findings [4,6,17]. To the best of our knowledge, this is the largest case series describing PLD and UVFD features of PK in a multicenter dataset.

This study provides a systematic description of the PLD and UVFD findings in PK, demonstrating that UVFD significantly improves the visualization of the peripheral keratin rim, representing the histopathological cornoid lamella, a characteristic feature of this condition. Additionally, we demonstrated that follicular plugging is more frequent than what has previously been reported. We hypothesize that the hyperkeratosis of the cornoid lamella and follicular plugs is likely responsible for the excited bright blue-whitish fluorescence observed as keratin has been described to be fluorescent under UVFD, making these findings more conspicuous [1]. Given that PK is a relatively rare entity that can often be misdiagnosed as other dermatological conditions or underdiagnosed due to subtle keratin rim, the ability to easily identify

a defining feature noninvasively, such as the peripheral keratin rim with frequent follicular plugs under UVFD, may substantially enhance diagnostic accuracy. This is particularly relevant for clinicians who do not frequently encounter PK as UVFD may facilitate a more confident and rapid clinical diagnosis.

Limitations

While this study provides valuable insights into the UVFD of PK, certain limitations should be acknowledged. While UVFD demonstrated an improved ability to detect key dermatoscopic features, the interpretation of fluorescence patterns relied on subjective assessments, which may have introduced interobserver variability. This variability was particularly evident in the detection of the peripheral keratin rim, where differences in individual evaluation criteria contributed to lower kappa values. One evaluator tended to mark the presence of the peripheral keratin rim even when confidence was low, while the other only marked it when it was clearly visible. Future studies with larger, multicenter cohorts and standardized diagnostic criteria are needed to further validate the utility of UVFD in the diagnosis and clinical management of PK. Additionally, it would be beneficial to conduct studies comparing UVFD findings with those of other differential diagnoses (controls). This would not only confirm UVFD's ability to highlight PK-specific structures but also to calculate UVFD potential to improve diagnostic sensitivity and specificity, ensuring that it aids in distinguishing PK from clinically similar conditions.

Conclusions

This study demonstrates that UVFD significantly enhances the visualization of the peripheral keratin rim and other key dermatoscopic features of PK compared with PLD. However, given the lack of clinically relevant controls and the absence of a reference standard, these results should be interpreted as descriptive rather than diagnostic. UVFD might help clinicians more confidently recognize PK features, but further controlled studies are needed to confirm its impact on diagnostic accuracy and patient management.

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