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Original Research Article

Correlation Between Dermoscopic Features and Histopathological Findings in Pigmented Skin Lesions: A Diagnostic Accuracy Study

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Abstract:

Background: Dermoscopy enhances the diagnostic accuracy of pigmented skin lesions (PSLs), yet the histopathological correlates of specific dermoscopic features remain incompletely characterized. This study aimed to evaluate the correlation between dermoscopic patterns and histopathological findings and determine the diagnostic accuracy of individual dermoscopic criteria for melanoma detection.

Methods: A prospective diagnostic accuracy study was conducted on 180 consecutive PSLs from 165 patients undergoing excisional biopsy at a tertiary center. Dermoscopic images were evaluated by two blinded dermatologists using standardized criteria. Histopathological examination served as the reference standard. Diagnostic performance metrics including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. Statistical significance was set at $p<0.05$.

Results: The mean participant age was 58.3 ± 12.7 years. Histopathology confirmed 40 melanomas (22.2%), 56 dysplastic nevi (31.1%), 52 common nevi (28.9%), 22 seborrheic keratoses (12.2%), and 10 solar lentigines (5.6%). Blue-white veil showed the highest specificity (94.2%) and PPV (78.3%) for melanoma, with an accuracy of 89.4% ($p<0.001$). Irregular pigment network demonstrated sensitivity of 82.5% and specificity of 76.4% ($p<0.001$). Multivariate analysis identified blue-white veil (OR=8.3, 95% CI: 3.7–18.6, $p<0.001$) and atypical vascular pattern (OR=5.9, 95% CI: 2.4–14.5, $p=0.001$) as independent predictors of melanoma. Interobserver agreement was substantial ($\kappa=0.74$, $p<0.001$).

Conclusion: Specific dermoscopic features demonstrate strong histopathological correlates and robust diagnostic accuracy for melanoma. Blue-white veil and atypical vascular patterns are highly predictive of melanocytic atypia and should prompt immediate histopathological evaluation. These findings validate dermoscopy as a reliable non-invasive tool for preoperative risk stratification of PSLs.

Keywords: Dermoscopy, Histopathology, Pigmented Skin Lesions, Melanoma, Diagnostic Accuracy, Correlation Study.

Introduction

Pigmented skin lesions represent a diagnostic challenge in clinical dermatology, with melanoma posing a significant public health burden due to its rising incidence and potential for metastasis [1]. Early and accurate diagnosis remains paramount, as five-year survival exceeds 95% for localized disease but drops to below 30% for distant metastases [2]. Dermoscopy, a non-invasive technique employing polarized light and magnification, has emerged as a critical adjunctive tool, improving diagnostic sensitivity by 10–27% compared to naked-eye examination alone [3]. Despite its widespread adoption, the histopathological underpinnings of many dermoscopic features remain subject to interpretive variability.

The histopathological evaluation of PSLs serves as the diagnostic gold standard, providing definitive assessment of architectural disorder, cytological atypia, and dermal invasion [4]. Previous investigations have established preliminary correlations between dermoscopic structures and specific histological patterns. For instance, pigment network irregularity corresponds to melanocytic proliferation along rete ridges, while blue-white veil reflects orthokeratosis overlying heavily pigmented melanocytes in the superficial dermis [5], [6].

However, most prior studies suffer from retrospective designs, small sample sizes, or limited correlation analyses, precluding robust conclusions about diagnostic accuracy [7], [8].

Recent advances in dermoscopic nomenclature, including the revised International Skin Imaging Collaboration (ISIC) criteria, have standardized feature definitions but have not been comprehensively validated against histopathological outcomes in large prospective cohorts [9]. Furthermore, the diagnostic performance of individual criteria for distinguishing melanoma from benign mimickers such as dysplastic nevi remains controversial [10]. This knowledge gap impedes the development of evidence-based algorithms for risk stratification and biopsy decision-making.

The present study was designed to address these limitations by conducting a prospective diagnostic accuracy analysis correlating specific dermoscopic features with histopathological findings in a consecutive series of excised PSLs. We hypothesized that certain dermoscopic patterns would demonstrate strong histological correlates and superior discriminatory capacity for melanoma detection. The primary aim was to determine the sensitivity, specificity, and predictive values of individual dermoscopic criteria, while secondary objectives included assessing interobserver reliability and identifying independent predictors of melanoma on multivariate analysis.

Materials and Methods

Study Design and Setting: This prospective diagnostic accuracy study was conducted at the tertiary care hospital.

Participants and Sample Size: Consecutive patients aged ≥18 years with clinically suspicious PSLs scheduled for excisional biopsy were enrolled. Sample size calculation based on expected melanoma prevalence of 20%, 95% confidence level, and 5% margin of error yielded a minimum of 153 lesions. To account for potential exclusions, we aimed to recruit 200 participants.

Inclusion Criteria

- Presence of pigmented lesion with clinical suspicion for melanoma
- Lesion diameter ≥3 mm
- Availability of high-quality dermoscopic images
- Consent for excisional biopsy and histopathological examination

Exclusion Criteria

- Previous trauma or treatment to the lesion
- Poor image quality precluding dermoscopic analysis
- Incomplete histopathological data
- Amelanotic lesions

Dermoscopic Evaluation: Lesions were imaged using a digital dermoscope (DermLite DL4, 3Gen LLC, California) at 10× magnification before biopsy. Two board-certified dermatologists (with 8 and 12 years of dermoscopy experience) independently assessed images in a blinded fashion, unaware of clinical history and final diagnosis. Evaluated features included: (1) pigment network (regular vs. irregular), (2) blue-white veil, (3) atypical vascular pattern (dots, globules, linear-irregular vessels), (4) negative pigment network, (5) shiny white structures, (6) streaks/pseudopods, and (7) regression structures. Features were coded as present or absent based on ISIC consensus criteria.

Histopathological Assessment: Excised specimens were fixed in 10% buffered formalin, processed routinely, and examined by two dermatopathologists blinded to dermoscopic findings. Diagnostic categories included: melanoma (subclassified by Breslow thickness), dysplastic nevus (mild, moderate, severe atypia), common nevus, seborrheic keratosis, solar lentigo, and other benign lesions. Melanocytic atypia was graded using standardized criteria: architectural disorder (asymmetry, poor circumscription), cytological atypia (nuclear enlargement, hyperchromasia), and dermal changes (pagetoid spread, dermal mitoses). Discrepancies were resolved by consensus review.

Statistical Analysis: Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY). Categorical variables were expressed as frequencies and percentages. Continuous variables were reported as mean ± standard deviation (SD). Diagnostic performance metrics (sensitivity, specificity, PPV, NPV, accuracy) were calculated with 95% confidence intervals (CI). The chi-square test or Fisher's exact test compared categorical variables. Interobserver agreement was assessed using Cohen's kappa coefficient (κ). Multivariate logistic regression identified independent predictors of melanoma. Statistical significance was defined as $p<0.05$.

Results

Patient and Lesion Characteristics: Of 195 initially screened lesions, 180 from 165 patients met inclusion criteria. The mean age was 58.3 ± 12.7 years (range: 23–84). Demographic and clinical characteristics are summarized in Table 1. The male-to-female ratio was 1.09:1. Lesions were predominantly located on the trunk (45.6%) and extremities (26.1%). Mean lesion diameter was 8.4 ± 4.2 mm.

Histopathological Diagnoses: Final histopathology revealed 40 melanomas (22.2%), including 18 in situ and 22 invasive lesions (mean Breslow thickness 0.84 ± 0.56 mm). Among benign lesions, dysplastic

nevi constituted the largest category (56 lesions, 31.1%), followed by common nevi (52 lesions, 28.9%). The remaining lesions comprised seborrheic keratoses (22, 12.2%) and solar lentigines (10, 5.6%).

Diagnostic Performance of Dermoscopic Features: Table 2 presents the diagnostic accuracy of individual dermoscopic criteria for melanoma detection. Blue-white veil exhibited the highest specificity (94.2%, 95% CI: 89.1–97.1) and PPV (78.3%, 95% CI: 62.2–88.8) with an overall accuracy of 89.4% ($p<0.001$). Irregular pigment network demonstrated moderate sensitivity (82.5%, 95% CI: 67.2–92.7) and specificity (76.4%, 95% CI: 68.7–82.9). Atypical vascular pattern showed specificity of 91.4% (95% CI: 85.6–95.2) but lower sensitivity (45.0%, 95% CI: 29.3–61.5). Negative pigment network and shiny white structures had specificities exceeding 85% but sensitivities below 50%.

Interobserver Reliability: Substantial agreement was observed between the two dermatologists for all evaluated features (κ range: 0.68–0.81). Overall interobserver concordance for melanoma diagnosis was substantial ($\kappa=0.74$, 95% CI: 0.63–0.85, $p<0.001$). The highest agreement was for blue-white veil ($\kappa=0.81$) and irregular network ($\kappa=0.76$).

Multivariate Analysis: Logistic regression identified three independent dermoscopic predictors of melanoma (Table 3). Blue-white veil conferred an eightfold increased risk (OR=8.3, 95% CI: 3.7–18.6, $p<0.001$), followed by atypical vascular pattern (OR=5.9, 95% CI: 2.4–14.5, $p=0.001$) and irregular pigment network (OR=4.7, 95% CI: 1.8–12.3, $p=0.002$). The model demonstrated good discriminatory capacity (AUC=0.91, 95% CI: 0.86–0.95).

Correlation with Histopathological Features: Blue-white veil strongly correlated with pagetoid spread ($r=0.72$, $p<0.001$) and severe cytological atypia ($r=0.68$, $p<0.001$). Irregular pigment network corresponded with architectural disorder ($r=0.61$, $p<0.001$) and rete ridge elongation ($r=0.58$, $p<0.001$). Atypical vessels were associated with dermal tumoral mitoses ($r=0.54$, $p=0.003$) and vertical growth phase ($r=0.49$, $p=0.007$).

Table 1: Baseline Characteristics of the Study Population and Lesions (n=180)

Characteristic	Value
Age, years (mean ± SD)	58.3 ± 12.7
Gender, n (%)	
Male	94 (52.2)
Female	86 (47.8)
Lesion location, n (%)	
Head/neck	51 (28.3)
Trunk	82 (45.6)
Extremities	47 (26.1)
Lesion diameter, mm (mean ± SD)	8.4 ± 4.2
Histopathological diagnosis, n (%)	
Melanoma	40 (22.2)
In situ	18 (10.0)
Invasive	22 (12.2)
Dysplastic nevus	56 (31.1)
Common nevus	52 (28.9)
Seborrheic keratosis	22 (12.2)
Solar lentigo	10 (5.6)

Table 2: Diagnostic Performance of Dermoscopic Features for Melanoma Detection

Dermoscopic Feature	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	p-value
Blue-white veil	62.5	94.2	78.3	88.1	89.4	<0.001
Irregular pigment network	82.5	76.4	52.4	93.8	77.8	<0.001
Atypical vascular pattern	45.0	91.4	65.5	82.7	79.4	0.001
Negative pigment network	37.5	87.1	51.7	79.3	74.4	0.008
Shiny white structures	32.5	89.3	54.2	77.8	73.3	0.012
Streaks/pseudopods	55.0	71.4	40.7	81.6	67.2	0.043
Regression structures	67.5	58.6	35.1	84.6	61.1	0.021

Table 3: Multivariate Logistic Regression Analysis of Dermoscopic Predictors for Melanoma

Dermoscopic Feature	Odds Ratio	95% CI	p-value
Blue-white veil	8.3	3.7–18.6	<0.001
Atypical vascular pattern	5.9	2.4–14.5	0.001
Irregular pigment network	4.7	1.8–12.3	0.002
Lesion diameter >6 mm	2.1	0.9–4.8	0.084
Location on trunk	1.4	0.6–3.2	0.392

Discussion

This prospective diagnostic accuracy study demonstrates robust correlations between specific dermoscopic features and histopathological findings in pigmented skin lesions, with blue-white veil and atypical vascular patterns emerging as highly specific markers of melanoma. The observed prevalence of melanoma (22.2%) aligns with tertiary referral center data, supporting the generalizability of our findings [11]. Our results extend previous retrospective analyses by providing prospectively validated performance metrics for individual dermoscopic criteria.

The superior diagnostic accuracy of blue-white veil (89.4%) corroborates earlier observations by Menzies et al., who reported 76% sensitivity and 82% specificity in a meta-analysis of 1,272 lesions [12]. The strong correlation with pagetoid spread (r=0.72) and severe cytological atypia elucidates the histopathological basis for this feature, representing orthokeratosis overlying heavily pigmented atypical melanocytes in the superficial dermis [13]. This structural relationship explains the high specificity (94.2%) observed in our cohort, suggesting blue-white veil should mandate expeditious excision.

Irregular pigment network demonstrated moderate sensitivity (82.5%) but lower specificity (76.4%) compared to blue-white veil, consistent with its occurrence in both dysplastic nevi and melanoma. This finding mirrors the work of Argenziano et al., who reported network irregularity in 68% of melanomas and 35% of dysplastic nevi [14]. The correlation with architectural disorder (r=0.61) reflects melanocytic proliferation along variably elongated and distorted rete ridges, a feature shared by both entities. Our multivariate analysis confirms irregular network as an independent predictor (OR=4.7), reinforcing its value in risk stratification algorithms.

Atypical vascular patterns exhibited high specificity (91.4%) but limited sensitivity (45.0%), indicating their utility lies in confirming suspicion rather than screening. This aligns with vascular morphology studies demonstrating that linear-irregular vessels and dotted vessels correlate with tumor-induced angiogenesis and dermal mitotic activity [15]. The association with vertical growth phase (r=0.49) supports the hypothesis that abnormal vasculature reflects advanced tumor progression and increased metabolic demands [16].

The substantial interobserver agreement (κ=0.74) exceeds that reported in previous studies (κ=0.52–0.68) [17], likely attributable to standardized ISIC criteria and observer training. This enhanced reliability is clinically significant, reducing variability in biopsy decisions and improving diagnostic consistency across practitioners.

Our study addresses several limitations of prior research. The prospective design minimized selection bias, while the consecutive recruitment strategy ensured representativeness of clinically suspicious lesions encountered in practice. Blinded evaluations eliminated information bias, and consensus resolution of discrepancies enhanced diagnostic certainty. However, certain limitations warrant acknowledgment. The single-center design may limit external validity, particularly in primary care settings where melanoma prevalence is lower. Additionally, the exclusion of amelanotic lesions precludes generalization to non-pigmented melanomas, which often present distinct dermoscopic patterns [18]. Finally, the specialized expertise of our observers may not reflect performance in routine clinical practice, necessitating validation in community-based cohorts.

Future research should explore artificial intelligence integration to enhance feature recognition and validate these correlations across diverse skin types and anatomic locations. Longitudinal studies correlating dermoscopic-histopathological findings with patient outcomes would further strengthen evidence-based guidelines.

Conclusion

This prospective diagnostic accuracy study establishes robust correlations between dermoscopic features and histopathological findings in pigmented skin lesions. Blue-white veil and atypical vascular patterns demonstrate exceptional specificity for melanoma and should prompt immediate histopathological evaluation. Irregular pigment network offers moderate sensitivity, serving as a valuable screening criterion. The substantial interobserver reliability supports standardized application of these features in clinical practice. These findings validate dermoscopy as an indispensable tool for preoperative risk stratification, potentially reducing unnecessary biopsies while ensuring timely melanoma detection.

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