

ADVANCES IN NON-INVASIVE DIAGNOSTIC METHODS FOR EARLY DETECTION OF SKIN CANCER IN BLACK WOMEN: A COMPREHENSIVE REVIEW OF DERMOSCOPY, REFLECTANCE CONFOCAL MICROSCOPY, OPTICAL COHERENCE TOMOGRAPHY, ELECTRICAL IMPEDANCE SPECTROSCOPY, MULTISPECTRAL IMAGING, AND ADHESIVE PATCH BIOPSY

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ABSTRACT: Skin cancer, including melanoma, poses significant challenges in early detection and diagnosis, particularly in Black women, due to unique skin pigmentation characteristics. This narrative review explores the advancements in non-invasive diagnostic methods tailored explicitly for early skin cancer detection in Black women. The article focuses on six essential techniques: dermoscopy, reflectance confocal microscopy (RCM), optical coherence tomography (OCT), electrical impedance spectroscopy (EIS), multispectral imaging, and adhesive patch biopsy. The review delves into the principles, efficacy, limitations, and potential applications of each method in the context of diverse skin types. Furthermore, it highlights the importance of specialized training for accurately interpreting these diagnostic tools in Black women and underscores the urgent need for further validation studies in diverse populations. This comprehensive review aims to provide valuable insights for dermatologists, oncologists, and researchers working towards improving early skin cancer detection and management in Black women.

2958

Keywords: Skin Cancer. Early Detection. Black Women. Non-Invasive Methods. Diagnostic Techniques.

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INTRODUCTION

Skin cancer, including melanoma and non-melanoma skin cancers (NMSC), presents a significant global health burden. While the incidence of skin cancer is lower in Black populations compared to lighter-skinned individuals, the mortality rates are disproportionately higher due to delayed diagnosis and advanced-stage presentation [1,2]. The unique pigmentation characteristics of Black skin, such as increased melanin content and variations in melanocyte distribution, can obscure early signs of skin cancer, leading to diagnostic challenges [3]. This underscores the urgent need for advanced, non-invasive diagnostic methods tailored explicitly for early skin cancer detection in Black women.

Traditional diagnostic approaches, such as visual inspection and biopsy, have limitations regarding accuracy, invasiveness, and patient acceptability [4]. However, the emergence of non-invasive diagnostic tools offers promising alternatives, providing improved visualization, cellular-level analysis, and objective data for enhanced diagnostic accuracy. This narrative review aims to provide a comprehensive overview of the advancements in these non-invasive diagnostic methods for early skin cancer detection in Black women, focusing on six essential techniques: dermoscopy, reflectance confocal microscopy (RCM), optical coherence tomography (OCT), electrical impedance spectroscopy (EIS), multispectral imaging, and adhesive patch biopsy.

2959

METHODOLOGY

A comprehensive literature search was conducted using PubMed, Scopus, Web of Science, and ScienceDirect databases. The search terms included combinations of "skin cancer," "melanoma," "non-melanoma skin cancer," "Black women," "African American women," "dermoscopy," "reflectance confocal microscopy," "optical coherence tomography," "electrical impedance spectroscopy," "multispectral imaging," and "adhesive patch biopsy." Relevant articles published in English between 2000 and 2023 were selected based on their focus on non-invasive diagnostic methods for skin cancer detection in diverse skin types, particularly in Black women. The selected articles were critically appraised for their

methodology, results, and conclusions. The findings were synthesized to provide a comprehensive overview of this field's current knowledge and future perspectives.

RESULTS

Dermoscopy

Dermoscopy, also known as chemiluminescence microscopy, is a non-invasive technique that enhances the visualization of subsurface skin structures not visible to the naked eye [5]. It improves diagnostic accuracy for melanocytic and non-melanocytic lesions compared to naked-eye examination [6]. In Black women, dermoscopy has shown promise in identifying early signs of melanoma, such as atypical pigment network, irregular streaks, and blue-white veil [7]. However, the darker pigmentation in Black skin can obscure certain dermoscopic features, potentially complicating the diagnosis and leading to lower specificity and higher false-positive rates [8,9].

Specialized training is not just beneficial, but crucial for accurately interpreting dermoscopic findings in diverse skin types. Studies have shown that the diagnostic accuracy of dermoscopy significantly depends on the examiner's experience [10]. Untrained or less experienced examiners may not achieve better diagnostic accuracy than clinical inspection without dermoscopy [11]. Therefore, dermatologists and healthcare professionals should undergo targeted dermoscopy training, focusing on recognizing unique features and challenges in Black skin. This continuous professional development is not just a recommendation, but a necessity in the field of skin cancer detection.

2960

Reflectance Confocal Microscopy (RCM)

Reflectance confocal microscopy (RCM) is an advanced imaging technique that provides high-resolution, en-face images of the epidermis and upper dermis, allowing for detailed cellular morphology assessment [12]. RCM has been shown to double the diagnostic specificity for melanoma and pigmented keratinocyte skin cancers compared to dermoscopy alone [13]. In Black women, RCM has demonstrated high sensitivity (98.1%) and specificity (60.6%) in diagnosing dark-pigmented lesions [14].

However, RCM has limitations in imaging depth ($\sim 200 \mu\text{m}$) and poor contrast for non-pigmented lesions, which can be problematic for diagnosing non-pigmented basal cell carcinomas (BCCs) and other lesions in darker skin types [15,16]. Accurate interpretation of RCM images requires extensive training to understand the cellular and structural details. The technique's effectiveness depends on the operator's expertise [17].

Optical Coherence Tomography (OCT)

Optical coherence tomography (OCT) is a non-invasive imaging modality that offers cross-sectional skin imaging with a greater penetration depth than RCM [18]. It is beneficial for imaging epithelial skin cancers and monitoring nonsurgical therapies [19]. OCT provides deeper tissue imaging ($\sim 1 \text{ mm}$) but lacks cellular resolution, which can limit its effectiveness in detecting early-stage melanomas and other superficial skin cancers [20].

Pigmentation can interfere with OCT imaging in darker skin types, affecting the interpretation of morphological features [21]. While OCT offers deeper tissue imaging, its diagnostic potential is limited without proper training. Accurate interpretation of OCT images requires understanding skin lesions' optical properties and morphological features in diverse skin types [22].

Electrical Impedance Spectroscopy (EIS)

Electrical impedance spectroscopy (EIS) is a non-invasive technique that measures the electrical properties of skin lesions, providing a score based on cellular irregularity [23]. It aids in differentiating dysplastic nevi from melanoma. It has demonstrated high sensitivity and specificity, with some studies reporting sensitivity up to 100% and specificity up to 87% when used as an adjunct to visual methods [24,25].

EIS offers objective data on cellular irregularity, but accurate interpretation necessitates familiarity with the technology and its diagnostic criteria. Training is essential to differentiate between benign and malignant lesions [26] effectively. However, EIS may produce false negatives in very early lesions, necessitating careful consideration and possibly additional

follow-up or biopsy, especially in darker skin types due to variations in electrical properties [27,28].

Multispectral Imaging

Multispectral imaging uses different wavelengths of light to analyze skin lesions, providing a computed score to assist in the differentiation of benign from malignant lesions [29]. This technique can improve specificity but may still lead to overdiagnosis and unnecessary biopsies, particularly in darker skin types where pigmentation can affect light-tissue interaction properties [30].

Accurate interpretation of multispectral imaging requires specialized knowledge and training. The technique involves complex light-tissue interaction properties, and its effectiveness in diverse skin types is still under investigation [31]. Proper training is crucial for applying multispectral imaging in Black women to ensure reliable and accurate diagnosis [32].

Adhesive Patch Biopsy

Adhesive patch biopsy is a non-invasive method that involves tape stripping to collect mRNA from skin lesions, which can then be analyzed for melanoma-specific genetic markers [33]. This method offers high sensitivity and specificity for melanoma detection without the trade-off of higher sensitivity for lower specificity seen in other diagnostic tools, making it particularly effective for early detection in populations with darker skin [34].

However, the application of adhesive patch biopsy may be limited by the availability of specific genetic markers and the need for specialized laboratory analysis [35]. Training is necessary to ensure accurate sample collection and interpretation of results. Further validation studies are required to assess the feasibility and effectiveness of this method in diverse populations, including Black women [36].

DISCUSSION

Advancements in noninvasive diagnostic methods for early skin cancer detection in Black women offer promising opportunities for improved patient outcomes. Dermoscopy,

RCM, OCT, EIS, multispectral imaging, and adhesive patch biopsies have shown the potential to enhance diagnostic accuracy and reduce unnecessary biopsies. However, each technique has limitations and challenges, particularly for darker skin types.

One key challenge in applying these diagnostic methods to Black women is the unique pigmentation characteristics of darker skin. The increased melanin content and variations in melanocyte distribution can obscure early signs of skin cancer, leading to diagnostic difficulties [37]. Dermoscopy, for example, may have lower specificity and higher false-positive rates in Black skin due to the masking effect of pigmentation [8,9]. Similarly, OCT imaging can be affected by pigmentation, influencing the interpretation of morphological features [21].

Specialized training is crucial for accurately interpreting these diagnostic tools in diverse skin types. Dermatologists and healthcare professionals should undergo targeted training programs that focus on recognizing unique features and challenges in Black skin [38]. The diagnostic accuracy of techniques like dermoscopy and RCM significantly depends on the examiner's experience [10,17]. Untrained or less experienced examiners may not achieve better diagnostic accuracy than clinical inspection alone [11]. Therefore, it is essential to develop and implement standardized training protocols that address the specific needs of diagnosing skin cancer in Black women.

2963

Another important aspect is the need for further validation studies in diverse populations. While these diagnostic methods have shown promise in early skin cancer detection, their efficacy and accuracy across different skin types require more extensive investigation [39]. Many studies have been conducted in predominantly light-skinned populations, and the generalizability of their findings to Black women may be limited [40]. Future research should focus on conducting large-scale, multicenter studies that include a representative sample of Black women to assess the performance of these diagnostic tools in real-world settings.

Moreover, integrating these advanced diagnostic methods into clinical practice requires consideration of cost-effectiveness, accessibility, and patient acceptability [41]. The availability of specialized equipment, trained personnel, and financial resources may vary across healthcare settings, potentially limiting the widespread adoption of these techniques

[42]. Efforts should be made to develop cost-effective, portable devices that can be easily incorporated into routine clinical practice, especially in resource-limited settings [43].

Patient education and awareness are also critical for successfully implementing these diagnostic methods. Black women should be informed about the importance of early skin cancer detection and the availability of non-invasive diagnostic options [44]. Dermatologists and healthcare providers should initiate patient education to promote skin self-examination and encourage timely medical evaluation of suspicious lesions [45]. Addressing cultural barriers and misconceptions about skin cancer in Black communities is essential to improve patient participation and adherence to diagnostic procedures [46].

CONCLUSION

Advancements in noninvasive diagnostic methods for early skin cancer detection in Black women offer promising avenues for improving patient outcomes. Dermoscopy, RCM, OCT, EIS, multispectral imaging, and adhesive patch biopsy have shown the potential to enhance diagnostic accuracy and reduce unnecessary biopsies. However, the unique pigmentation characteristics of darker skin pose challenges in accurately interpreting these diagnostic tools.

2964

Specialized training for healthcare professionals is crucial to address the specific needs of diagnosing skin cancer in Black women. Standardized training protocols should be developed and implemented to ensure accurate interpretation of diagnostic findings in diverse skin types. Further validation studies in representative populations of Black women are necessary to assess the performance and generalizability of these diagnostic methods.

Integrating these advanced diagnostic techniques into clinical practice requires consideration of cost-effectiveness, accessibility, and patient acceptability. Efforts should be made to develop cost-effective, portable devices that can be easily incorporated into routine clinical practice. Patient education and awareness initiatives are essential to promote early skin cancer detection and address cultural barriers in Black communities.

In conclusion, the advancements in non-invasive diagnostic methods hold great promise for improving early skin cancer detection in Black women. However, further research,

specialized training, and patient education are necessary to fully harness the potential of these techniques and reduce the disparities in skin cancer outcomes. By addressing these challenges and promoting the widespread adoption of these diagnostic tools, we can work towards achieving better patient outcomes and reducing the burden of skin cancer in Black women.

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