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Recent developments in dermoscopy for dermatology

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Abstract

Background: Dermoscopy is considered to be a bridge between clinical observation and histopathological examination, allowing the in vivo examination of skin microstructures that are not visible to the naked eye, from the epidermis to the superficial dermis. Dermoscopy has undergone rapid development, witnessing the history from natural light to polarized light, from handheld dermoscopy to videodermoscopy, and from classic dermoscopy to digital dermoscopy. Its application extends from the initial differential diagnosis of pigmented skin diseases (melanocytic and nonmelanocytic) to general dermatology, including appendage (nail and hair) abnormalities and diseases related to infection and inflammation.

Aims: We aimed to provide the latest developments in dermoscopy from the perspective of handheld dermoscopy, videodermoscopy, fluorescence-advanced videodermatoscopy, polarized transilluminating dermoscopy, and digital dermoscopy.

Methods: In this review, we searched the PubMed, Embase, Web of Science, and Cochrane Library databases for reviews, case reports, and observational studies on dermoscopy.

Results: We provided an updated review of dermoscopy based on published literature.

Conclusion: Dermoscopy is an indispensable diagnostic tool in dermatology, and it is expected to be further developed in the future.

KEYWORDS

computer-aided diagnosis, dermoscopy, digital dermoscopy, videodermoscopy

1 | INTRODUCTION

In the early 20th century, the first dermoscopic binocular was invented and applied to melanoma diagnosis. Within the past 30 years, dermoscopy has become a widely used noninvasive technique, and its application has extended from the initial differential diagnosis of pigmented lesions (melanocytic and nonmelanocytic) to general dermatology including infections and infestations (inflammoscopy, entodermoscopy), hair and scalp disorders (trichoscopy), and nail abnormalities (onychoscopy).[1] Dermoscopy was vividly called the dermatologist's stethoscope. A dermoscope is not a mere magnifying glass but a more sophisticated and complex optical device, allowing the visualization of the epidermis, dermo-epidermal junction, and papillary dermis that are invisible to the naked eye. Different from the vertical view of histopathology, the dermoscopic image comes from the superimposition of skin layers and is just like an aerial view.[2] Local dermoscopic findings are clearly related to specific histopathological features. For example, the location of melanin in skin layers determines the color observed by dermoscopy and the arrangement of melanin determines certain structures; similarly, the distribution of hemoglobin in the lesion also determines structures and patterns of vascularization.[2] Based on the direct and accurate dermoscopy–pathology relationship, several dermoscopy algorithms have been proposed to differentiate between pigmented lesions (melanocytic and nonmelanocytic) (Table 1).

Chen and Lu equally contributed to this article.

TABLE 1 Diagnostic algorithms of dermoscopy

Algorithms	Contents
ABCD rule	A: asymmetry; B: border; C: color; D: differential structure
Seven features for melanoma	(1) regression-erythema, (2) radial streaming, (3) gray-blue veil, (4) irregularly distributed pseudopods, (5) lack of homogeneity, (6) irregular pigment network, and (7) sharp margin at the periphery
Menzies method	Negative features for melanoma: (1) symmetry of pigmentation pattern (does not require symmetry of shape); (2) presence of a single color. Positive features: (1) blue-white veil; (2) multiple brown dots; (3) pseudopods; (4) radial streaming; (5) scarlike depigmentation; (6) peripheral black dots or globules; (7) multiple colors (≥5); (8) multiple blue-gray dots; (9) broadened network
Seven-point checklist	Three major criteria (atypical pigment network, atypical vascular pattern, blue whitish veil); four minor criteria (irregular streaks, irregular pigmentation, irregular dot or globules, regression structures)
CASH	C: color; A: architecture; S: symmetry; H: homogeneity
Three-point checklist	Asymmetry; atypical pigment network; blue-white structures

The introduction of dermoscopy improves the diagnosis accuracy compared to the inspection with naked eye to varying degrees (depending on the type of skin lesion and the experience of the clinician), and reduces the need for semi-invasive (skin scrapings) or invasive procedures (biopsy).[1] It is important to emphasize that histopathology is the gold standard for the diagnosis of specific skin diseases, and dermatologists cannot completely rely on dermoscopy in clinical practice. Notably, dermoscopy can help to determine the biopsy site, accurately outline the tumor margins before surgery, and detect and extract intradermal foreign bodies during treatment.[3]

In the past 10 years, computer-assisted diagnosis has been developed to complement dermatologist's knowledge. Although dermoscopy technology is quite mature, a large number of primary dermatologists do not have a clear understanding of it. Based on the published reviews, case reports, and observational studies, we try to provide an updated review on dermoscopy in this article to give clinicians inspiration.

2 | HANDHELD DERMOSCOPY

The classic handheld dermoscope mainly consists of light source (halogen or light-emitting diode light bulbs) to illuminate the field of vision and lens that generally allow 10 times magnification.[4] For nonpolarized dermoscopy (NPD), an immersion liquid at the interface between the skin and the device's glass slide is required to eliminate light reflection and render the stratum corneum translucent. However, in some cases such as the evaluation of scaling, follicular hyperkeratosis, hair shaft disorders, and nail plate surface, a dermoscopy without immersion liquid (dry dermoscopy) is recommended.[5,6] NPD requires direct contact between the device and the skin, and a thorough cleaning before and after use is necessary to avoid the spread of infectious diseases (such as warts, parasites) among patients. Moreover, the close contact may exert a certain pressure on the skin surface, thereby interfering with the presentation of vascular patterns. Unlike NPD, polarized light dermoscopy (PD) can absorb all scattered waves on the skin surface without the need for a medium while avoiding direct skin contact.[7]

Functionally, NPD and PD are not equivalent but complementary.[8] NPD allows better visualization of relatively superficial structures such as milia-like cysts and comedo-like openings, facilitating the recognition of seborrheic keratosis. By contrast, PD is more useful for deeper structures (such as melanin, collagen, or fibrosis).[9] For most dermoscopic colors, there is medium to excellent consistency between NPD and PD, with the exception of granularity (peppering), lighter colors, and blue-white veil. These colors are important signs of histologic regression in pigmented skin lesions (such as melanomas), which tend to be ignored with polarized light and are more evident under NPD. One study showed that brown and blue colors and their shades appear darker under PD than under NPD, which significantly changes the appearance of certain lesions. For example, blue nevi show a classic steel-blue color under NPD (an emphasized feature in diagnosis), but under PD, the color is darker along with multiple shades of blue. The impact of these differences on the identification and management of blue nevi needs further exploration. Vascular pattern and pigment distribution are crucial evidence for the diagnosis and differential diagnosis of skin lesions (especially skin tumors), which can be better visualized with noncontact polarized dermoscopy.[10]

At present, not only unpolarized and polarized light, but also ultraviolet light is accessible in some dermoscope devices. Dermoscopy with ultraviolet light utilizes the fluorescence emitted by skin lesions to help detect superficial mycosis, nail diseases, *Demodex* mites, scabies, and pigmented diseases, and identify the demarcation of melanin distribution in cutaneous melanoma for complete excision.[11-13] Compared with Wood's lamps, dermoscopy with ultraviolet light does not require a dark room for image acquisition, but has a relatively small field of view and cannot replace Wood's lamps.[11]

Handheld dermoscopy has no storage function and can only be achieved by externally connecting a smartphone or a digital camera. Some manufacturers provide specially designed coupling adapters to achieve better fixation between the dermoscope and smart image capture devices. In addition, a dermoscope accessory composed of dermoscopic optics and light source can replace a complete dermoscope and be directly connected to a camera to achieve the same effect.

3 | VIDEODERMOSCOPY

Videodermatoscopy (VD) is performed by a high-resolution color videocamera equipped with optic fibers (linked to a computer) and lenses with magnifications ranging from 10 to 1000 (depending on the manufacturer) (Table 2).[14] Compared with handheld dermoscopy, VD can achieve quick zooming up to ×1000 magnification and enable a more detailed online examination of the skin on the computer monitor with a possible free switch between micro and macro images. The obtained images can be stored directly in an organized storage system, which can hold many more photos than a mobile phone or a digital camera connected to a handheld dermoscope and simplifies image organization and retrieval (Table 3).

In most cases, a handheld dermoscope with ×10 magnification is sufficient to identify morphological features peculiar to certain skin lesions, whereas VD can provide visualization for specific dermoscopic features that are visualized only at higher magnifications, such as the light brown nests of basal cell carcinomas that are seen at ×50-70 magnification, twisted red capillary loops seen in psoriasis at ×50 magnification, and longitudinal white indentations seen on nail plates affected by onychomycosis at ×20 magnification.[15-17] Furthermore, VD is an effective noninvasive approach to the diagnosis of demodicosis, trombiculosis, and scabies with diagnostic accuracy comparable to that of standardized skin surface biopsy, which is semi-invasive and not well accepted. VD is particularly useful for the screening of asymptomatic contacts and family members in scabies; it can perform a comprehensive examination of the skin surface in minutes to clearly identify the caves, parasites, or their products (eggs or feces).[18] VD can enhance the monitoring of clinical responses to treatment in scabies and pediculosis, and determine the optimal timing of drug application to avoid overtreatment and enhance patient compliance.[19]

A classic dermoscopy lens allows only a single viewer at every cutaneous examination, and trainees need to search for dermoscopic features noted by the instructor independently and laboriously.[20] By contrast, VD permits the simultaneous examination of skin lesions by onlookers, allowing for discussion among physicians and good interaction in teaching. Furthermore, VD has a high-magnification capability, making subtle dermoscopic findings more obvious to novices. In summary, VD as a novel tool may be helpful for dermoscopy training. The simultaneous and high-magnification view of VD can be partly achieved by attaching the handheld dermoscope to a camera, including those integrated into mobile phones, digital cameras, or tablets. A report also suggests the use of mobile application to better perform VD with a handheld dermoscope. The smartphone's camera can be displayed on the computer monitor using various mobile applications (such as EpocCam) and the prior connection between a phone and a computer via Wi-Fi network or USB.[21]

TABLE 2 Main available videodermatoscope devices

Product	Company	Magnification
DermoGenius ultra	Dermoscan (Germany)	×10
FotoFinder dermoscope	Fotofinder (Germany)	×20 to ×70
Dino-Lite	AnMo Electronics Corporation (Taiwan)	×10 to ×200
Skin Cam	Medicam (India)	×10 to ×200
Optilia	Optilia Instruments (Sweden)	×20 to ×50
Hi-scope	Hirox (Japan)	×4 to ×1000
IRSkin	CA-MI (Italy)	×10 to ×100
Horus	Adamo SRL (Italy)	×30 to ×150
Videocap 3.0	DS Medica (Italy)	×20 to ×200
Videocap	DS Medica (Italy)	×10 to ×1000
Videoderm	Zovam Europe (Italy)	×10 to ×300
Medicalscope	Fastbrain (Italy)	×10 to ×200
Dermoscope	Medici Medical (Italy)	×30 to ×300
Easyscan	Business Enterprise (Italy)	×30 to ×150
Vidix	Medicimedical (Italy)	×7 to ×100
Molemax HD	Derma Medical (Austria)	×20 to ×100
Molemax	Dermamedical (Austria)	×30

TABLE 3 Handheld dermoscopy versus videodermoscopy

Characteristics	Handheld dermoscopy	Videodermoscopy
Price	Cheap	Expensive
Portability	Convenient enough to carry in a pocket	Relatively fixed; poor mobility
Accessibility	Easy to obtain	Not universal
Magnification	×10	×10 to ×1000
Image display	Dermoscopy lenses; cameras integrated in smartphones or digital cameras	Computer monitor
Image storage	Temporarily stored in smartphones or digital cameras and later transferred to personal computers for permanent storage; complicated and time-consuming	Directly stored in organized system; easy for retrieval
Teledermoscopy	E-mail based	E-mail based or/and live teleconferencing
Computer-assisted diagnosis	No standard software designed for individual dermoscopy images	Available in several manufacturers

4 | FLUORESCENCE-ADVANCED VIDEODERMATOSCOPY

Fluorescence-advanced videodermatoscopy (FAV) has recently been proposed as a new type of VD instrument for in vivo skin evaluation at ×12 primary magnification (Table 4). FAV is an optical electronic system consisting of a handheld probe and a monochromatic light-emitting source with a λ of 405 nm (±5 nm) and a fixed angle of incidence.[22,23] In normal conditions, FAV provides optical penetration depth varying from 200 μm to 400 μm and allows the visualization of subcutaneous structures to the point below the papillary dermis.[22] To prevent light diffusion on the corneum stratus, glycerol is applied to the skin surface.

The working mechanism underlying FAV exists in the ability of endogenous molecules to emit fluorescence after absorbing specific wavelengths.[23] The fluorescence intensity is expressed as the gray-scale of images (black, no fluorescence; white, highest fluorescence), reflecting the absorption levels of a specific skin structure. FAV is particularly suitable for studying structures and cells containing melanin or hemoglobin. In the observation of normal skin with FAV, we can identify the honeycomb pattern of the stratum spinosum, and by manually adjusting the focus depth, we can check the deeper skin layers and visualize dermal papillae with capillary loops in the middle, surrounded by basal-layer cells at the dermo-epidermal junction. Several studies presented that FAV allowed correct characterization between benign and malignant skin melanocytic lesions at a cellular resolution. In a benign lesion, FAV images show honeycomb arrangement of hyperpigmented cells without any atypia at the stratum spinosum; the cells of the stratum basale are all regular in shape and distribution and clearly demarcated from the previous layer. However, in melanoma, FAV exhibits pleomorphic cells with relevant atypia in number, shape, and dimension with no structural order, which makes it difficult to distinguish the stratum spinosum from the stratum basale.[24] Another study showed that FAV can also help hypomelanotic melanomas diagnosis by identifying irregular vascular structures and malignant melanocytes. The appearance of malignant melanocytes and pigmented keratinocytes of the epidermis basal layer under FAV is similar to the reflectance confocal microscopy (RCM) images. Notably, melanin and hemoglobin are dark in FAV but bright in RCM.[25]

One study proposed FAV as a promising technique for the in vivo evaluation of vitiligo. FAV displays a complete disappearance of epidermal pigmentation and a lack of melanocytes at the stratum basale in well-established vitiliginous lesions, and the erythrocytes within

TABLE 4 Characteristics and limitations of fluorescence-advanced videodermatoscopy, polarized transilluminating dermoscopy, and digital dermoscopy

Dermoscopy	Characteristics	Limitations
Digital dermoscopy	Facilitate acquisition and storage of dermoscopy images for follow-up; accessible to second opinions either through teledermoscopy or by computer-assisted diagnosis	Risk of health information leakage
Fluorescence-advanced videodermatoscopy	Particularly suitable for structures and cells containing melanin or hemoglobin; cell-level resolution	Not universally applicable
Polarized transilluminating dermoscopy	Make up for the failure of dermoscopy in the diagnosis of trichothiodystrophy; expected to be used for other hair diseases, reducing the need for polarizing microscope	Not universally applicable

the capillaries of the papillary dermis are the only visible structures. For repigmented skin areas, FAV reveals a proliferation of pigmented cells at the dermal-epidermal junction. These findings indicate that FAV has similar potential to RCM for disease staging and therapeutic monitoring in patients with vitiligo.[23]

FAV can also be used to evaluate superficial angiomas. With FAV, we can track the flow of circulating blood cells and obtain functional information by manually modulating the pressure applied on the blood vessels. In addition, FAV allows the visualization of pathogens, such as scabies and *Demodex* mites in skin infection.[22] Further research is still needed to investigate the potential of FAV in the assessment of other pigmented lesions.

5 | POLARIZED TRANSILLUMINATING DERMOSCOPY

Polarized transilluminating dermoscopy (PTD) described by Yang and colleagues is a new technology that combines the features of handheld dermoscopy and polarizing microscopy used for the diagnosis of trichothiodystrophy (TTD).[26] For TTD, polarizing microscopes used by pathologists are the primary diagnostic method and reveal characteristic alternate dark and white bands of the hair shaft with a tiger-tail appearance.[27] The polarizing microscope is a simple device but not always available to dermatologists.[28] Additionally, dermoscopy is nonspecific for TTD,[29] although it is a valuable technique for the evaluation of most hair disorders. For these two reasons, if a patient is suspected with TTD, some pulled hairs are generally sent to a pathologist for polarizing microscopy examination, which is complicated and time-consuming.

PTD can be performed using two dermoscopes and a light source or one dermoscope and a mirror. The effectiveness of polarized transillumination dermoscopy in TTD has been initially demonstrated and needs to be further determined in the future. Additionally, the application of PTD is expected to extend to other conditions in which a polarizing microscope is used for the evaluation of hair abnormalities, such as steroid sulfatase deficiency and gray hair syndromes (Table 4).[28]

6 | DIGITAL DERMOSCOPY

Digital dermoscopy refers to the acquisition and storage of digital dermoscopy images via digital cameras, smartphones, tablets, or an entirely digital system (VD) (Table 4).[30] Handheld dermoscopy lenses have a limited view, making it difficult to obtain a complete digital image of large lesions, and in this case, dermatologists generally analyze multiple separate photographs. Several studies suggested that the digital image montage technique is helpful to create a wide area digital dermoscopy (WADD) image.[31] First, a smartphone or digital camera is used to obtain multiple consecutive dermoscopy images covering the entire skin lesion, with adjacent images overlapping by 20%-30%. Second, the acquired images are transferred to the Photoshop software installed on a computer to be combined into a single image. The WADD concept can be applied to various situations, such as preoperative dermoscopic mapping of skin lesions and follow-up of atypical dysplastic nevus syndrome or a congenital melanocytic nevus. As technology advances, current smartphones generally have the option of high-dynamic-range imaging, which can be used to combine multiple images taken with different exposures into one image to achieve greater dynamic range (brightness range) than ordinary digital image technology. Given this feature of smartphones, the appearance of dermoscopic structures (including vessels) can be enhanced.[32]

With digital dermoscopy, dermatologists can better record skin lesions for patient follow-up, which may reduce the excision rate of potentially benign lesions, especially if the lesions are located in areas that are prone to scarring. Furthermore, dermatologists are more accessible to second opinions either through teledermoscopy or by computer-assisted diagnosis. The former can be performed by attaching images acquired by traditional dermoscopy or VD to E-mails. Notably, VD of certain manufacturers allows live-interactive video consultation as another way for teledermoscopy.

Computer-assisted diagnosis is now available in certain entirely digital systems to provide a second diagnostic opinion, especially for pigmented skin lesions. First, the computer can correctly identify what we want to analyze in a skin lesion via standardized processes known as segmentation and extraction of borders.[33] Then, special software programs are used to recognize and measure certain morphological features, such as geometric variables, colors, and other diascopic structures that are indispensable for diagnosis.[34] Although this procedure uses the same dermoscopy criteria as a skilled dermatologist, it is more objective because digital images can be broken up into components by the computer software to determine the exact weight of each component in the formulation of a given diagnosis. Moreover, this digital dermoscopy analysis allows objective follow-up by comparing different images mathematically.

The realization of computer-aided diagnosis relies heavily on machine learning (an artificial intelligence).[35] Machine learning is able to automatically improve diagnostic accuracy by analyzing large data sets with the use of computational algorithms such as neural networks.[36] In dermatology, machine learning has some limitations. For example, databases contain an incomplete spectrum of skin lesions and few common lesions, such as seborrheic keratoses, thereby affecting the diagnosis accuracy of pigmented skin lesions.[37] In the future, more high-quality and standardized images are needed to supplement databases and improve machine learning.

In digital dermoscopy, there is an ongoing effort to standardize digital dermatologic image acquisition to facilitate data analysis and improve collaboration among experts.[38] The true holy grail of image standardization is Digital Imaging and Communications in Medicine (DICOM), which is a comprehensive imaging standard for image storage, annotation, transmission, and display.[39,40] In addition to the most notable application in radiology, DICOM is now available for new imaging modalities in dermatology (such as optical coherence tomography, RCM).[41,42] Moreover, studies have been conducted

to develop DICOM standards for dermoscopy, and this work will continue.

Although dermoscopy images are usually not recognized, they are often stored alongside clinical photographs. Therefore, when taking and storing images, digital dermoscopy faces the risk of patient information leakage. The Health Insurance Portability and Accountability Act aims to stress secure encrypted digital dermoscopy image acquisition and storage. In medicine, digital systems, especially automated diagnostic systems, will always be limited by the extreme complexity of biological systems compared with physical ones.[43] Therefore, computer-assisted diagnosis should be used as a tool to provide second opinion, not as a substitute for diagnosis. Suspicious lesions still require biopsy or removal to determine the nature.[44]

7 | CONCLUSION

Dermoscopy is a promising diagnostic tool for pigmented or non-pigmented skin lesions, and has the advantages of being convenient, accurate, fast, easy to operate, and cheap. Despite the rise of other noninvasive diagnostic technologies such as optical coherence tomography and in vivo RCM with better resolution, dermoscopy remains the most advanced and popular method. We look forward to the greater application of dermoscopy in dermatology and further development of computer-aided diagnosis.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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