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2 PRINCIPLES OF DERMOSCOPY AND DERMOSCOPIC EQUIPMENT

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DOI: 10.1201/9780429487873-2

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Introduction

Dermatoscopy, also known as dermoscopy, uses a handheld microscope called a dermatoscope that is equipped with a magnification lens and a light source. Although unaided (naked-eye) visual inspection of the skin affords the clinician an appreciation of the gross morphologic features of lesions, such as their size, symmetry, shape, colors, contour, and surface topography, dermoscopy is unique in allowing the clinician to see structures not visible to the naked eye. This device allows the observer to survey the subsurface primary morphology of cutaneous lesions through an examination of the stratum corneum to the level of the superficial dermis. For this reason, in the hands of experienced users, dermoscopy can improve the clinician's diagnostic accuracy [3, 11] and confidence level [5] for pigmented [7, 17, 19] and nonpigmented skin lesions.

In the 1970s, Rona MacKie was one of the first clinicians to recognize the advantages of dermoscopy for the preoperative evaluation of equivocal pigmented skin lesions [12, 13]. Thereafter, many clinicians and researchers worldwide have studied it extensively, and significant progress has been made in defining benign and malignant dermoscopic structures and patterns of pigmented and nonpigmented skin lesions. Today, there remains little doubt that dermoscopy is a valuable clinical tool for the noninvasive, in vivo evaluation and diagnosis of cutaneous lesions.

In order to effectively utilize a dermatoscope, every clinician should understand the optical principles of the device. Furthermore, familiarity with both nonpolarized dermoscopy and polarized dermoscopy is crucial to understanding pertinent applications of each modality in the evaluation of pigmented and nonpigmented skin lesions.

Principles of nonpolarized dermoscopy

Dermoscopy provides additional information beyond that gleaned by evaluating the lesion through a simple magnifying lens. To grasp how dermoscopy provides this information requires an understanding of its optical principles, in particular, the interactions of light with the skin. Because the refractive index of the stratum corneum is higher than that of air, much of the

incident light is reflected off the surface of the skin (Figure 2.1) [2, 15]; this diffuse backscattered light overwhelms the retina and thereby obscures the visualizing of light that is reflected from the deeper layers of the skin. Consequently, with naked-eye examination, we are mostly able to observe the morphologic features manifest on the surface layer of the skin (stratum corneum) and only minimally able to appreciate the colors and structures located in the deeper layers of the epidermis and the dermis.

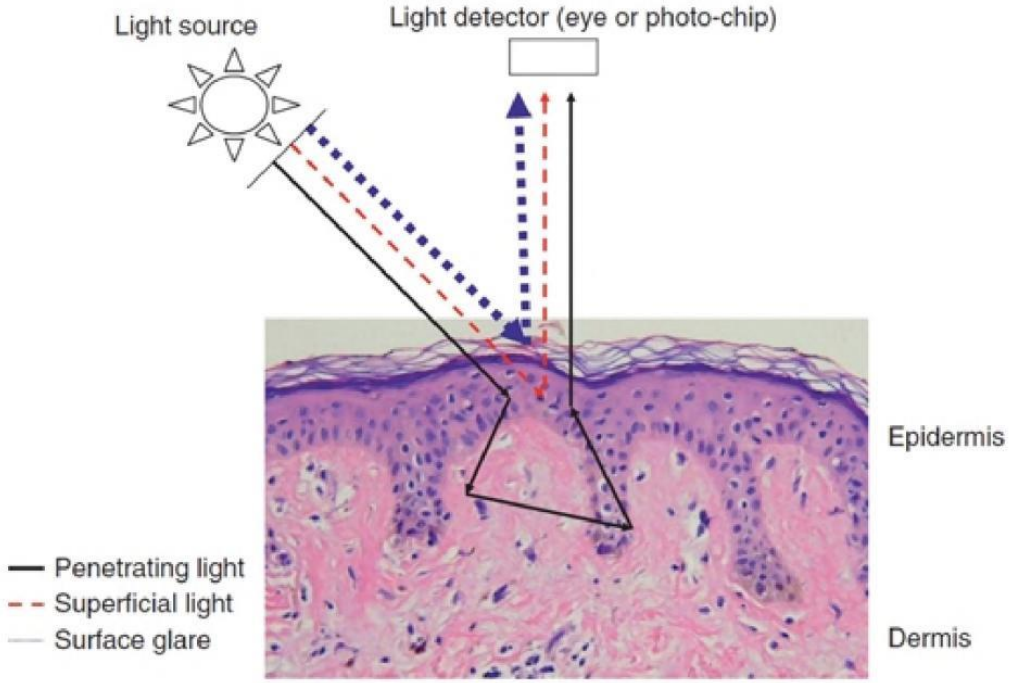

FIGURE 2.1 Schematic representation of optical properties of light without the use of dermoscopy. The arrows indicate the pathway of light through the skin. Some of the light is absorbed by the superficial layers of the epidermis and is scattered only slightly (thin red line), and some of the light penetrates more deeply and undergoes more scattering events (thin black line). However, most of the incident light is reflected off the stratum corneum (thick blue line); this surface glare overwhelms the retina and thereby precludes the observer from visualizing the light reflected from the deeper layers of the skin (red and black lines). Thus, the clinical (nondermoscopic) examination of the skin with or without a magnifying lens only sees the light that is reflected from the skin surface (thick blue line), and therefore, most subsurface structures remain hidden from view.

The first handheld dermatoscope introduced into clinical practice used a nonpolarized light source to illuminate the skin. Most nonpolarized dermatoscopes (NPD) today contain light-emitting diodes (LEDs) to provide illumination and a 10× magnification lens. Examining lesions with NPD necessitates direct contact of the dermatoscope's glass plate with the skin, and the presence of a liquid interface between them is required; ideally, this immersion liquid should have a refractive index equal to that of skin (Figure 2.2). This setup replaces the normal skin–air

interface with a skin–liquid interface. Because there is a closer match of refractive indices within the skin–liquid–glass interface, light reflection is decreased. As a result, glare is minimized, which in turn makes the stratum corneum appear more translucent. This optical setup permits the observer to see deeper structures in the skin (Figure 2.3). When utilizing NPD, it is imperative that air pockets (i.e., air bubbles) present between the dermoscope's glass plate, the liquid, and the skin be eliminated; such air pockets create a skin–air interface that will preclude the observer from visualizing structures below the stratum corneum.

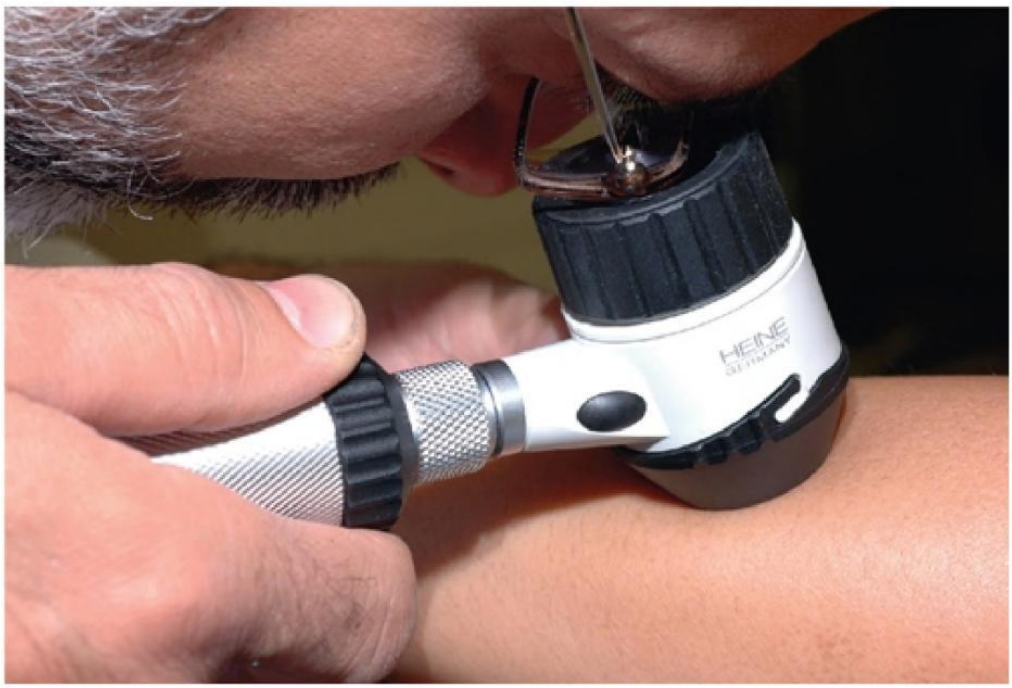

FIGURE 2.2 Physician examining the skin with a contact nonpolarized dermatoscope.

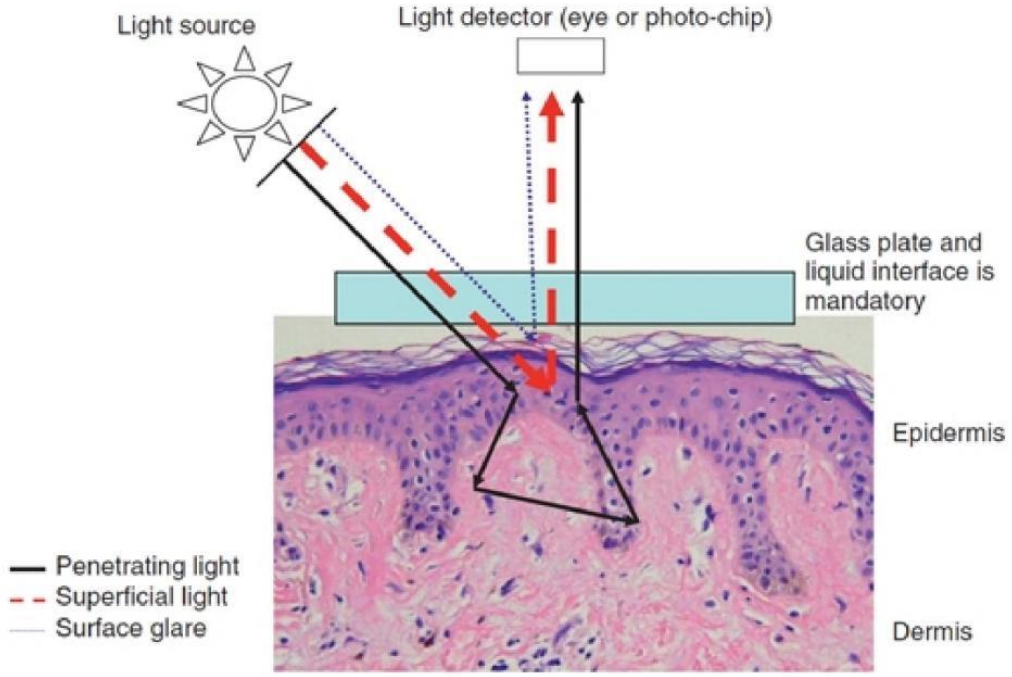

FIGURE 2.3 Schematic representation of optical properties of light during the use of contact NPD with a liquid interface. The arrows indicate the pathway of light through the skin. Most of the light is absorbed and reflected from the superficial layers of the epidermis after undergoing minimal scattering events (thick red line). Some of the light is reflected off the stratum corneum (thin blue line), but this surface glare is insufficient to interfere with the ability to visualize subsurface dermoscopic structures. Some of the light penetrates more deeply and is absorbed and reflected back after multiple scattering events (thin black line); however, the light from the deeper layer contributes only a small fraction to that detected with NPD, and most of the light reaching our eye is from the more superficial, minimally scattered light (thick red line). Abbreviation: NPD, nonpolarized dermoscopy.

Different immersion liquids can be used for dermoscopy, including water, mineral oil, alcohol, or gel (i.e., ultrasound gel, antibacterial gel). In one study [8], 70% alcohol was reported to be the best immersion liquid, since it yielded fewer air bubbles and provided clearer images. An added benefit of alcohol is the potential for it to reduce bacterial contamination, and thus, it is more hygienic as compared with other liquids [18]. However, for examination of the nail apparatus, ultrasound or antibacterial gels are superior to alcohol [10, 16], because the gel's viscosity prevents it from rolling off the convex nail surface. It is common to have air bubbles trapped in the gel; the bubbles can be distracting and may prevent the observer from getting a clear view of the lesion. To minimize the number of air bubbles in the gel, it is best to store the gel bottles upside down, to avoid shaking the bottle, and to squeeze out a small amount of the gel before use so as to discard remnant dried gel.

Principles of polarized dermoscopy

Polarized dermoscopy (PD) units were introduced into the clinical arena around the year 2000. These handheld dermatoscopes rely on a different set of optical principles than those described for NPD. The PD devices use two polarizers to achieve cross-polarization. The two polarizers—known as the "'source" polarized filter and the cross-polarized "detector" filter—are oriented perpendicular to each other. The light emitted from the dermatoscope initially passes through the "source" filter, leading to the production of a polarized, unidirectional light, which subsequently interacts with the skin. The reflected light from the skin must then pass through the second "detector" filter in order to be visualized by our eye. For light to pass through the "detector" filter, which is orthogonal to the "source" filter, it must undergo optical rotation. Such 90-degree rotation in the direction of the light wave is dependent on sufficient scattering events through collisions of the light wave with several tissue structures. The light reflected from the stratum corneum or superficial layers of the epidermis does not undergo sufficient scattering events to cause the required optical rotation for passage through the "detector" filter. Hence, light reflected back from the surface and superficial layers of the epidermis is blocked from view by the "detector" filter. However, light penetrating at deeper levels, the dermal epidermal junction (DEJ) and superficial dermis, undergoes sufficient scattering events to allow 90-degree optical rotation and can pass through the "detector" filter (Figure 2.4). On average, polarized light must transverse a distance of between 0.06 and 0.1 mm of skin before sufficient polarized light changes

its angle of polarization. Hence, PD allows the backscattered light from the deeper layers of the skin to be captured, and therefore, visualization of the DEJ and dermal structures (e.g. blood vessels) is enhanced. In contrast, superficial structures are poorly visualized (e.g., comedo-like openings in a seborrheic keratosis).

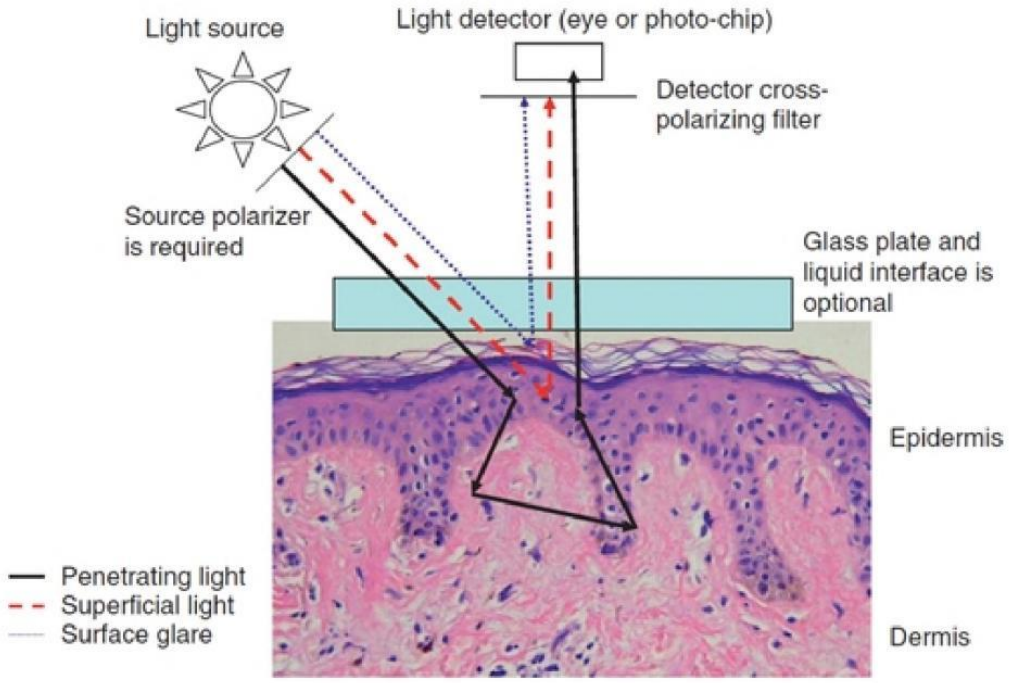

FIGURE 2.4 Schematic representation of optical properties of light during the use of polarized dermoscopy. Light emitted from the dermoscopy unit (source) passes through a polarizer, resulting in the generation of polarized (unidirectional) light. Light reflecting back toward our eye (detector) must first pass through a cross-polarized filter whose direction is perpendicular (orthogonal) to that of the source polarizer. Thus, polarized light cannot pass through the cross-polarizing filter unless the light changes its direction by 90°, which can only occur if the original polarized light undergoes sufficient scattering that changes its direction (i.e., randomization of polarization). Light reflected from the stratum corneum that maintains its original polarization cannot pass through the cross-polarized filter (blue line). Similarly, light that is absorbed by the superficial layers of the epidermis, but does not undergo enough scattering events to result in randomization of polarization, will also be blocked by the cross-polarizing filter (red line). Only light penetrating more deeply and/or undergoing multiple scattering events will result in randomization of polarization (black line). When this light is reflected back, it will be able to pass through the cross-polarization filter, thus allowing the observer to visualize

dermoscopic structures. While PD does not require direct contact and a liquid interface, some of the devices have the option for contact PD.

Since surface glare is blocked by cross-polarization, the cross-polarized system does not mandate the use of a liquid interface and does not require direct contact with the skin (Figure 2.5). These innovations may enable the examiner to scan lesions at a relatively faster pace than with NPD. However, PD typically requires stronger LED lighting to compensate for the photons blocked by cross-polarization. It is recommended to ask the patient to close their eyes during examination of the face to avoid directly looking into this strong light source.

FIGURE 2.5 Physician examining a cutaneous lesion with a polarized noncontact dermatoscope.

Although PD does not mandate direct contact and a liquid interface, the authors' personal experience is that with some dermatoscopes, PD provides higher-quality visualization of dermoscopic structures and colors when used with immersion fluid (e.g., alcohol 70%) and direct skin contact.

More recently, hybrid dermatoscopes have been developed that allow the user to toggle between PD and NPD. These "hybrid" dermatoscopes should be applied using direct skin contact with a liquid interface. If this is not done, then the user will see dermoscopic structures only in the polarized mode, and no dermoscopic structures will be discernible with the nonpolarized mode; instead, the observer will simply see a magnified clinical (not dermoscopic) image of the surface of the lesion.

Polarized versus nonpolarized dermoscopy

For most pigmented and nonpigmented skin lesions, PD and NPD offer overall similar images. However, there are some important differences between the two types of dermoscopes (Table 2.1; Figure 2.6) [1, 4, 20].

TABLE 2.1: Differences between Nonpolarized Dermoscopy and Polarized Dermoscopy

Colors and structures	Nonpolarized dermoscopy	Polarized dermoscopy
Colors	+	++
Melanin		
Red/pink	+	+++
Blue-white veil (due to melanin underlying orthokeratosis)	+++	+
Gray-blue hue due to dermal regression	+++	++
Structures	+++	++
Granularity		
White shiny lines and strands	-	+++
Blood vessels	+	+++
Milia-like cyst	+++	+/-

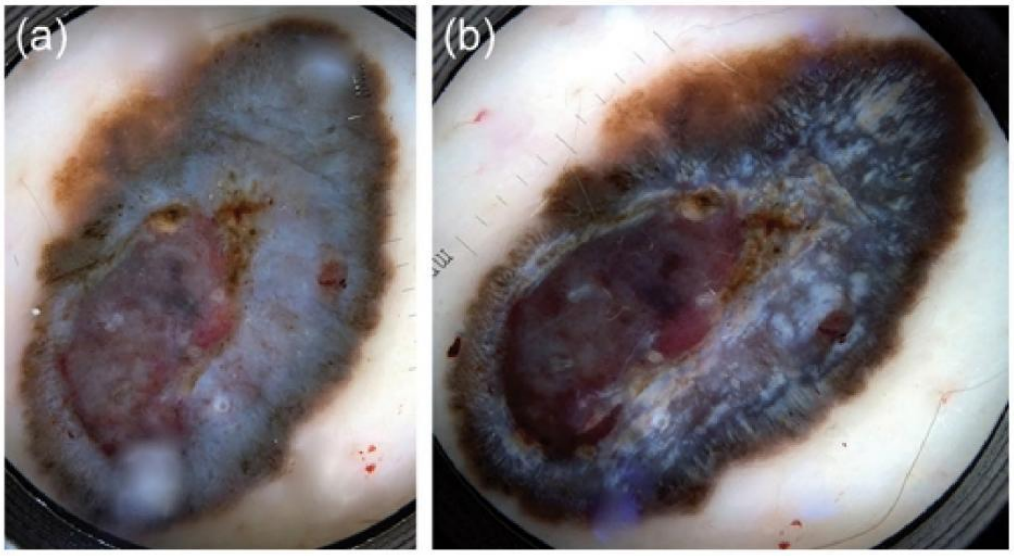

FIGURE 2.6 This is a melanoma 0.9 mm in thickness. Notice that the blue-white veil at the center of the lesion is more conspicuous under NPD and is difficult to appreciate with PD. However, white shiny lines (known also as crystalline structures) can only be seen with PD. Since the whitish veil is due to orthokeratosis overlying the dermal melanin, it will be most conspicuous when viewed with a device that preferentially images the superficial layers (NPD). In contrast, shiny white lines corresponding to altered stromal collagen will only be visible with a device that captures the birefringence of collagen (PD). Image taken with (a) NPD and (b) PD. Abbreviations: PD, polarized dermoscopy; NPD, nonpolarized dermoscopy.

In general, epidermal structures such as comedo-like openings and milia-like cysts (Figure 2.7a, b) are more conspicuous under NPD due to their epidermal location. A whitish veil due to orthokeratosis (Figure 2.6a, b) is also better seen with NPD. In contrast, dermal structures such as blood vessels (Figure 2.8a, b), vascular blush due to increased blood volume (Figure 2.9a, b), and shiny white structures (previously called crystalline structures) (Figure 2.6a, b) are more conspicuous under PD. The gray-blue granularity (peppering) due to regression (i.e., free melanin in dermis or within melanophages in the superficial dermis) is slightly more conspicuous with NPD, although this will vary depending on the thickness of the skin (epidermis together with the stratum corneum) and the location of the melanin within the dermis. For example, peppering

located in the superficial papillary dermis within thin sun-damaged skin of the face will be more conspicuous with NPD.

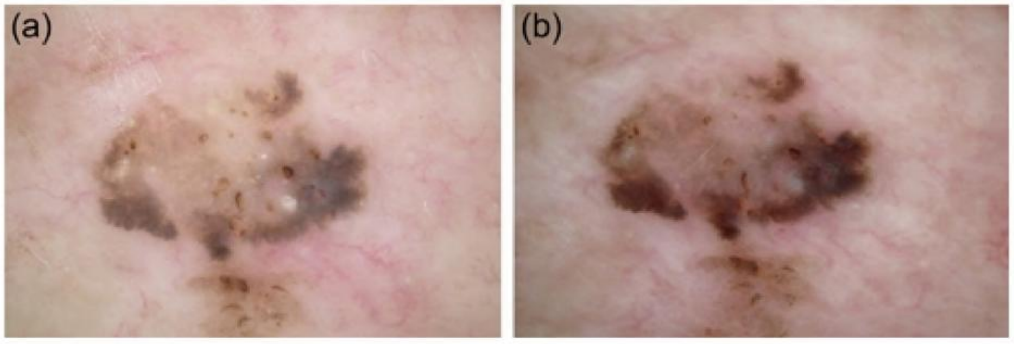

FIGURE 2.7 This is a seborrheic keratosis. Because milia-like cysts are not as visible under PD, this lesion could be misdiagnosed as a melanoma. However, with NPD, the milia-like cysts are readily identifiable, and the correct diagnosis can be rendered with ease. Image taken with (a) NPD and (b) PD. Abbreviations: PD, polarized dermoscopy; NPD, nonpolarized dermoscopy.

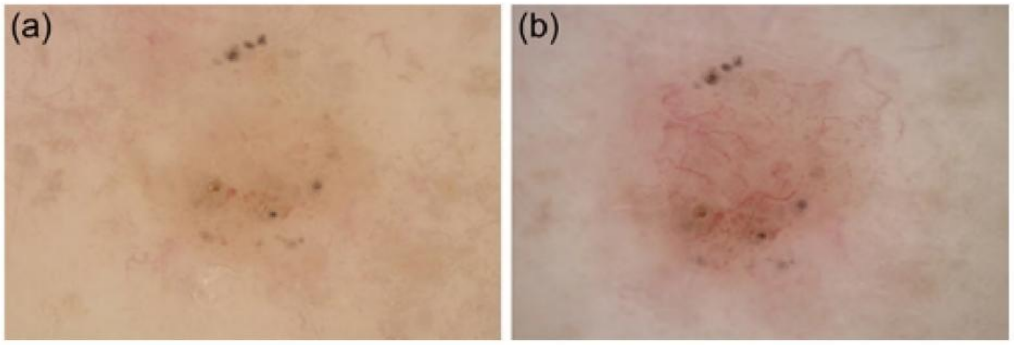

FIGURE 2.8 This is a basal cell carcinoma. Notice that the arborizing blood vessels are better seen with PD than with NPD. This is partially due to the compression of blood vessels during the examination with NPD and partially due to the enhanced ability to visualize deeper structures with PD. Image taken with (a) NPD and (b) PD. Abbreviations: PD, polarized dermoscopy; NPD, nonpolarized dermoscopy.