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A Kaleidoscopic Navigation Through Different Shades of Colors in Dermoscopy

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Abstract

Dermoscopy has traveled a long way from its initial application limited to tumoral dermatology, especially melanocytic tumors, to its indispensable role in general dermatology as well as in procedural dermatology. Dermoscopy primarily serves as a diagnostic tool by virtue of its ability to visualize skin surfaces and sub-surface structures in a magnified and illuminated manner. Colors are critical and significant in dermoscopy. They are imparted by different chromophores in skin tissue. Hence, recognition of diverse colors and their variations is of paramount importance in the analysis of a dermoscopic image. In this review, we describe the various colors observed in dermoscopy, emphasizing the same in order to interpret them appropriately for an accurate diagnosis.

Key words: Dermoscopy; Color; Pattern; Polarised; Ultraviolet

Introduction

Initially used in the diagnosis of skin tumors, especially melanocytic tumors, the role of dermoscopy in general dermatology has evolved to a great extent. Dermoscopy primarily serves as a diagnostic tool by its distinct ability to visualize skin surfaces and sub-surface structures in a magnified and illuminated manner. One of the important elements in dermoscopic diagnosis is the colors exhibited by the lesions reflecting the underlying tissue involved. In this review, we describe the various colors observed in dermoscopy with an emphasis on the basis of the same in order to interpret them appropriately for an accurate diagnosis.

The instrument

Dermoscope is the tool, and dermoscopy is the method. Dermoscopes can be hand-held with 10-fold magnification and the facility to capture images. The instrument consists of an achromic lens, in-built light emitting diodes (LED) lamps, and a power supply. Lenses provide magnification, and LEDs act as light sources (Figure 1a).

Figure 1: (a) Hand held dermoscope with power button (black arrow), polarized and non-polarized knob (red arrow), brightness enhancing knob (yellow arrow) and faceplate of dermoscope (blue

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arrow). Inset: Illumination system with the circular arrangement of light emitting diode lamps. (b) Dermoscope is attached to a smart mobile phone by a universal adaptor for quick attach and detach. [Reused with permission from editor-in-chief; Ankad BS, Smitha S V, Koti VR. Basic science of dermoscopy. Clin Dermatol Rev 2020; 4:69-73]

Hand-held dermoscopes need to be attached to a smart phone to capture and save the images (Figure 1b). A videodermoscope with magnifications from 20 x to 160 x to 220 x, allows simultaneous visualization of images on the monitor screen, and these images can be saved (Figure 2). [1, 2]

Figure 2: Videodermoscope with simultaneous display of image in the monitor. (FotoFinder Medicam 1000)

Principle

The eyes cannot perceive the structures that are subsurface in the skin. This is largely due to reflection, refraction, scattering, and the absorption of light. These factors are reduced to a greater extent by the achromic lens, the use of the interface medium, and polarized light. The achromic lens reduces the refraction between the air and stratum corneum, while the interface medium decreases the specular reflection. Polarization mode modifies the scattering and absorption of light so that the deeper structures are made visible (Figure 3). [3] The illumination in dermoscopy is achieved by different light sources, such as non-polarized, polarized, blue light, or UV light. The dermoscopic features thus observed reflect the histological aspects of the skin lesion and hence assist in a more accurate clinical diagnosis of the same. The dermoscopic features observed are described in terms of structures and their morphology, the patterns formed by the structures and the various colors imparted by the structures ,and patterns.

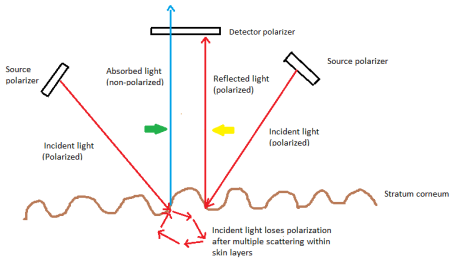


Figure 3: Schematic diagram depicting the physics of cross polarization. Source and detector polarizers are placed perpendicularly. Detector polarizer allows nonpolarized absorbed light from the skin surface that has lost its phase or polarization (green arrow) whereas it blocks the reflected polarized light that has retained its phase or polarization (yellow arrow). [Reused with permission from editor-in-chief; Ankad BS, Smitha S V, Koti VR. Basic science of dermoscopy. Clin Dermatol Rev 2020; 4:69-73]

Basic structures and patterns

The basic structures in dermoscopy include the dot, clod, line, circle, pseudopod, and structureless area. Dot- a non-measurable point-like solid object; clod- solid object bigger than the dot with variable color and shape; line-structure with length greater than width; pseudopod- a line with a bulbous end; and structureless area- an area that covers 10-25% of the field without identifiable basic structures.[4] These structures are basically described from the perspective of pigmented lesions, especially melanocytic lesions. They form the language of dermoscopy. Each lesion is described using these terms to maintain uniformity for better understanding and learning dermoscopy. Multiple repeats of the structures form the patterns in dermoscopy.

Description of a lesion

The dermoscopic features observed are described in terms of structures and their morphology, the patterns formed by the structures, and the various colors imparted by the structures and patterns. The colours are the main determinants of dermoscopic diagnosis as they reflect the tissue involved in the pathology, or the tissue alterations/reactions. A given lesion is analyzed and described based on the following parameters; background color (white, brown, black, or pink), pigmented structures (pigment network, grey clods, brown clods), follicular changes (follicles ostia present or absent, dilated follicular openings, follicular plugs), scales (morphology and distribution, [focal, eccentric, perifollicular, diffuse]), vascular elements (morphology and distribution) and a special clue. [5]

Determinants of basic color in dermoscopy

The colors in dermoscopy are determined by the tissue chromophores. The three essential chromophores in the skin are keratin, melanin, and haemoglobin. White, black, and red are primarily imparted by keratin, melanin, and hemoglobin respectively. However, these colors are not exclusive to them, and certain other tissue elements or alterations can impart similar colors as outlined in Table 1 and depicted in Figures 4-6. [6]

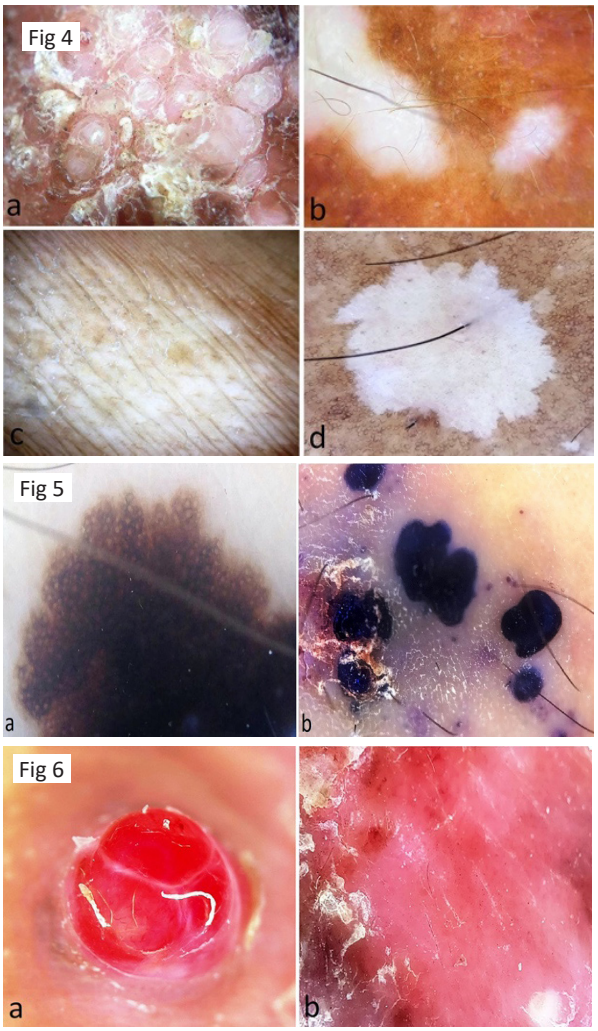


Figure 4: White color in dermoscopy of keratin (a) in a keratinizing lesion, dermal sclerosis (b) and atrophy in lichen sclerosus et atrophicus (c), and amelanosis (d) in vitiligo.
Figure 5: Black color in dermoscopy of melanin (a) in a melanocytic lesion and of deoxygenated blood (b) due to thrombosed vessels in a case of lymphangioma circumscriptum.
Figure 6: Red color in dermoscopy of haemoglobin (a) in a pyogenic granuloma and red-pink background color of collagen (b) in an eroded skin lesion.

Determinants of different shades of basic colors in dermoscopy

The basic colors described above can have different variants. The variations are determined by various factors, as described in Table 2 and depicted in Figures 7-9.

As with the basic colors, the variants of the basic colors can also be imparted by other tissue elements or alterations, as delineated in Table 3 and depicted in Figures 10-12. [1,6,7]

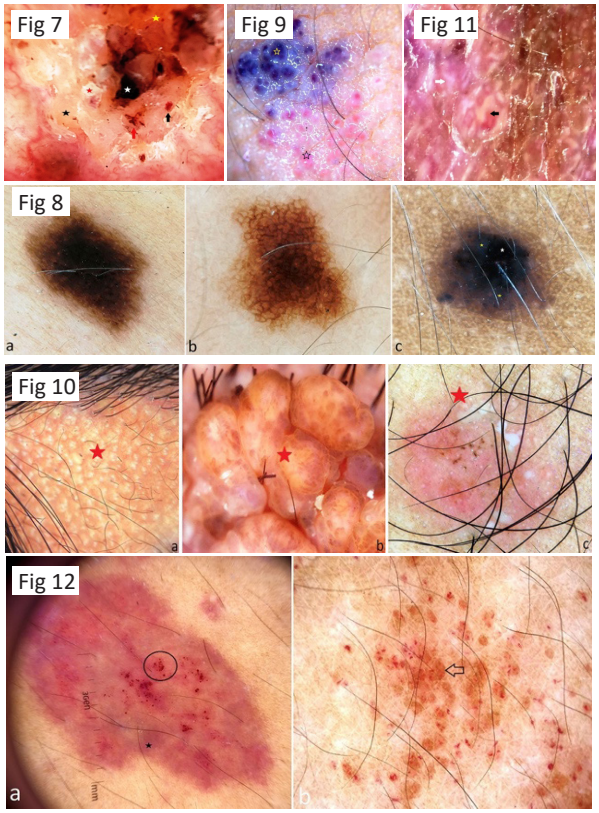


Figure 7: Different colors of keratin. Keratin appears yellow (black star) when it is dense and compact whereas loose and lamellated keratin imparts a white color (red star). Keratin admixed with serum appears yellow-orange (yellow star), with fresh bleed appears red (black arrow), with an old bleed appears black (white star) due to deoxygenation of the hemoglobin and brown when admixed with hemosiderin (red arrow)
Figure 8: Different colors of melanin in melanocytic nevi. Melanin in stratum corneum and upper granular layer appears black (a), appears brown in Malpighian layer (b), grey to grey-blue at the level of papillary dermis and upper reticular dermis (c, yellow stars) and in deep reticular dermis melanin appears bluish due to Tyndall effect (c, white star).
Figure 9: Different colors of haemoglobin in a case of lymphangioma circumscriptum. Oxygenated haemoglobin imparts a red color to the blood seen as red clods (black star) and deoxygenated blood in thrombosed vessels appears bluish-black seen as blue-black clods (yellow star).
Figure 10: Yellow color imparted by various tissues such as sebaceous glands (a) in nevus sebaceous, fat (b) in nevus lipomatosus and pus (c) in inflammatory tinea as whitish-yellow color.
Figure 11: Variations of yellow color such as yellow-orange is imparted by dense or granulomatous cellular infiltrate seen as a yellow-orange clod (black arrow) and sparse of non-compact cellular infiltrate appears yellow-white to white color (white arrow).
Figure 12: Variations of red color such as (a) bright red imparted by extravasated red blood cells seen as red dots (black circle) and the extravasated red blood cells with inflammatory infiltrate appears as purplish as seen in the background (black star). (b) As the hemorrhage resolves, brown color develops seen as brown clods (black arrow) attributable to hemosiderin.

It is hence of paramount importance to interpret the colors contextually. Colours in dermoscopy other than the basic colors and/or their variations most likely represent exogenous factors (e.g., tattoo pigment) or certain optical phenomena as described below.

Colored phenomena in dermoscopy

Rainbow phenomenon

The rainbow phenomenon (RP) is seen as multi-coloured pattern in dermoscopy and does not have a specific corresponding change in histopathology. Earlier, it was thought to be specific for Kaposi sarcoma. However, it is found in many dermatoses, including lichen planus, dermatofibroma, melanoma, acroangiodermatitis, etc. [8]

It is thought that RP is because of microscopic vascular structure, as it was observed in vascular tumors. Recently, RP has been found in non-vascular lesions, explaining the role of the optical phenomenon of polarized light. It is not seen with non-polarized light, with or without an interface medium. Hence, it is a complex and intricate process that takes place when polarized light traverses and interacts with the vascular and other structures of the skin. The multicolored pattern is due to the interplay of different states of polarization of light with absorption and interference of colors.[9] The histopathological correlation of this dermoscopic feature is not established. [10]

As mentioned earlier, RP is increasingly found in many vascular and non-vascular dermatoses, diagnosis should not be counted only on the presence of RP; rather ,other relevant dermoscopic features and clinical context are taken into consideration. RP is observed in basal cell carcinoma (Figure 13a), dermatofibroma, pyogenic granuloma (Figure 13b), malignant melanoma, etc. [8, 11]

Auroa borealis

This pattern is exclusively observed in onychomycosis. It produced, as a result of onycholysis, longitudinal spikes and striae and multiple colors of chromonychia (Figure 14). The name Aurora borealis is derived from light waves in the northern hemisphere because of its appearance. It should be noted that this pattern is specific and sensitive to onychomycosis. [12]

Blue-white veil

Blue-white veil (BWV) is a confluent blue pigmentation over the underlying ground-glass haziness. It is due to the combination of compact orthokeratosis with heavily pigmented and aggregated melanocytes, melanophages, or melanin in the dermis. [13] Although it is characteristically seen in melanoma, few conditions, such as blue nevus (Figure 15a) and basal cell carcinoma (BCC) (Figure 15b) display this feature. In melanoma, it is always focal and nonuniform in nature (Figure 15c) as compared to other benign conditions such as blue nevus, wherein BWV occupies entire lesion. The presence of BWV in BCC has been reported recently. Studies from the Indian population showed the occurrence of BWV in 57.3% and 53.4% of patient with micro-nodular and nodular variants respectively. [11, 14] It is noted in pigmented variants of BCC. Obviously, heavily pigmented tumor cells and orthokeratosis, and epidermal hypergranulosis contribute to BWV. Interestingly, BWV is also found in BCC without hypergranulosis and orthokeratosis. The authors are of the opinion that BWV is due to heavily pigmented melanophages and fibrosis between the stroma and tumor cells. [15] Hence, further studies are recommended to validate BWV in BCC in terms of its histopathological correlation. Furthermore, regressing lesions also demonstrate blue-grey areas, which are difficult to distinguish from BWV. It is documented that BWV is frequently observed in palpable lesions, whereas blue-grey areas are noted in atrophic or flat lesions. Interestingly, diffuse light brown pigmentation is associated with blue-grey areas and not seen with BWV. [16]

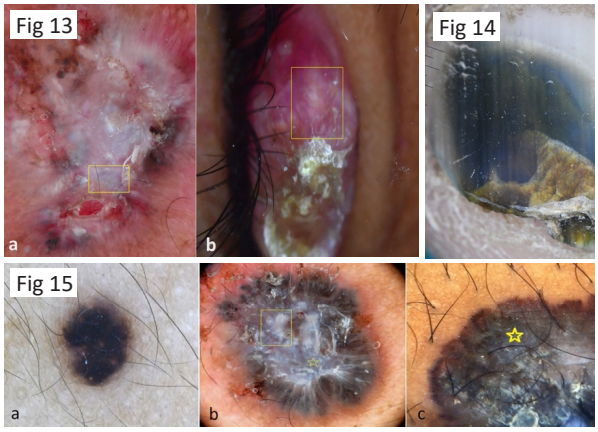


Figure 13: Rainbow phenomenon in (a) basal cell carcinoma and (b) pyogenic granuloma (yellow rectangle) with combination of multicolors like blue, red, yellow and purple. **Figure 14:** Onychomycosis shows multiple colors of chromonychia in aurora borealis phenomenon. **Figure 15:** Blue white veil as confluent bluish pigmentation covering entire lesion in (a) blue nevus and focal in (b) basal cell carcinoma and (c) malignant melanoma (yellow star). Rainbow phenomenon is also seen in basal cell carcinoma (yellow rectangle).

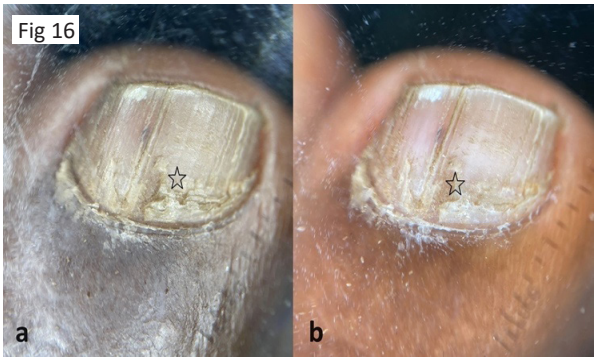
Colours in different types of dermoscopy

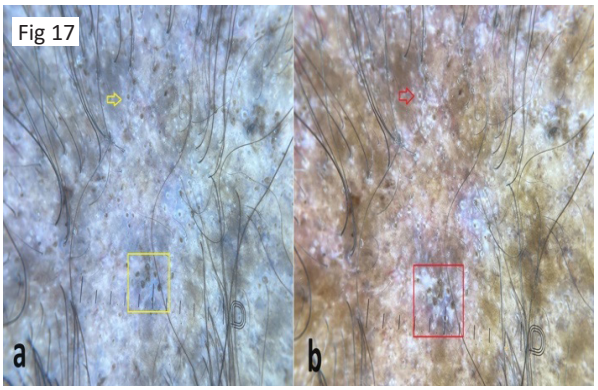
Polarized and non-polarized light

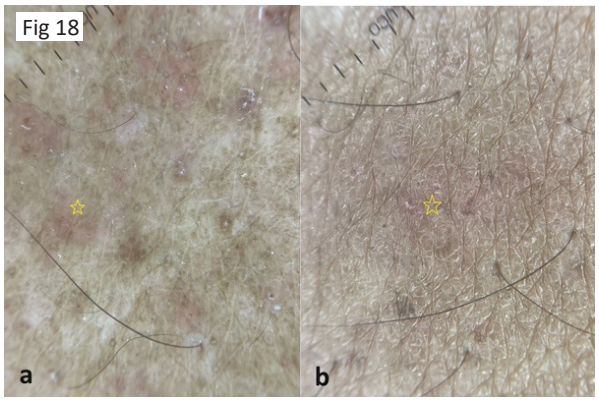
Polarized (PD) and non-polarized (NPD) lights are used in dermoscopes, and they complement each other. NPD mode with an achromic lens reduces the surface glare, and with an interface medium (ultrasound gel or isopropyl alcohol), it allows deeper penetration of light and visibility of subsurface structures up to the dermo-epidermal junction. Whereas PD mode uses cross-polarization to prevent contact with skin lesions and visualize deeper structures up to the reticular dermis. [3, 17] Blood vessels and pink color are well visualized in PD due to the lack of pressure effect (non-contact) and deeper location of vessels in the skin layers. Additionally, pigmented lesions with pigment in the dermo-epidermal junction show darker shades of brown and blue as compared to NPD. [18]

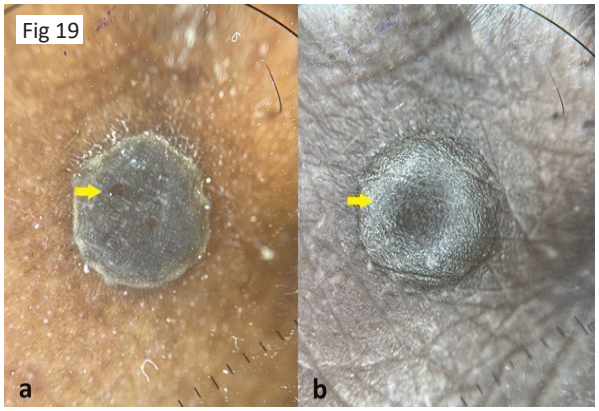
PD and NPD demonstrate minute differences in the

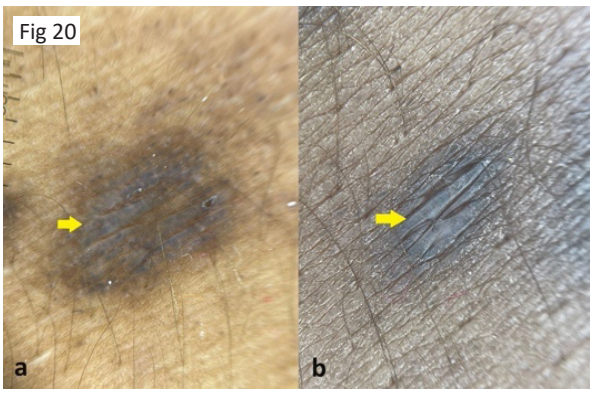
structures that assist in an accurate diagnosis. For example, amelanotic or structure-poor melanoma is better seen with PD, and comedo-like openings and milia-like cysts are better appreciated with NPD. Now-a-days, all scopes have the inbuilt facility of both polarized and non-polarized lights. Thus, just toggling between the two will show the differences even better with both PD and NPD. This is referred to as a blink sign as structures blink at you when you toggle between PD and NPD. There are a few examples of polarized and non-polarized light dermoscopy, as follows. Scales appear prominent in NPD (Figure 16a) as compared to PD (Figure 16b). Similarly, follicular plugs are better visualized in NPD than in PD (Figure 17). The pink area is better appreciated in PD than in NPD (Figure 18). Fluid in the vesicular lesion is easily visible with PD (Figure 19a), while the surface is well appreciated in NPD (Figure 19b). Dermal melanin is readily visible in PD (Figure 20a),while it is not appreciated with NPD (Figure 20b). Hence, the color of melanin appears brown or gray if it presents in the epidermis and dermis, respectively (Figure 8). White rosettes and white shiny streaks are prototype features that are better visualized only in polarized dermoscopy. The former appears as four white clods meeting at a center point (Figure 21) and it represents hyperkeratotic dilated infundibulum, while the latter is due to collagen in the dermis, seen as whitish shiny strands (Figure 22). White rosettes are non-specific and noted in many dermatoses, including discoid lupus erythematosus. [19] Conditions with increased collagen demonstrate white, shiny streaks. [20]

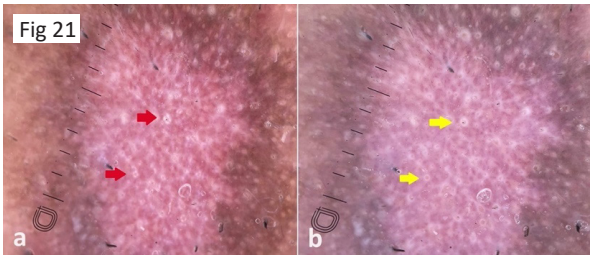












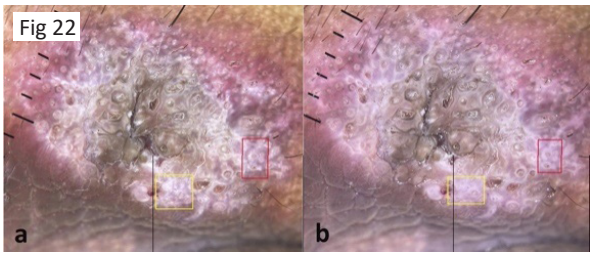


Figure 16: Surface scales and keratin (black star) is better visualized with (a) non-polarized as compared to (b) polarized dermoscopy

Figure 17: Follicular plugs (yellow rectangle and arrow) in discoid lupus erythematosus are well appreciated in (a) non-polarized compared to (b) polarized dermoscopy (red rectangle). White rosettes are better seen in polarised (red arrow) as compared to non-

polarised dermoscopy. [Image courtesy: Dr Soumil Khare, Assistant Professor, AIIMS, Raipur, Chhattisgarh] **Figure 18:** (a) Polarised dermoscopy shows pink areas (yellow star) clearly as compared to (b) non-polarized dermoscopy. **Figure 19:** Fluid filled lesion shows pink areas (yellow arrow) in polarized dermoscopy (a) whereas non-polarized dermoscopy (b) shows only surface (yellow arrow). **Figure 20:** (a) Polarised dermoscopy reveals grey globules (yellow arrow) while (b) non-polarized dermoscopy shows only surface. **Figure 21:** (a) Polarised dermoscopy reveals white rosettes (red arrows) which are not appreciated in (b) non-polarized dermoscopy (yellow arrows). [Image courtesy: Dr Soumil Khare, Assistant Professor, AIIMS, Raipur, Chhattisgarh] **Figure 22:** (a) Polarised dermoscopy reveals white shiny streaks (yellow square) and subtle follicular plugs (red rectangle). In (b) non-polarized dermoscopy white shiny streaks are not visible (yellow square) and prominent follicular plugs are seen (red rectangle). [Image courtesy: Dr Soumil Khare, Assistant Professor, AIIMS, Raipur, Chhattisgarh]

Parallel polarisation

It is a new addition to the dermoscope. Here, two polarizing filters are placed in the same direction so that polarized light reflected from the skin surface is allowed to traverse the second filter, which is helpful in visualization of surface and subsurface structures (Figure 23a). probably gives more details of superficial structures than the non-polarized light (Figure 23b). Cross polarization has two filters in 90^0 in which polarized light reflected from the skin surface is blocked by a second filter, permitting only non-polarized light (light that loses its polarization in deeper layers of skin) reflected from deeper layers. It is better utilized in the visualization of deeper structures (Figure 23c). [21]

Blue light

Blue light is incorporated into a multispectral dermoscope because of its wavelength of 470-nm, which is absorbed by melanin. As compared to white light, sharp borders in stable vitiligo are well demarcated by blue light (Figure 24). In contrast, spreading borders are not visualized better with blue light. Thus, blue light differentiates stable and unstable vitiligo by increasing the contrast between areas with melanin and those without melanin. [22]

Yellow light

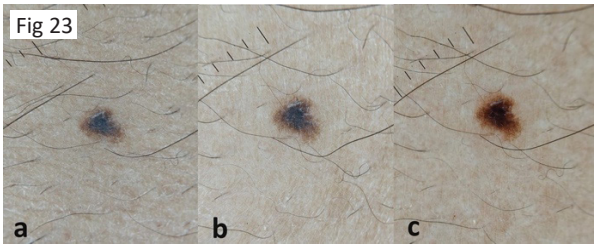
Yellow light in ultraviolet spectrum has higher wavelength and it penetrates deeper in dermis. Hence, it matches with absorptive spectrum of melanin and hemoglobin. The lesions with more vasculature and dermal melanin are visualised better with yellow light. They stand-out well against a yellow background. Yellow light, similar to blue light is incorporated in multispectral dermoscope by DermLite. Vessels in rosacea (Figure 25), dermal melanin in pigmented contact dermatitis and nail fold capillaries are well visualised with yellow light. [23]

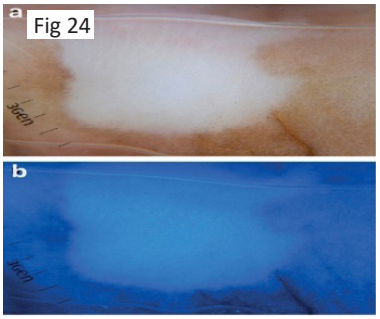
Ultraviolet light

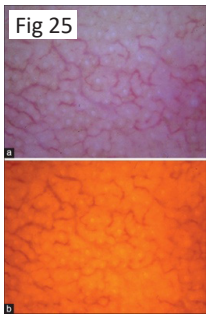
Recently, the facility of an ultraviolet (UV) light source with 365nm was introduced in dermoscopy. It is akin to the basic physics of using Wood's lamp. This technique is based on the Stokes shift phenomenon, which describes that UV light stimulates fluorescence by skin chromophores, thereby detecting particular fluorescents in a given skin lesion. [24, 25] Accordingly, UV fluorescent (UVF), induced dermoscopy gives an additional clue to many non-neoplastic dermatoses. UVF dermoscopy shows characteristic fluorescence in inflammatory, infective, and pigmentary dermatoses. [24] Erythrasma demonstrates coral red fluorescence in a polygonal pattern (Figure 26), and vitiligo shows no fluorescence (Figure 27). In the herpes zoster, green and purplish fluorescence are noted in the center and periphery respectively (Figure 28). Bullous pemphigoid reveals green fluorescence (Figure 29).

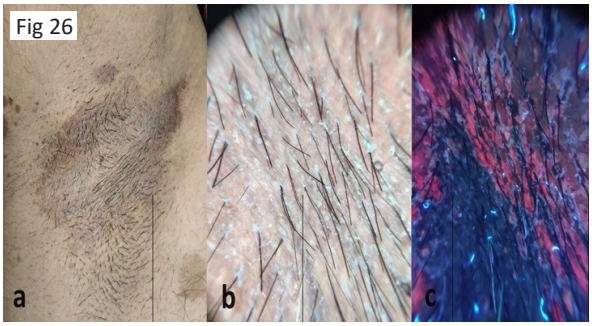
Conclusion

Dermoscopy serves as a very useful auxiliary tool in the clinical diagnosis of skin lesions. The colors of the structures and patterns in dermoscopy are the main determinants of the pathological aspects of the skin lesion, and awareness about the appropriate and contextual interpretation of the same is imperative to optimally apply dermoscopy as a diagnostic tool.









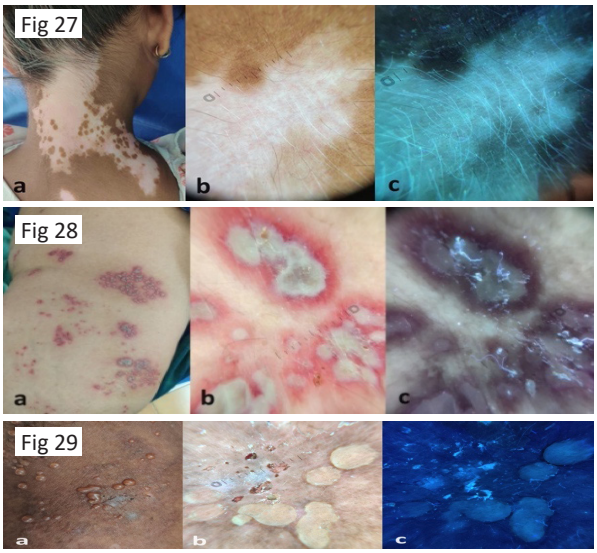


Figure 23: Dermoscopy of melanocytic nevus. (a) superficial features are prominent in parallel polarisation, (b) non-polarisation shows subtle pigmentary changes as well. (c) polarised dermoscopy reveals typical pigment network. **Figure 24:** Blue light dermoscopy of stable vitiligo. (a) White light shows poorly demarcated border and (b) blue light delineates the amelanotic area sharply. [Reused with permission from author; Nirmal B. Utility of blue light in dermoscopy for diagnosing stable lesions in vitiligo. Dermatol Pract Concept. 2021;11(1):e2021141. DOI: https://doi.org/10.5826/dpc.1101a141] **Figure 25:** Yellow light dermoscopy of rosacea. (a) White light shows vascular polygons which standout with yellow background contrast in yellow light (b). [Reused with permission from editor-in-chief; Nirmal B. Yellow Light in Dermatoscopy and Its Utility in Dermatological Disorders. Indian Dermatology Online Journal 2017 ;8(5): 384-385] **Figure 26:** Dermoscopy of erythrasma. (a) Clinical image, (b) white light dermoscopy reveals whitish scales with white concretions on the hair with brownish background. (c) Ultraviolet induced fluorescence dermoscopy shows coral red fluorescence in polygonal pattern. **Figure 27:** Dermoscopy of vitiligo. (a) Clinical image, (b) white light dermoscopy reveals white structureless area with vasculature (due to topical corticosteroid) and leucotrichia. (c) Ultraviolet induced fluorescence dermoscopy shows no fluorescence. **Figure 28:** Dermoscopy of herpes zoster. (a) Clinical image, (b) white light dermoscopy reveals whitish globular structures with brown clods in the centre with reddish rim in the periphery. (c) Ultraviolet induced fluorescence dermoscopy shows greyish-white structures with purplish rim. **Figure 29:** Dermoscopy of bullous pemphigoid. (a) Clinical image, (b) white light dermoscopy reveals yellowish polylobular structures with erosions. (c) Ultraviolet induced fluorescence dermoscopy shows bluish-white structures.

Table 1: Basic colors in dermoscopy

Color	Primary chromophores	Other tissues/pathological changes
White	Keratin	Fibrosis/sclerosis Atrophy Absence of melanin
Black	Melanin	Deoxygenated blood Thrombosed vessels
Red	Hemoglobin	Collagen (pink-red color)

Table 2: Variations of the basic colors in dermoscopy

Primary chromophores	Basic color imparted	Variations
Keratin	White	Yellow: compact dense keratin, keratin admixed with serum or contaminated Yellow-white to white: less compact or lamellated keratin Red: keratin admixed with oxygenated blood (fresh bleed) Black: keratin admixed with deoxygenated blood (old bleed) Brown/yellow-brown/coppery: keratin admixed with hemosiderin (resolving bleed)
Melanin	Black	Black: melanin in stratum corneum or upper granular layers Light brown: melanin in upper Malpighian layers Dark brown: melanin in basal layer and dermoepidermal junction Gray: melanin in papillary dermis Gray-blue: melanin in upper reticular dermis Blue-black: melanin in deep dermis (Tyndall effect)
Hemoglobin	Red	Bright red: oxygenated blood, non-thrombosed vessels blue-black: deoxygenated blood, thrombosed vessels

Table 3: Variations of the basic colors imparted by other tissues or tissue reactions

Color	Tissues or tissue reactions
Yellow	Sebaceous glands, adipose tissue, pus
Yellow-orange	Granulomatous or dense dermal cellular infiltrate
Yellow-white to white	Sparse dermal cellular infiltrate
Bright red	Extravasation of red blood cells in the dermis
Purplish red	Extravasation of red blood cells with inflammatory infiltrate
Brown/yellow-brown/coppery	Hemosiderin
Gray to grey-white	Acanthosis and hypergranulosis Necrosis

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