MASTER THESIS

A literature review of the differences between Polarized and Non-Polarized dermoscopy in the evaluation of skin lesions

Submitted by

Dr Krish Ramsay Dinesh

for the academic degree

Master of Science (MSc)

at the

Medical University of Graz

Executed as part of the

Master of Science in Dermoscopy and Preventive Dermatooncology

Under the supervision of

Professor Dr. Rainer Hofmann-Wellenhof

Melbourne, Australia

March 2023

Statutory declaration

I declare that I have written this work independently and without assistance other than those specified sources and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. The Master Thesis was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

Dr Krish Ramsay Dinesh

Melbourne, Australia

March 2023

Acknowledgements

I thank **Professor Dr. Rainer Hofmann-Wellenhof** for his constant support, encouragement, and supervision of this master thesis.

I thank **Dr Ashfaq Marghoob** for permitting me to adapt and reproduce the clinical images and tables used in this literature review.

Table of Contents

Abstract

Background

Dermoscopy is a non-invasive technique used for the visualisation of sub-surface structures in the skin. The advent of non-polarised dermoscopy devices since 2001 has led to the development of 'hybrid' dermoscopes which allows the clinicians to use either non-polarized dermoscopy (NPD) or polarized dermoscopy (PD). NPD and PD vary in their ability to visualise the various sub-surface structures.

Aim

This thesis aims to analyse the relevant scientific literature and produce a review that explains the differences between NPD and PD in their ability to visualise the various sub-surface skin structures.

Method

A literature search was performed using the following databases: PubMed, Embase, Scopus, Web of Science Core Collection and Google Scholar. Titles and abstracts were appraised to identify suitable papers. The reference lists in the chosen articles were reviewed and further publications were selected. Finally, the publications that compared the NPD and PD dermoscopy methods and also papers that reviewed the advantages or limitations of one modality over the other in showing specific lesion characteristics were included for the final literature review.

Result

NPD was found best to visualise structures in the epidermis and dermo-epidermal junction (DEJ). PD was superior to visualise deeper structures from DEJ to the superficial dermis. Structures such as shiny white lines are visualised only with PD. The difference in the optical properties of NPD and PD have been shown to be the cause of the differing ability of these modalities in visualising the various sub-surface skin structures.

Conclusion

NPD and PD offers clinicians varying but complementary information when examining skin lesions. A thorough knowledge of the optical properties and the advantages and limitations of NPD and PD will enable clinicians to use the appropriate modality for the correct diagnosis of various skin lesions and to avoid diagnostic pitfalls.

Introduction

Dermoscopy, also known as dermatoscopy, epiluminescence microscopy or skin surface microscopy is a non-invasive, in-vivo technique used for the evaluation of pigmented and non-pigmented skin lesions.[1] Over the last few years, dermoscopy has also been used for the diagnosis of dermatological disorders including inflammatory, pigmentary, and infectious dermatosis as well as the disorders of hair, scalp, and nails.

Background

One in every 3 diagnosed cancers is a skin cancer.[2] Globally, there were more than 150,000 cases of melanoma in 2022.[3] Australia has the highest incidence of melanoma in the world with an estimated 17,756 cases diagnosed in 2022.[4] This is 11% of all cancer diagnosis in Australia in 2022. The age-standardised incidence rate of melanoma has increased from 27 cases per 100,000 in 1982 to 49 per 100,000 in 2016.[5]

Meta-analysis of various studies has confirmed that in the hands of trained clinicians, dermoscopy can improve the diagnostic accuracy for melanoma.[6,7] The addition of dermoscopy to naked eye clinical examination has been shown to reduce excisions of benign pigmented lesions in both tertiary[8] and in primary care settings.[9,10]

Non-polarized dermoscopy (NPD) was the only available modality for dermoscopic examination of skin lesions until 2000. In 2001, the first non-contact dermatoscope based on the principles of cross-polarization was introduced. As polarized dermoscopy (PD) devices does not need an immersion medium between the device and skin, this enabled clinicians to quickly scan skin lesions resulting in increased efficiency.

While similar in their ability to visualize subsurface structures, NPD and PD have some important differences. NPD was found to best visualise structures in the epidermis and dermoepidermal junction (DEJ) while PD was found to be best suited to visualise deeper structures from DEJ to the superficial dermis. Some structures such as shiny white lines are only visualised with PD and cannot be seen with NPD.

This literature review explores the history of dermoscopy, the optical properties of NPD and PD, the clinical implications for clinicians using NPD and PD devices and to discuss the future of dermoscopy.

History

Dermoscopy as a speciality has grown exponentially in the last 20 years. It is now considered to be an integral part of skin examination and its reach has grown beyond the assessment of pigmented lesions to include non-pigmented lesions and various inflammatory and infective conditions. However, as with any new development in science, there were some initial scepticism and resistance to using dermoscopy among the scientific community,[11] but multiple studies have confirmed that dermoscopy improves the diagnostic accuracy,[6,7] and confidence level for pigmented,[12,13,14] and non-pigmented skin lesions.

The origins of dermoscopy could be traced to the 17th century French doctor and alchemist Dr Pierre Borel (1620-1689) who pioneered the use of microscope. He was credited with the first use of the microscope to observe the capillaries of the nail bed.[15]

In 1663, Johan Kohlhaus and in 1879 Carl Hueter reproduced these studies confirming the diagnostic use of magnifying glass under artificial light in examination of the capillaries.[16]

In 1878, Ernst Karl Abbe, a German optometrist and physician collaborated with Carl Zeiss, a manufacturer of optical systems including microscopes and telescopes,[17] pioneering the application of cedar oil instead of water to increase the resolution of microscopes. This was the foundation of immersion microscopy, which resulted in shaper, brighter and higher magnification images.

A breakthrough was achieved by Dr Paul Gerson Unna in 1893 with the publication of the paper “Diaskopie” describing the use of immersion oil for use with a microscope for skin surface microscopy.[18] He described how the skin could be made more translucent with water soluble oils and other fluids to prevent the upper layers of epidermis reflecting incident light.

The German dermatologist Johann Saphier was the first to use the word ‘dermatoskopie’ in 1920 and used a binocular microscope with a built-in light source.[18] In 1971, Dr Ronald Mackie, a Scottish doctor described the advantage of using surface microscopy for preoperative evaluation of equivocal pigmented lesions.[21]

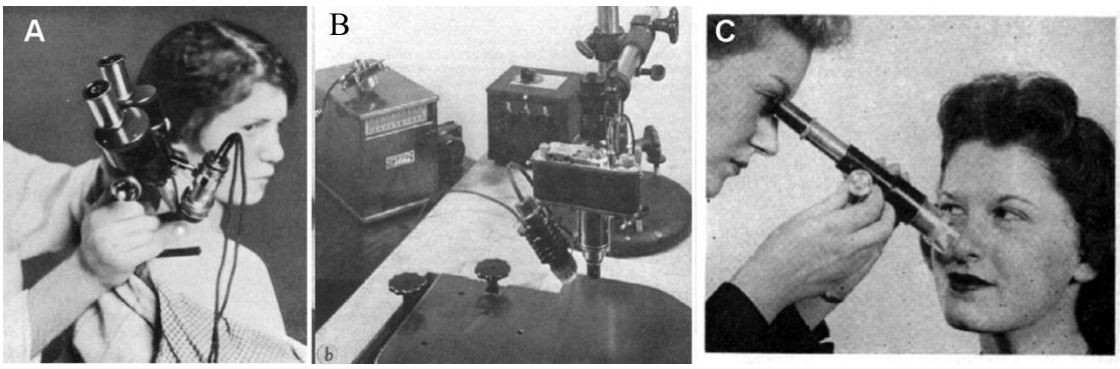


Fig.1 A-1920 dermatoscope used by Johann Saphier. B-1953 desktop dermatoscope. C-1958 portable dermatoscope without a light source.

The devices remained cumbersome until in 1989, Heine, a German company developed the world’s first handheld non-polarized dermatoscope- the Delta 10. This device was illuminated by a halogen lamp and featured an achromatic lens with 10-fold magnification.

Fig. 2 World’s first non-polarized dermatoscope- Heine Delta 10

This set off a revolution in skin lesion examination and very soon the dermatoscope became the ‘stethoscope’ of the dermatologist. In 2001, 3Gen, a California based medical device manufacturer, developed the first handheld polarized dermatoscope, the Dermlite DL100. The polarized dermatoscope, having the ability to visualise the deeper structures and not needing contact with skin, stretched the boundaries of the utilities of dermoscopy.

Fig.3 World’s first polarized dermatoscope- Dermlite DL100

In late 2022, Dermlite released the DL5, a dermatoscope that offers users the option to toggle between the traditional cross-polarization and non-polarization but also the option to use parallel or linear polarization to visualise very superficial structures such as skin markings. In a recent study,[19] the authors determined that skin markings are frequently absent or less conspicuous in dysplastic naevi and malignant skin lesions.

Components of a Dermoscope

1. Illumination System
2. Achromatic lens
3. Contact plate
4. Power supply

First generation dermatoscopes used halogen lamp illumination system which rendered a yellowish hue to the images. The more recent dermatoscopes use white-light-emitting diodes as light source which also consumes less energy when compared to the halogen lamps. The achromatic lens provides a magnification of x10 in most dermatoscopes. Contact plates are made of multicoated silicone glass and are either graduated or non-graduated. The graduated plates have a scale inscribed to measure the dimensions of the lesion examined.[20]

Unaided skin examination

Natural light when incident on objects is reflected, absorbed, or scattered. Light incident on the skin surface is normally reflected back. This phenomenon is called glare or specular reflectance. Light is reflected back because the stratum corneum has a higher refractive index of 1.55 as compared to 1.0 of air. The reflected light overwhelms the retina and renders the visualisation of the deeper structures of the skin ineffective. The clinical or naked eye examination of the skin mainly allows the assessment of the morphological appearance of the stratum corneum and to a much lesser extent, the colours, and structures of the deeper layers of the epidermis and the superficial dermis.[21]

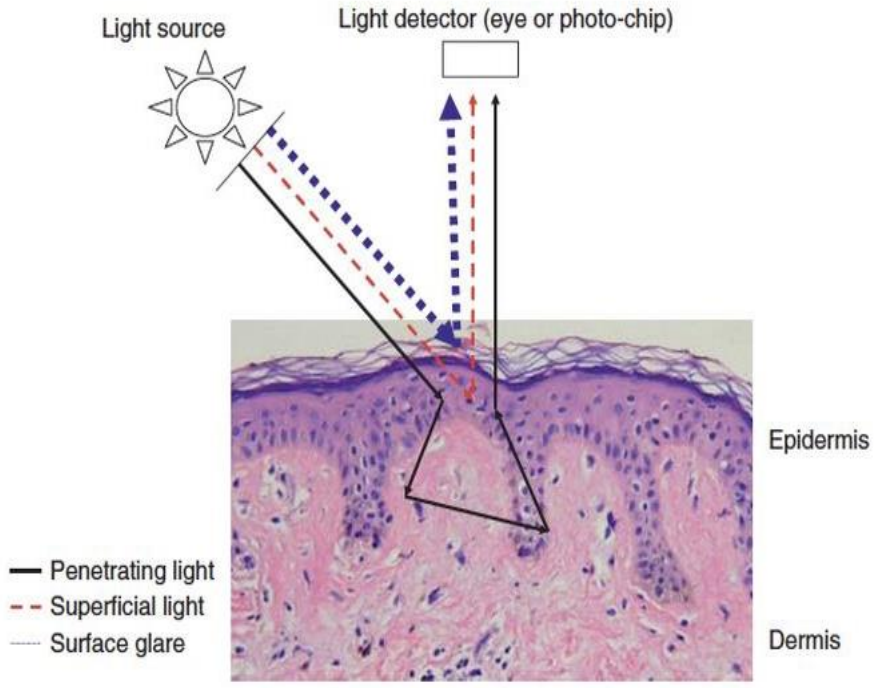


Fig.4 This figure represents the optical properties of light without the use of dermoscopy. Most of the incident light is reflected off the stratum corneum (thick blue line). Some of the light is absorbed by the superficial layers of the epidermis and is scattered only slightly (thin red line) and some of the light penetrates more deeply and undergoes more scattering events (thick black line). The light reflected off the stratum corneum overwhelms the retina and precludes the observer from visualizing the light reflected from the deeper layers of the skin (red and black lines). When the skin is examined with or without a magnifying lens, the clinician is able to see only the light that is reflected from the skin surface (thick blue line), and most of the subsurface structures remain hidden from view.

Optical principles of non-polarized dermoscopy

Non-polarized dermoscopy overcomes the problem of specular reflectance with a use of a glass plate with a refractive index of 1.52 that comes in contact with the stratum corneum. An interface fluid is used in between the glass plate and the skin. The refractive index of the fluid interface should ideally be equal to that of the skin to match it optically and minimize glare, allowing more light to penetrate through the stratum corneum. Various immersion fluids have been used that include 70% alcohol gel, ultrasound and anti-bacterial gel, water, or mineral oil. 70% alcohol was reported to be the best immersion liquid due to its anti-bacterial properties and also it yielded fewer air bubbles and provided clearer images. However, in the case of nail apparatus examination, ultrasound or anti-bacterial gels are superior to 70% alcohol, because the gel's viscosity prevents it from rolling off the convex nail surface.[21,22]

Air bubbles can get trapped between the glass plate, immersion fluid and the skin surface creating a skin-air interface. This can cause a backscattering of light rendering visualisation of

deeper structures difficult. This can be minimized by storing the gel bottles upside down, to avoid shaking the bottle and to discard the first squeeze dried gel.[21]

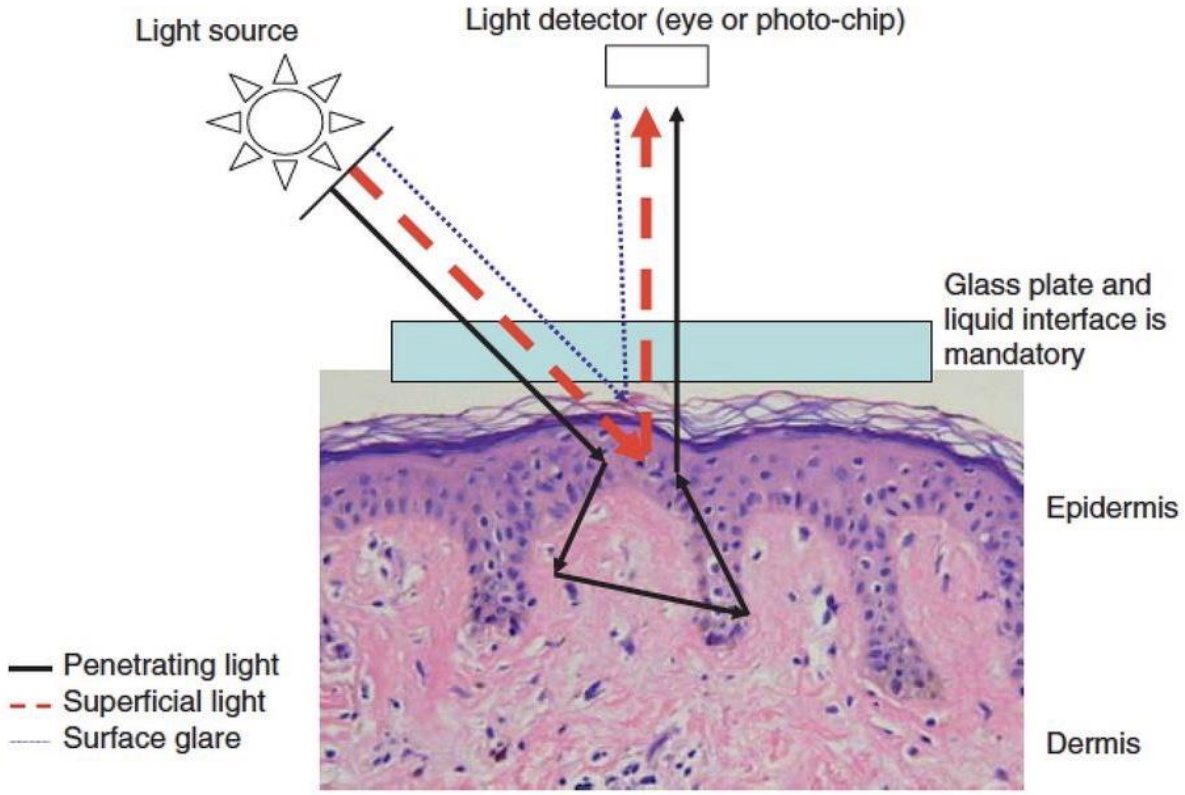


Fig.5 This figure represents the optical properties of light during the use of contact non-polarized dermoscopy (NPD) with a liquid interface. Most of the light is absorbed and reflected from the superficial layers of the epidermis after undergoing minimal scattering events (thick red line). Some of 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 the retina is from the more superficial, minimally scattered light (thick red line).

Surface glare as shown by thin blue line in the above figure is eliminated by the use of the interface fluid between the glass plate and the skin. Superficial penetrating light as shown by thick red line is the main source of contrast in NPD. The superficial penetrating light undergoes minimal scattering events and is the main source of light that is reflected back and is absorbed by melanin or reflected back by keratin in milia like cysts at the epidermis and dermo-epidermal junction. The deep penetrating light, as shown by the thick black line contributes minimally to the total back-reflected light in NPD due to decay of light by multiple scattering events in the deeper layers of the skin.[22]

Optical principles of polarized dermoscopy

Polarizers are widely used in the field of photography to reduce glare. Polarized Dermoscopy utilizes two filters held orthogonally at 90 degrees (cross-polarization). PD does not require direct contact with the skin and does not require use of immersion fluids. The more recent PD devices allow the use of contact and non-contact PD. Contact PD with use of immersion fluid can enhance image quality by eliminating surface glare.[21]

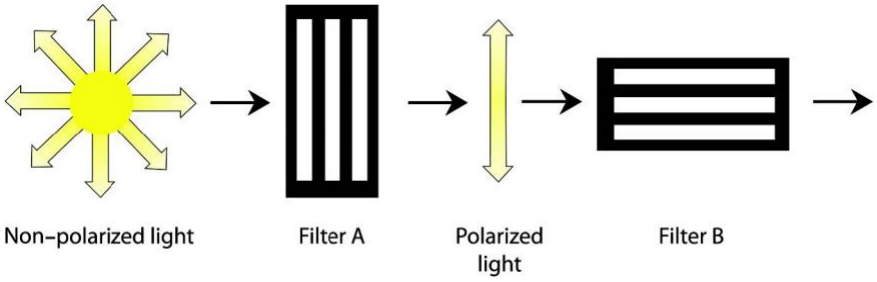


Fig.6 Light emitted from a polarized device passes through a polarizer (filter A in the image) that results in the generation of unidirectional polarized light.

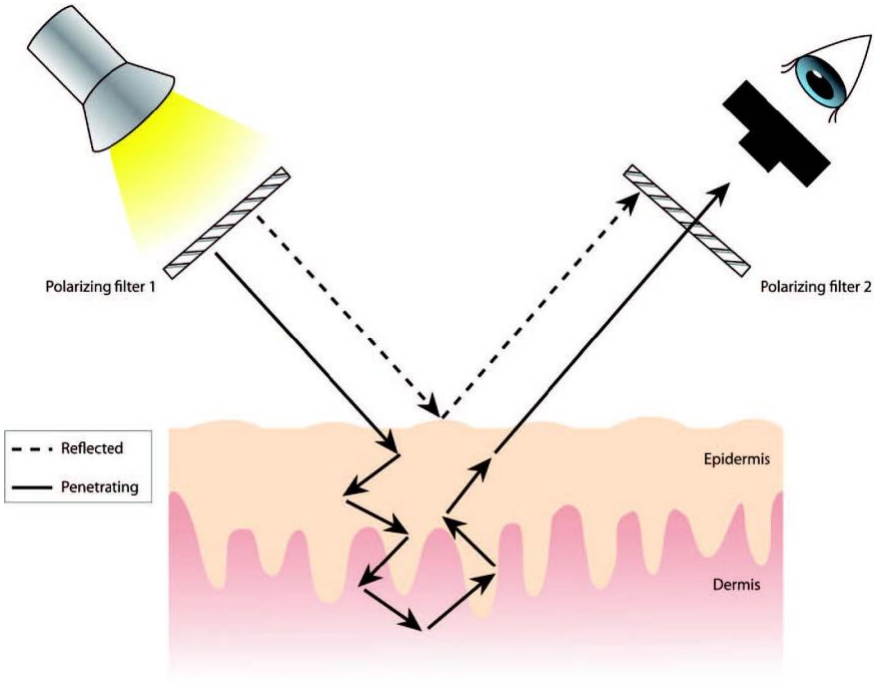


Fig.7 The light that enters the deeper layers of the skin is reflected back and is made to pass through another polarizer which is placed perpendicular to the source polarizer.

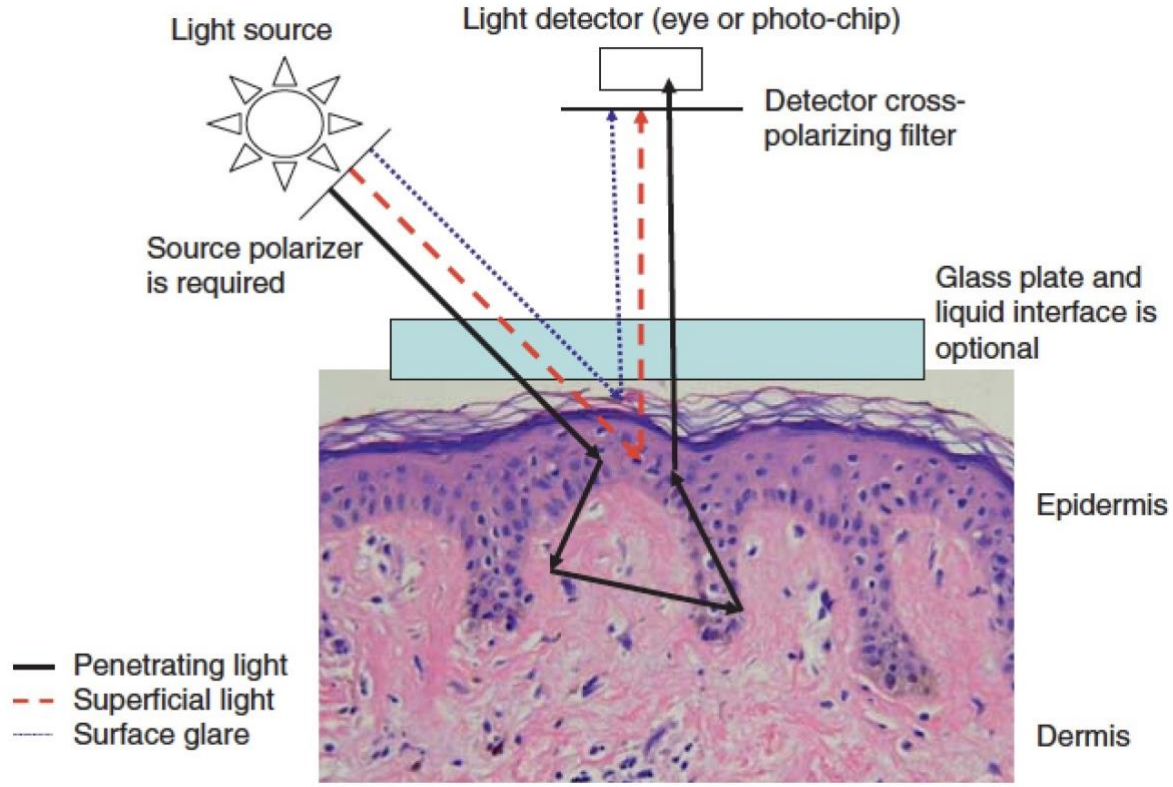


Fig.8 This figure represents the optical properties of light during the use of polarized dermoscopy (PD). Light emitted from the dermoscopy unit (source) passes through a polarizer resulting in the generation of polarized unidirectional light. Light reflected back towards the eye (detector) must first 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^{o}, which can only occur if the original polarized light begins to undergo sufficient scattering that changes its direction (randomization of polarisation). Light reflected from the stratum corneum maintains its original polarization, and thus cannot pass through the cross polarized filter (blue line). Light that is absorbed at 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. When this light is reflected back, it will be able to pass through the cross-polarization filter, thus allowing the observer to visualize the dermoscopic structures. PD does not require direct contact and a liquid interface, but some of the newer devices have the option for contact PD.

The part of light which is reflected from the skin surface (blue line) maintains its polarization and is blocked by the second filter, thus eliminating surface glare. The superficial light that manages to enter the skin (red line) does not undergo sufficient scattering events to result in randomization of polarization and hence is also blocked from entering the second polarizer. The part which penetrates the skin surface (black line) loses its polarization due to multiple

scattering events in the skin that changes its direction and hence is allowed to pass through the second filter. This is termed as cross-polarization.[21,23]

Polarized light penetrates 60-100 microns deep into the skin surface. This allows visualization of structures located at the dermal-epidermal junction or superficial dermis but are unable to visualize structures in the superficial epidermis (eg., milia like cysts or comedo like openings).[24]

Literature review search methods

The literature review was searched with the following keywords: dermoscopy, dermatoscopy, epiluminescence microscopy, skin surface microscopy, polarized dermoscopy and non-polarized dermoscopy differences and the following databases were searched: PubMed, Embase, Scopus, Web of Science Core Collection and Google Scholar. The inclusion criteria were publications in the English language, published between 1980 to 2023. The publications were further reviewed to look for papers that compared the differences between polarized and non-polarized dermoscopy and also those that looked at the advantages or limitations of these techniques in the evaluation of various skin lesions. A total of 13 original papers, 3 review articles and 2 case reports satisfied the selection criteria and were selected for the literature review.

Summary of the most relevant publications

- **Benvenuto-Andrade et al[25]- Differences Between Polarized Light Dermoscopy and Immersion Contact Dermoscopy for the Evaluation of Skin Lesions, 2007**

  One of the seminal papers that evaluated the dermoscopic features and patterns of various skin lesions by using conventional and polarized light dermoscopy. The authors explored the levels of agreement between polarized and non-polarized dermoscopic images. PD renders brown and blue colours sharper and darker, milia-like cysts and comedo-like openings, peppering, lighter colours, and blue-white structures are clearer with NPD. Vessels and vascular blush are better visualised with polarized non-contact

dermoscopy (PNCD), presumably due to the ability to assess deeper structures and avoiding pressure on the skin during examination.

- **Wang et al[26]- Differences in Dermoscopic Images from Nonpolarized Dermoscope and Polarized Dermoscope Influence the Diagnostic Accuracy and Confidence Level: A Pilot Study, 2008**

  The authors explored whether diagnostic accuracy and diagnostic confidence changes when viewing dermoscopic images from PDs and NPDs. The authors did not find any difference in diagnostic accuracy between PD and NPD for BCC but confidence in diagnosing BCC was higher for PD, likely due to better appreciation of vessels and red colour with PD. No differences were noted between PD and NPD in the diagnostic accuracy and confidence for blue naevi, haemangioma, and dermatofibroma.

- **Agero et al[27]- Conventional and Polarized Dermoscopy Features of Dermatofibroma, 2006**

  This original article evaluated the dermoscopic features and patterns of dermatofibromas using conventional and polarized light dermoscopy. The most common pattern identified with NPD and PCD was the combination of a peripheral pigmented network and a central white patch. A central patch characterized by shiny white streaks was observed with PCD. With polarized noncontact dermoscopy, the characteristic feature was a central pink hue or vascular blush.

- **Pan et al[28]- Polarized and Nonpolarized Dermoscopy- The explanation for the observed differences, 2008**

  The authors address the science behind the differences in observed structures, colours and patterns present in lesions imaged with NPD and PD. NPD better visualizes the superficial layers of the skin, identifying structures such as milia-like cysts and blue-white veil. PD is essentially blind to the superficial layers but allows better visualization of deeper structures such as vasculature and collagen.

- **Marghoob et al[29]- Observation of Chrysalis Structures with Polarized Dermoscopy, 2009**

  This publication is the first to come up with the term 'chrysalis structures' which are seen in skin lesions with an increased amount of collagen. The structures are seen as shiny, bright white, orthogonal linear streaks when examined with polarized dermoscopy. Collagen bundles have birefringent properties that cause rapid randomization of polarized light, explaining why collagen is more conspicuous under polarized dermoscopy. The authors also explained about the term 'angular dependence of polarized light' which is demonstrated by rotating the polarized dermoscope while keeping the eye stationary which will cause the chrysalis structures to appear more or less prominent depending on the angle of polarization.

- **Karminska-Winciorek et al[30]- Tips and tricks in the dermoscopy of pigmented lesions, 2012**

  The authors describe a number of practical dermoscopic methods which can be implemented to achieve a faster and more accurate diagnoses of difficult skin lesions. NPD is superior at visualizing milia-like cysts, comedo-like openings, blue-grey homogenous areas, peppering and regression areas, blue-white structures, and brightly coloured areas. PD is better at assessing vascular structures and red areas.

- **Marghoob at al[31]- Dermoscopy for the family physician, 2013**

  This review paper published in the American Family Physician journal gave a review of the science behind dermoscopy, dermoscopic structures and the pitfalls. NPD is better in visualizing superficial layers while PD visualizes deeper layers better. Chrysalis structures or shiny white structures which could help differentiate melanomas from naevi are seen only with PD and cannot be visualized under NPD.

- **Liebman et al[32]- Dermoscopic Features of Basal Cell Carcinomas: Differences in Appearance Under Non-Polarized and Polarized Light, 2012**

  This original article described a retrospective study of 149 BCCs under nonpolarized dermoscopy, polarized contact dermoscopy and polarized non-contact dermoscopy to evaluate dermoscopic features of BCCs using the various modalities and to highlight similarities and differences between the modalities. Vascular structures are more easily visualised under PNCD. Chrysalis structures are best visualized with PD. The majority of dermoscopic features seen with BCCs such as ulcerations, pigmented structures including dots, globules, spoke wheel areas, concentric structures, structureless brown-grey areas and blue-grey ovoid nests did not exhibit any major differences between the various dermoscopic modalities.

- **Liebman et al[33]- White shiny structures: dermoscopic features revealed under polarized light, 2012**

  This paper evaluated the presence of various morphologies of shiny white structures in melanoma, basal cell carcinoma (BCC), squamous cell carcinoma (SCC), actinic keratosis (AK) and lichen planus-like keratosis (LPLK) with the use of polarized dermoscopy. BCCs are significantly more likely to display a combination of shiny white areas and shiny white lines. Melanomas are more likely to display short shiny white lines in an orthogonal distribution and without shiny white areas. Actinic keratoses are most likely to exhibit rosettes.

- **Rosendahl et al[34]- Nodular melanoma: five consecutive cases in a general practice with polarized and non-polarized dermatoscopy and dermatopathology, 2013**

  This original article described a retrospective study of 5 nodular melanomas out of a total of 212 melanomas in one general practice in Australia and evaluated the diagnostic clues and dermoscopic characteristics and compared this to the published literature. 4 of the 5 nodular melanomas exhibited polarizing specific shiny white lines which was found to correspond to vertical bands of collagen in the dermis. The authors recommended that nodular lesions exhibiting polarizing specific shiny white lines

should be biopsies unless a confident specific benign diagnosis could be made on historical and clinical grounds.

- **Haspeslagh et al[35]- Rosettes and other white shiny structures in polarized dermoscopy: histological correlate and optical explanation, 2016**

  The authors attempted to estimate the frequency of rosettes in a series of 6108 consecutive skin biopsies when examined with ex vivo polarized dermoscopy. Rosettes are defined as four white points, arranged as a four-leaf clover only observed with polarized dermoscopy. The authors concluded from the study that rosettes are not lesion specific and are seen in a wide variety of skin lesions and inflammatory conditions. The smaller rosettes are mainly caused by polarizing horny material in adnexal openings and the larger rosettes by concentric perifollicular fibrosis.

- **Gulseren and Hofmann-Wellenhof[36]- Evaluation of dermoscopic criteria for seborrheic keratosis on non-polarized versus polarized dermoscopy, 2019**

  The authors aimed to explore the differences between polarized dermoscopy (PD) and non-polarized dermoscopy (NPD) in the diagnosis of seborrheic keratosis (SK). The authors concluded that the two methods are compatible with each other in diagnosing seborrheic keratoses. NPD is better in assessing milia-like cysts, comedo-like openings, sharp demarcation, and a mica-like pattern. In contrast, PD is better in visualizing hairpin vessels, dotted vessels, glomerular vessels, a moth-eaten border, network like structures and shades of colours.

- **Manci et al[19]- Skin markings to differentiate benign from malignant lesions: A prospective observational study, 2022**

  This most recent publication explores the concept of linear polarization for the evaluation of the presence or absence of skin markings. Previous research has suggested that loss of skin markings may indicate cutaneous malignancy, but the practical application of this concept is uncommon. The authors determined that skin markings are frequently less conspicuous or are absent, compared to the non-lesional surrounding

skin in dysplastic naevi and malignant lesions, but often similar to the non-lesional surrounding skin in benign lesions. The authors further suggested that it might be beneficial to replace non-polarized lenses with linear-polarized lenses in conventional dermatoscopes in future.

Discussion

This literature search has confirmed that although for most pigmented and non-pigmented skin lesions, polarized dermoscopy (PD) and non-polarized dermoscopy (NPD) offer similar images, there are some important differences between the two modalities.

	Nonpolarized	*Polarized*
Factor	*Classic contact dermoscopy*	*Contact and noncontact dermoscopy*
Technique	Requires a liquid interface and direct contact between the scope and the skin	Although it can be used in contact or noncontact mode, and can be used with or without a liquid interface, direct contact and liquid interface provide superior image clarity
Skin layers	Superficial layers are better visualized	Deep layers of epidermis and papillary dermis (depth of polarized light approximately 60 to 100 μm) are better visualized
Colors and structures	Blue-white veil due to orthokeratosis is more conspicuous	Pink and red colors are more conspicuous
	Milia-like cysts and comedo-like openings are more conspicuous	Milia-like cysts and comedo-like openings are less conspicuous
	Steel blue color in blue nevi appears more homogeneous	Blue color in blue nevi will appear darker, with differing hues
	Regression structures (peppering, blue-white areas, and gray color) are more conspicuous	White scar-like areas are more conspicuous
	Ability to visualize vascular structures depends on the amount of pressure applied to the skin	Vascular structures and collagen are more conspicuous
	White shiny structures cannot be visualized adequately	White shiny streaks, also known as crystalline structures, are more conspicuous

Table 1. Differences between Nonpolarized and Polarized Dermoscopy

Table reproduced with permission of Dr Ashfaq Marghoob

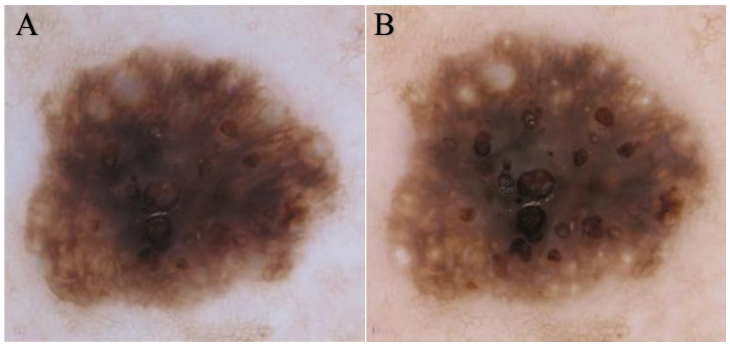


Fig.9 Seborrheic Keratosis seen with polarized (A) and non-polarized (B) dermoscopy. Milia like cysts and comedo like openings are better visualized with non-polarized dermoscopy.

Images reproduced with permission from Dr Ashfaq Marghoob

	NPD	PCD	PNCD
Colors			
Melanin pigment	+	++	++
Red or pink	+	++	++++
Blue-white	+++	++	+
Structures			
Peppering	+++	++	+
Shiny-white streaks	+/–	+++	++
Blood vessels	+	++	++++
Milialike cysts and comedolike openings	++++	+/–	+/–
Patterns			
Homogeneous blue pattern of a blue nevus	Homogeneous blue color	Heterogeneous with different shades of blue	Heterogeneous with different shades of blue

Abbreviations: NPD, nonpolarized light contact dermoscopy; PCD, polarized light contact dermoscopy; PNCD, polarized light noncontact dermoscopy.

Table 2. Differences between Non-polarized dermoscopy, polarized contact dermoscopy and polarized non-contact dermoscopy. Reproduced with permission from Dr Ashfaq Marghoob.

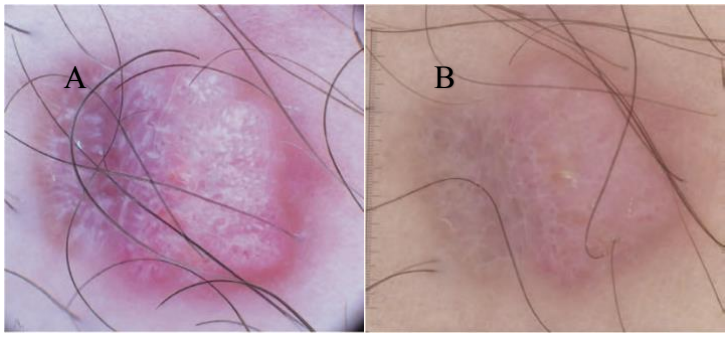


Fig.10 An amelanotic melanoma seen with polarized (A) and non-polarized (B) dermoscopy. The shiny white structures are only visualized with polarized dermoscopy.
Images reproduced with permission from Dr Ashfaq Marghoob

Naked eye examination of skin lesions permits only a few morphological features to be visualised whereas a dermatoscope can reveal many subsurface features which help the clinician in the correct identification of the skin lesion. These include colour, structures, pigmentation, milia-like cysts, comedo-like openings, blue-white veil, peppering, vascularization, vascular blush, and shiny white structures. Every skin lesion, whether benign or malignant has a certain set of characteristics by which they are identifiable, and the correct use of PD and NPD increases the sensitivity and specificity in identifying the lesion.[21]

Colours

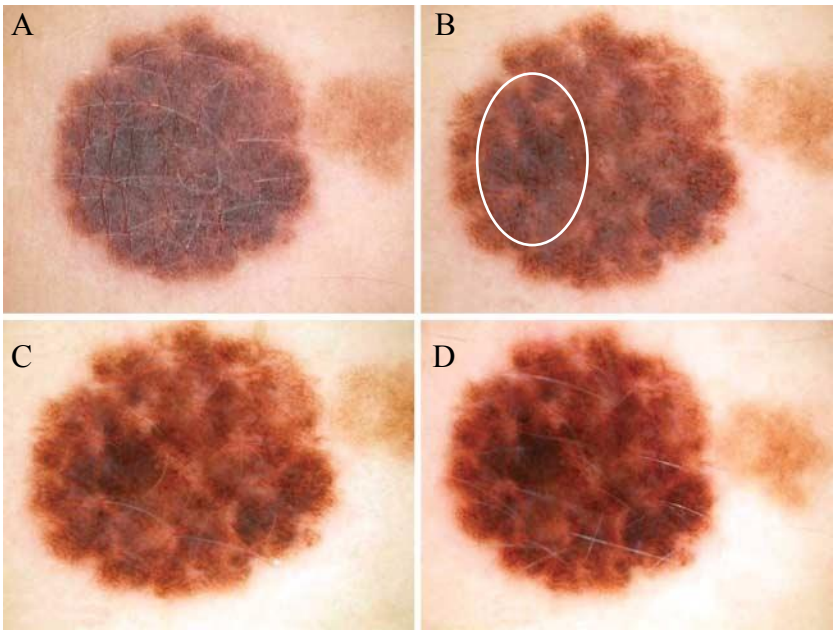


Fig.11 A dysplastic nevus shown by clinical photography (A), nonpolarized light contact dermoscopy (NPD) (B), polarized light contact dermoscopy (C), and polarized light non-contact dermoscopy (D). The dark-brown colors are more prominent under polarized light dermoscopy, and more light-brown colors are seen under NPD. In the NPD image there is a blue-white veil (highlighted by a oval), which is less prominent to almost absent in the polarized dermoscopy images.

Images reproduced with permission from Dr Ashfaq Marghoob

Colours are visualized differently with PD compared to NPD. PD displays melanin pigment with varying and darker shades of brown and blue compared with NPD.

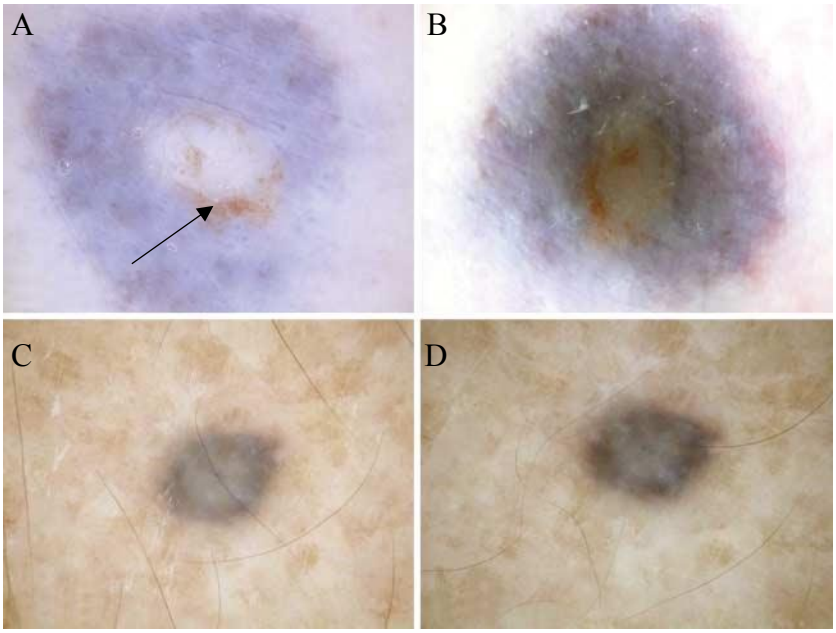
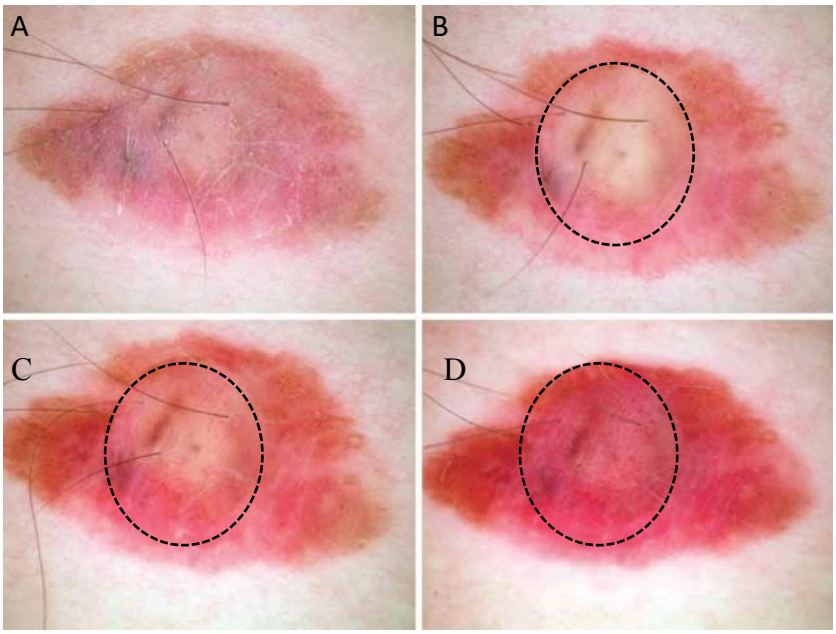


Fig.12 Appearance of congenital blue nevus (A and B) and conventional blue nevus (C and D) under nonpolarized light dermoscopy (NPD) (A and C) and polarized light contact dermoscopy (PCD) (B and D). These lesions show the classic steel-blue color under NPD, but on PCD images the color was replaced with multiple shades of blue and brown. Also, milia-like cysts are present in the congenital blue nevus when viewed with NPD (arrow in A) but are no longer visible under polarized dermoscopy (B).

Images reproduced with permission from Dr Ashfaq Marghoob

PD displays blue nevi with more shades of darker blue, with less blue-gray and blue-white veil-type areas compared to NPD. PD renders blue nevi more concerning with darker blue shades and this has implications for clinical management of these lesions.[25]

Pink colour is more evident with PD. This is partly due to the ability of PD to visualise structures in the dermis but also due to fact that pressure applied on the skin with the NPD device can compress blood vessels obliterating the vascular blush. As little as 18 mm Hg pressure can blanch out the blood volume within the lesion.[21] As PD devices does not require direct contact with the skin, blood vessels and pink colour are more evident with this mode.[21] However, the improved vascular blush seen with PD in lesions with dense vascularity could mask melanin distribution and other pigment structures.



Images reproduced with permission from Dr Ashfaq Marghoob

Fig.13 An amelanotic 1.6-mm melanoma (dotted circle) arising in a dysplastic nevus shown by clinical photography (A), nonpolarized light contact dermoscopy (NPD) (B), polarized light contact dermoscopy (PCD) (C), and polarized light noncontact dermoscopy (PNCD) (D). The dermoscopic structure that aids most in correctly identifying this lesion is the irregular polymorphic vessels, which are much more prominent under polarized dermoscopy (C and D). More vessels can be seen under PNCD (D) than PCD (C). Also, a prominent vascular blush (pink veil) is seen under PNCD and not PCD or NPD.

Hypomelanotic and amelanotic skin tumours are commonly featureless and the identification of polymorphic vessel pattern is an important clue for their diagnosis. Non-contact polarized dermoscopy (NCPD), with no pressure on the skin from the device, help identify the presence, quantity, distribution, and shape of blood vessels increasing the sensitivity in diagnosing these malignant tumours.[25]

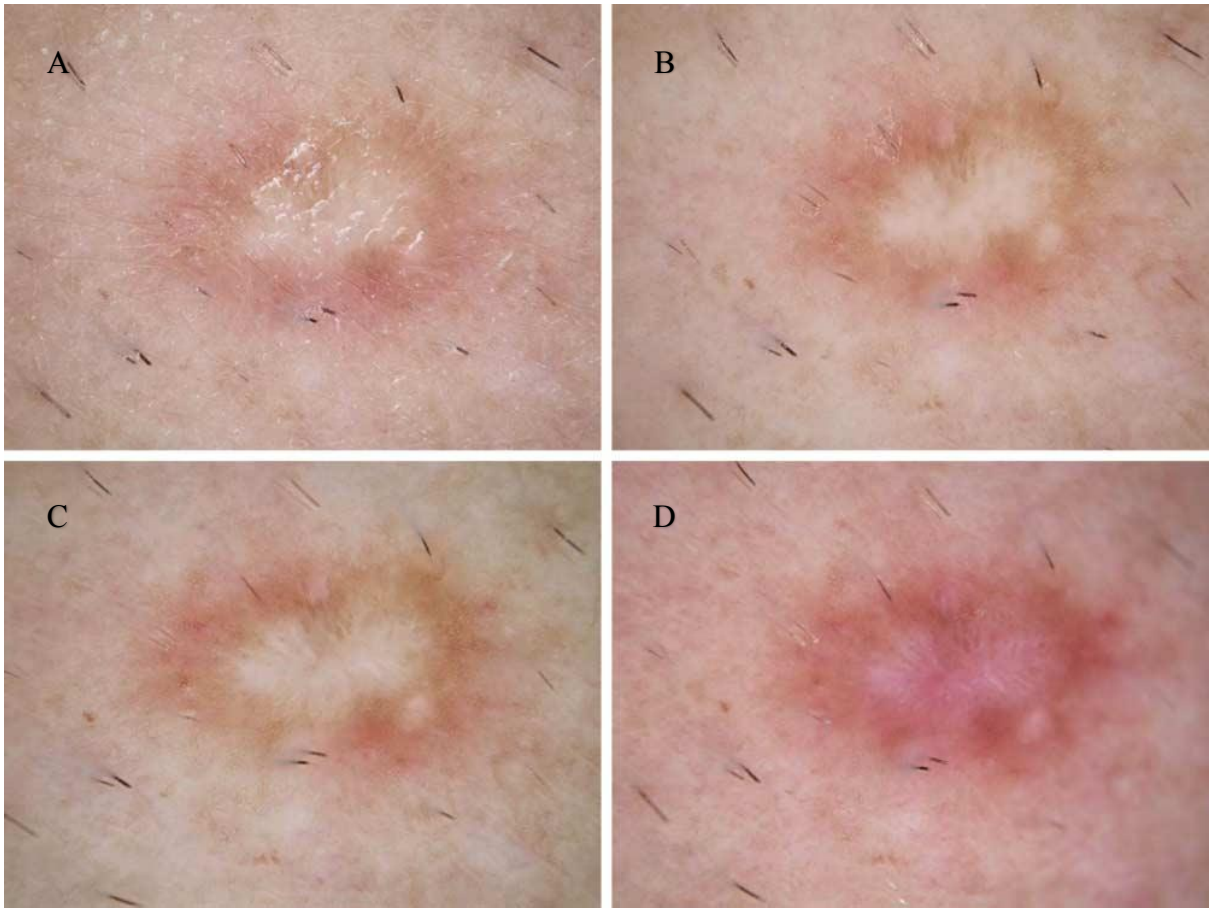


Fig.14 Images of a classic dermatofibroma obtained using 3 methods. A, Close-up clinical image. B, Nonpolarized contact dermoscopic image. C, Polarized light contact dermoscopic image. D, Polarized light noncontact dermoscopic image. Note that the central patch appears pink and shows the shiny white lines under polarized noncontact dermoscopy.

Images reproduced with permission from Dr Ashfaq Marghoob

Dermatofibromas have a pale central area when seen with NPD, but they appear to have a pink central area with PD.[27] Clinicians need to aware of this difference to avoid misdiagnosis of these benign lesions.

Lighter colours and blue-white veil are better appreciated under NPD. The whitish veil due to orthokeratosis is better visualized with NPD due to their epidermal location.[21]

Structures

Superficial structures such as milia-like cysts and comedo-like openings are best visualized with NPD. The blocking of superficial component of light by PD diminishes the visualization of superficial structures.[24]

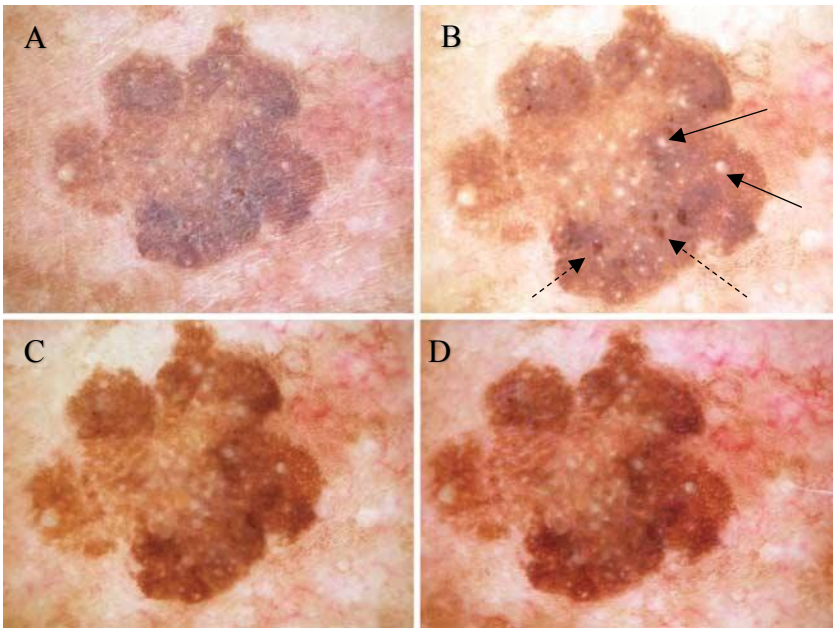


Fig.15 A seborrheic keratosis shown by clinical photography (A), nonpolarized light contact dermoscopy (NPD) (B), polarized light contact dermoscopy (C), and polarized light non-contact dermoscopy (D). The NPD image clearly shows multiple comedo-like openings (dotted arrows in B)
and milia-like cysts (solid arrows in B). In the polarized images the comedo-like openings and milia-like cysts are difficult to appreciate.

Images reproduced with permission from Dr Ashfaq Marghoob

Milia-like cysts are commonly seen in seborrheic keratoses (SK) and congenital naevi and reduced visualization of these structures with PD may affect the clinical diagnosis of SK.[25] However, a more recent study[36] concluded that they could not recommend one modality over the other for the dermoscopic examination of SK. The authors suggested the methods are complementary.

Regression is seen as blue-gray granularity (peppering). This is due to the presence of free melanin in the dermis or within melanophages in the superficial dermis.

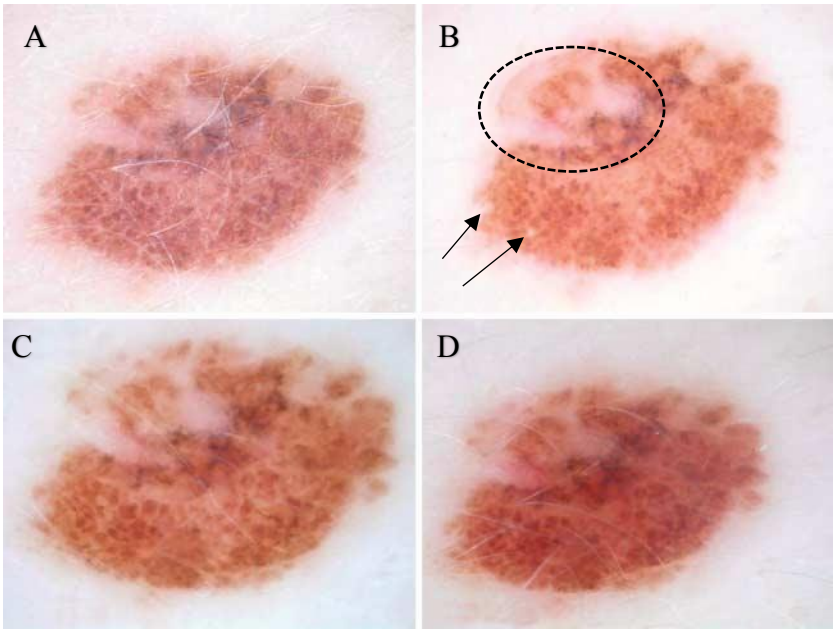


Fig.16 A congenital melanocytic nevus shown by clinical photography (A), non-polarized light contact dermoscopy (NPD) (B), polarized light contact dermoscopy (C) and polarized light non-contact dermoscopy (D). Notice the prominent regression structures, with peppering and blue-white veil, in the NPD image (B, dotted oval). In addition, milia-like cysts
(arrows) can be seen in the NPD image. The regression structures become less prominent and the
Milia-like cysts can no longer be seen under polarized dermoscopy.

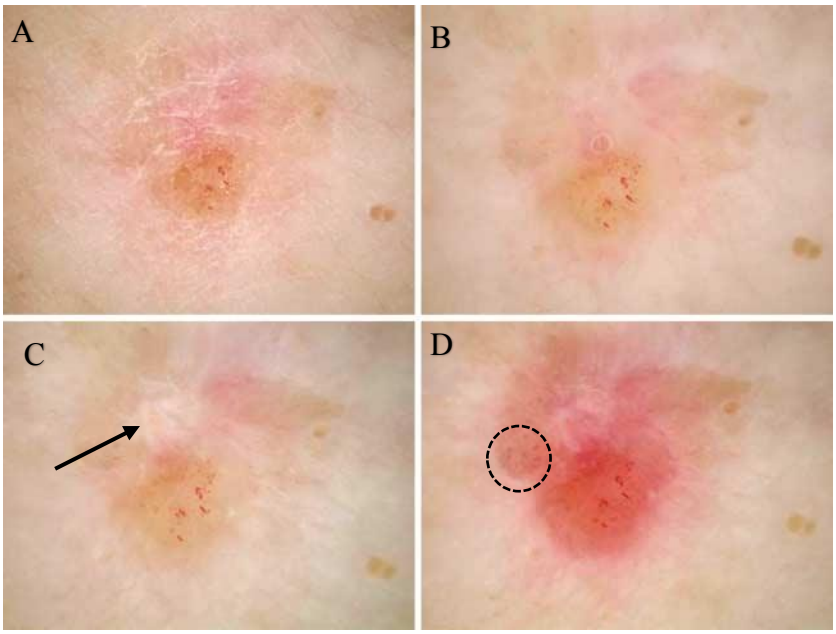
Images reproduced with permission from Dr Ashfaq Marghoob

Peppering is slightly more conspicuous with NPD, although this will vary depending on the thickness of the skin and the location of melanin within the dermis. For instance, peppering located in the superficial papillary dermis within thin sun damaged skin of the face will be better seen with NPD.[21]

Another explanation is the small gray dots seen in peppering appear darker with PD, almost giving a brownish hue. In some instances, the gray colour seen in peppering disappear when seen with PD as the surrounding pigment appear darker with this modality.[25]

Peppering, along with blue-white areas, is an important dermoscopic finding and attenuation of this sign by PD has important clinical implications.

The majority of dermoscopic features seen with BCCs such as ulcerations, pigmented structures including dots, globules, spoke wheel areas, concentric structures, structureless brown-grey areas and blue-grey ovoid nests did not exhibit any major differences between the various dermoscopic modalities.



Images reproduced with permission from Dr Ashfaq Marghoob

Fig.17 A basal cell carcinoma shown by clinical photography (A), nonpolarized light contact dermoscopy (NPD) (B), polarized light contact dermoscopy (PCD) (C), and polarized light non-contact dermoscopy (PNCD) (D). The PNCD image (D) shows blood vessels (dotted circle) that are not seen under NPD (B) or PCD (C). A prominent vascular blush (pink veil) is present throughout the lesion on PNCD (D) and is not visible in the NPD or PCD images (B and C, respectively). Shiny-white stellate streak-like areas can be seen in the PCD image (arrow). These shiny-white areas, which often have a stellate or streak-like appearance, are not usually seen under NPD dermoscopy but can usually be seen under PCD and PNCD. In this lesion, the shiny-white areas are seen clearly in the PCD image (arrow in C) but not in the PNCD image (D) because they are obscured by the prominent vascular blush.

However, vascular structures are best visualized with PNCD, and shiny white structures seen with BCCs are only seen with PD.[32]

Shiny white structures

A separate category of dermoscopic structures called shiny white structures are visualized only with PD. These include short shiny white lines, shiny white blotches and strands and rosettes. These are not visualized with NPD. This has been explained due to the unique optical properties of polarized light.[21]

Collagen bundles have birefringent properties that cause a rapid randomization of polarized light which makes the structure appear bright white. The ability of collagen to rotate polarized light depends on the orientation of the collagen fibres. The shiny white lines seen with polarized light display only two orthogonal orientations, so rotating the dermoscope on its axis with PD will make some shiny white lines disappear while a new set of lines appear with all lines maintaining their orthogonal orientation.[29]

Shiny white lines are commonly seen in dermatofibromas, scars, spitz naevi, BCCs and particularly in melanomas.

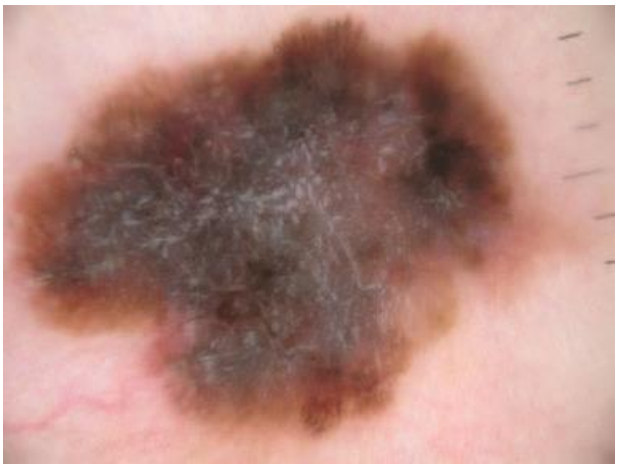


Fig.18 Shiny white lines (crystalline lines) in an orthogonal orientation in melanoma under polarized contact dermoscopy (PCD).
Image reproduced with permission from Dr Ashfaq Marghoob

It has been postulated that these polarizing specific lines are seen in melanomas due to changes in the composition and orientation of collagen in the stroma and this collagen remodelling has been deemed important for the invasion of tumour cells into the dermis.[29]

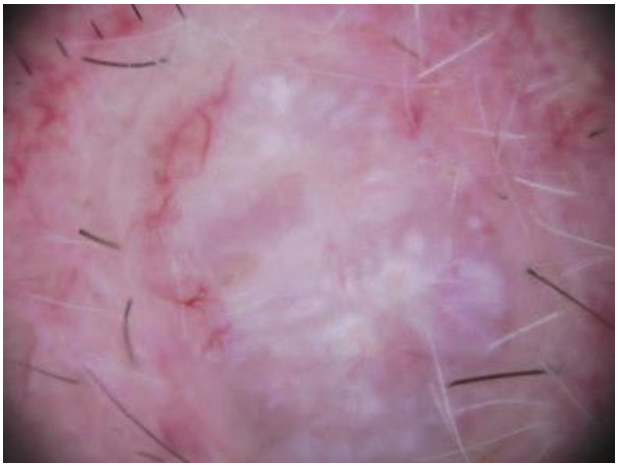


Fig.19 White shiny areas in a basal cell carcinoma under polarized contact dermoscopy (PCD)
Image reproduced with permission from Dr Ashfaq Marghoob

The shiny white blotches and strands seen in BCCs are thought to be due to a combination of mucin and BCC matrix and not due to collagen.[21]

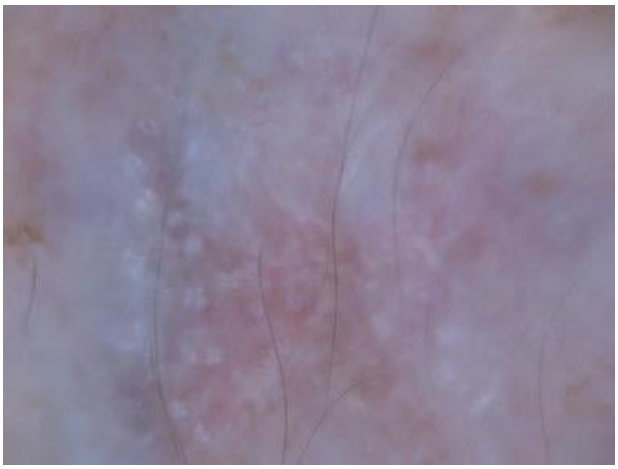


Fig.20 Rosettes in a squamous cell carcinoma under polarized contact dermoscopy (PCD)
Image reproduced with permission from Dr Ashfaq Marghoob

Rosettes are defined as four white points, arranged as a four-leaf clover.[37] This polarizing specific finding is seen only with PD in many tumoral and inflammatory skin lesions and is not lesion specific. However, they are more common in sun damaged skin. Smaller rosettes are caused by polarizing horny material in adnexal openings whereas larger rosettes are caused by concentric perifollicular fibrosis.[35]

Trichoscopy

Trichoscopy is now a well-established technique of visualising hair shafts, follicles and the adjoining epidermis using a dermatoscope. A study investigated the differences in visualizing trichoscopy characteristics using both NPD and PNCD.[38] Generally, trichoscopy features are better seen with PNCD but black dots and broken hairs are better visualized with NPD.

General Dermatoses

The histopathology of many inflammatory and infectious dermatoses is associated with alterations of vascular structures, cellular infiltrations, and epidermal thickness, in contrast to skin tumours where pigment deposition is the primary feature. Non-polarized dermoscopy has the potential to alter the underlying vascular structures due to the pressure applied at skin contact. Hence, for assessment of inflammatory dermatoses, polarized non-contact dermoscopy is highly recommended.[40] It has to be emphasised that this is the opinion of the authors based on clinical experience and there is a dearth of high-quality studies that have compared polarized and non-polarized dermoscopy for the evaluation of general dermatoses.

Diagnostic accuracy and clinical confidence

Dermoscopy has been proven to improve the clinician's diagnostic accuracy[6,7] and clinical confidence[39] for pigmented[12,13,14] and non-pigmented skin lesions. However, the study by Wang et al[26] has highlighted that differences between PD and NPD can impact on the diagnostic accuracy and confidence levels in diagnosing skin lesions.

The study showed statistically significant differences in the diagnosis of seborrheic keratosis (SK), atypical naevus (AN) and melanoma arms. Diagnostic accuracy for assessment of seborrheic keratosis was best with NPD compared with PD (75% vs 59%, P-value <0.0001). This is due to the inability of PD to accurately visualize milia-like cysts and comedo-like openings.

The diagnostic accuracy for assessment of melanoma is better with PD compared with NPD (34% vs 23%, P-value 0.0008). Amelanotic or featureless melanomas are identified mainly due to the presence of dotted or polymorphous blood vessels, vascular blush and sometimes by the presence of shiny white lines. These structures are best visualized with PD and are often difficult or impossible to visualize with NPD.

The study also showed that clinical confidence in diagnosing seborrheic keratosis and atypical naevus is better with NPD compared with PD images. For BCCs, clinical confidence is better when viewing images with PD compared to NPD images. This could be due to telangiectasia and vascular blush being easily identifiable with PD compared to NPD.

Diagnostic accuracy and confidence levels in the assessment of blue naevi, haemangiomas and dermatofibromas showed no difference when examined with NPD verses PD.

The study concluded that NPD and PD appear to provide different but complementary information. The strengths and weaknesses of each modality could be utilized by the clinicians to improve the diagnoses of various skin lesions.

Conclusion

PD and NPD provides complementary and synergistic information. NPD facilitates viewing structures from the stratum corneum to the DEJ, whereas PD highlights structures from DEJ to the superficial dermis.

PD provides maximum sensitivity for detecting a dermatological malignancy while NPD provides maximum specificity by helping to identify benign lesions.[21] Using both of these modalities with an understanding of the underlying optical properties helps clinicians to achieve the highest diagnostic accuracy and avoiding potential misdiagnosis of skin lesions.

The most recent dermatoscopes such as the Dermlite DL5 offers the full gamut of polarization from non-polarization to 4 grades of cross-polarization and 4 grades of linear polarization to visualise the skin surface markings. Hybrid dermatoscopes such as these can be used with direct contact to the skin with a liquid interface to visualize all depths of the skin by choosing the desired modality.

Dermatoscopes for use by the general public, such as Sklip[41] are designed to be attached to a smartphone. These devices capture images with dermoscopic details which are sent virtually to their clinical providers for assessment and advice and utilize artificial intelligence to analyse the images. Concepts such as these has the potential to revolutionize skin cancer screening by widening the use of dermatoscopes outside healthcare settings.

Artificial Intelligence (AI) has already been shown to outperform dermatologists in dermoscopic melanoma diagnosis.[42] AI assisted dermoscopy might be the next frontier in our battle to conquer the melanoma epidemic the world is witnessing.

References

1. Sonthalia S, Kaliyadan F. Dermoscopy Overview and Extradiagnostic Applications [Internet]. PubMed. Treasure Island (FL): StatPearls Publishing; 2020 [cited 2023 March 18]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537131/
2. World Health Organization. Radiation: Ultraviolet (UV) radiation and skin cancer [Internet]. www.who.int. 2017 [cited 2023 March 18]. Available from: https://www.who.int/news-room/questions-and-answers/item/radiation-ultraviolet-(uv)-radiation-and-skin-cancer
3. Skin cancer statistics | World Cancer Research Fund International [Internet]. WCRF International. [cited 2023 March 18] Available from: https://www.wcrf.org/cancer-trends/skin-cancer-statistics/#:~:text=Latest%20skin%20cancer%20data
4. http://www.canceraustralia.gov.au. Melanoma of the skin statistics | Cancer Australia [Internet].Canceraustralia.gov.au.2019 [cited 2023 March 18] Available from: https://www.canceraustralia.gov.au/cancer-types/melanoma/statistics#:~:text=In%202022%2C%20it%20is%20estimated%20that%20a%20person%20has%20a
5. Australian Institute of Health and Welfare. Skin cancer in Australia, Summary - Australian Institute of Health and Welfare [Internet]. Australian Institute of Health and Welfare. 2016 [cited 2023 March 18].Available from: https://www.aihw.gov.au/reports/cancer/skin-cancer-in-australia/summary
6. Kittler H, Pehamberger H, Wolff K, Binder M. Diagnostic accuracy of dermoscopy. The Lancet Oncology [Internet]. 2002 [cited 2023 March 18];3(3):159–65.Available from: https://www.ncbi.nlm.nih.gov/pubmed/11902502
7. Bafounta ML, Beauchet A, Aegerter P, Saiag P. Is Dermoscopy (Epiluminescence Microscopy) Useful for the Diagnosis of Melanoma? Archives of Dermatology. 2001 Oct 1;137(10).
8. van der Rhee J, Bergman W, Kukutsch N. Impact of Dermoscopy on the Management of High-risk Patients From Melanoma Families: A Prospective Study. Acta Dermato Venereologica. 2011;91(4):428–31.
9. Menzies SW, Emery J, Staples M, Davies S, McAvoy B, Fletcher J, et al. Impact of dermoscopy and short-term sequential digital dermoscopy imaging for the management

of pigmented lesions in primary care: a sequential intervention trial. British Journal of Dermatology. 2009 Dec;161(6):1270–7.

10. Koelink CJL, Vermeulen KM, Kollen BJ, de Bock GH, Dekker JH, Jonkman MF, et al. Diagnostic accuracy and cost-effectiveness of dermoscopy in primary care: a cluster randomized clinical trial. Journal of the European Academy of Dermatology and Venereology. 2013 Nov 7;28(11):1442–9.
11. Skin surface microscopy: Anything new under the sun? The Lancet. 1989 Jun;333(8649):1239.
12. Carli P, De Giorgi V, Crocetti E, Mannone F, Massi D, Chiarugi A, et al. Improvement of malignant/benign ratio in excised melanocytic lesions in the "dermoscopy era": a retrospective study 1997-2001. British Journal of Dermatology. 2004 Apr;150(4):687–92.
13. Salerni G, Terán T, Puig S, Malvehy J, Zalaudek I, Argenziano G, et al. Meta-analysis of digital dermoscopy follow-up of melanocytic skin lesions: a study on behalf of the International Dermoscopy Society. Journal of the European Academy of Dermatology and Venereology. 2012 Nov 26;27(7):805–14.
14. Vestergaard ME, Macaskill P, Holt PE, Menzies SW. Dermoscopy compared with naked eye examination for the diagnosis of primary melanoma: a meta-analysis of studies performed in a clinical setting. The British Journal of Dermatology [Internet]. 2008 Sep 1 [cited 2023 March 18];159(3):669–76. Available from: https://pubmed.ncbi.nlm.nih.gov/18616769/
15. Guiote Domínguez MV, Kieselová K. História da Dermatoscopia. Journal of the Portuguese Society of Dermatology and Venereology. 2016 Aug 3;74(2):117–22.
16. W Stolz, Braun-Falco O. Color atlas of dermatoscopy. Berlin: Blackwell Wissenschafts-Verlag; 2002; P.3-5.
17. Braun RP, Rabinovitz HS, Oliviero M, Kopf AW, Saurat JH. Dermoscopy of pigmented skin lesions. Journal of the American Academy of Dermatology. 2005 Jan;52(1):109–21.
18. Kittler H, Rosendahl C, Cameron A, Philipp Tschandl. Dermatoscopy. 2016; P.9.
19. Manci R, Marchetti MA, Dusza SW, Dauscher M, Marghoob AA. Skin markings to differentiate benign from malignant lesions: A prospective observational study. Journal of the American Academy of Dermatology. 2021 Aug;

20. Khopkar U, Nischal K. Dermoscope. Indian Journal of Dermatology, Venereology and Leprology. 2005;71(4):300.
21. Marghoob AA, Jaimes N, Braun R. Atlas of Dermoscopy. CRC Press; 2022. P.2-6.
22. Non polarized dermoscopy - dermoscopedia [Internet]. Dermoscopedia.org. [cited 2023 Mar22].Availablefrom:https://dermoscopedia.org/w/index.php?title=Non_polarized_dermoscopy&oldid=17032.
23. Polarized dermoscopy - dermoscopedia [Internet]. Dermoscopedia.org. [cited 2023Mar22].Availablefrom:https://dermoscopedia.org/w/index.php?title=Polarized_dermoscopy&oldid=17042.
24. Nirmal B. Dermatoscopy: Physics and principles. Indian Journal of Dermatopathology and Diagnostic Dermatology. 2017;4(2):27.
25. Benvenuto-Andrade C, Dusza SW, Agero ALC, Scope A, Rajadhyaksha M, Halpern AC, et al. Differences Between Polarized Light Dermoscopy and Immersion Contact Dermoscopy for the Evaluation of Skin Lesions. Archives of Dermatology. 2007 Mar 1;143(3).
26. Wang SQ, Dusza SW, Scope A, Braun RP, Kopf AW, Marghoob AA. Differences in Dermoscopic Images from Nonpolarized Dermoscope and Polarized Dermoscope Influence the Diagnostic Accuracy and Confidence Level: A Pilot Study. Dermatologic Surgery. 2008 Jul 14;34(10):1389–95.
27. Agero ALC, Taliercio S, Dusza SW, Salaro C, Chu P, Marghoob AA. Conventional and Polarized Dermoscopy Features of Dermatofibroma. Archives of Dermatology. 2006 Nov 1;142(11).
28. Pan Y, Gareau DS, Scope A, Rajadhyaksha M, Mullani NA, Marghoob AA. Polarized and Nonpolarized Dermoscopy. Archives of Dermatology. 2008 Jun 1;144(6).
29. Marghoob AA, Cowell L, Kopf AW, Scope A. Observation of Chrysalis Structures with Polarized Dermoscopy. Archives of Dermatology. 2009 May 1;145(5).
30. Kaminska-Winciorek G, Spiewak R. Tips and tricks in the dermoscopy of pigmented lesions. BMC Dermatology. 2012 Aug 24;12(1).
31. Marghoob AA, Usatine RP, Jaimes N. Dermoscopy for the family physician. Am Fam Physician. 2013;88(7):441-450.
32. Liebman TN, Jaimes-Lopez N, Balagula Y, Rabinovitz HS, Wang SQ, Dusza SW, et al. Dermoscopic Features of Basal Cell Carcinomas: Differences in

Appearance Under Non-Polarized and Polarized Light. Dermatologic Surgery. 2012 Mar;38(3):392–9.

33. Liebman TN, Rabinovitz HS, Dusza SW, Marghoob AA. White shiny structures: dermoscopic features revealed under polarized light. Journal of the European Academy of Dermatology and Venereology. 2011 Oct;26:1493-97.
34. Rosendahl C, Hishon M, Cameron A, Barksdale S, Weedon D, Kittler H. Nodular melanoma: five consecutive cases in a general practice with polarized and non-polarized dermatoscopy and dermatopathology. Dermatology Practical & Conceptual [Internet]. 2014 Apr 30;4(2):69–75. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4029260/#:~:text=The%20incidence%20of%20nodular%20melanoma
35. Haspeslagh M, Noë M, De Wispelaere I, Degryse N, Vossaert K, Lanssens S, et al. Rosettes and other white shiny structures in polarized dermoscopy: histological correlate and optical explanation. Journal of the European Academy of Dermatology and Venereology. 2015 Mar 19;30(2):311–3.
36. Gülseren D, Hofmann-Wellenhof R. Evaluation of dermoscopic criteria for seborrheic keratosis on non-polarized versus polarized dermoscopy. Skin Research and Technology. 2019 May 22.
37. Cuellar F, Vilalta A, Puig S, Palou J, Salerni G. New Dermoscopic Pattern in Actinic Keratosis and Related Conditions. Archives of Dermatology. 2009 Jun 1;145(6).
38. Nikam V, Mehta H. A Nonrandomized study of trichoscopy patterns using nonpolarized (contact) and polarized (noncontact) dermatoscopy in hair and shaft disorders. International Journal of Trichology. 2014;6(2):54.
39. Benvenuto-Andrade c, Dusza SW, Hay JL, Agero ALC, Halpern AC, Kopf AW, et al. Level of Confidence in Diagnosis: Clinical Examination Versus Dermoscopy Examination. Dermatologic Surgery. 2006 May;32(5):738–44.
40. Aimilios Lallas, Enzo Errichetti, Dīmī́tros Iōannidīs, Taylor. Dermoscopy in general dermatology. Boca Raton I 2 Pozostałe: Crc Press Taylor & Francis Group; 2019.
41. SKLIP – Artificial Intelligence for Skin Cancer Detection [Internet]. [cited 2023 Mar 25]. Available from: https://sklip.ai/
42. Pham TC, Luong CM, Hoang VD, Doucet A. AI outperformed every dermatologist in dermoscopic melanoma diagnosis, using an optimized deep-

CNN architecture with custom mini-batch logic and loss function. Scientific Reports [Internet]. 2021 Sep 1 [cited 2022 Jan 4];11(1):17485. Available from: https://www.nature.com/articles/s41598-021-96707-8