IMAGING IN DERMATOLOGY

Edited by

MICHAEL R. HAMBLIN

PINAR AVCI

GAURAV K. GUPTA

ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Academic Press is an imprint of Elsevier

Academic Press is an imprint of Elsevier
125 London Wall, London EC2Y 5AS, United Kingdom
525 B Street, Suite 1800, San Diego, CA 92101-4495, United States
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom

Notices
Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-0-12-802838-4

Publisher: Mica Haley
Editorial Project Manager: Lisa Eppich
Production Project Manager: Edward Taylor
Designer: Mark Rogers

Typeset by TNQ Books and Journals

Dedication

To the love of my life, my beautiful wife Angela, to whom I have been devoted for 36 years.

Michael R. Hamblin

To Ari, Afsin, Atul, Thao, Thomo, Theo, Yair and Zehra whose advice, encouragement and support have been genuine and precious.

Pinar Avci

To my parents, Dr. Ram P Gupta and Sudha Gupta, and my best friend and loving wife, Dr. Tanupriya Agrawal.

Gaurav K. Gupta

List of Contributors

J. Aguirre Institute of Biological and Medical Imaging, Helmholtz Zentrum München, Neuherberg, Germany

I. Alarcon Ramon y Cajal Hospital, Madrid, Spain

A. Alavi Hospital of the University of Pennsylvania, Philadelphia, PA, United States

Z. Apalla Aristotle University, Thessaloniki, Greece

G. Argenziano Second University of Naples, Naples, Italy

P. Avci Harvard Medical School & Massachusetts General Hospital, Boston, MA, United States

V. Beylergil Metrohealth Campus of Case Western University, Cleveland, OH, United States

M. Bonmarin Zurich University of Applied Sciences, Winterthur, Switzerland

A.C. Bourgeois The University of Tennessee Graduate School of Medicine, Knoxville, TN, United States

Y.C. Bradley The University of Tennessee Graduate School of Medicine, Knoxville, TN, United States

S.A. Burkes University of Cincinnati, Cincinnati, OH, United States

C.H. Camp, Jr. National Institute of Standards and Technology, Gaithersburg, MD, United States

S. Campos Hospital de Santo António dos Capuchos, Centro Hospitalar de Lisboa Central, Lisboa, Portugal

G.C. Casazza University of Utah School of Medicine, Salt Lake City, Utah, United States

F. Castagnetti Arcispedale Santa Maria Nuova-IRCCS, Reggio Emilia, Italy

G. Charles-Edwards Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom; King's College London, London, United Kingdom

K. Chen Nanyang Technological University, Singapore

R. Cicchi National Institute of Optics, National Research Council (INO-CNR), Sesto Fiorentino, Italy; European Laboratory for Non-linear Spectroscopy (LENS), Sesto Fiorentino, Italy

A. Doronin University of Otago, Dunedin, New Zealand

K.P. Eaton University of Cincinnati, Cincinnati, OH, United States

B.M. Erovic Medical University of Vienna, Vienna, Austria

C.L. Evans Harvard Medical School & Massachusetts General Hospital, Boston, MA, United States

S. Fardin Hospital of the University of Pennsylvania, Philadelphia, PA, United States

D.L. Farkas Spectral Molecular Imaging Inc., Beverly Hills, CA, United States; University of Southern California, Los Angeles, CA, United States

X. Feng University of Massachusetts, Lowell, MA, United States

S. Gardini Arcispedale Santa Maria Nuova-IRCCS, Reggio Emilia, Italy

S. Gholami Hospital of the University of Pennsylvania, Philadelphia, PA, United States

K.E. Göbel University Medical Center Freiburg, Freiburg im Breisgau, Germany; University of Freiburg, Freiburg im Breisgau, Germany

V. Goh Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom; King's College London, London, United Kingdom

S. González Ramon y Cajal Hospital, Madrid, Spain; Universidad de Alcalá, Madrid, Spain; Instituto Ramón y Cajal de Investigación Sanitaria (IRYCIS), Madrid, Spain; Memorial Sloan-Kettering Cancer Center, New York, NY, United States

N. Griffin Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom

G. Guan University of Dundee, Dundee, Scotland, United Kingdom; University of Washington, Seattle, WA, United States

G.K. Gupta Harvard Medical School & Massachusetts General Hospital, Boston, MA, United States

M.R. Hamblin Harvard Medical School & Massachusetts General Hospital, Boston, MA, United States

J. Hegyi Inštitút klinickej a experimentálnej dermatovenerológie, Bratislava, Slovakia

V. Hegyi Inštitút klinickej a experimentálnej dermatovenerológie, Bratislava, Slovakia

H.W. Higgins II Brown University, Providence, RI, United States

D. Ho University of California at Davis, Sacramento, CA, United States; Sacramento VA Medical Center, Mather, CA, United States

Z. Huang University of Dundee, Dundee, Scotland, United Kingdom

D. Ioannides Aristotle University, Thessaloniki, Greece

S.L. Jacques Oregon Health & Science University Portland, OR, United States

J. Jagdeo University of California at Davis, Sacramento, CA, United States; Sacramento VA Medical Center, Mather, CA, United States; State University of New York Downstate Medical Center, Brooklyn, NY, United States

N. Jain Kaya Skin Clinic, Mumbai, India

G.B.E. Jemec Zealand University Hospital, Roskilde, Denmark

L. Kadletz Medical University of Vienna, Vienna, Austria

D. Kapsokalyvas European Laboratory for Non-linear Spectroscopy (LENS), Sesto Fiorentino, Italy

U. Khopkar Kaya Skin Clinic, Mumbai, India

E. Kraeva Sacramento VA Medical Center, Mather, CA, United States

A. Lallas Aristotle University, Thessaloniki, Greece

E. Lazaridou Aristotle University, Thessaloniki, Greece

T.K. Lee BC Cancer Agency, Vancouver, BC, Canada; Vancouver Coastal Health Research Institute and University of British Columbia, Vancouver, BC, Canada

F.A. Le Gal Geneva University Hospital, Geneva, Switzerland

A. Lencastre Hospital de Santo António dos Capuchos, Centro Hospitalar de Lisboa Central, Lisboa, Portugal

R.M. Levenson UC Davis Medical Center, Sacramento, CA, United States

C. Li University of Dundee, Dundee, Scotland, United Kingdom; University of Washington, Seattle, WA, United States

Q. Liu Nanyang Technological University, Singapore

C. Longo Arcispedale Santa Maria Nuova-IRCCS, Reggio Emilia, Italy

H. Lui University of British Columbia and Vancouver Coastal Health Research Institute, Vancouver, BC, Canada; BC Cancer Agency, Vancouver, BC, Canada

N. MacKinnon Spectral Molecular Imaging Inc., Beverly Hills, CA, United States

A. Mamalis University of California at Davis, Sacramento, CA, United States; Sacramento VA Medical Center, Mather, CA, United States

I. Markhvida Vancouver Coastal Health Research Institute and University of British Columbia, Vancouver, BC, Canada

D.I. McLean University of British Columbia and Vancouver Coastal Health Research Institute, Vancouver, BC, Canada; BC Cancer Agency, Vancouver, BC, Canada

I. Meglinski University of Otago, Dunedin, New Zealand; University of Oulu, Oulu, Finland

M.M. Monroe University of Utah School of Medicine, Salt Lake City, Utah, United States

A.J. Moy University of Texas at Austin, Austin, TX, United States

V.A. Neel Massachusetts General Hospital, Boston, MA, United States

S.F. Nemec Medical University of Vienna, Vienna, Austria

V. Ntziachristos Institute of Biological and Medical Imaging, Helmholtz Zentrum München, Neuherberg, Germany

M. Omar Institute of Biological and Medical Imaging, Helmholtz Zentrum München, Neuherberg, Germany

Y.H. Ong Nanyang Technological University, Singapore

J.R. Osborne Memorial Sloan Kettering Cancer Center, New York, NY, United States; Weill-Cornell Medical College, New York, NY, United States

Alexandru D.P. Papoiu Therapeutics Inc., San Diego, CA, United States

A.S. Pasiak The University of Tennessee Graduate School of Medicine, Knoxville, TN, United States; The University of Tennessee Medical Center, Knoxville, TN, United States

F.S. Pavone National Institute of Optics, National Research Council (INO-CNR), Sesto Fiorentino, Italy; European Laboratory for Non-linear Spectroscopy (LENS), Sesto Fiorentino, Italy

G. Pellacani University of Modena and Reggio Emilia, Modena, Italy

J.A. Perez Memorial Sloan Kettering Cancer Center, New York, NY, United States

B. Peters University Hospital Antwerp, Edegem, Belgium; AZ Sint-Maarten, Mechelen-Duffel, Belgium

B.W. Petersen Brown University, Providence, RI, United States

S. Piana Arcispedale Santa Maria Nuova-IRCCS, Reggio Emilia, Italy

M. Ragazzi Arcispedale Santa Maria Nuova-IRCCS, Reggio Emilia, Italy

R. Randall Wickett University of Cincinnati, Cincinnati, OH, United States

A.H. Rook Hospital of the University of Pennsylvania, Philadelphia, PA, United States

C. Rowlands Massachusetts Institute of Technology

M. Schwarz Institute of Biological and Medical Imaging, Helmholtz Zentrum München, Neuherberg, Germany

A. Sidoroff Medical University of Innsbruck, Innsbruck, Austria

P.T.C. So Massachusetts Institute of Technology; Laser Biomedical Research Center; Singapore-MIT Alliance for Science and Technology (SMART) Center

L. Tchvialeva Vancouver Coastal Health Research Institute and University of British Columbia, Vancouver, BC, Canada

L. Themstrup Zealand University Hospital, Roskilde, Denmark

J.W. Tunnell University of Texas at Austin, Austin, TX, United States

F.M. Vanhoenacker University Hospital Antwerp, Edegem, Belgium; AZ Sint-Maarten, Mechelen-Duffel, Belgium; University Hospital Ghent, Ghent, Belgium

F. Vasefi Spectral Molecular Imaging Inc., Beverly Hills, CA, United States

M.O. Visscher University of Cincinnati, Cincinnati, OH, United States

H. Wang Harvard Medical School & Massachusetts General Hospital, Boston, MA, United States

L.V. Wang Washington University in St. Louis, St. Louis, Missouri, United States

R. Wang University of Washington, Seattle, WA, United States

T.J. Werner Hospital of the University of Pennsylvania, Philadelphia, PA, United States

O. Westerland Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom

X. Wortsman University of Chile, Santiago, Chile

A.N. Yaroslavsky University of Massachusetts, Lowell, MA, United States; Massachusetts General Hospital, Boston, MA, United States

E. Yew Singapore-MIT Alliance for Science and Technology (SMART) Center

C. Yuen Nanyang Technological University, Singapore

H. Zeng University of British Columbia and Vancouver Coastal Health Research Institute, Vancouver, BC, Canada; BC Cancer Agency, Vancouver, BC, Canada

J. Zhao University of British Columbia and Vancouver Coastal Health Research Institute, Vancouver, BC, Canada; BC Cancer Agency, Vancouver, BC, Canada

Y. Zhou Washington University in St. Louis, St. Louis, Missouri, United States

CHAPTER

1

Introduction to Imaging in Dermatology

M.R. Hamblin, P. Avci, G.K. Gupta

Harvard Medical School & Massachusetts General Hospital, Boston, MA, United States

OUTLINE

Dermatology is one of the most important medical specialties. The prevalence of skin diseases exceeds that of obesity, hypertension, and cancer added together [1]. Skin disease accounts for 12.4% of primary care visits in the United States, and it is estimated that one out of three people in the United States has a skin disease at any given time. Although the number of dermatologists has grown more quickly than the US population (increasing from 1.9 to 3.2 per 100,000 persons between 1970 and 2010, respectively) [2], there is still considered to be an overall shortage of dermatologists [3].

The origins of dermatology have always relied heavily on visual observation of the skin. In *The Canon of Medicine* by Avicenna (who was also known as Ibn Sina) written in Persia in 1025, treatments were described for a variety of skin conditions, including skin cancer [4]. In 1572, Girolamo Mercuriale published in Venice, Italy, *De morbis cutaneis (On the Diseases of the Skin)*, considered to be first scientific work to be devoted to dermatology [5]. Daniel Turner, who was born in London, received the first doctoral degree from the College of the Academy of Yale in Connecticut in the American colonies (later to become the United States) [6]. Interestingly, Turner also published a book of the same name *De morbis cutaneis*, subtitled *A Treatise of Diseases Incident to the Skin* in 1712. This work was the first book published in English devoted to dermatology [7]. In 1777 Anne-Charles Lorry (1726–1783) published the 700 page *Tractatus de morbis cutaneis* and for the first time referred to the skin as an organ [8]. Jean-Louis Alibert (1768–1837) was a pioneer of dermatology in France. Alibert was personal physician to Louis XVIII and Charles X, and was appointed Professor of Materia Medica and Therapeutics in Paris in 1823 [9]. Alibert introduced a classification system for skin diseases that became known as the "Tree of Dermatoses." He produced the first illustrated atlas of dermatology called *Descriptions des maladies de la peau: observées à l'Hôpital Saint-Louis, et exposition des meilleures méthodes suivies pour leur traitement* in 1806 [10]. The Vienna School of Dermatology was founded by Ferdinand von Hebra in the mid-19th century [11] and became the one of leading academic centers for the study of dermatology.

In the last half of the 19th century and going on into the 20th century, dermatopathology assumed an increasingly important role in dermatology, and microscopic examination of biopsies became the gold standard for diagnosis of a wide range of dermatological conditions. However, now that we are well into the 21st century, this status quo may be beginning to change. One of the main reasons for this change is the almost unbelievable rise in the use of noninvasive imaging in (almost) all branches of medicine.

The origin of this explosive growth in medical imaging can be traced back to the discovery of X-rays. Wilhelm Conrad Röntgen (1845–1923) discovered this highly penetrating form of radiation in 1895, and called them *X-rays* (signifying an unknown quantity), although many others referred to them as "Röntgen rays." Röntgen was awarded the Nobel Prize for Physics in

http://dx.doi.org/10.1016/B978-0-12-802838-4.00001-7

1901. It did not take long before the new science of radiology was put to practical use. In the Greco-Turkish war of 1897, battlefield radiographic imaging was used to detect bullets in injured soldiers. The radiographs were produced by an apparatus manufactured by the London company Miller and Woods, that was then shipped to Piraeus in 15 crates and powered by electricity from accumulators (a forerunner of lead-sulfuric acid batteries) [12].

In the same year as Röntgen's discovery, Henri Becquerel (1852–1908, Professor of Physics at Muséum National d'Histoire Naturelle in Paris) was studying phosphorescent uranium salts. He initially thought that the penetrating radiation he found was phosphorescence emission from the salt produced by exposure to bright sunlight, but soon realized that the radiation came from the uranium itself without any external excitation. This discovery of radioactivity earned him the Nobel Prize in Physics in 1903 in conjunction with Marie Curie and her husband Pierre Curie [13].

For the first half of the 20th century radiographs remained the only widely employed imaging modality. In the 1950s nuclear medicine emerged as a medical specialty after radionuclides (radioactive isotopes) were first produced for medical use by the Oak Ridge National Laboratory in Tennessee. The development of the rectilinear scanner and the gamma scintillation camera helped establish nuclear medicine as a fully developed medical imaging specialty [14].

Conventional tomography (rotating the X-ray tube and the film synchronously in opposite directions) had been described in a patent issued in 1922 to the French dermatologist Andre Bocage (1892–1953) [15]. However, it was not until development of sufficient computing power in the 1970s that radiographic computed tomography (CT) emerged as the one of the dominant imaging modalities with its ability to image soft tissue as well as bone. The first CT scan took place on a patient with a suspected frontal lobe brain tumor in 1971 at Atkinson Morley's Hospital, in London, England. The patient was scanned with a prototype scanner developed by Godfrey Hounsfield and his team at EMI Central Research Laboratories in Hayes [16].

Professor Isidor I. Rabi (1898–1988), while working in the Pupin Physics Laboratory in Columbia University, New York City, in 1937 observed the quantum phenomenon dubbed *nuclear magnetic resonance (NMR).* He discovered that atomic nuclei (particularly hydrogen atoms) will absorb and emit radio waves when exposed to a sufficiently strong magnetic field. He received the Nobel Prize in Physics in 1944 for this work [17]. Raymond Vahan Damadian (born on March 16, 1936) is an American of Armenian origin, credited with being the inventor of the principle of the magnetic resonance imaging (MRI) device [18]. His research into sodium and potassium in living cells led him to his first experiments with NMR, which caused him to first propose the MR body scanner in 1969. Damadian discovered that tumors and normal tissue could be distinguished in vivo by NMR because of the longer relaxation times in tumors, both T1 (spin-lattice relaxation) or T2 (spin–spin relaxation) [19]. Damadian was the first to perform a full body scan of a human being in 1977 to diagnose cancer. However Damadian's point scanning approach called *field focused NMR (FONAR)* was time-consuming, and it was the rival device of Paul C. Lauterbur and Sir Peter Mansfield, which was based on field gradients and was able to provide linear localization, that eventually succeeded. In a controversial decision, the Nobel Committee awarded the Nobel Prize in Physiology or Medicine of 2003 to Lauterbur and Mansfield only, whereas Damadian was excluded [20]. It was remarked upon by commentators that the Nobel citation was able to include up to three recipients.

Positron emission tomography (PET) is a nuclear medicine imaging technique that produces a three-dimensional image of active processes occurring in the body. The system detects pairs of gamma rays emitted when a positron emitted from a particular type of radionuclide isotope decomposes. The PET isotope is introduced into the body as a tracer by tagging it to a biologically active molecule. Three-dimensional images of tracer concentration within the body are then constructed by computer analysis. In modern PET-CT scanners, three-dimensional imaging is enabled with the aid of a concurrent CT radiography scan performed on the patient in the same machine [21]. In 1953, Sweet and Brownell reported the use of positron-emitting isotopes to localize brain tumors [22], The use of 2-fluoro-2-deoxy-D-glucose (^{18}F) as a glucose-analog tracer was introduced by a collaborative group consisting of Martin Reivich, David Kuhl, and Abass Alavi at the Hospital of the University of Pennsylvania and Alfred Wolf at Brookhaven National Laboratory [23]. The compound was first administered to two normal human volunteers by Alavi in August 1976 at the University of Pennsylvania. Brain images obtained with an ordinary (non-PET) nuclear scanner demonstrated the concentration of ^{18}F-fluorodeoxyglucose (FDG) in that organ [24]. The PET-CT scanner was developed by Dr. David Townsend, Dr. Ronald Nutt, et al. [25] and was named by *Time Magazine* as the medical invention of the year in 2000.

Ultrasound as used for diagnostic imaging is called *ultrasonography.* English-born physicist John Wild (1914–2009) first used ultrasound to assess the thickness of bowel tissue as early as 1949 [26]; he has been described as the "father of medical ultrasound" [27]. Professor Ian Donald et al. at the Glasgow Royal Maternity Hospital were the first to use ultrasound to diagnose live volunteer patients with abdominal masses [28].

Donald and Dr. James Willocks then refined their techniques to obstetrical applications including fetal head measurement to assess the size and growth of the fetus [29].

Optical imaging covers such a large field that it is difficult to decide what was the first medical application. Could it be said that the introduction of spectacles in 1270, in Florence, Italy was the first use of optical imaging in medicine? Or the introduction in 1590 of the compound microscope by the father and son team of Hans and Zacharias Janssen in the Netherlands? It is more likely that optical imaging (as understood by the general scientific community) and the application of biomedical optics to diagnose various diseases, came to prominence with the discovery of optical coherence tomography (OCT) in the 1990s [30], although there had been a variety of fluorescence and other simple optical imaging techniques being sporadically explored for many years earlier. Now there are many sophisticated optical imaging methodologies being studied and explored for diagnosis, such as in vivo confocal microscopy [31], optical frequency domain imaging [32], diffuse optical imaging [33], fluorescence tomography [34], Brillouin microscopy [35], Cerenkov imaging [36], polarization sensitive techniques [37], photoacoustic techniques [38], and so on.

The present volume attempts to gather together information on the use of a variety of medical imaging technologies applied to the general area of dermatology.

This text book has been divided into eight broad sections. The first section describes simple optical imaging modalities including dermoscopy, trichoscopy, and onychoscopy that are routinely used in clinical practice. In Chapter 2, Sidoroff discusses the current function and role of clinical photography in dermatology. In Chapter 3, Lallas et al. provide an overview of the basic dermoscopic findings seen in melanocytic and nonmelanocytic tumors, as well as the inflammatory and infectious skin diseases. In Chapter 4, Khopkar and Jain highlight the diagnostic features of noncicatricial and cicatricial alopecias and genetic hair shaft disorders, as well as psoriasis and seborrheic dermatitis. In Chapter 5, Lencastre and Campos describe dermatoscopic findings in tumors of the nail apparatus as well as bacterial and fungal nail infections and inflammatory nail diseases. Themstrup and Jemec, in Chapter 6, review applications of OCT in nonmelanoma skin cancer, with an emphasis on basal cell carcinoma and actinic keratosis. In Chapter 7, Mamalis et al. focus on a specific application of OCT, assessment of skin fibrosis. In Chapter 8, Lee at al. discusse the utilization of interference and polarization techniques for evaluation of skin roughness, which aids in differentiating melanoma from other benign skin lesions, such as seborrheic keratoses. In Chapter 9, Hegyi and Hegyi cover the use of fluorescence in the detection and localization of poorly demarcated skin lesions. In Chapter 10, Longon et al. describe the clinical applications of the novel imaging technique of ex vivo fluorescence confocal microscopy (FCM). In Chapter 11, Wang and Evans describe coherent Raman scattering, microscopy which provides not only the morphological/structural information of the skin, but also the chemical and molecular information. Zhao et al., in Chapter 12, present a rapid real-time Raman system and an imaging-guided confocal Raman system, both of which can be utilized for in vivo skin evaluation. Chen and associates, in Chapter 13, introduce the concept of surface-enhanced Raman spectroscopy and discuss how nontoxic nanoscale substrates and a variety of strategies can bring the substrates and target molecules together for intradermal measurements. In Chapter 14, Camp gives an overview of broadband coherent anti-Stokes Raman scattering microspectroscopy. In Chapter 15, Alarcon et al. describe reflectance confocal microscopy, which enables the analysis of the skin horizontally with a nearly histological resolution. Hyperspectral and multispectral imaging in dermatology is described by Vasefi et al. in Chapter 16. Hyperspectral imaging generates a three-dimensional data cube that contains absorption, reflectance, or fluorescence spectrum data for each image pixel. Moy and Tunnell, in Chapter 17, cover diffuse reflectance spectroscopy and its applications in dermatology, including skin cancer, port wine stain, erythema, sunscreen evaluation, and burns. Moreover, future directions combining diffuse reflectance with other optical methods are also presented. In Chapter 18, Ho et al. provide a broad description of spectral imaging in vivo and ex vivo skin specimens. So et al. discusse the uses of multiphoton imaging to study skin immunoresponse, aging, and regeneration in Chapter 19. In Chapter 20, Cicchi et al. mainly describe use of two-photon microscopy, second-harmonic generation microscopy, and their combination for differentiation of epidermal layers and characterization of the skin dermis. In Chapter 21, Jacques highlights the principles of confocal reflectance and polarized light imaging. Yaroslavsky et al. give an overview of polarization optical imaging of skin pathology and aging in Chapter 22. Huang et al.define mechanical characterization of skin using surface acoustic waves, a novel combination of phase-sensitive OCT technology with a simple mechanical impulse surface wave stimulation in Chapter 23. In Chapter 24, Zhou and Wang discuss use of photoacoustic tomography of both primary and metastatic melanomas. Wortsman summarizes use of ultrasound in detection of common skin, nail, and hair diseases in Chapter 25. Raster scan optoacoustic mesoscopy, a high-resolution optical imaging technique that can penetrate several millimeters in tissues is described by Schwarz et al. in Chapter 26.

Chapter 27 by Petersen and Higgins explicates the use of total body photography and serial digital dermoscopy in dermatology. Papoiu introduces utilization of functional MRI in detection of brain processing of itch in Chapter 28. In Chapter 29, Gobel provides an overview of MRI of skin. Westerland et al. discusse a specific application of MRI in the management of anogenital hidradenitis suppurativa in Chapter 30. Bonmarin and Gal, in Chapter 31, review the current technologies and applications of thermal imaging in dermatology. Bourgeois et al. describe the use of PET combined with CT in staging, imaging, and surveillance of cutaneous melanoma in Chapter 32. In Chapter 33, Beylergil et al. introduce the concept of molecular imaging in Merkel cell carcinoma. On the other hand, Lorenz et al. describe the use of other imaging modalities, such as ultrasound, CT, MRI, and lymphoscintigraphy in Merkel cell carcinoma in Chapter 34. In Chapter 35, Fardin et al. describe the use of FDG−PET-CT in cutaneous lymphoma. A general overview of imaging in cutaneous squamous cell carcinoma of the head and neck is given by Casazza and Monroe in Chapter 36. Peters and Vanhoenacker outline the imaging patterns of metastatic melanoma in Chapter 37. In the final chapter, Chapter 38, Visscher et al. discuss most up-to-date technologies, emerging methods, and unmet needs of image processing in dermatology.

References

[1] Bickers DR, et al. The burden of skin diseases 2004: a joint project of the American Academy of Dermatology Association and the Society for Investigative Dermatology. J Am Acad Dermatol 2006;55(3):490−500.

[2] Yoo JY, Rigel DS. Trends in dermatology: geographic density of US dermatologists. Arch Dermatol 2010;146(7):779.

[3] Kimball AB, Resneck Jr JS. The US dermatology workforce: a specialty remains in shortage. J Am Acad Dermatol 2008;59(5):741−5.

[4] Abdel-Halim RE. The role of Ibn Sina (Avicenna)'s medical poem in the transmission of medical knowledge to medieval Europe. Urol Ann 2014;6(1):1−12.

[5] Siraisi NG. History, antiquarianism, and medicine: the case of Girolamo Mercuriale. J Hist Ideas 2003;64(2):231−51.

[6] Editorial. Daniel Turner (1667−1740): dermatologist, surgeon, physician. JAMA 1970;213(5):863−4.

[7] Loewenthal LJ. Daniel Turner and "De morbis cutaneis". Arch Dermatol 1962;85:517−23.

[8] Everett MA. Anne-Charles Lorry: the first French dermatologist. Int J Dermatol 1979;18(9):762−4.

[9] Karamanou M, et al. Baron Jean-Louis Alibert (1768−1837) and the first description of mycosis fungoides. J BUON 2014;19(2):585−8.

[10] Alibert JL. Description des maladies de la peau: observées à l'Hôpital Saint-Louis, et exposition des meilleures méthodes suivies pour leur traitement. Bruxelles, Belgium: Wahlen; 1825.

[11] Finnerud CW. Ferdinand von Hebra and the Vienna school of dermatology. AMA Arch Derm Syphilol 1952;66(2):223−32.

[12] Ramoutsaki IA, Giannacos EN, Livadas GN. Birth of battlefield radiology: Greco-Turkish war of 1897. Radiographics 2001;21(1):263−6.

[13] Dutreix J, Dutreix A. Henri Becquerel (1852−1908). Med Phys 1995;22(11 Pt 2):1869−75.

[14] Williams LE. Anniversary paper: nuclear medicine: fifty years and still counting. Med Phys 2008;35(7):3020−9.

[15] Editorial. Andr'e Bocage (1892−1953): French tomographer. JAMA 1965;193:233.

[16] Webb S. Historical experiments predating commercially available computed tomography. Br J Radiol 1992;65(777):835−7.

[17] Shampo MA, Kyle RA, Steensma DP. Isidor Rabi: 1944 Nobel laureate in physics. Mayo Clin Proc 2012;87(2):e11.

[18] Prasad A. The (amorphous) anatomy of an invention: the case of magnetic resonance imaging (MRI). Soc Stud Sci 2007;37(4):533−60.

[19] Damadian R. Tumor detection by nuclear magnetic resonance. Science 1971;171(3976):1151−3.

[20] Dreizen P. The Nobel prize for MRI: a wonderful discovery and a sad controversy. Lancet 2004;363(9402):78.

[21] Bailey DL, et al. Positron emission tomography: Basic sciences. Secaucus, NJ: Springer-Verlag; 2005.

[22] Sweet WH, Brownell GL. Localization of brain tumors with positron emitters. Nucleonics 1953;11:40−5.

[23] Gallagher BM, et al. Radiopharmaceuticals XXVII: ^{18}F-labeled 2-deoxy-2-fluoro-d-glucose as a radiopharmaceutical for measuring regional myocardial glucose metabolism in vivo: tissue distribution and imaging studies in animals. J Nucl Med 1977;18(10):990−6.

[24] Reivich M, et al. Measurement of local cerebral glucose metabolism in man with ^{18}F-2-fluoro-2-deoxy-d-glucose. Acta Neurol Scand Suppl 1977;64:190−1.

[25] Beyer T, et al. A combined PET/CT scanner for clinical oncology. J Nucl Med 2000;41(8):1369−79.

[26] Wild JJ, Neal D. Use of high-frequency ultrasonic waves for detecting changes of texture in living tissues. Lancet 1951;1(6656):655−7.

[27] Brady T. Wild ideas: medical researcher and inventor John Julian Wild led the field of ultrasound medicine. Minn Med 2010;93(3):19−21.

[28] Donald I, Macvicar J, Brown TG. Investigation of abdominal masses by pulsed ultrasound. Lancet 1958;1(7032):1188−95.

[29] Willocks J, et al. Foetal cephalometry by ultrasound. J Obstet Gynaecol Br Commonw 1964;71:11−20.

[30] Huang D, et al. Optical coherence tomography. Science 1991;254(5035):1178−81.

[31] Villringer A, et al. Confocal laser microscopy to study microcirculation on the rat brain surface in vivo. Brain Res 1989;504(1):159−60.

[32] Pogue BW, et al. Initial assessment of a simple system for frequency domain diffuse optical tomography. Phys Med Biol 1995;40(10):1709−29.

[33] Pogue B, et al. Comparison of imaging geometries for diffuse optical tomography of tissue. Opt Express 1999;4(8):270−86.

[34] Graves EE, et al. A submillimeter resolution fluorescence molecular imaging system for small animal imaging. Med Phys 2003;30(5):901−11.

[35] Scarcelli G, Yun SH. In vivo Brillouin optical microscopy of the human eye. Opt Express 2012;20(8):9197−202.

[36] Li C, Mitchell GS, Cherry SR. Cerenkov luminescence tomography for small-animal imaging. Opt Lett 2010;35(7):1109−11.

[37] de Boer JF, et al. Two-dimensional birefringence imaging in biological tissue by polarization-sensitive optical coherence tomography. Opt Lett 1997;22(12):934−6.

[38] Li C, Wang LV. Photoacoustic tomography and sensing in biomedicine. Phys Med Biol 2009;54(19):R59−97.

CHAPTER

2

The Role of Clinical Photography in Dermatology

A. Sidoroff
Medical University of Innsbruck, Innsbruck, Austria

OUTLINE

INTRODUCTION

Clinical dermatology depends very much on optical impressions. Although palpation, odor, and a patient's given history may enhance diagnostic decisions, clinicians rely heavily on what they actually see when making an initial assessment of skin lesions. Verbal descriptions, accurate as they attempt to be, cannot come close to and will never replace visual perception. In the days before photography was invented, there were only three possible ways to depict and communicate such visual perceptions: drawings by a skilled illustrator; moulages (three-dimensional wax reproductions of disease-affected body parts); or actually seeing the disease of a patient on-site. The main objective was learning and teaching; visualization was a major part of that medical education. A sea change was unleashed at the beginning of the 19th century [1] through the launch of Joseph Nicéphore Niépce's lithography and Louis Daguerre's daguerreotype, but it took several decades before photography became accessible to the general public. Around 1900, photographic pictures were used in scientific medical publications (Fig. 2.1).

Ever-increasing opportunities of taking clinical photographs made a deep impact on the transfer of optical information, and not only in dermatology. It was above all else the accessibility of the motive, ie, skin, which predisposed dermatology to benefit inordinately highly from this technique. Pictures of skin diseases could not only be printed but also projected onto screens at clinical conferences and lectures at teaching institutions. The development and availability of computers and the resulting opportunity to digitize clinical pictures (at the beginning by scanning analog photographs or

Imaging in Dermatology
http://dx.doi.org/10.1016/B978-0-12-802838-4.00002-9

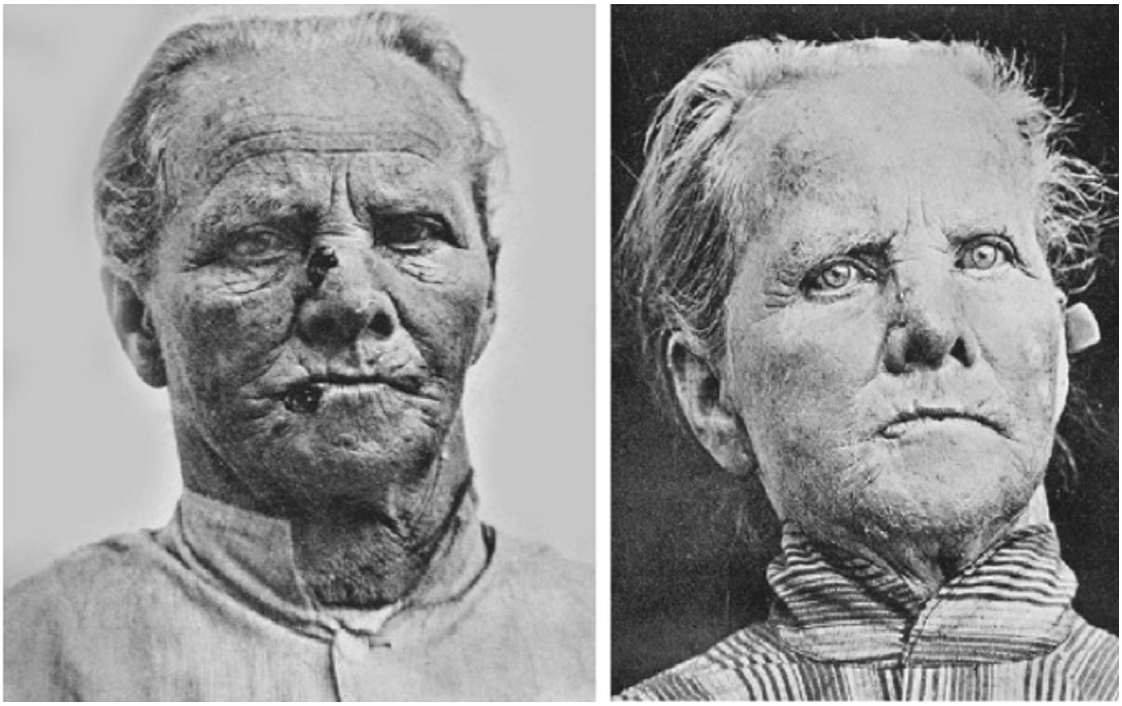


FIGURE 2.1 Early documentation of a photodynamic treatment of NMSC around 1900.

slides) was the next step. The development of digital photography then became the major breakthrough in heightening the status of photography in modern clinical dermatology [2]. Pairing affordable digital cameras and computers gives every dermatologist a way to take and store pictures of patients digitally in an extremely simple process. The aim of this chapter is to discuss the implications of this technical status quo in the context of dermatology [3–5].

THE EQUIPMENT

Today a broad spectrum of digital cameras is available on the market. Ranging from expensive high-resolution camera systems to integrated cameras in mobile phones, every demand can be met. The choices range from camera systems costing thousands of US dollars to photographic equipment nearly everybody already owns and has readily available, for example, as a feature of a mobile phone [6,7].

The relevant question, of course, is the purpose of the picture. Nonetheless, even cameras in high-end smart phones used under optimal conditions suffice to meet the basic resolution requirements of reproduction in printed media, eg, medical journals. For projections at talks or lectures, resolution requirements are even lower. The need for large-scale high-resolution prints is rather limited and not part of routine clinical use.

Given the extremely rapid development in the sector of photographic devices, only a few basic questions can be posed to aid in selecting the right equipment:

- Does the camera have the capability to take overview pictures as well as close-ups? Many simple "point and shoot" devices have a limited capacity in the macro range, which means that close-up pictures are often ruled out. One cannot rely on the manufacturers' nearest-distance specifications. They are based on measurements only in optimal light conditions.
- Is the autofocus system [8] able to deal with low-contrast pictures? Especially in close-up situations the contrast between normal skin and pathologically influenced skin could be very low. Cheaper camera systems might have difficulties bringing the region of interest into focus.
- Is an integrated flash sufficient? Frontal flashes have the disadvantage of forfeiting the three-dimensional aspect of a lesion, ie, it could get lost. (Additional lighting from the side is often essential to make this third dimension visible, eg, urticarial lesions, granuloma anulare.)
- How much influence can be exercised on the resulting picture? Most cheap and easy-to-use cameras have automated algorithms for standard situations but very limited possibilities to influence the ultimate pictures. Taking clinical pictures in dermatology is not a standard situation. The ability to optimize the

camera's behavior to a suit dermatologist's actual needs demands such possibilities as modification of focus, white balance, and labeling of the picture. One must be aware, though, that changing settings is a time-consuming process that needs a lot of expertise.

- How standardized do pictures need to be? Especially before-and-after pictures have to be taken under the exactly same light conditions for camera settings to be meaningful. Lighting from a different angle or a slight shift in the automatic white balance can make a useful comparison of two pictures impossible. This also holds true for follow-up pictures of pigmented lesions (if not documented with special mole-documentation devices). In such cases, cameras that automatically regulate their parameters are of little use. It is clear that not only camera parameters but also positioning of the patient has to be standardized to make pictures comparable [9].
- How should the connection between the camera system and the existing computer system be set up? Ordinarily, cameras store pictures on memory cards and the data are then transferred to a computer. This can be a cumbersome procedure. There are different levels to facilitate this, from integration of the import function into the clinical documentation software to complex (and expensive) systems with full control of the camera from the utilized software. The main issue in this context is that full integration is usually restricted to a limited number of cameras.
- Can data security or authenticity be verified? As mentioned, many camera systems regulate their illumination and focusing parameters themselves. Because these algorithms are based on general consumer demands, the resulting picture might not reproduce the desired result in a dermatological setting. Postprocessing might be imperative to give an account to the typical color of, for example, a heliotrope erythema in dermatomyositis. On the other hand, the picture has been "manipulated." Some systems emphasize the point that manipulation of pictures is not possible. But this necessitates that the original picture is perfect the moment it is taken, which is rarely the case.
- What is the quality of illumination? From all the points mentioned, it is clear that light conditions are as important as the camera system itself, especially when pictures need to be compared or a third dimension needs to be documented. Integrated flashes, ring flashes around the objective, external flashlights, natural light, or artificial light in a room all deliver different results.

In conclusion, it can be said that there is no optimal camera device for dermatologists, because optical documentation needs are quite different and no general standard has been established thus far. The choice of one's camera system is a highly individual decision and depends on the purpose of the pictures, technical skills of the physician, and costs.

THE "ART" OF TAKING DERMATOLOGICAL CLINICAL PICTURES

Poor quality pictures are not usually a result of inadequate technology or insufficient options of camera equipment, but of the unskilled use of technology. As with every skill, there is a learning curve, which cannot be skipped. Low-quality pictures are usually caused by insufficient care on the part of the photographer. In particular, illumination and selection of the details to focus on are significant components of the visual information a picture ultimately provides. Just *point and shoot* (as propagated in other photographic situations) might not lead to ideal results in imaging skin diseases. For example, as elaborated, if one wants to show the infiltration/elevation of a lesion, side lighting is important. A frontally integrated camera flash will never be able to highlight this morphological feature. Or a close-up view of one lesion will not show the distribution pattern of a rash or its potential change over time. Although it has become an everyday routine, dermatological education has not honed this skill in its educational curriculum; moreover, few articles and courses deal with the topic. In most educational institutions there is much room for improvement in teaching dermatologists how to take qualitative, informative clinical pictures. It is important to get to know the camera being used and how to use it. It requires just a few hours to learn the essentials. The rest comes with accumulated experience.

WHY PHOTOGRAPHS?

According to estimates, dermatology has to deal with 3000 diagnoses [at least in Europe, where autoimmune diseases, malignancies, allergology, sexually transmitted diseases (STDs), and other pathologies are part of this specialty]. As mentioned, dermatologists have developed a special terminology to verbally describe the morphology of skin diseases. *Primary lesions*, *secondary lesions*, *distribution pattern*, and, in particular, use of color terms can, when properly used, describe the clinical appearance in such a way that a diagnosis can often be made. On the other hand, it is clear that verbal descriptions depend heavily on the language used. Furthermore, it takes a lot of time to compose these descriptions. The old saying that a

picture is worth more than a thousand words holds true to a certain extent. Good clinical pictures can replace a host of descriptive sentences and, in addition, are more objective, ie, not susceptible to the describer's bias. Time is precious. It takes but a few minutes to snap some pictures and store them to a patient's chart, whereas the time needed to elucidate a skin disease in words may require more than an hour. However, the obvious timesaving advantage of taking photographs has one drawback, which is usually underestimated; the necessity to verbally describe what one sees makes it imperative to analyze the patient thoroughly. This has long been the cornerstone of gaining diagnostic skills. On the one hand, one does not have to be a dermatologist to take a picture; taking photographs does not need the analytical competence involved in verbal description. However, the better documentation becomes through photographs, the less attention is paid to what can really be seen. It is a vicious cycle; photographs all too often replace instead of complement clinical observations.

PHOTOGRAPHS AS AN EDUCATIONAL TOOL

There is no doubt that clinical pictures are extremely helpful for educational purposes. Dermatology is a specialty in which visual clinical experience plays a very important, in fact an unparalleled, role. Once one has consciously seen a rare disease, the linked synapses will remember it and call it into mind when it is seen another time. Pictures are only a pale runner-up compared with the real thing; the distance separating the two modes of perception is larger than ordinarily assumed. Associative memory is a very complex procedure. It means that apart from the "typical lesion" seen in a photograph in a textbook, dealing directly with a patient offers a whole range of details that may not have anything to do with the disease itself. The face of the patient, the situation, the patient's name, and the local setting are all apparently unimportant pieces of information but can turn out to be very helpful when recalling a disease. A picture in a textbook or on a piece of paper lacks these subliminary "add-ons." Most of the time a photograph is not given the same attention as a patient, especially when it is only part of the flood of information in a textbook. Nonetheless, as an addition to the correlating plain text, the correct picture can be extremely helpful in giving an impression about a disease. Even then one has to keep aware that years might go by before a dermatologist sees a certain skin disease in the real world that he or she has once seen in a textbook or lecture, if ever at all.

PHOTOGRAPHS AS A DIAGNOSTIC TOOL

A typical constellation in daily clinical routine is to examine a (rare) skin disease and not be able to make a diagnosis. The plethora of cutaneous diseases and the fact that they: (1) often have atypical presentations, and (2) may change their appearance over time make it impossible to keep all the possibilities in mind. A good clinician will therefore come up with a variety of differential diagnoses. In such a case, locating a suitable, comparable photograph in the literature or a photo database can be very helpful. Although several books about differential diagnoses in dermatology are available, it still can be a tedious and cumbersome task to find an appropriate picture. The basic idea of creating dermatological atlases has been picked up by many institutions (academic and commercial). Whereas it may be easy to find pictures of a certain disease, it still remains a challenge to find pictures via descriptive search terms.

This is where the skill of verbal description and the use of a correct, standard vocabulary come back into play. Unfortunately, up to now even the challenge of compiling a list and/or code of skin diseases has not been satisfactorily accomplished. All the same, one can say that good reference pictures are a helpful tool in finding the correct diagnosis.

THREE ADDITIONAL ASPECTS THAT NEED TO BE CONSIDERED IN THIS CONTEXT

First, with the new technology it is relatively easy to transmit pictures via electronic media. However, data security and confidentiality have to be guaranteed. Once this condition is met, getting a second opinion in a challenging case becomes extremely easy. Moreover, different approaches to teledermatology can spare patients unnecessary trips from remote places to specialized centers if the transferred information is sufficient [10,11].

The second point concerns the dynamics of skin diseases. It is a common scenario that by the time a patient can see a dermatologist, the clinical picture has changed in such a way that a clear diagnosis is no longer possible. More and more patients try to overcome this problem by taking pictures themselves during the acute phase of the disease. Although to our knowledge, this method has not been formally evaluated and statistics are not available, personal experience suggests that this approach is very helpful, particularly for diseases where clinical pictures are subject to short-term changes or the time lag between the acute phase and the appointment at the doctor is longer than desired.

Third, the availability of a clinical picture can be very useful for clinicopathological correlation in countries or institutions where histological slides are still seen by a clinically experienced dermatopathologist. Although the usual approach is to first look at the histopathological slide unbiased, the possibility of having a look at the clinical picture can help to confirm or question the result of a skin biopsy, especially when interaction between clinician and histopathologist is possible.

PHOTOGRAPHY AS A TOOL FOR DOCUMENTATION

Documentation has become one of the most time-consuming parts of medical routine. There are many nonmedical reasons for extensive documentation, but from a medical point of view, clinical pictures can be very helpful when it is a question of viewing the evolution of a skin disease or when different doctors are caring for a patient, as is routinely the case in larger hospitals.

PHOTOGRAPHY AS A TOOL IN RESEARCH

Dermatology has a long history. The names of many diseases (eg, mycosis fungoides, a cutaneous T-cell lymphoma that has no relation to fungi) and their classification go far back in history. Not wishing to get involved in a discussion about splitters and lumpers, it is nonetheless clear that new insights underscore the necessity of reevaluating many clinical patterns [12]. Diseases that look similar often have utterly different causes; disparate-appearing morphologies are commonly variants of the selfsame disease. A lot of work has to be put into transferring basic research findings into clinical practice. One approach is to look at clinical pictures and pinpoint subtle differences in them. But one still has to find the lowest common denominator to subordinate a variety of clinical appearances to a superordinate disease. Doing this, particularly for rare diseases, often takes longer than today's timetable for publication allows. Many institutions have a large collection of clinical pictures (including digital and printed photographs and slides). Retrospective screening of these archives in the context of the disease in question can provide new insight to an evaluation of morphological clinical findings. But again, the result of this type of research can only be as good as the written documentation attached to it.

PHOTOGRAPHS FROM THE PATIENT'S PERSPECTIVE

From everyday life we know that many healthy people do not like to have their pictures taken. This discomfort obviously gets worse in a clinic when a disease is present as a visible flaw [13,14]. The main strategy thus far has been to explain to the patient that clinical pictures are a routine part of dermatological documentation (eg, by comparing it with a radiograph in other disciplines). It can often be helpful to place emphasis on the fact that skin diseases are a dynamic process and imaging is the best way to document their stages and changes. Making lesions visible, for example, if they are located on a part of the body where they cannot be seen by the patient, or using techniques like fluorescence diagnosis to make subclinical lesions visible, can also be a good tool to convince patients about the need for treatment. It goes without saying, discomfort for patients while taking pictures should be reduced as much as possible so as not to stigmatize them even more than the disease does. An example is covering a patient's genital area when its documentation is not part of the purpose of the photograph. Another strategy is to avoid taking pictures of the face. Although from the doctor's point of view, this approach has disadvantages because doctors commonly recognize patients sooner from their faces than from their names and makes allocation and relocation of pictures easier. Sometimes it is important for the diagnosis and documentation of a disease that certain parts of the body are not affected. This should be communicated to the patient when photographs are taken of obviously healthy parts of the skin. For patients, the camera system used also seems to matter. In a study on 300 patients, 97.7% preferred a hospital-owned camera device over the use of a physician's camera or smartphone [15].

PHOTOGRAPHS FROM A LEGAL POINT OF VIEW

As can be concluded from the previously mentioned considerations, from a medical point of view there is no doubt that today's possibilities of digital imaging are of great advantage in education and clinical practice. However (allowing for differences from country to country), a series of legal aspects also needs to be considered [16]. The most obvious one is that the identity of the patient has to be protected on pictures seen by others apart from the treating physicians. It hardly needs be said that barring or pixeling the eyes by digital image processing often deteriorates the quality of information intrinsic to the clinical appearance of the disease. Second, more and more journals and publishers make written consent

of a patient a prerequisite for publishing one or more of his or her pictures. This clearly makes sense in cases where publication could lead to a disadvantage for the patient. In many cases, however, it is just a tool to protect publishers from legal risks. Such an overly defensive attitude often leads to good, informative pictures not being used in textbooks or publications simply because they were taken long before it was common practice to ask patients for their consent to publish pictures in which their identity is not recognizable. Although a weighing of interests is essential in publishing such pictures, the overly strict rules of many journals make use of many highly informative pictures nearly impossible. A typical example from the author's own experience is pictures of toxic epidermal necrolysis. In a rare disease like this (1–2 cases per million inhabitants per year) with a mortality of over 30%, the bureaucratic action to get written consent to publish clinical pictures is utterly disproportionate to the patient's actual physical and psychological condition.

The sticking point here is the use of clinical pictures in malpractice lawsuits, a phenomenon that has reached an almost unbearable level, especially in the United States. Once a definite diagnosis is known, it is often easy to recognize features of a disease on documented photographs, even if they are not typical. Yet the information on a diagnosis, which relies on doctors highly specialized in the disease, can lead to the conclusion that "it would have been possible to make a certain diagnosis earlier." In this context, this a posteriori judgment (ie, when the diagnosis is known) is submitted to a significant bias. If physicians at the same level of expertise (general practitioner, specialist, expert) and blind to the diagnosis were the ones to evaluate a clinical photograph, the assessment of a physician's malpractice would be much more objective. One must be aware that the many faces of cutaneous diseases and the constant flow of new publications supersede the amount of information that any single person can cope with. As a result of this, one has to be exceedingly careful about judging whether a doctor should have recognized a disease (earlier) on the basis of clinical pictures at a point in time when the diagnosis is already known. That said, in clear cases of misdiagnosis, pictures taken at a relevant moment can often help a patient achieve his or her rights.

On the other hand, because clinical picture-taking in most countries is neither compulsory nor reimbursed, it is no wonder that this method is not utilized as often as it might be.

PHOTOGRAPHY AS AN INFORMATIVE TOOL FOR THE GENERAL POPULATION

With the availability and reproducibility of clinical photographs, health and prevention campaigns now have a viable tool to inform the general public and indicate what people need to watch out for. Such pictures can be used in leaflets, posters, newspapers, or television clips. The reverse side of the coin is the enormous availability of images on the Internet. There are many doubtless informative sites with serious and high-quality content. However, one can also find thousands of websites with inadequate or downright incorrect information. That includes sites published by people through mistaken personal perceptions, as well as sites that pursue commercial interests. The amount of misinformation is overwhelming. Unfortunately, all these pictures and unfiltered data give Internet users the false impression that they can be their own doctors, not realizing that even if a posted clinical picture resembles their own perception of their disease, the associated information might be completely wrong. In search of solutions for their problems, patients often resort to clutching at the straws the Internet has to offer, paying little attention to the seriousness of the source of information. The most commonly used tools in this context are carefully selected before-and-after pictures. Without knowledge of the correct background, they are one of the best means of misleading and manipulating patients' expectations.

CONCLUSIONS

Today's technical possibilities of taking high-quality pictures of skin disease through a very simple act has significantly changed the way dermatological disorders can be documented for purposes of education, research, teledermatology, and patient documentation. Nevertheless, it is up to the physician/photographer to optimally employ this tool. To put it simply, the task of taking good clinical photographs depends not so much on the quality of the equipment as on the photographer's skills.

Digital photography and computer technology provide us the possibility of transferring and storing visual information better and more easily than ever before. But one has to be aware of the danger that for most cases imaging alone is not sufficient. For dermatologists, not only documentation but a thorough analysis of what one sees is a major part of diagnosis and experience.

In addition, clinical pictures can be helpful in less obvious constellations, such as interdisciplinary communication, patient guidance, prevention and/or early detection, and information designed for the general public. The caveat remains: dermatological photographs always have to be seen in their clinical or general context.

Last but not least, the importance of clinical photography in dermatology needs to be reflected to a greater extent in educational curricula and reimbursement policies. It needs to become an integral part of everyday dermatology.

References

[1] Neuse WH, Neumann NJ, Lehmann P, Jansen T, Plewig G. The history of photography in dermatology: milestones from the roots to the 20th century. Arch Dermatol 1996;132(12):1492−8.

[2] Levy JL, Trelles MA, Levy A, Besson R. Photography in dermatology: comparison between slides and digital imaging. J Cosmet Dermatol 2003;2(3−4):131−4.

[3] Kaliyadan F, Manoj J, Venkitakrishnan S, Dharmaratnam AD. Basic digital photography in dermatology. Indian J Dermatol Venereol Leprol 2008;74(5):532−6.

[4] Ratner D, Thomas CO, Bickers D. The uses of digital photography in dermatology. J Am Acad Dermatol 1999;41(5 Pt 1):749−56.

[5] Witmer WK, Lebovitz PJ. Clinical photography in the dermatology practice. Semin Cutan Med Surg 2012;31(3):191−9.

[6] Ashique KT, Kaliyadan F, Aurangabadkar SJ. Clinical photography in dermatology using smartphones: an overview. Indian Dermatol Online J 2015;6(3):158−63.

[7] Helm TN, Wirth PB, Helm KF. Inexpensive digital photography in clinical dermatology and dermatologic surgery. Cutis 2000;65(2): 103−6.

[8] Taheri A, Yentzer BA, Feldman SR. Focusing and depth of field in photography: application in dermatology practice. Skin Res Technol 2013;19(4):394−7.

[9] Halpern AC, Marghoob AA, Bialoglow TW, Witmer W, Slue W. Standardized positioning of patients (poses) for whole body cutaneous photography. J Am Acad Dermatol 2003;49(4):593−8.

[10] Kaliyadan F. Digital photography for patient counseling in dermatology − a study. J Eur Acad Dermatol Venereol 2008; 22(11):1356−8.

[11] Leggett P, Gilliland AE, Cupples ME, McGlade K, Corbett R, Stevenson M, et al. A randomized controlled trial using instant photography to diagnose and manage dermatology referrals. Fam Pract 2004;21(1):54−6.

[12] Katugampola R, Lake A. The role of photography in dermatology research. J Vis Commun Med 2012;35(1):5−10.

[13] Hacard F, Maruani A, Delaplace M, Caille A, Machet L, Lorette G, et al. Patients' acceptance of medical photography in a French adult and paediatric dermatology department: a questionnaire survey. Br J Dermatol 2013;169(2):298−305.

[14] Leger MC, Wu T, Haimovic A, Kaplan R, Sanchez M, Cohen D, et al. Patient perspectives on medical photography in dermatology. Dermatol Surg 2014;40(9):1028−37.

[15] Hsieh C, Yun D, Bhatia AC, Hsu JT, Ruiz de Luzuriaga AM. Patient perception on the usage of smartphones for medical photography and for reference in dermatology. Dermatol Surg 2015;41(1): 149−54.

[16] Kunde L, McMeniman E, Parker M. Clinical photography in dermatology: ethical and medico-legal considerations in the age of digital and smartphone technology. Australas J Dermatol 2013;54(3):192−7.

CHAPTER

3

Dermoscopy

A. Lallas, Z. Apalla, E. Lazaridou, D. Ioannides

Aristotle University, Thessaloniki, Greece

OUTLINE

INTRODUCTION

Dermoscopy is a noninvasive imaging technique that enables the visualization of submacroscopical structures invisible to the naked eye. The handheld dermatoscope is an inexpensive, easy to use device using either nonpolarized or polarized light and providing a ×10 magnification of the examined skin lesions [1,2].

Imaging in Dermatology
http://dx.doi.org/10.1016/B978-0-12-802838-4.00003-0

Dermoscopy Is an Integral Part of Clinical Examination

Although representing an imaging technique, dermoscopy should not be regarded as a second-level examination to be applied only in clinically preselected lesions. Instead, the dermatoscope should be considered as the dermatologist's stethoscope, because it is easy to carry and use, and it provides diagnostic information that cannot be otherwise acquired [3]. Overall, dermoscopy is not more (or less) important than any other part of the clinical examination. In contrast, the findings of the dermoscopic examination should always be integrated with all the information acquired from the macroscopic inspection, palpation, or patient's history, and interpreted within the context of a given patient. Opponents of the method argue that dermoscopy is time consuming, but it has been shown that, with experience, it adds only a little extra time to the clinical consultation [4]. The applicability of the method has been significantly enhanced by the introduction of new-generation dermatoscopes, which, by using polarized light and not requiring immersion fluid, allow a rapid screening of multiple lesions.

Initially, dermoscopy has been mainly used for the evaluation of melanocytic skin tumors, with research efforts focusing mainly on identification of dermoscopic characteristics of nevi and melanoma. With time, continuously gathering evidence established the value of dermoscopy in improving melanoma detection, and the technique gained global appreciation for assessment of melanocytic tumors [5]. Meanwhile, the dermoscopic patterns of several nonmelanocytic pigmented and nonpigmented tumors were described [6,7]. More recently, dermoscopy has been shown to be useful also for the assessment of infectious and inflammatory dermatoses [8]. Overall, the dermatoscope is now regarded as the dermatologist's stethoscope, providing to a clinician experienced in the technique useful additional information on the morphology of skin lesions or eruptions.

DERMOSCOPY OF MELANOCYTIC SKIN TUMORS

Dermoscopy as an in vivo, noninvasive technique enables the visualization of diagnostic features of pigmented skin lesions, which are not seen with the naked eye [1,2]. The value of dermoscopy in significantly improving the discrimination between melanoma and nevi has been confirmed by several meta-analyses [5,9]. In everyday practice, dermoscopy is considered a first-level clinical tool that facilitates the evaluation of pigmented skin lesions by allowing the recognition of early melanoma signs, prompting clinicians to check clinically banal-looking lesions and digitally monitor their patients [10]. At the same time, dermoscopy helps clinicians minimize the unnecessary excisions of nevi that might clinically look worrisome, by revealing their characteristic dermoscopic architecture.

Dermoscopy of pigmented skin lesions is based on various analytic approaches or algorithms, which take into consideration established specific dermoscopic features that create different patterns. These dermoscopic patterns represent the backbone for the morphologic diagnosis of nevi and melanoma.

A two-step procedure has been suggested as the optimal approach to evaluate a pigmented skin lesion [11]. The first step aims to differentiate melanocytic from nonmelanocytic tumors, assessing the presence or absence of predefined structures that are associated with melanocytic lesions.

The dermoscopic criteria considered to be suggestive of a melanocytic tumor are:

1. pigment network (reticular pattern)
2. globules (globular pattern)
3. streaks (starburst pattern)
4. homogeneous blue pigmentation (homogeneous pattern)
5. parallel pattern (for acral lesions).

If the lesion is judged as melanocytic, it enters the second analytic step, which aims to distinguish nevi from melanoma. This step is mainly based on the so-called "pattern analysis," namely the assessment of the global dermoscopic morphology (pattern), as well as the presence of local features. Alternatively, several algorithms attempting to quantify the presence of dermoscopic criteria have been suggested, including the ABCD rule, Menzies' scoring method, the 7-point and the revised 7-point checklist, and the 3-point checklist [12–14] (Table 3.1).

Pattern Analysis

Pattern analysis is regarded as the classic dermoscopic method for evaluating pigmented skin lesions [15,16]. This method includes the assessment of the symmetry of the lesion, the presence of one or more colors, the global dermoscopic appearance of the lesion according to predefined patterns, and the presence of local features. The global pattern results from predominant features occupying large areas of the lesion. A global pattern usually consists of one (usually) or two (less often) predominant features. In the presence of more than two predominant features, the pattern is classified as *multicomponent*. Instead, local features can be

TABLE 3.1 Algorithms for Evaluation of Melanocytic Lesions

ABCD rule	
Asymmetry in 0, 1 ή 2 axes, regarding contour, color and structures – Score 0-2	
Border abruptly interrupted at the periphery in 0-8 segments – Score 0-8	
Colour : Presence of up to 6 colors (white, red, light brown, dark brown, blue-gray, black) – Score 1-6	
Dermoscopic structures: presence of pigment network, dots, globules, streaks, structureless homogeneous areas – Score 1-5	
Total dermoscopic score (TDS): (A score × 1.3) + (B score × 0.1) + (C score × 0.5) + (D score × 0.5) = TDS	
Interpretation of TDS: < 4.75 Benign melanocytic lesion, 4.75–5.45 suspicious lesion, > 5.45 Melanoma	
Menzies method	
Negative features	**Positive features**
Symmetry of dermoscopic structures	Blue white veil
Presence of a single color	Multiple brown dots
	Pseudopods
	Radial streaks
	Scar like depigmentation
	Peripheral dots/globules
	Multiple (5 or 6) colors
	Multiple blue-gray dots
	Broadened network
Interpretation: A diagnosis of melanoma is made when both negative features are absent and 1 or more of the 9 positive features are present	
7 point checklist	
Dermoscopic features	**Score**
Major criteria	
1. Atypical pigment network	2
2. Blue-white veil	2
3. Atypical vascular pattern	2
Minor criteria	
4. Irregular streaks	1
5. Irregular dots and globules	1
6. Irregular blotches	1
7. Regression structures	1
Interpretation: Total score ≥ 3: melanoma, total score < 3: nonmelanoma	
3 point checklist	
1. Asymmetry of colors and/ or structures	
2. Atypical pigment network	Presence of more than one criterion ⟶ excision
3. Blue-white structures	
For nonexperts in dermoscopy–It aims in the recognition of suspicious lesions	

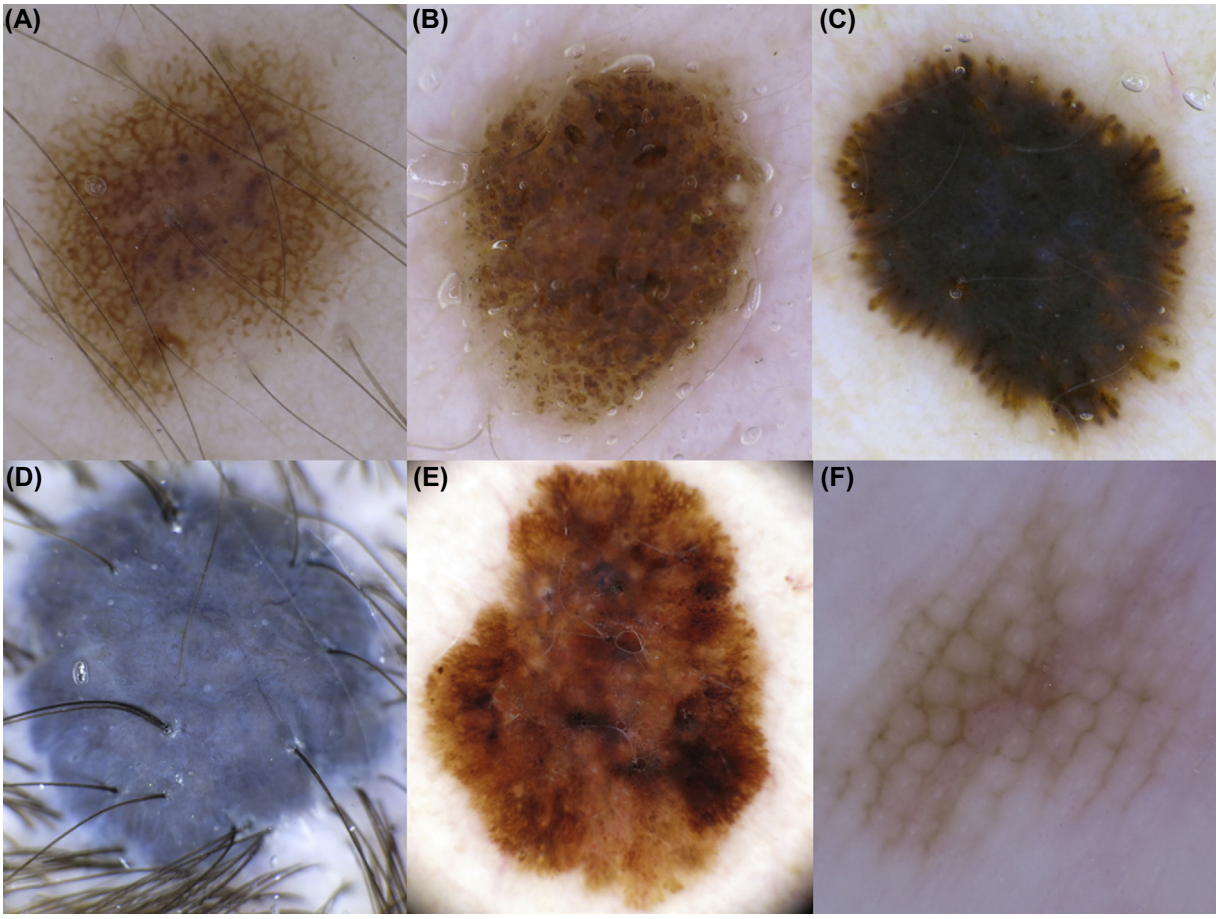


FIGURE 3.1 Global dermoscopic patterns. (A) Reticular (nevus). (B) Globular (nevus). (C) Starburst (Spitz nevus). (D) Homogeneous (blue nevus). (E) Multicomponent (melanoma). (F) Parallel furrow pattern (acral nevus).

recognized as single or grouped characteristics, and several of them can coexist in the same lesion.

There are five basic global patterns, including reticular (resulting from pigment network), globular (resulting from multiple globules), starburst (resulting from peripheral streaks or pseudopods), homogenous (resulting from structureless pigmentation), and multicomponent (resulting from the combination of more than two of the above patterns). The first four patterns can be seen in both nevi and melanoma, whereas the multicomponent pattern is directly suggestive of melanoma (see Fig. 3.1). Two different patterns can be combined in nevi (eg, globular and reticular, homogenous and reticular), but this combination also follows some kind of structured architecture (eg, globular in the center and reticular at the periphery). If a lesion exhibits one of these four patterns, further assessment will be based on the overall symmetry, colors, and the presence of local features, so-called "melanoma-specific criteria."

In general, nevi are characterized by symmetry of structures and display one or two colors. In contrast, melanoma exhibits architectural disorder and often more than two colors.

Melanoma-Specific Criteria

Atypical pigment network: brown-black network with irregular meshes and irregularly distributed lines of different thickness (high specificity for the diagnosis of melanoma).

Irregular dots and/or globules: brown-black or gray, dots and globules of different size, irregularly distributed within the lesion.

Irregular blotches: black, brown, or gray areas with irregular shape and/or distribution.

Irregular streaks and/or pseudopods: radial lines irregularly distributed at the periphery of the lesion (streaks), sometimes with a bulbous projection at their peripheral ending (pseudopods).

Regression structures: seen in the flat area of the lesion and may exhibit as either white scarlike areas corresponding to fibrosis or blue-gray areas (peppering) corresponding to melanophages.

Blue-white veil: seen in the elevated part of the lesion; blue-gray or blue-white, diffuse, irregular pigmentation.

Irregular vascular structures: polymorphous vessels, coexistence of dotted, linear, or hairpin vessels in the same lesion.

Dermoscopy may also offer a preoperative assessment of the Breslow thickness and sentinel lymph node positivity [17,18]. An atypical pigment network is usually found in thin melanomas with a Breslow thickness of <0.76 mm, whereas atypical vascular patterns, radial streaming, and blue-white areas are usually seen in deeper lesions with a Breslow thickness of >0.75 mm [19].

Pigmented melanocytic lesions in certain locations (face, palms, soles, and nails) exhibit unique dermoscopic features because of the specific skin anatomy.

Facial lesions are characterized by a pseudonetwork, which consists of structureless pigmentation interrupted by the numerous, and often enlarged, follicular openings [20]. A pseudonetwork can be found both in melanocytic and nonmelanocytic lesions and, effectively, the first step of the two-step algorithm does not work in facial lesions. Nevi on the face are characterized by brown color, symmetric perifollicular pigmentation, and regular borders. Furthermore, nevi on the face of elderly individuals are usually dermal, papillomatous, and minimally pigmented, whereas flat pigmented nevi are exceedingly rare on the face of elderly individuals. Subsequently, facial melanoma [lentigo maligna (LM) type] does not have to be differentiated from nevi, but mainly from other pigmented flat tumors, including pigmented actinic keratosis (AK) and solar lentigo (SL) [20]. The early dermoscopic criteria of LM include gray color, asymmetric perifollicular pigmentation, and granular and rhomboidal structures [21,22]. In contrast, SL/early seborrheic keratosis (SK) rarely displays gray color under dermoscopy, unless undergoing regression, forming the so-called "lichen planus-like keratosis (LPLK)" [20].

Melanocytic lesions on the palms and soles exhibit unique dermoscopic patterns because of the peculiar anatomy of the acral skin. Nevi show pigmentation along the furrows, whereas melanoma shows pigmentation along the ridges [23].

Benign dermoscopic patterns in acral lesions include:

1. the parallel furrow pattern (see Fig. 3.1F): pigmentation along the furrows of the skin markings (the most common dermoscopic pattern in acral melanocytic nevi)
2. the lattice-like pattern: pigmentation along and across the furrows
3. the fibrillar pattern: fine fibrillar pigmentation perpendicular to the furrows
4. the globular pattern
5. the homogeneous pattern
6. the reticular pattern.

Malignant dermoscopic patterns are:

1. the parallel ridge pattern: pigmentation located on the ridges of the skin markings (acral melanoma in situ or early invasive melanoma)
2. diffuse pigmentation
3. the multicomponent pattern.

Nail Pigmentation

The most common clinical presentation of melanocytic lesions of the nail plate is melanonychia striata. Dermoscopy improves the assessment of pigmented nail bands, allowing early melanoma detection and reducing the number of diagnostic surgical interventions. Subungual nevi are characterized by brown longitudinal parallel lines with regular pattern. Subungual melanoma exhibits irregular multicolor longitudinal bands and the micro-Hutchinson sign, namely a clinically invisible but dermoscopically evident pigmentation of the proximal nail fold [24].

Digital dermoscopy is a useful strategy in the management of patients at risk of melanoma and in monitoring melanocytic lesions. Short- or long-term dermoscopic follow-up observation with special equipment helps the clinician recognize thin melanomas with subtle changes and minimize unnecessary excisions of benign nevi [25,26].

DERMOSCOPY OF COMMON BENIGN NONMELANOCYTIC SKIN TUMORS

A broad spectrum of heterogeneous cutaneous neoplasms is described under the umbrella of *benign nonmelanocytic skin tumors*. Among them, the most common are the vascular tumors, including pyogenic granuloma (PG), hemangioma and angiokeratoma, SK, and dermatofibroma. Dermoscopy is considerably helpful in the diagnosis of the latter group of skin neoplasms [27].

Seborrheic Keratosis

SK is the most common benign epidermal tumor in the elderly. Sites of predilection are the trunk, face, scalp, and extremities. Common clinical variants of SK are the acanthotic, reticulated, and verrucous types, whereas uncommon variants include the clonal and irritated types, LPLK, melanoacanthoma, and stucco keratosis. The dermoscopic picture of an SK significantly depends on its clinical type. However, some dermoscopic features, when present, are considered pathognomonic

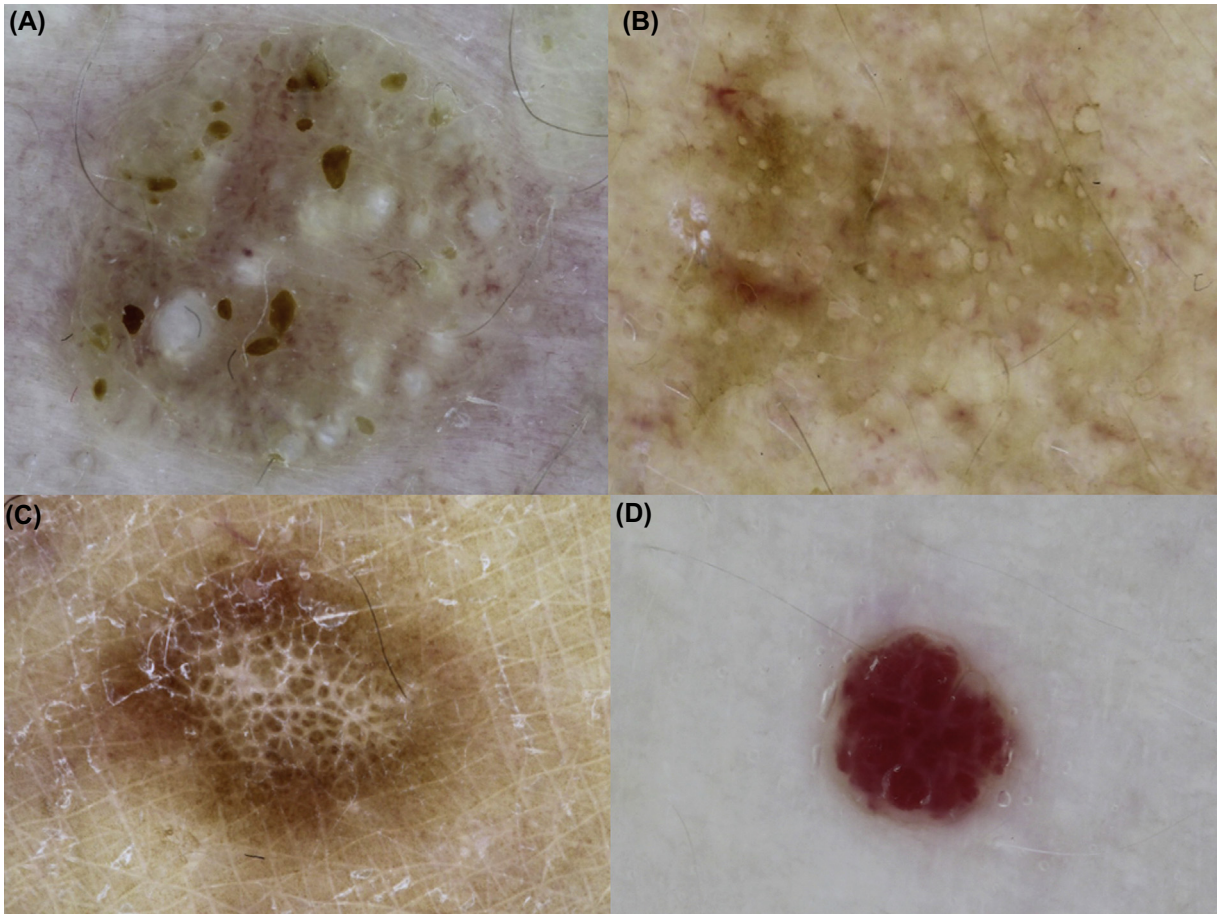


FIGURE 3.2 (A) Multiple milia-like cysts and comedo-like openings are typical for seborrheic keratosis (SK). (B) Solar lentigo (SL), dermoscopically displaying a fine network and sharply demarcated borders. (C) Dermatofibroma is dermoscopically characterized by a peripheral delicate network, whereas the center might display a white network, as in this case, or a whitish structureless area. (D) Angioma is dermoscopically typified by the characteristic well-demarcated red globules (lacunae).

for the diagnosis. Milia-like cysts and comedo-like openings are the classic dermoscopic structures found in an SK (Fig. 3.2A). Milia-like cysts are differently sized, roundish, white or white-yellowish structures corresponding to intraepidermal horn globules. Milia-like cysts are mostly present in acanthotic SK. Comedo-like openings are roundish, ovoid, or even irregularly shaped, sharply defined structures with coloration ranging from brown-yellow to brown-black. Irregularly shaped comedo-like openings are also called *irregular crypts*. Histopathologically they correspond to keratin plugs that fill dilated follicular openings. Additional features that improve the diagnostic accuracy, such as the fingerprint and fat finger signs, the "moth-eaten" border, a "brainlike" appearance (fissures and ridges), and the delicate pigment network have been described [28]. The latter dermoscopic finding is highly representative of SL (see Fig. 3.2B). Ink-spot lentigo, a distinct form of SL, is dermoscopically characterized by a special reticular pattern forming a sharply in-focus, black, broken-up network in the absence of any additional features. This pattern is virtually diagnostic of ink-spot lentigo [29].

Furthermore, in pale-skinned patients, we can easily recognize the specific vascular pattern of SK, mainly characterized by the presence of hairpin and dotted vessels. Nonpolarized dermoscopy is recommended for the examination of SK, because it highlights the presence of milia-like cysts and comedo-like openings. LPLK, which represents SK in regression, displays a distinguished dermoscopic pattern, mainly consisting of gray granules, corresponding to melanophages in histology [30]. In terms of differential diagnosis, the most difficult to diagnose variants are the clonal and the melanoacanthoma type, because they may closely mimic melanoma, both clinically and dermoscopically [31–33].

Dermatofibroma

Dermatofibroma, or fibrous histiocytoma, is a common cutaneous benign neoplasm mostly affecting young and middle-aged adults, with a female predominance.

Clinically, dermatofibromas present in palpation as single or multiple firm and hard papules, or nodules, usually characterized by color variability ranging from light yellowish to dark brown, or purple-red. They can develop anywhere on the body, with a predilection for the lower extremities. In the majority of cases, the diagnosis is set on a clinical basis; however, dermoscopy can be useful in challenging lesions, where differentiation from other benign or malignant tumors is difficult. The prototype of a dermatofibroma in dermoscopy consists of a white scarlike patch in the center and a fine pigment network at the periphery of the lesion. Homogenous pigmentation and a white network are other common dermoscopic features of dermatofibroma (see Fig. 3.2C) [34,35]. The previously mentioned dermoscopic structures may combine together to form 10 different dermoscopic patterns, as described by Zaballos et al.:

Pattern 1 pigment network located throughout the lesion
Pattern 2 delicate pigment network at the periphery and central white scarlike patch
Pattern 3 delicate pigment network at the periphery and central white network
Pattern 4 delicate pigment network at the periphery and central homogeneous pigmentation
Pattern 5 white network throughout the lesion
Pattern 6 homogeneous pigmentation throughout the lesion
Pattern 7 total scarlike patch and a variant with multiple white scarlike patches regularly distributed
Pattern 8 peripheral homogeneous pigmentation and central white scarlike patch
Pattern 9 peripheral homogeneous pigmentation and central white network
Pattern 10 atypical pattern that consists of the presence of atypical pigment network, atypical scarlike patch or white network, atypical homogeneous pigmentation, or irregular distribution of these structures [35].

Aneurysmal dermatofibroma is a relatively rare form of histiocytoma representing less than 2% of total cases [36]. The latter entity and the atypical dermatofibroma share many clinical and dermoscopic similarities with other skin tumors, especially malignant melanoma and Kaposi sarcoma, which can make differentiation problematic [36,37].

Vascular Tumors

Dermoscopy improves the diagnostic accuracy in the clinical evaluation of vascular lesions such as hemangioma, angiokeratoma, and PG. The dermoscopic hallmarks of the vascular lesions are the red, blue, or black lacunae and the red-bluish or red-black homogenous areas (see Fig. 3.2D). Lacunae are well-circumscribed, roundish, or ovoid areas with a reddish, red-bluish, or dark-red to black coloration. Histopathologically they correspond to dilated vascular spaces situated in the upper dermis [38,39]. A rare variant of hemangioma is the targetoid hemosiderotic hemangioma, which may clinically be worrisome; however, the presence of the characteristic lacunae in the central elevated part of the lesion in dermoscopy is indicative of the benign nature of the lesion [40]. Venous lake, also known as *phlebectases*, is a solitary, soft, compressible, dark-blue to violaceous papule commonly involving sun-exposed areas, with a predilection for the lip vermilion, face, and ears. Lesions are common among the elderly. Homogenous blue is the dermoscopic hallmark of the lesion and can be particularly useful in the differentiation of melanoma [41]. Variations on the theme of red, blue, or black lacunae may be occasionally observed in subungual and subcorneal hematomas [24,42,43].

Regarding PG, the most commonly seen dermoscopic features include red homogeneous areas, the white collaret, "white rail lines" that intersect the lesion, and ulceration. Even though the latter dermoscopic criteria may be suggestive of a PG, it is important to underline that amelanotic melanoma represents a major potential diagnostic pitfall. Therefore histopathological confirmation is highly recommended for all lesions with a clinical dermoscopic or differential diagnosis of PG [44,45].

Angiokeratoma is a rare malformation of the vascular network of the upper dermis that clinically presents as single or multiple dark red to black papules, nodules, or plaques. Lacunae, whitish veil, erythema, and hemorrhagic crusts represent the main dermoscopic structures observed in angiokeratoma. Combination of the features results in three distinct dermoscopic patterns. Pattern 1 is composed of dark lacunae and a whitish veil; pattern 2 consists of dark lacunae, whitish veil, and peripheral erythema; and pattern 3 is characterized by dark lacunae, whitish veil, and presence of hemorrhagic crusts [41].

DERMOSCOPY OF COMMON MALIGNANT NONMELANOCYTIC TUMORS

Basal Cell Carcinoma

Basal cell carcinoma (BCC) is the most common form of skin cancer. It mostly affects the sun-exposed body sites, especially the head and neck area. There are five clinicopathological types of BCC (namely, nodular, infiltrative, micronodular, morpheaform, and superficial), each of which has a distinct biological behavior [46]. The variability of BCC in dermoscopy is a result

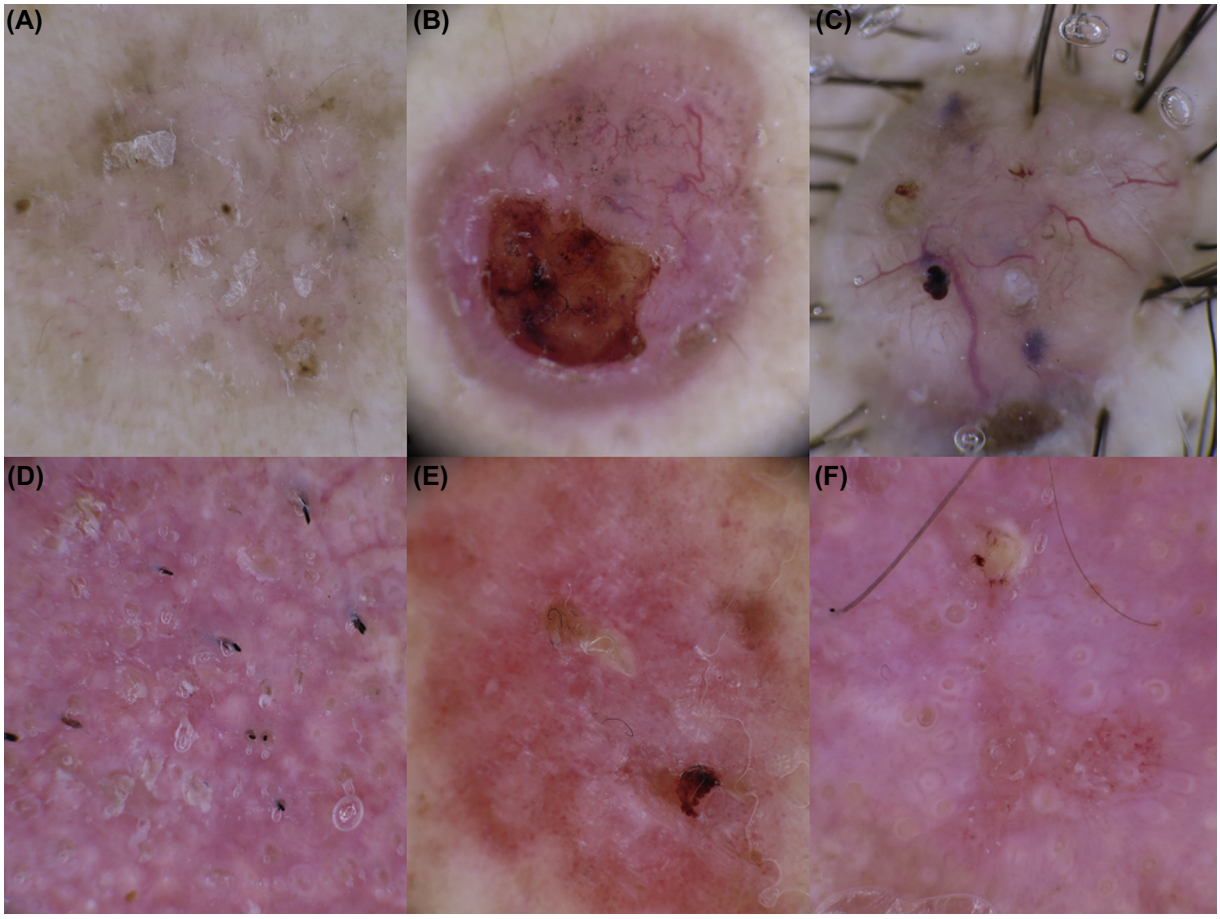


FIGURE 3.3 (A) Dermoscopy of superficial basal cell carcinoma (BCC) usually reveals short, fine telangiectasia; multiple small erosions; and brown-colored pigmented structures. (B) and (C) Nodular BCC displays large arborizing vessels, large ulcerations, and, if pigmented, blue-gray ovoid nests. (D) The "strawberry" pattern of actinic keratosis, consisting of a reddish color interrupted by the white to yellowish follicular openings, which may be filled with keratin plugs. (E) Dotted and glomerular vessels combined with yellow scales comprise the typical dermoscopic pattern of Bowen disease. (F) The white circles surrounding follicular openings represent the most specific dermoscopic criterion of well-differentiated squamous cell carcinoma (SCC).

of different combinations of the dermoscopic features, depending on various factors, including clinicopathological subtype, location, gender, age, and pigmentary trait (Fig. 3.3A–C) [47].

Arborizing vessels are the dermoscopic hallmark of nodular BCC, but can also be seen in all the other subtypes. They represent the supportive neovasculature of the tumor nests and they are large in diameter, branching irregularly into fine terminal capillaries. Their color is bright red, and these vessels are perfectly in focus in the images because of their location on the surface of the tumor (just below the epidermis) [47].

Another vascular dermoscopic structure typically characterizing the superficial BCC (sBCC) is superficial fine telangiectasia (SFT). SFTs appear in focus as short, fine, linear vessels with very few branches [48].

Apart from the vessels, pigmented structures are very representative of a BCC.

Blue-gray ovoid nests are sharply demarcated, usually confluent, ovoid or elongated configurations that histopathologically correspond to large, well-defined tumor nests with pigment aggregates, invading the dermis. Blue-gray ovoid nests represent a stereotypical feature of nodular, pigmented BCC, but they can be also seen in all subtypes except the superficial type BCC [49,50].

Multiple blue-gray dots and globules are numerous, loosely arranged, roundish well-defined structures, which are smaller than the nests. Their histopathological correlation is small, roundish tumor nests with central pigmentation, localized to the papillary or reticular dermis. Blue-gray dots and globules can be observed in all BCC subtypes [49,50].

Maple leaf-like areas represent a highly specific BCC feature and can be seen in all subtypes, but more commonly in sBCC. Maple leaf-like areas are translucent brown to gray-blue peripheral bulbous extensions that

closely mimic the shape of the leaves of a maple tree. In histopathology, they correlate to multifocal tumor nests containing pigment aggregates connected to each other by lobular extensions. They are usually found in the epidermis or, less often, in the upper dermis [49,50].

Spoke-wheel areas are a variation of maple leaf-like areas. These are well-defined radial projections, usually brown but sometimes blue or gray, connecting to each other via a darker central axis. Their histopathological correlation is tumor nests arising and connected to the epidermis, characterized by fingerlike projections and centrally located pigmentation. Spoke-wheel areas are highly specific for BCC and can be seen in all subtypes, but they are more common in the superficial type [46–50].

In-focus dots is a term used to describe small, loosely arranged, and well-circumscribed gray dots, which are sharply in focus. Histopathologically, they correspond to melanophages or free pigment deposition in the papillary and reticular dermis [46–50].

Concentric structures are irregularly shaped roundish structures with various colors (blue, gray, brown, black) and a darker central area. They possibly represent variations or precursors of the spoke-wheel areas. They are more common in sBCC [46–50].

It is well known that BCC is a fragile neoplasm that bleeds easily. Minimal trauma results in ulceration, which under dermoscopy may be seen as one or more large structureless areas of red to black-red color. At the sites of ulceration there is a loss of the epidermis, usually covered by hematogenous crusts in histology. Ulceration is mostly seen in nodular BCC. Similarly, multiple small erosions are often seen as small brown-red to brown-yellow crusts. They correlate to thin crusts overlying superficial loss of the epidermis. They are typical features of sBCC [46–50].

Shiny, white/red structureless areas have been reported as a dermoscopic feature of sBCC and may correlate to fibrotic tumoral stroma [47,48].

Another interesting recently described dermoscopic finding in BCC is the presence of chrysalis structures or short white streaks. They can be seen only under polarized light as orthogonal short and thick crossing white lines. They may be attributed to the presence of collagenous stroma and fibrosis in the dermis [51].

Keratinocyte Skin Cancer

Historically, keratinocyte tumors were subdivided into premalignant or precursor lesions (AK), tumors of intermediate biological nature [Bowen disease (BD)], and highly malignant ones [invasive squamous cell carcinoma (SCC)] [52]. However, AK and BD are now classified as in situ SCC, whereas keratinocyte skin cancer is considered to represent an apparent continuum of malignant neoplasms in different progression stages, with AK on one edge and poorly differentiated SCC on the other [46].

Actinic Keratosis

Also known as *solar keratosis*, AK represents the most common carcinoma (in situ) in humans [53]. The incidence of AK is significantly higher in individuals with skin types I–III and in regions with a sunny climate.

The reported risk of an individual AK to progress to invasive SCC varies from 0.1% to 20% [54]. However, patients with multiple AKs have a 5-year cumulative probability of 14% to develop SCC, either within the AK or de novo, highlighting the need of regular follow-up examinations [54].

AKs typically present as erythematous hyperkeratotic macules, papules, or plaques on chronically sun-exposed areas such as the bald scalp, ears, face, forearms, and dorsum of the hands [46].

According to a recently introduced clinical classification scheme, grade I AKs are slightly palpable (better felt than seen), grade II includes AKs of moderate thickness (easily felt and seen), and grade III AKs are clinically obvious, very thick, and usually hyperkeratotic [55]. It has been suggested that these clinical grades of AK also dermoscopically correspond to three different patterns. Grade I AKs display a red pseudonetwork and white scales, and grade II lesions are typified by the so-called "strawberry" pattern, consisting of an erythematous background interrupted by white to yellow enlarged follicular openings with or without keratin plugs (see Fig. 3.3D). In grade III AKs, the dense hyperkeratosis, seen as a white-yellow structureless area, often impedes the visualization of the follicular openings, which are typically filled with keratotic plugs [7]. The diagnostic sensitivity and specificity of dermoscopy in the diagnosis of nonpigmented AK has been reported to reach 98% and 95%, respectively [56].

Less often, AK may be slightly or heavily pigmented [pigmented AK (PAK)], clinically presenting as a red-brownish or even brown macules. In such cases, it has to be discriminated from SL and early LM [20]. When located on the face, dermoscopy of PAK typically reveals a pseudonetwork consisting of a diffuse brown pigmentation interrupted by nonpigmented follicular openings, histopathologically corresponding to pigmented keratinocytes along the flattened dermoepidermal junction of the facial skin. The latter dermoscopic pattern can be also seen in SL and LM and, accordingly, the differential diagnosis of a pigmented facial macule relies on the detection of additional specific criteria [20].

PAK is known to occasionally display several of the dermoscopic criteria of LM, such as asymmetrically pigmented follicular openings, rhomboidal structures, and gray dots or globules, rendering the discrimination

between these two entities highly troublesome. Dermoscopic features highly suggestive of PAK are superficial scales, keratin plugs, rosettes, and white circles. Furthermore, a potentially useful clue is that in contrast to LM, the pigmentation in PAK does not have the tendency to obscure the visualization of the follicular openings. Notably, the discrimination between the two entities may even be histopathologically difficult when it is not clear whether the pigmented atypical cells in the basal layer are keratinocytes or melanocytes [20]. The dermoscopic recognition of SL (which is considered a type of early SK) is usually feasible based on the absence of gray color and the detection of light brown fingerprint areas, yellow opaque areas, milia-like cysts, moth-eaten border, and a sharp demarcation [20].

Bowen Disease (Intraepidermal Carcinoma)

BD is defined as an SCC in situ with full epidermal thickness dysplasia that has the potential for significant lateral spread before invasion [57].

BD may progress to invasive SCC in 3–20% of cases. Notably, SCC developing on preexisting BD is associated with an unfavorable prognosis and a high rate of regional or distant metastasis [58].

Typically BD presents as an asymptomatic, slowly enlarging, erythematous, well-demarcated, scaly patch or plaque. This unspecific clinical presentation often results in a delayed diagnosis, sometimes complicating the management of the tumor.

The typical dermoscopic pattern of BD consists of dotted and/or glomerular vessels, white to yellowish surface scales, and a red-yellowish background color (see Fig. 3.3E) [59]. Glomerular (or coiled) vessels represent a variation of dotted vessels, which are larger in size and characterized by tortuous capillaries, reminiscent of the histological appearance of the glomerular apparatus of the kidney. Both dotted and glomerular vessels often appear within the same lesion and are usually distributed in small, densely packed clusters or groups [46,59].

The characteristic vessel morphology and distribution seen in BD is particularly useful in distinguishing the disease from clinically similar skin tumors and inflammatory skin diseases [60]. Discrimination from sBCC is usually straightforward based on the vessels' morphology, which is dotted/glomerular in BD and linear in sBCC. The differential diagnosis between BD and psoriasis is problematic in cases where the latter manifests with one or few plaques distributed on nontypical sites, which can be misinterpreted as BD. Conversely, BD developing in psoriatic patients, especially those undergoing phototherapy, might be easily overlooked among the plethora of psoriatic lesions. The dermoscopic discrimination among the two entities might also be difficult, because psoriasis typically displays regularly distributed dotted vessels and white scales, closely resembling the features seen in BD [61]. However, some useful clues do exist and include: (1) the diameter of the vascular structures, which is typically larger in BD (glomerular vessels vs. red dots); (2) the distribution of the vascular structures, which is almost always regular (symmetric) in psoriasis and most often clustered in BD; and (3) the presence of yellow-colored scales, which minimizes the possibility of psoriasis, although scales are very common in BD [8].

It has been shown that the simultaneous presence of a clustered vascular pattern and glomerular vessels is associated with a diagnostic probability of 98% for BD, compared with psoriasis and sBCC [60].

A characteristic linear arrangement of glomerular or dotted vessels has been described in pigmented BD [62]. Although not very common (present in approximately 10% of cases), the latter finding has been suggested to represent a highly specific feature of pigmented BD, allowing its discrimination from melanoma in particular [62].

In addition to the vascular criteria, dermoscopy of pigmented BD has been shown to reveal two main patterns: a brown structureless pattern and a mixed pattern combining a hypopigmented structureless eccentric area and small brown/black dots. The dots in pigmented BD are arranged either in a patchy distribution or in peripheral lines, the latter representing a highly specific arrangement [62].

Squamous Cell Carcinoma

Cutaneous SCC is the second most common skin cancer [63]. The majority (70%) of SCCs develop on the head and neck, with an additional 15% arising on the upper extremities.

Clinically, SCC usually presents as an indurated hyperkeratotic nodule with or without ulceration. Less often, SCC lacks signs of keratinization and manifests as an ulcer. The presence of AKs is usually evident on the neighboring and surrounding skin surface [46].

The dermoscopic pattern of SCC depends on the grade of histopathological differentiation [46]. Specifically, well differentiated tumors exhibit a white predominant color, resulting from one or more of the following structures: white structureless areas, white circles (surrounding the follicular openings), white halos (surrounding vessels), and white amorphous masses of keratin (see Fig. 3.3F) [7,46,64]. White structureless areas represent the most common but less specific feature. In contrast, white circles represent the most specific feature of SCC when compared with other common nonpigmented skin tumors [64]. White halos and amorphous white keratin masses are indicative of a keratinizing tumor, but cannot predict a specific diagnosis. Vascular structures may be dermoscopically seen in well-differentiated SCC, usually as linear irregular or hairpin

vessels of large diameter [7]. However, the quantity of vascular structures is usually low in well-differentiated SCC, with white structures typically predominating. A specific combination of central keratin masses surrounded by hairpin or linear irregular vessels distributed at the periphery of the tumor has been suggested to typify keratoacanthoma [7,64].

In contrast, poorly differentiated SCC is clinically typified by a flat appearance and dermoscopically by a red predominant color, attributed to the absence of scaling and the presence of bleeding and/or dense vascularity [65]. Vessel quantity is significantly correlated to the differentiation grade of SCC, because tumors displaying vessels in more than 50% of the lesion surface have a 30- to 120-fold increased possibility of being poorly differentiated. Vessels caliber also represents a significant predictor of differentiation grade, with a small caliber associated with poor differentiation [65].

DERMOSCOPY IN GENERAL DERMATOLOGY

Continuously gathering evidence suggests that in addition to its usefulness for the evaluation of skin tumors, dermoscopy is also helpful for the assessment of nontumoral lesions [8,66]. The latter is based on the observation that apart from pigmentation structures formed by melanin deposition, dermoscopy may also reveal vascular alterations, color variegation, follicle disturbances, and other features invisible to the unaided eye. The dermoscopic patterns of several inflammatory and infectious skin diseases have been described. It has been suggested that four parameters should be assessed when applying dermoscopy in the realm of inflammatory and infectious diseases: (1) morphological vascular patterns, (2) arrangement of vascular structures, (3) colors, and (4) follicular abnormalities, although other specific features (clues) should also be evaluated [8]. In Table 3.2, the dermoscopic characteristics of several inflammatory skin diseases are presented.

Papulosquamous Skin Diseases

Psoriasis

Dotted vessels represent the most common dermoscopic feature of psoriasis, and are typically present in every psoriatic plaque. Effectively, detection of any other morphological type of vessel should raise doubts about the diagnosis of psoriasis.

However, red dots do not represent a specific finding, because they can be found in several other inflammatory diseases. Instead, their uniform or regular distribution within the lesion represents the dermoscopic hallmark of psoriasis, being particularly useful in differential diagnosis. Another less common but equally specific vessel arrangement pattern for psoriasis is the so-called "red globular rings." Other types of vessel distribution are extremely rare in psoriasis.

Light red background color and white superficial scales represent two common additional dermoscopic criteria of psoriasis. The scale color is of particular value for differentiating the disease from dermatitis, which typically displays yellow scales [61].

Psoriatic lesions located on specific body sites exhibit the same pattern, with variations in the degree of scaling. For example, in psoriatic balanitis and inverse psoriasis lesions that lack scaling, the typical vascular pattern of regularly distributed red dots is prominent under dermoscopic examination. Conversely, in scalp or palmoplantar psoriasis, the thick hyperkeratotic plaque surface does not allow visualization of the underlying vascular structures, which are highlighted after removal of the scales [67].

Dermatitis

Typically, dermatitis dermoscopically exhibits red dots in a patchy distribution and fine, diffuse, yellowish scales [61]. Morphologically, no difference exists between the vessels of dermatitis and those of psoriasis. However, the vessels are not symmetrically distributed but are usually aggregated or clustered in some sites of the lesion and absent in others, forming an overall asymmetrical "patchy" pattern. Most importantly, dermatitis lesions typically display yellowish scales, which are particularly useful clues for the recognition of the disease [61]. Notably, yellow scale color can be dermoscopically detected not only in cases of acute dermatitis, but also in long-standing lesions. Although the dermoscopic pattern of each disease subtype has not been separately investigated, several case studies including contact dermatitis, nummular eczema, generalized dermatitis, chronic dermatitis, seborrheic dermatitis, and other subtypes report on similar dermoscopic findings (as described) [61,68,69].

Lichen Planus

White crossing streaks (Wickham striae) are considered the dermoscopic hallmark of lichen planus, being a constant finding in almost all types of lesions associated with the disease [61,70]. Vessels of mixed morphology (dotted and linear), usually distributed at the periphery of the lesion, represent additional dermoscopic findings of the disease [61].

Pityriasis Rosea

A yellowish background color and peripheral whitish scales (collarette) are the most important dermoscopic features of pityriasis rosea. Dotted vessels can be also

TABLE 3.2 Dermoscopic Criteria of Inflammatory Skin Diseases

Disease	Dermoscopic criteria
Darier disease	Pseudocomedones, erythema, dotted/linear vessels
Dermatitis	Dotted vessels with patchy distribution, yellow crusts/scales
Discoid lupus erythematosus	Early lesions: perifollicular whitish halo, follicular plugging, and white scales
	Late lesions: telangiectasias, pigmentation structures, and whitish structureless areas
Erythema multiforme	Linear vessels peripherally, bluish patches in the center
Granuloma annulare	Dotted, linear, or dotted/linear vessels; white, red, or yellow background
Granuloma faciale	Dilated follicular openings, perifollicular whitish haloes, pigmentation structures, follicular keratotic plugs, elongated or linear branching vessels
Henoch–Schönlein purpura	Irregularly shaped red patches with blurred borders
Lichen planus	Wickham striae, peripheral dotted/linear vessels
Lichen sclerosus	Genital lesions: white-yellowish structureless areas, linear vessels
	Extragenital lesions: white/yellowish structureless areas, yellowish keratotic plugs (pseudocomedones)
Livedo reticularis	Linear vessels with a regular distribution
Mastocytosis	Light-brown blot, pigment network, reticular vascular pattern, or yellow-orange blot
Morphea	Whitish fibrotic beams, linear vessels
Mycosis fungoides	Short linear vessels, orange-yellowish areas, spermatozoa-like structures
Necrobiosis lipoidica	Prominent network of linear arborizing vessels and a yellow background color
Pigmented purpuric dermatoses	Purpuric dots or globules, orange-brown background
Pityriasis rosea	Yellowish background, peripheral white scales, dotted vessels with patchy distribution
Pityriasis rubra pilaris	Yellowish areas, dotted and linear vessels with patchy or peripheral distribution
Porokeratosis	White-yellowish or brownish peripheral annular structure; in the center, brownish pigmentation, dotted/linear vessels, or structureless whitish areas
Psoriasis	Dotted vessels with regular distribution, white scales
Rosacea	Erythematotelangiectatic type: polygonal vessels
	Papulopustular type: follicular plugs, follicular pustules, polygonal vessels
Sarcoidosis	Orange-yellowish globules or areas, linear vessels
Sweet syndrome	Structureless bluish patches
Urticaria	Network of linear vessels surrounding avascular areas
Urticarial vasculitis	Purpuric dots or globules, orange-brown background

found in several lesions, but they are arranged in an irregular or patchy pattern, unlike the characteristic regular distribution of psoriasis [61].

Granulomatous Skin Diseases

Dermal granulomas dermoscopically project as translucent orange-yellowish patches or structureless areas. These structures, often associated with linear vessels, are highly indicative of a granulomatous skin disease, including sarcoidosis, lupus vulgaris, and granulomatous rosacea. However, dermoscopy is insufficient to differentiate among these entities [71].

Discoid Lupus Erythematosus

Perifollicular whitish halo, follicular plugging, and white scales represent the predominant features of early lesions of discoid lupus erythematosus (DLE), whereas telangiectasias, pigmented structures, and whitish structureless areas characterize longer-standing lesions [72]. By highlighting the characteristic follicular disturbances

of DLE or the yellowish patches of lupus pernio (cutaneous sarcoidosis) and lupus vulgaris, dermoscopy might significantly facilitate this particularly difficult differential diagnosis [71].

Rosacea

A characteristic dermoscopic vascular pattern of polygonal vessels has been described in erythematotelangiectatic rosacea (ER) [71]. Intense vasodilation, which is well known to represent a major pathophysiological alteration of the disease, results in a characteristic morphological pattern of dermoscopic vascular polygons. Telangiectasias may also be detected on chronically sun-damaged, atrophic facial skin, but they usually lack the characteristic arrangement in polygons. Additional dermoscopic findings of ER include follicular plugs, white scales, features related to the presence of *Demodex*, namely "*Demodex* tails," and whitish amorphic follicular material [73]. In papulopustular rosacea, dermoscopy might highlight clinically nonvisible pustules, providing a useful diagnostic clue.

Lichen Sclerosus and Morphea

White-yellowish structureless areas represent the predominant dermoscopic feature of genital and extragenital lichen sclerosus. Genital lesions often also display linear vessels, whereas early extragenital lesions commonly exhibit keratotic plugs and may be surrounded by an erythematous halo, which represents a marker of disease activity. In contrast, linear vessels within a lilac ring and "fibrotic beams" (correlating histopathologically with dermal sclerosis) have been reported to characterize morphea [74].

Urticaria and Urticarial Vasculitis

A red, reticular network of linear vessels has been described to dermoscopically characterize common urticaria [75]. In contrast, urticarial vasculitis displays purpuric dots or globules, suggestive of the underlying vasculitis, on an orange-brown background [76].

Pigmented Purpuric Dermatoses (Capillaritis)

Five distinct entities are traditionally described under the term *pigmented purpuric dermatoses (PPD)*: Schamberg disease, Majocchi purpura, eczematoid purpura of Doucas and Kapetanakis, lichen aureus, and pigmented purpuric lichenoid dermatitis of Gougerot–Blum. The typical dermoscopic pattern of PPDs consists of purpuric dots or globules and orange-brown areas [77].

Mastocytosis

Four dermoscopic patterns characterize cutaneous mastocytosis: light-brown blot, pigment network, reticular vascular pattern, and yellow-orange blot [78,79]. Notably, an association has been suggested between the dermoscopic pattern and the disease subtype. In detail, light-brown blot and pigment network were associated with maculopapular mastocytosis, yellow orange blot with solitary mastocytoma, and a reticular vascular pattern was detected in all cases of telangiectasia macularis eruptiva perstans [79].

Mycosis Fungoides

Short linear vessels and orange-yellowish areas represent the most common dermoscopic findings of early mycosis fungoides (MF), whereas dotted vessels might also be present [69]. A peculiar vascular structure consisting of a dotted and a linear component (spermatozoon-like structure) can be found in half of MF cases. The dermoscopic pattern of MF might be particularly useful for its discrimination from dermatitis. Specifically, dermatitis typically displays only dotted vessels, with the exception of lesions under long-term treatment with topical steroids, which might result in atrophy and telangiectasia [69].

Dermoscopy of Infectious Skin Diseases

Specific dermoscopic patterns have been described for several infectious skin diseases, including those of viral, fungal, and parasitic origin [80]. Of note, use of the new-generation dermatoscopes that do not require direct contact to the skin minimizes the risk of transfection. Table 3.3 summarizes the main dermoscopic findings in several infectious skin diseases, and the most common of them are also described in the following sections.

Scabies

The typical dermoscopic pattern of scabies consists of small, dark brown, triangular structures located at the end of whitish curved or wavy lines, giving an appearance reminiscent of a delta-wing jet with a contrail. Microscopically, the brown triangle corresponds to the pigmented anterior part of the mite, whereas the burrow of the mite correlates dermoscopically to the contrail feature [81].

The diagnostic accuracy of dermoscopy has been reported to be at least equal to traditional ex vivo microscopic examination, but requiring less time, cost, and experience [81,82].

Mycoses

Tinea nigra is dermoscopically typified by a reticulated pattern consisting of superficial fine, wispy, light brown strands or pigmented spicules [83]. In tinea capitis, dermoscopy typically reveals comma hairs, broken dystrophic hairs, or corkscrew or convoluted hairs.

TABLE 3.3 Dermoscopic Criteria of Infectious Skin Diseases

Disease	Dermoscopic criteria
Cutaneous lavra migrans	Translucent brownish structureless areas in a segmental arrangement
Human papillomavirus infections	Common warts: multiple densely packed papillae with a central red dot or loop, surrounded by a whitish halo; hemorrhages (small red to black dots or streaks) may also be present
	Plantar warts: prominent hemorrhages within a well-defined, yellowish papilliform surface in which skin lines are interrupted
	Plane warts: regularly distributed red dots, light brown to yellow background
	Genital warts: mosaic pattern (early/flat lesions), fingerlike and knoblike pattern (raised/papillomatous lesions), unspecific pattern
Leishmaniasis	Orange-yellowish globules or areas, linear vessels, erythema, follicular plugs, hyperkeratosis, central ulceration
Lupus vulgaris	Orange-yellowish globules or areas, linear vessels
Molluscum contagiosum	Central pore or umbilication, white to yellow amorphous structures, peripheral linear or branching vessels ("red corona")
Pediculosis	The lice itself, ovoid brownish structures (nits with vital nymphs), ovoid translucent structures (empty nits)
Scabies	"Jet with contrail" structure
Spider leg spines	Small black spines
Tick bites	Visualization of the anterior legs protruding from the skin surface, brown to gray translucent "shield"
Tinea nigra	Reticulated pattern, consisting of superficial fine, wispy, light brown strands or pigmented spicules
Tungiasis	White to light brown color, targetoid brownish ring surrounding a black central pore

Molluscum Contagiosum

Dermoscopy is particularly useful for the diagnosis of molluscum contagiosum by revealing a characteristic pattern consisting of a central umbilication in conjunction with polylobular white to yellow amorphous structures and surrounded by linear or branched vessels [84].

Pediculosis

Dermoscopy allows a rapid and reliable diagnosis of pediculosis by revealing the lice itself or the nits fixed to the hair shaft [85]. Nits containing vital nymphs dermoscopically display ovoid brown structures, whereas the empty nits are translucent and typically show a plane and fissured free ending. Additionally, dermoscopy enables the discrimination between nits and the so-called "pseudo-nits," such as hair casts and debris of hair spray or gel. The latter are not firmly attached to the hair shaft and appear dermoscopically as amorphous, whitish structures [86].

CONCLUSION

Dermoscopy has gained an irreplaceable role in the evaluation of skin tumors, because it significantly improves the performance of clinicians. Furthermore, with novel dermoscopic patterns of several skin diseases continuously coming to light, the dermatoscope gradually acquires a role similar to the pathologist's stethoscope.

References

[1] Malvehy J, Puig S, Argenziano G, Marghoob AA, Soyer HP, International Dermoscopy Society Board Members. Dermoscopy report: proposal for standardization. Results of a consensus meeting of the International Dermoscopy Society. J Am Acad Dermatol 2007;57(1):84–95.
[2] Menzies SW, Zalaudek I. Why perform dermoscopy? The evidence for its role in the routine management of pigmented skin lesions. Arch Dermatol 2006;142(9):1211–2.
[3] Lallas A, Zalaudek I, Apalla Z, Longo C, Moscarella E, Piana S, et al. Management rules to detect melanoma. Dermatology 2013;226(1):52–60.
[4] Zalaudek I, Kittler H, Marghoob AA, Balato A, Blum A, Dalle S, et al. Time required for a complete skin examination with and without dermoscopy: a prospective, randomized multicenter study. Arch Dermatol 2008;144(4):509–13.
[5] Kittler H, Pehamberger H, Wolff K, Binder M. Diagnostic accuracy of dermoscopy. Lancet Oncol 2002;3(3):159–65.
[6] Menzies SW, Westerhoff K, Rabinovitz H, Kopf AW, McCarthy WH, Katz B. Surface microscopy of pigmented basal cell carcinoma. Arch Dermatol 2000;136(8):1012–6.
[7] Zalaudek I, Giacomel J, Schmid K, Bondino S, Rosendahl C, Cavicchini S, et al. Dermatoscopy of facial actinic keratosis,

intraepidermal carcinoma and invasive squamous cell carcinoma: a progression model. J Am Acad Dermatol 2012;66(4):589–97.
[8] Lallas A, Giacomel J, Argenziano G, García-García B, González-Fernández D, Zalaudek I, et al. Dermoscopy in general dermatology: practical tips for the clinician. Br J Dermatol 2014;170(3): 514–26.
[9] 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. Br J Dermatol 2008;159(3):669–76.
[10] Argenziano G, Albertini G, Castagnetti F, De Pace B, Di Lernia V, Longo C, et al. Early diagnosis of melanoma: what is the impact of dermoscopy? Dermatol Ther 2012;25(5):403–9.
[11] Argenziano G, Soyer HP, Chimenti S, Talamini R, Corona R, Sera F, et al. Dermoscopy of pigmented skin lesions: results of a consensus meeting via the Internet. J Am Acad Dermatol 2003; 48(5):679–93.
[12] Johr RH. Dermoscopy: alternative melanocytic algorithms, the ABCD rule of dermatoscopy, Menzies' scoring method, and 7-point checklist. Clin Dermatol 2002;20(3):240–7.
[13] Argenziano G, Catricalà C, Ardigo M, Buccini P, De Simone P, Eibenschutz L, et al. Seven-point checklist of dermoscopy revisited. Br J Dermatol 2011;164(4):785–90.
[14] Soyer HP, Argenziano G, Zalaudek I, Corona R, Sera F, Talamini R, et al. Three-point checklist of dermoscopy: a new screening method for early detection of melanoma. Dermatology 2004;208(1):27–31.
[15] Pehamberger H, Steiner A, Wolff K. In vivo epiluminescence microscopy of pigmented skin lesions. I. Pattern analysis of pigmented skin lesions. J Am Acad Dermatol 1987;17(4):571–83.
[16] Braun RP, Rabinovitz HS, Oliviero M, Kopf AW, Saurat JH. Pattern analysis: a two-step procedure for the dermoscopic diagnosis of melanoma. Clin Dermatol 2002;20(3):236–9.
[17] De Giorgi V, Carli P. Dermoscopy and preoperative evaluation of melanoma thickness. Clin Dermatol 2002;20(3):305–8.
[18] Gonzalez-Alvarez T, Carrera C, Bennassar A, Vilalta A, Rull R, Alos L, et al. Dermoscopy structures as predictors of sentinel lymph node positivity in cutaneous melanoma. Br J Dermatol 2015;172(5):1269–77.
[19] Argenziano G, Fabbrocini G, Carli P, De Giorgi V, Delfino M. Clinical and dermatoscopic criteria for the preoperative evaluation of cutaneous melanoma thickness. J Am Acad Dermatol 1999;40(1): 61–8.
[20] Lallas A, Argenziano G, Moscarella E, Longo C, Simonetti V, Zalaudek I. Diagnosis and management of facial pigmented macules. Clin Dermatol 2014;32(1):94–100.
[21] Stolz W, Schiffner R, Burgdorf WH. Dermatoscopy for facial pigmented skin lesions. Clin Dermatol 2002;20(3):276–8.
[22] Pralong P, Bathelier E, Dalle S, Poulalhon N, Debarbieux S, Thomas L. Dermoscopy of lentigo maligna melanoma: report of 125 cases. Br J Dermatol 2012;167(2):280–7.
[23] Saida T, Koga H, Uhara H. Key points in dermoscopic differentiation between early acral melanoma and acral nevus. J Dermatol 2011;38(1):25–34.
[24] Braun RP, Baran R, Le Gal FA, Dalle S, Ronger S, Pandolfi R, et al. Diagnosis and management of nail pigmentations. J Am Acad Dermatol 2007;56(5):835–47.
[25] Kittler H, Binder M. Risks and benefits of sequential imaging of melanocytic skin lesions in patients with multiple atypical nevi. Arch Dermatol 2001;137(12):1590–5.
[26] Fikrle T, Pizinger K, Szakos H, Panznerova P, Divisova B, Pavel S. Digital dermatoscopic follow-up of 1027 melanocytic lesions in 121 patients at risk of malignant melanoma. J Eur Acad Dermatol Venereol 2013;27(2):180–6.
[27] Marghoob AA, Usatine RP, Jaimes N. Dermoscopy for the family physician. Am Fam Physician 2013;88(7):441–50.
[28] Braun RP, Rabinovitz HS, Krischer J, Kreusch J, Oliviero M, Naldi L, et al. Dermoscopy of pigmented seborrheic keratosis: a morphological study. Arch Dermatol 2002;138(12):1556–60.
[29] Bottoni U, Nisticò S, Amoruso GF, Schipani G, Arcidiacono V, Scali E, et al. Ink spot lentigo: singular clinical features in a case series of patients. Int J Immunopathol Pharmacol 2013;26(4): 953–5.
[30] Zaballos P, Blazquez S, Puig S, Salsench E, Rodero J, Vives JM, et al. Dermoscopic pattern of intermediate stage in seborrhoeic keratosis regressing to lichenoid keratosis: report of 24 cases. Br J Dermatol 2007;157(2):266–72.
[31] Longo C, Zalaudek I, Moscarella E, Lallas A, Piana S, Pellacani G, et al. Clonal seborrheic keratosis: dermoscopic and confocal microscopy characterization. J Eur Acad Dermatol Venereol 2014; 28(10):1397–400.
[32] Rossiello L, Zalaudek I, Ferrara G, Docimo G, Giorgio CM, Argenziano G. Melanoacanthoma simulating pigmented spitz nevus: an unusual dermoscopy pitfall. Dermatol Surg 2006; 32(5):735–7.
[33] Shankar V, Nandi J, Ghosh K, Ghosh S. Giant melanoacanthoma mimicking malignant melanoma. Indian J Dermatol 2011;56(1): 79–81.
[34] Espasandín-Arias M, Moscarella E, Mota-Buçard A, Moreno-Moreno C, Lallas A, Longo C, et al. The dermoscopic variability of dermatofibromas. J Am Acad Dermatol 2015;72(Suppl. 1):S22–4.
[35] Zaballos P, Puig S, Llambrich A, Malvehy J. Dermoscopy of dermatofibromas: a prospective morphological study of 412 cases. Arch Dermatol 2008;144(1):75–83.
[36] Zaballos P, Llambrich A, Ara M, Olazarán Z, Malvehy J, Puig S. Dermoscopic findings of haemosiderotic and aneurysmal dermatofibroma: report of six patients. Br J Dermatol 2006;154(2): 244–50.
[37] Morariu SH, Suciu M, Vartolomei MD, Badea MA, Cotoi OS. Aneurysmal dermatofibroma mimicking both clinical and dermoscopic malignant melanoma and Kaposi's sarcoma. Rom J Morphol Embryol 2014;55(Suppl. 3):1221–4.
[38] Oiso N, Kawada A. The dermoscopic features in infantile hemangioma. Pediatr Dermatol 2011;28(5):591–3.
[39] Haliasos EC, Kerner M, Jaimes N, Zalaudek I, Malvehy J, Lanschuetzer CM, et al. Dermoscopy for the pediatric dermatologist. II. Dermoscopy of genetic syndromes with cutaneous manifestations and pediatric vascular lesions. Pediatr Dermatol 2013; 30(2):172–81.
[40] Piccolo V, Russo T, Mascolo M, Staibano S, Baroni A. Dermoscopic misdiagnosis of melanoma in a patient with targetoid hemosiderotic hemangioma. J Am Acad Dermatol 2014;71(5):179–81.
[41] Zaballos P, Daufí C, Puig S, Argenziano G, Moreno-Ramírez D, Cabo H, et al. Dermoscopy of solitary angiokeratomas: a morphological study. Arch Dermatol 2007;143(3):318–25.
[42] Oztas MO. Clinical and dermoscopic progression of subungual hematomas. Int Surg 2010;95(3):239–41.
[43] Massa AF, Dalle S, Thomas L. Subcorneal hematoma. Ann Dermatol Venereol 2013;140(1):63–4.
[44] Zaballos P, Carulla M, Ozdemir F, Zalaudek I, Bañuls J, Llambrich A, et al. Dermoscopy of pyogenic granuloma: a morphological study. Br J Dermatol 2010;163(6):1229–37.
[45] Zaballos P, Rodero J, Serrano P, Cuellar F, Guionnet N, Vives JM. Pyogenic granuloma clinically and dermoscopically mimicking pigmented melanoma. Dermatol Online J 2009;15(10):10.
[46] Lallas A, Argenziano G, Zendri E, Moscarella E, Longo C, Grenzi L, et al. Update on non-melanoma skin cancer and the value of dermoscopy in its diagnosis and treatment monitoring. Expert Rev Anticancer Ther 2013;13(5):541–58.
[47] Lallas A, Apalla Z, Argenziano G, Longo C, Moscarella E, Specchio F, et al. The dermatoscopic universe of basal cell carcinoma. Dermatol Pract Concept 2014;4(3):11–24.

[48] Giacomel J, Zalaudek I. Dermoscopy of superficial basal cell carcinoma. Dermatol Surg 2005;31(12):1710–3.
[49] Lallas A, Argenziano G, Kyrgidis A, Apalla Z, Moscarella E, Longo C, et al. Dermoscopy uncovers clinically undetectable pigmentation in basal cell carcinoma. Br J Dermatol 2014;170(1):192–5.
[50] Lallas A, Tzellos T, Kyrgidis A, Apalla Z, Zalaudek I, Karatolias A, et al. Accuracy of dermoscopic criteria for discriminating superficial from other subtypes of basal cell carcinoma. J Am Acad Dermatol 2014;70(2):303–11.
[51] Balagula Y, Braun RP, Rabinovitz HS, Dusza SW, Scope A, Liebman TN, et al. The significance of crystalline/chrysalis structures in the diagnosis of melanocytic and nonmelanocytic lesions. J Am Acad Dermatol 2012;67(2):194.e1-8.
[52] MacKie RM, Quinn A. Non-melanoma skin cancer and other epidermal skin tumours. In: Burns T, Breathnach SM, Cox NH, Griffiths CEM, editors. Rook's textbook of dermatology. 7th ed. Oxford: Blackwell Publishing; 2004. p. 36.1–36.39.
[53] Memon AA, Tomenson JA, Bothwell J, Friedmann PS. Prevalence of solar damage and actinic keratosis in a Merseyside population. Br J Dermatol 2000;142(6):1154–9.
[54] Glogau RG. The risk of progression to invasive disease. J Am Acad Dermatol 2000;42(1 Pt 2):23–4.
[55] Rowert-Huber J, Patel MJ, Forschner T, Ulrich C, Eberle J, Kerl H, et al. Actinic keratosis is an early in situ squamous cell carcinoma: a proposal for reclassification. Br J Dermatol 2007;156(Suppl. 3):8–12.
[56] Huerta-Brogeras M, Olmos O, Borbujo J, Hernández-Núñez A, Castaño E, Romero-Maté A, et al. Validation of dermoscopy as a real-time noninvasive diagnostic imaging technique for actinic keratosis. Arch Dermatol 2012;148(10):1159–64.
[57] Lee M-M, Wick MM. Bowen's disease. CA Cancer J Clin 1990; 40(10):237–42.
[58] Kossard S, Rosen R. Cutaneous Bowen's disease: an analysis of 1001 cases according to age, sex, and site. J Am Acad Dermatol 1992;27(3):406–10.
[59] Zalaudek I, Argenziano G, Leinweber B, Citarella L, Hofmann-Wellenhof R, Malvehy J, et al. Dermoscopy of Bowen's disease. Br J Dermatol 2004;150(6):1112–6.
[60] Pan Y, Chamberlain AJ, Bailey M, Chong AH, Haskett M, Kelly JW. Dermatoscopy aids in the diagnosis of the solitary red scaly patch or plaque-features distinguishing superficial basal cell carcinoma, intraepidermal carcinoma, and psoriasis. J Am Acad Dermatol 2008;59(2):268–74.
[61] Lallas A, Kyrgidis A, Tzellos TG, Apalla Z, Karakyriou E, Karatolias A, et al. Accuracy of dermoscopic criteria for the diagnosis of psoriasis, dermatitis, lichen planus and pityriasis rosea. Br J Dermatol 2012;166(6):1198–205.
[62] Cameron A, Rosendahl C, Tschandl P, Riedl E, Kittler H. Dermatoscopy of pigmented Bowen's disease. J Am Acad Dermatol 2010;62(4):597–604.
[63] Alam M, Ratner D. Cutaneous squamous cell carcinoma. N Engl J Med 2001;344(13):975–83.
[64] Rosendahl C, Cameron A, Argenziano G, Zalaudek I, Tschandl P, Kittler H. Dermoscopy of squamous cell carcinoma and keratoacanthoma. Arch Dermatol 2012;148(12):1386–92.
[65] Lallas A, Pyne J, Kyrgidis A, Andreani S, Argenziano G, Cavaller A, et al. The clinical and dermoscopic features of invasive cutaneous squamous cell carcinoma depend on the histopathological grade of differentiation. Br J Dermatol 2015;172(5):1308–15.
[66] Lallas A, Zalaudek I, Argenziano G, Longo C, Moscarella E, Di Lernia V, et al. Dermoscopy in general dermatology. Dermatol Clin 2013;31(4):679–94.
[67] Lallas A, Apalla Z, Argenziano G, Sotiriou E, Di Lernia V, Moscarella E, et al. Dermoscopic pattern of psoriatic lesions on specific body sites. Dermatology 2014;228(3):250–4.
[68] Vazquez-Lopez F, Kreusch J, Marghoob AA. Dermoscopic semiology: further insights into vascular features by screening a large spectrum of nontumoral skin lesions. Br J Dermatol 2004;150(2): 226–31.
[69] Lallas A, Apalla Z, Lefaki I, Tzellos T, Karatolias A, Sotiriou E, et al. Dermoscopy of early stage mycosis fungoides. J Eur Acad Dermatol Venereol 2013;27(5):617–21.
[70] Vázquez-López F, Manjón-Haces JA, Maldonado-Seral C, Raya-Aguado C, Pérez-Oliva N, Marghoob AA. Dermoscopic features of plaque psoriasis and lichen planus: new observations. Dermatology 2003;207(2):151–6.
[71] Lallas A, Argenziano G, Apalla Z, Gourhant JY, Zaballos P, Di Lernia V, et al. Dermoscopic patterns of common facial inflammatory skin diseases. J Eur Acad Dermatol Venereol 2014;28(5): 609–14.
[72] Lallas A, Apalla Z, Lefaki I, Sotiriou E, Lazaridou E, Ioannides D, et al. Dermoscopy of discoid lupus erythematosus. Br J Dermatol 2012;168(2):284–8.
[73] Segal R, Mimouni D, Feuerman H, Pagovitz O, David M. Dermoscopy as a diagnostic tool in demodicidosis. Int J Dermatol 2010; 49(9):1018–23.
[74] Shim W-H, Jwa SW, Song M, Kim HS, Ko HC, Kim MB, et al. Diagnostic usefulness of dermatoscopy in differentiating lichen sclerous et atrophicus from morphea. J Am Acad Dermatol 2012; 66(4):690–1.
[75] Vázquez-López F, Fueyo A, Sánchez-Martín J, Pérez-Oliva N. Dermoscopy for the screening of common urticaria and urticaria vasculitis. Arch Dermatol 2008;144(4):568.
[76] Vazquez-Lopez F, Maldonado-Seral C, Soler-Sánchez T, Perez-Oliva N, Marghoob AA. Surface microscopy for discriminating between common urticaria and urticarial vasculitis. Rheumatology (Oxford) 2003;42(9):1079–82.
[77] Zaballos P, Puig S, Malvehy J. Dermoscopy of pigmented purpuric dermatoses (lichen aureus): a useful tool for clinical diagnosis. Arch Dermatol 2004;140(10):1290–1.
[78] Akay BN, Kittler H, Sanli H, Harmankaya K, Anadolu R. Dermatoscopic findings of cutaneous mastocytosis. Dermatology 2009; 218(3):226–30.
[79] Vano-Galvan S, Alvarez-Twose I, De las Heras E, Morgado JM, Matito A, Sánchez-Muñoz L, et al. Dermoscopic features of skin lesions in patients with mastocytosis. Arch Dermatol 2011; 147(8):932–40.
[80] Zalaudek I, Giacomel J, Cabo H, Di Stefani A, Ferrara G, Hofmann-Wellenhof R, et al. Entodermoscopy: a new tool for diagnosing skin infections and infestations. Dermatology 2008; 216(1):14–23.
[81] Walter B, Heukelbach J, Fengler G, Worth C, Hengge U, Feldmeier H. Comparison of dermoscopy, skin scraping, and the adhesive tape test for the diagnosis of scabies in a resource-poor setting. Arch Dermatol 2011;147(4):468–73.
[82] Park JH, Kim CW, Kim SS. The diagnostic accuracy of dermoscopy for scabies. Ann Dermatol 2012;24(2):194.
[83] Piliouras P, Allison S, Rosendahl C, Buettner PG, Weedon D. Dermoscopy improves diagnosis of tinea nigra: a study of 50 cases. Australas J Dermatol 2011;52(3):191–4.
[84] Zaballos P, Ara M, Puig S, Malvehy J. Dermoscopy of molluscum contagiosum: a useful tool for clinical diagnosis in adulthood. J Eur Acad Dermatol Venereol 2006;20(4):482–3.
[85] Di Stefani A, Hofmann-Wellenhof R, Zalaudek I. Dermoscopy for diagnosis and treatment monitoring of pediculosis capitis. J Am Acad Dermatol 2006;54(5):909–11.
[86] Zalaudek I, Argenziano G. Dermoscopy of nits and pseudonits. N Engl J Med 2012;367(18):1741.

CHAPTER

4

Trichoscopy: The Dermatologist's Third Eye

U. Khopkar, N. Jain

Kaya Skin Clinic, Mumbai, India

OUTLINE

INTRODUCTION

Dermoscopy/dermatoscopy, or epiluminescence microscopy, is the examination of skin lesions with a dermatoscope (digital magnifier, typically ×10). In 2006, Lidia Rudnicka and Malgorzata Olszewska coined the term *trichoscopy* for the dermoscopy of the hair and scalp [1].

When introduced, dermatoscopy was extensively used for early and noninvasive diagnosis of melanoma. However, in the later years, multiple other significant uses of a dermatoscope in evaluating tumoral/nontumoral skin conditions and hair and scalp disorders has been reported.

Trichoscopy has recently evolved as a simple, noninvasive, and relatively inexpensive technique to evaluate hair and scalp. The other advantages include being able to inspect a larger area in less time and the fact that it can be easily mastered if one has a keen eye.

Most trichoscopes available come with an in-built software that makes record-keeping easy with good quality digital images. Comparison of the pretreatment and post-treatment images helps in guiding the course of therapy and evaluating the treatment results. It has a high patient satisfaction quotient and obviates the need for biopsy or choice of the best site for biopsy when one is indicated. Trichoscopy is also being used to

Imaging in Dermatology
http://dx.doi.org/10.1016/B978-0-12-802838-4.00004-2

calculate the follicular density in the donor area before follicular unit transplantation. Thus the trichoscope has become a must-have gadget in a dermatologist's arsenal.

TECHNICAL CONSIDERATIONS

A dermoscope can be of contact or noncontact type. Most of the manual hand-held dermoscopes are contact dermoscopes that require an interface solution, such as oil or alcohol. Pigment patterns are best visualized through a contact dermoscope.

Videodermoscopes are noncontact dermoscopes that usually have three modes: white light, ultraviolet light, and polarized light (PL). The interfollicular patterns, which relate to vascular structures and pigmentation, are visualized only with a polarizing light source or a polarizing filter. Vascular patterns are best seen through a videodermoscope because direct contact can result in blanching [2,3]. Videodermoscopes are in-motion dermoscopes and have higher patient satisfaction because the doctor and patient can simultaneously view the videographic images on the monitor and record the selected images for comparison during subsequent follow-up visits.

For scalp examination, a manual dermoscope (×10 magnification) or a videodermoscope with lenses ranging from ×20 to ×1000 magnification can be used [2,3] (Fig. 4.1A–C).

DERMOSCOPIC FEATURES

Systematic trichoscopic evaluation mandates evaluating the hair and scalp for

1. Follicular signs
   - **a.** Yellow dots
   - **b.** White dots
   - **c.** Black dots
2. Hair shaft characteristics
3. Interfollicular patterns
   - **a.** Vascular patterns
   - **b.** Pigment patterns

What does normal (physiologic) hair and scalp look like? Knowing the normal is a must to differentiate it from the abnormal. Trichoscopic findings may vary with variations in skin color and racial types. Dermoscopy of normal healthy scalp shows follicular units containing two to four terminal hairs and one or two vellus hairs (Fig. 4.2).

In darker races, a prominent brown homogenous honeycomb pigment network is seen over the scalp, which is accentuated over sun-exposed areas [4,5]. Vascular patterns are easily visualized in the fair skin population using a videodermoscope with a polarizing filter. However, in darkly pigmented skin, the heavy pigment prevents visualization of the underlying dermal vasculature.

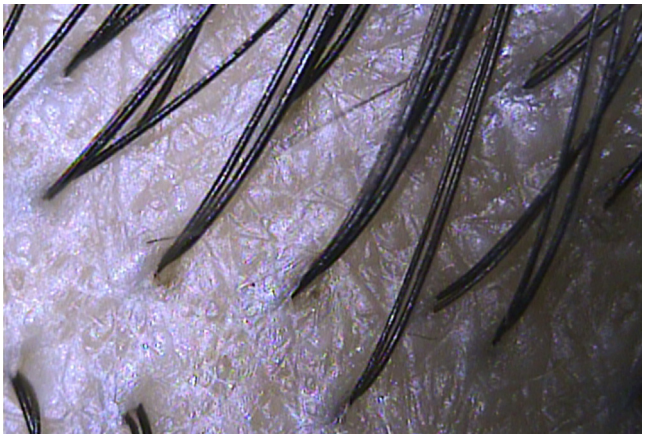


FIGURE 4.2 Dermoscopy of normal scalp with follicular units bearing two to four terminal hairs and a uniform pigment network in the background.

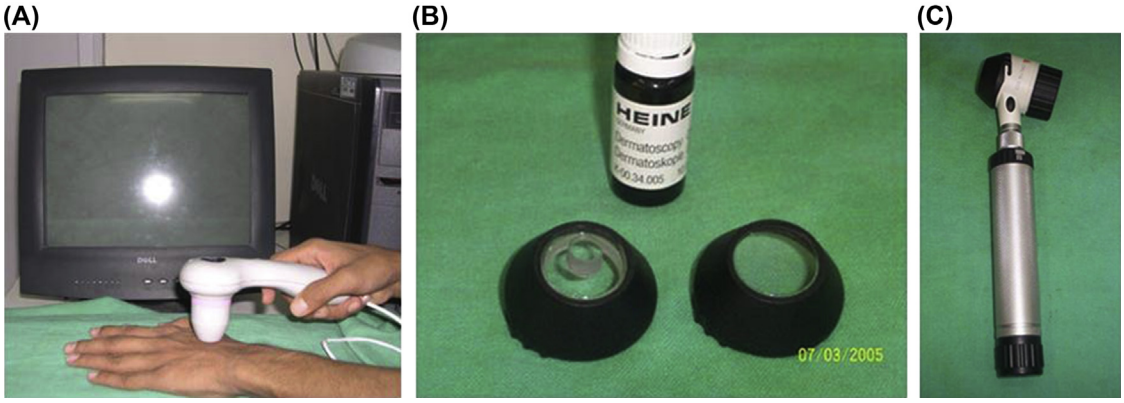


FIGURE 4.1 (A) Various lenses and interface solution for contact dermoscopy. (B) Manual Heine delta 20 hand-held dermoscope. (C) A standard videodermoscope.

Follicular Signs

Follicular signs observed on trichoscopy in various conditions can be correlated with the pathological changes occurring in the surface and subsurface structures. Perifollicular and interfollicular inflammation may result in alteration in vascular patterns, pigmentary changes, and scaling. Hair shaft affection results in changes in hair shaft diameter and breakage resulting in black dots. Common follicular signs described are discussed here.

Yellow Dots

Yellow dots is the term used to describe the follicular infundibulum, which is clogged with degenerating keratinocytes and excess sebum [2–6]. These are usually round and are best seen under PL. In lighter skin shades, they appear yellow, whereas in brown/darker skin types they appear pale against the pigmented background. Yellow dots are seen in alopecia areata (AA), androgenetic alopecia (AGA), and alopecia incognito Fig. 4.3.

In AA, yellow dots are the most common and most sensitive finding. They represent keratinous debris, which is not cleared from the infundibulum because of the presence of dystrophic/broken hairs. Yellow dots are usually associated with other findings of AA, such as black dots and cadaverized hair [2,6]. Yellow dots may have a hair strand within them or may even be empty.

In AGA, pearly white to yellowish dots are seen prominently over areas with sparse terminal hairs (ie, the frontoparietal and temporal areas). Distended follicles with hypertrophied sebaceous glands account for this finding. These are seen in advanced stages of AGA (Fig. 4.4).

FIGURE 4.3 Follicular yellow dots in a case of alopecia areata (*blue arrows*). A single exclamation mark hair (*red arrow*) can be seen as well along with multiple vellus hairs. Black dots can also be observed (*green arrow*).

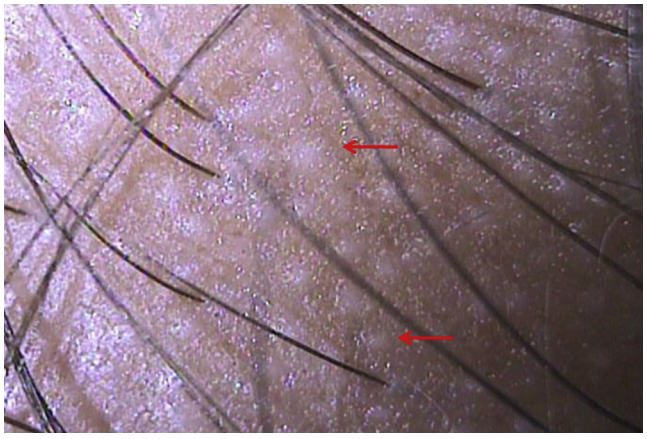


FIGURE 4.4 Advanced stage of androgenetic alopecia. All of the follicles show a single hair within. Multiple yellow to pearly white dots can also be observed (*red arrows*).

In alopecia incognita, they may be seen even in the areas with terminal hairs [2].

"Three-dimensional" soap bubbles like yellow dots have been described in dissecting cellultis of scalp [7,8].

White Dots

Follicles destroyed because of scarring are visualized as pale white dots in conditions that spare the interfollicular areas [2,3,7,9]. White dots represent fibrous tracts of scarred follicles seen in cicatricial alopecias, such as lichen planopilaris (LPP) and folliculitis decalvans [9]. White dots were reported by Kossard and Zagarella in cicatricial alopecia [10]. They are best seen in dark skin types and over tanned, sun-exposed areas where the honeycomb pattern pigment background provides a good contrast (Fig. 4.5).

Conditions causing complete scarring with affliction of the interfollicular areas cause a break in the scalp pigment network; hence the white dots are not visualized. Eccrine duct openings may look similar but can be differentiated because they are well-defined, rounded structures that are numerous and are seen over the diseased and the normal scalp. Sometimes active sweat secretion may be seen emanating from them [11,12].

Black Dots

Black dots represent broken/fractured dystrophic hairs and the remnants of exclamation mark hairs that break at the proximal end [2,3,7,13]. Black dots may be seen in AA, tinea capitis (noninflammatory black dot variant more commonly), dissecting cellulitis, and trichotillomania.

Black dots (cadaverized hairs) have been described most commonly in AA and are a finding reportedly associated with disease activity. They have been described to be the most specific markers by Inui et al. [14] (Fig. 4.6).

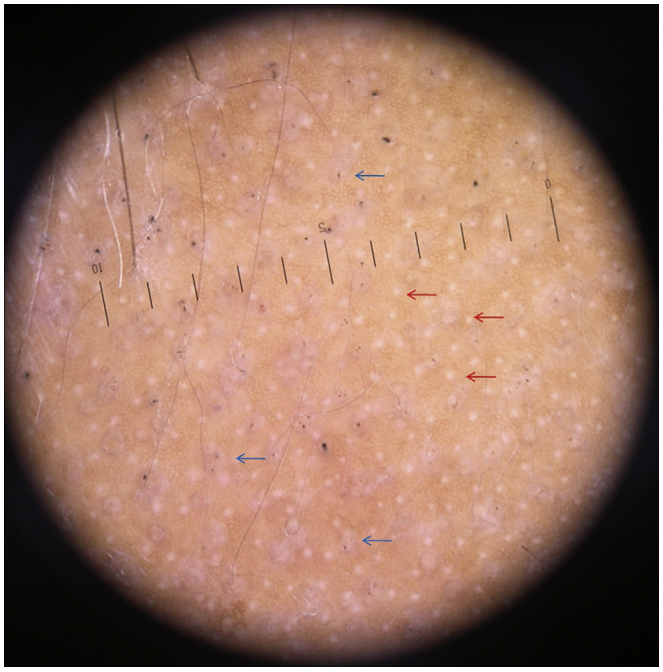


FIGURE 4.5 A case of cicatricial alopecia with multiple white dots that represent fibrosed follicles (*blue arrows*) and some white dots have broken hair shafts within. A prominent feature is the eccrine duct openings (*red arrows*). In addition, a break in the honeycomb pigment network can be seen at the sites of scarring.

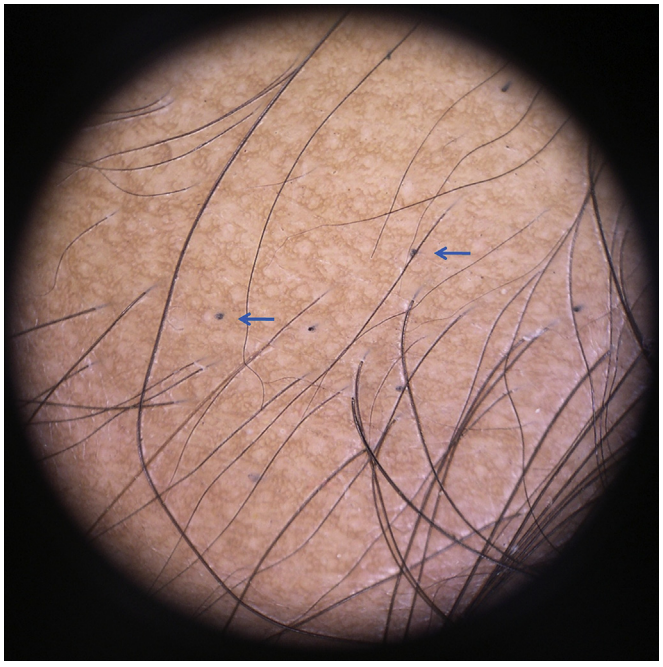


FIGURE 4.6 Multiple black dots (*blue arrows*) in a case of alopecia areata. A homogenous honeycomb pigment network can be seen in the background.

In AA, black dots are usually present within yellow dots. These are dystrophic hairs that fracture before emergence from the scalp [3,7,14,15].

Hair Shaft Characteristics

Trichoscopy of the hair shaft is useful to diagnose genetic and acquired hair shaft defects. Variation in thickness and pigment characteristics can be readily picked up. In addition, hair shaft changes in other conditions, such as AGA, telogen effluvium, and alopecia incognito help in confirming the diagnosis and monitoring therapy response.

Normal hair shafts are usually terminal with up to 10% being vellus hair shafts. The terminal hairs have uniform distribution of pigment and are thicker. They may be medullated or nonmedullated. Vellus hairs are thin, short, hypopigmented, and nonmedullated.

The hair shaft should be evaluated from the proximal to the distal end to look for alteration in thickness, pigmentation, length, presence of fractures, nodes, twists, and casts. Specific hair signs associated with different conditions have been described.

Evaluation of hair shaft thickness can be done for evaluating treatment response in conditions, such as AGA, which is characterized by progressive miniaturization of the hair follicle and an increased proportion of vellus hairs. Videodermoscopes with an in-built software that helps in detailed evaluation can be used for this purpose.

Interfollicular Patterns

Pathological changes in the interfollicular areas can be observed as changes in the pigment pattern and changes in the normal vascular pattern. Primary and secondary cicatricial alopecias and nonalopecic scalp conditions, such as psoriasis and seborrheic dermatitis can be diagnosed.

Vascular Patterns

Various vascular patterns associated with unaffected and affected scalp have been best described by Tosti and Duque-Estrada [2,3]. In pigmented skin types, the vascular patterns are generally obfuscated by the overlying prominent pigment network. Vascular patterns are best observed through a videodermoscope (noncontact) using the polarizing filter. The characteristic patterns described are as follows:

- *Interfollicular simple red loops*: These are seen in normal healthy scalp [2,3]. Hair and scalp conditions that do not affect the epidermis also show this pattern of capillary arrangement. This capillary pattern appears as multiple regularly spaced hairpin-like structures.

Absent loops indicate epidermal atrophy; thus they are not seen in advanced cases of discoid lupus erythematosus (DLE).

- *Interfollicular twisted loops*: These appear as twisted coils and are best seen with the probe placed tangentially to the scalp surface [2]. Conditions characterized by acanthosis, such as psoriasis and folliculitis decalvans, show this pattern [2–5]. Some cases of inflammatory seborrheic dermatitis also reveal this capillary pattern. The number, visibility, and tightness of the coiling correlate with disease severity. The presence of twisted capillaries on dermoscopy correlates with the histological finding of tortuous interpapillary loops in psoriasis.
- *Arborizing red lines*: These are seen as lines that underlie the loops in normal and affected scalp in all conditions [2,3]. They are of wider caliber. These are best seen at higher magnifications and are believed to represent the subpapillary plexus.

Pigment Pattern

At higher magnification, a diffuse homogenous, honeycomb pigment network is classically seen in normal scalp and is more pronounced in individuals with darker skin shades (Fig. 4.6) [2,3]. Bald areas and areas with sparse hair, as seen in men with advanced AGA, have a darker pigment network that corresponds to tanning due to excessive sun exposure. Even in normal scalp the extent of the pigment varies over the scalp depending upon the sun exposure and the density of hair.

This pattern is characterized by grid (irregular lines) and holes. The lines are hyperchromic and represent melanotic rete ridges, whereas holes are the hypochromic suprapapillary epidermis [2].

Variation in the continuity of the pigment pattern is generally seen in cicatricial alopecias, which affect the interfollicular epidermis. In conditions, such as LPP, where the interfollicular epidermis is spared, pigmentary changes are seen in the perifollicular areas.

TRICHOSCOPY FINDINGS IN COMMON HAIR AND SCALP CONDITIONS

Androgenetic Alopecia

Look for the following:

1. Hair shaft diameter diversity
2. Increase in proportion of vellus hairs with reduction of terminal-to-vellus hair ratio
3. Predominance of follicles with single hair
4. Peripilar brown halo
5. Yellow dots
6. Accentuated pigment pattern

AGA is the most common cause of hair loss across the world, affecting men and women alike. The diagnosis of AGA is mostly clinical. Confusion arises in cases occurring in very young individuals, fast progression, slow/nonresponse to therapy, and association with systemic conditions or where multiple conditions may co-exist. In such circumstances, trichoscopy helps to differentiate between AGA and conditions, such as telogen effluvium, AA, frontal fibrosing alopecia (FFA), and alopecia incognito.

The pathogenesis of AGA involves progressive miniaturization of hair follicles, which results in a progressive reduction in the hair shaft diameter. The corresponding trichoscopic finding is an increase in the proportion of vellus hairs. The earliest diagnostic feature of AGA has been described as variation in hair shaft diameter involving more than 20% of hair shafts [2,4,16].

Progressive miniaturization of the follicle also leads to a reduction in the number of terminal hairs per follicle. On trichoscopy, this is seen as a predominance of follicles bearing single hairs (normal follicles have two to four terminal hairs) over affected areas. A similar finding can also be seen in telogen effluvium and anagen effluvium. In patients with AGA, comparative analysis with the unaffected areas shows the disparity. Several commercially available software help to calculate the terminal-to-vellus hair ratio, monitor hair shaft thickness, grade the severity, and monitor treatment response at a later date.

Another significant finding in early cases of AGA is the peripilar sign. Mild perifollicular inflammation seen in early stages gives rise to a subtle brown halo that is usually missed on clinical examination (Fig. 4.7).

Yellow dots, described earlier, are seen as pearly white to yellowish rounded structures (papules) in

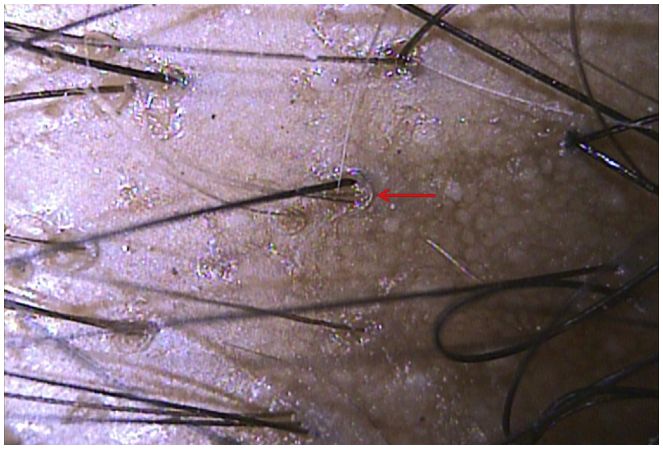


FIGURE 4.7 Early stage of androgenetic alopecia with increased number of vellus hair shafts and peripilar brown halo. Some follicles show single hair.

advanced cases, more commonly over the temporoparietal areas. These represent hypertrophied sebaceous glands [13,15]. The sebaceous gland activity is intact even in a miniaturized terminal follicle and in fact the gland may be hypertrophied because of increased end-organ sensitivity to circulating androgens (Fig. 4.4). Advanced cases may show a prominent honeycomb pigment pattern over the bald areas and the presence of yellow dots.

Most findings in pattern baldness are similar in both sexes. In female AGA (FAGA), focal areas of baldness (atrichia) are more commonly seen [13].

Kibar et al. evaluated the trichoscopic findings and their relations with disease severity in AGA in males and females and found no significant relation between trichoscopic findings and severity in male AGA and FAGA. In addition, this study described multiple other findings, such as brown dots, white dots, multihair follicular units, and hidden hair [17].

Trichoscopic criteria for diagnosing FAGA have been devised by Rakowska et al. based on a trichoscopy study of 131 females [16]. The study was a comparative analysis of the frontal and occipital areas visualized in patients of chronic telogen effluvium (39), FAGA (59), and healthy controls (33). In every patient the frontal, occipital, and right and left temporal areas were visualized, each for five images: one at 20-fold magnification and four images at 70-fold magnification.

The criteria evaluated were as follows: (1) number of vellus hairs; (2) hair thickness [percentage of thin (<0.03 mm), medium (0.03–0.05 mm), and thick (>0.05 mm) hairs]; (3) percentage of pilosebaceous units with one, two, and three hairs at 20-fold magnification; (4) number of yellow dots; and (5) percentage of perifollicular hyperpigmentation at 20-fold magnification. A trichoscopy record scheme in tabular format has been proposed by the authors [16]. To diagnose FAGA, comparative analysis of the frontal and occipital area is important. Major and minor criteria have been devised. The presence of two major or one major and two minor criteria diagnoses FAGA with a 98% specificity [16].

The criteria are as follows:

Major criteria

1. Total number of yellow dots in four fields of vision (FAGA criteria more than four yellow dots in frontal area)
2. Mean hair thickness in millimeters [1, thin hairs (<0.03 mm); 2, medium hairs (0.03–0.05 mm); FAGA criteria—lower hair thickness in frontal area and >10% thin hairs in frontal area]
3. Thick hairs (>0.05 mm)

Minor criteria

1. Percentage of units in one field of vision at 20-fold magnification (single hair, two-hair units, three-hair units; FAGA criteria—ratio of single-hair units, frontal area:occipital area >2:1)
2. Total number of vellus hairs in four fields of vision at 70-fold magnification (FAGA criteria—frontal area: occipital area >1.5:1)
3. Percentage hair follicles with perifollicular discoloration at 20-fold magnification (FAGA criteria—frontal area: occipital area >3:1)

Alopecia Areata

Clinical features are as follows:

1. Black dots
2. Yellow dots
3. Tapering hairs/exclamation hairs, cadaverized hairs
4. Short regrowing vellus hairs

AA is one of the most common forms of autoimmune, patchy, noncicatricial alopecias in all age groups affecting scalp and nonscalp sites. Although clinical diagnosis is simple, trichoscopy helps in differentiating it from other patchy alopecias, especially in pediatric patients.

The pathogenesis in AA is an abrupt arrest of hair cycle and formation of dystrophic hairs [2,18]. Black dots and yellow dots have been described above in detail. Trichoscopy findings may vary depending upon severity and disease duration.

Tapering hairs (exclamation mark hair) are short dystrophic hair strands with a narrow proximal end. It is a marker of active disease and can be seen at the periphery of a patch [7,13,15,19] (Fig. 4.8A and B). Exclamation mark hairs may also be seen in trichotillomania [7].

Yellow dots are seen in all of the stages of the disease and correlate well with disease severity [7,15] (Figs. 4.3 and 4.8A). Population variation in occurrence of yellow dots (may not be easily seen in dark-skinned individuals) can be attributed to variations in skin color and cleansing habits [2,3]. Yellow dots usually contain fractured dystrophic hair (cadaverized hair, black dots), short vellus hairs, or telogen hairs.

Various studies conducted in different parts of the world differ in their conclusions over the sensitivity and specificity of individual markers [4–6,14,19]. A recent study from Egypt concludes that in pediatric AA cases, black dots are the most common finding and can be a sensitive marker if associated with other findings of AA [19] (Fig. 4.8C).

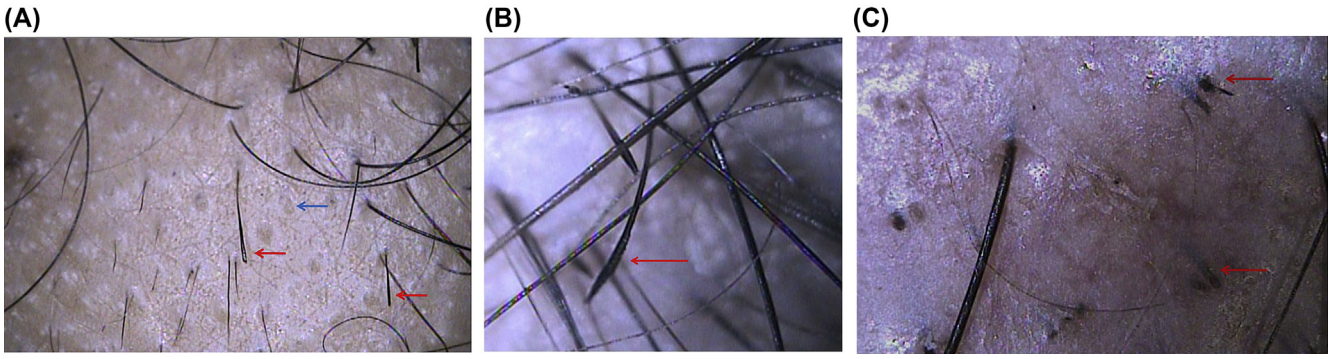


FIGURE 4.8 (A) A case of alopecia areata with multiple exclamation mark hairs (*red arrows*) yellow dots (*blue arrows*) and (B) regrowing short vellus hairs (*red arrow*). (C) Multiple black dots can be seen in a case of alopecia areata (*red arrows*).

Acute progressive cases are characterized by exclamation mark hairs and black dots. In chronic cases, the dystrophic hairs may be shed; thus the follicles may appear empty. Regrowing vellus hairs may also be seen. Short vellus hairs are a sensitive marker of hair regrowth. These regrowing hairs may be coiled as a pigtail as described by Rudnicka et al, [7].

The coudability sign, which represents terminal hair kinking toward the proximal end when pushed perpendicular to the scalp surface, can be seen in active disease [20].

Trichoscopic examination of epilated hair can be done by placing the hair against a light background and visualizing the roots at higher magnification (dermoscopic trichogram). Active disease is characterized by dystrophic hairs with fractured roots and telogen hairs [2,3].

Tinea Capitis

Clinical features are as follows:

1. Comma hair, corkscrew hairs
2. Black dots
3. Scales
4. Short broken hairs
5. Blotchy pigmentation
6. Erythema
7. Pustules, follicular scale crust

Tinea capitis is a fungal infection of the scalp, and it is the single greatest cause of alopecia in children. Trichoscopy helps in differentiation from other patchy alopecias, such as AA and trichotillomania. The black dot variant may especially cause confusion, and culture is considered to be the gold standard for diagnosis. Trichoscopy is convenient because it gives instant confirmation of the diagnosis. Standard sterile measures should be observed, or a separating transparent film can alternatively be used.

Features vary between inflammatory and noninflammatory variants. Comma-shaped hair stubs, which are slightly curved, and fractured hair shafts are a specific feature [7,13,15,21,22]. Hughes et al. has described that comma-shaped hairs and corkscrew hairs are a feature of zoophilic infection [19,23].

Numerous black dots, which are the remnants of broken hairs/dystrophic hairs, may be seen in the black dot variant (noninflammatory tinea). These black dots represent breakage of hair shafts infested by fungal hyphae. Unlike in AA, black dots in tinea are numerous and are not associated with yellow dots and tapering hairs (Fig. 4.9).

Other features, such as broken hairs, damaged hairs, and zigzag hairs have been described [7,19]. Short broken hairs are most common but a nonspecific feature. The zigzag hairs, corkscrew hair seems to be a variation of the comma hair, manifesting in Black patients [19,23].

Inflammatory tinea capitis is characterized by blotchy pigmentation, scaling, erythema, pustules, and follicular

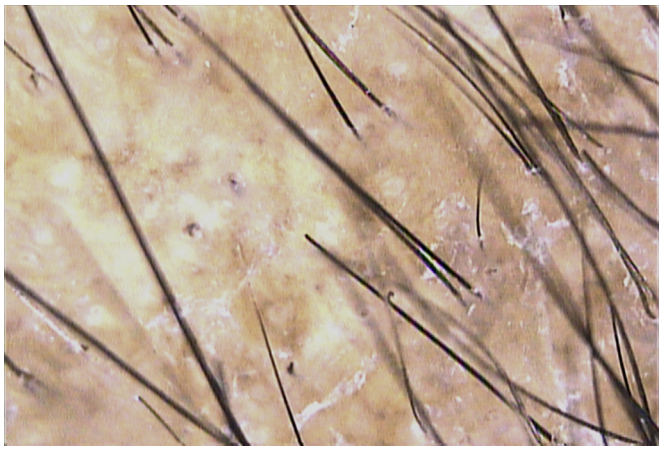


FIGURE 4.9 Tinea capitis with multiple black dots, scaling, and blotchy pigment pattern.

scale crust formation. Scaling is a feature in all tinea infections. Videodermoscopes with additional ultraviolet light mode help in demonstrating fluorescence caused by fungi.

Trichotillomania

Clinical features are as follows:

1. Broken hairs with variable length
2. Coiled hairs, hook hairs (question mark hair)
3. Trichoptilosis (longitudinal splits in hair shaft)
4. Flame hairs, V-sign
5. Tulip hairs, hair powder
6. Regrowing pigtail hairs

Trichotillomania is a psychocutaneous disorder, characterized by an impulse to pull out hair. It is commonly seen in children and young adults, with a significant female preponderance of 70–93% [24].

Clinically, trichotillomania is a type of patchy hair loss with patches mostly over the easy-access areas of the scalp-like vertex [25,26]. An extensive tonsure pattern may be seen at times [27]. Because of the similar age group of affliction and patchy nature, conditions, such as AA and tinea capitis need to be differentiated. Findings, such as black dots, yellow dots, and exclamation mark hairs may cause confusion because of their nonspecificity.

Classically, trichoscopy reveals broken hair shafts of variable length with longitudinal splitting/fraying (trichoptilosis) [24,26,27] (Fig. 4.10A). Some fractured hairs may be coiled because of the excessive pulling force applied, and its distal part may contract and coil [3]. Partial coiling may give the hook hair [24]/question mark hair appearance [28] (Fig. 4.10B).

The pulling tractional force and subsequent fracturing may also give the "flame hairs" sign. Flame hairs are short proximal hair stubs that look twisted/wavy and thinned out, left behind following anagen hair breakage [24,26]. They are seen in active disease. Another characteristic finding is the V-sign, created when two or more hairs that originate from one follicular unit break at same level. Rakowska et al. have reported that the V-sign was observed in 57% of trichotillomania cases [24,26]. Diagonally fractured hair shafts may have tulip-flower–shaped distal hyperpigmentation. This finding is called tulip hairs. These hairs are short with tulip-flower–shaped, darker distal ends [24,26,27].

In severe mechanical trauma, hair shafts may be completely damaged, giving a shattered/sprinkled appearance. This finding has been described as "hair powder" by Rakowska et al. [24,26,27].

Other well-known trichoscopic findings of trichotillomania includes short vellus hairs, yellow dots, black dots, and exclamation mark hairs [3,19,24,26,27]. Short vellus hairs may sometimes be seen but differ from AA because they are never white. Furthermore, yellow dots are generally less numerous than in AA [19]. Other less common findings include perifollicular erythema, pigmentation, and hemorrhages [21]. Coexistence of other conditions should be looked for.

Telogen Effluvium

Clinical features are as follows:

1. Predominance of follicles with single hair
2. Upright regrowing hairs
3. Decreased hair density and empty follicles

Trichoscopy is of limited use in diagnosing telogen effluvium because no specific features have been described. On trichoscopy, telogen effluvium is a diagnosis of exclusion [7,15,29]. However, a predominance of hair follicles with a single hair and upright regrowing hairs have been described as a common finding [7,29]. In one case report yellow dots and short vellus hairs have been described. It needs to be differentiated from AGA and AA. Telogen effluvium can be easily differentiated from AGA because of the absence of hair shaft diameter

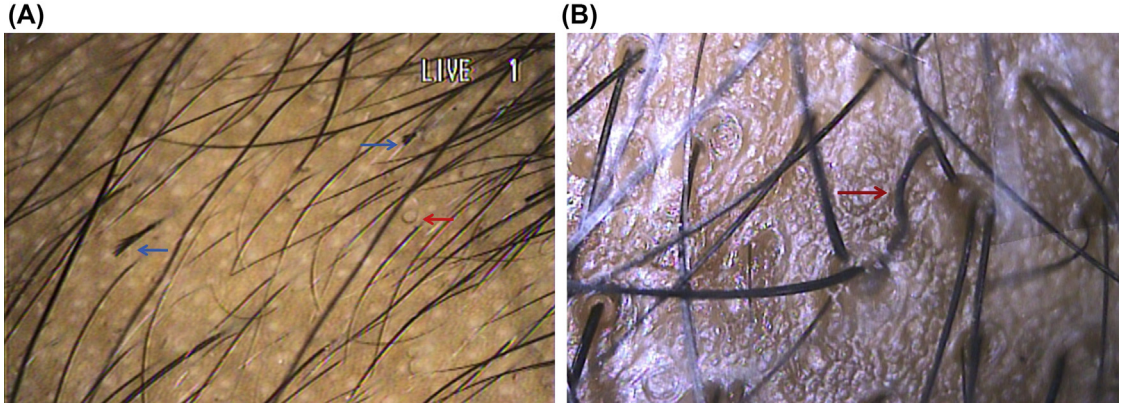


FIGURE 4.10 Trichotillomania: Longitudinal splitting/fraying of hair shafts (*blue arrows*) and coiled hairs (*red arrow*) can be seen. (A) Hair shafts of variable length are a feature. (B) Hairs with partial coiling, called question mark/hook hairs, can also be visualized Fig. 4b.

variation and peripilar halo. It affects the entire scalp, unlike AGA.

Lichen Planopilaris

Clinical features are as follows:

1. Sparing of interfollicular epidermis
2. Peripilar casts
3. Target pattern blue-gray dots
4. White dots

LPP is the most common cause of cicatricial alopecia of the scalp and is occasionally also seen on other body areas. On histopathology, active LPP is characterized by perifollicular interface dermatitis and pigmentary incontinence. These features are recognized on surface dermoscopy as perifollicular scales, which form tubular casts and may extend up to a few millimeters above the skin surface [3,7,13,15]. Elongated, concentrically arranged blood vessels can also be observed [7,8,30] (Fig. 4.11A).

Pigment incontinence is characterized by presence of blue-gray dots in a target pattern around the follicles [3,9,13,15] (Fig. 4.11B). The hair pull test reveals anagen roots with thickened hair sheaths [2,15,30,31].

The fibrotic stage is characterized by multiple white dots, which represent the scarred follicles, replaced by fibrous tracts [3,8,9,15].

In brown skin types, the spared interfollicular epidermis shows an intact, homogenous, honeycomb pigment pattern and some spared, terminal-hair–bearing follicles.

Discoid Lupus Erythematosus

Clinical features are as follows:

1. Loss of follicular ostia
2. Arborizing/branching capillaries
3. Hyperkeratotic follicular plugs
4. Blue-gray dots in speckled pattern
5. White dots

DLE is an uncommon cause of cicatricial alopecia. It presents as single or multiple, well-defined, erythematous scaly plaques over the prominent sun-exposed areas of the scalp. It can easily be confused with other patchy alopecias, especially LPP.

Dermoscopy of a DLE plaque shows atrophic skin with complete loss of follicular ostia. Arborizing telangiectasia and scaling are prominent features [8,9,15,30] (Fig. 4.12).

Histological features of DLE, such as follicular keratotic plugs, interface dermatitis, and pigment incontinence, can be seen as hyperkeratotic plugging (more so over the margins of the plaque) and a blue-gray pigment pattern on surface dermoscopy.

Inactive DLE plaques are characterized by white dots, reminiscent of follicles that are replaced by fibrous tracts. Whitish to milky red areas caused by fibrosis of the interfollicular epidermis and loss of follicular ostia are also seen [8,9,30].

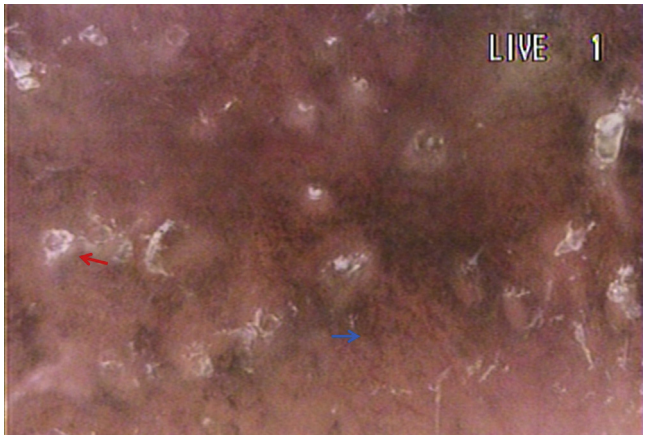


FIGURE 4.12 Discoid lupus erythematosus: Characteristic keratotic plugs (*red arrow*) and arborizing telangiectasia (*blue arrow*) can be seen. In addition, follicular paucity, atrophy, and scaling are visible findings.

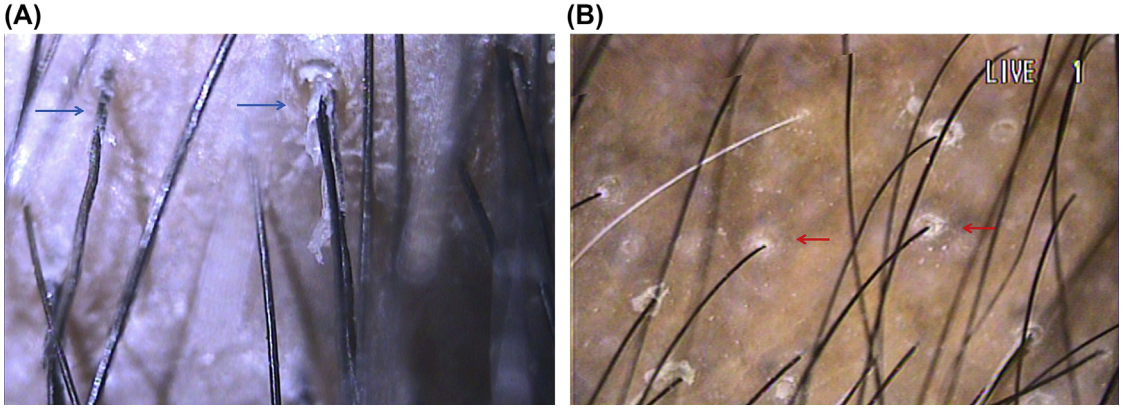


FIGURE 4.11 (A) A case of lichen planopilaris. Tubular hair casts of thick perifollicular scales caused by perifollicular inflammation can be seen. (B) Perifollicular inflammation with pigment incontinence (*red arrows*) gives the target blue-gray dot appearance.

Large yellow dots have been described [7,8]. Radial, thin, arborizing vessels emerging from the dot are considered characteristic for DLE. This feature is sometimes referred to as "red spider in yellow dot" [7,8].

Differentiation between LPP and DLE may be required in certain cases because features may overlap. The most important differentiating feature is the sparing of the interfollicular epidermis in LPP. Thus the honeycomb pigment pattern is a feature of LPP but is not seen in DLE. In addition, the blue-gray pigment seen in LPP is distributed in a "target pattern" around the follicles because of follicular pigment incontinence, whereas in DLE it is distributed in a "speckled" fashion because the pigment incontinence also affects the interfollicular areas. In addition, in LPP some follicles may be spared whereas in DLE all of the follicles in the plaque are affected. White dots are a feature seen in both conditions [9,15,30].

Frontal Fibrosing Alopecia

Clinical features are as follows:

1. Perifollicular scaling
2. Perifollicular erythema
3. Loss of follicular ostia
4. Branching capillaries

FFA is a rare cause of cicatricial alopecia seen in postmenopausal women. It is usually patchy and affects the frontotemporal areas. Patients present with frontotemporal hair recession and eyebrow loss [32,33]. It can sometimes be misdiagnosed as AA or AGA because of the distribution pattern because it mostly causes hairline recession and is patchy. FFA is considered to be a variety of LPP [32].

Trichoscopy findings in FFA that have been described include perifollicular scaling, perifollicular erythema, and loss of follicular ostia [7–9,32]. Branching/arborizing vessels [9] as well as predominance of single-hair–bearing follicles has been described [7].

Folliculitis Decalvans

Clinical features are as follows:

1. Multiple hairs emerging from single follicular ostium
2. Follicular scaling and follicular pustules
3. Interfollicular twisted capillary loops
4. White dots

Folliculitis decalvans is characterized by the presence of multiple upright hairs (>5) emerging from a single ostium, corresponding to the classic clinical picture [7]. Follicular scaling is seen, and it represents follicular inflammation (Fig. 4.13). In addition, follicular pustules can be observed at the active border. Interfollicular twisted/coiled capillary loops may be present around affected follicles as well as white dots [7,34]. These vascular patterns may not be well appreciated in the darker pigmented skin types even with polarizing light source. The inactive scarred areas are seen as pinkish-white patches with absent follicular openings.

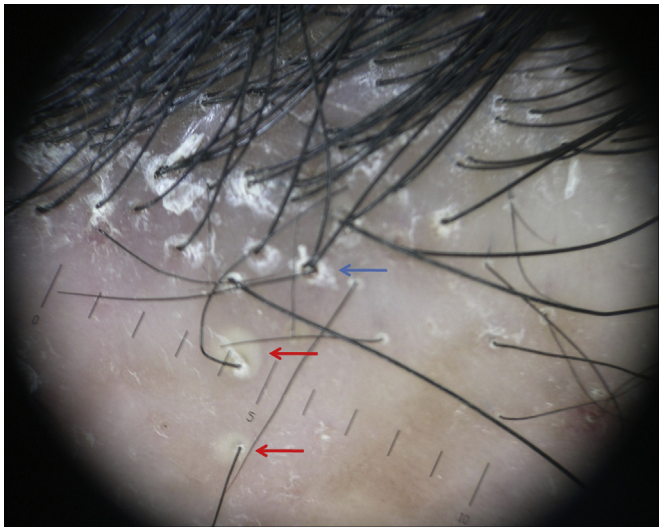


FIGURE 4.13 Folliculitis decalvans: Characteristic follicular scaling (*blue arrow*) and follicular pustules (*red arrow*) at the periphery of the patch are visible. Inactive scarred area can be seen as atrophic, shiny patch with complete follicular paucity. A break in the honeycomb pigment pattern is evident.

Other Cicatricial Alopecias

Dissecting cellulitis is characterized by yellow dots, appearing as three-dimensional structures imposed over dystrophic hairs [7,15]. Advanced cases are difficult to differentiate from other scarring alopecias because of their fibrosed patchy appearance with absent follicular ostia.

Pseudopelade of Brocq is a diagnosis of exclusion because nonspecific features are usually seen. Scarred hypopigmented areas with follicular paucity and few dystrophic hairs are the most common features [7,15].

Cicatricial marginal alopecia is an uncommon cause of hair loss affecting the hair margins (frontal, temporal, and occipital). Dermoscopic findings include low hair density, loss of follicular ostia, and thinning of the remaining hair shafts [35].

Hair Shaft Disorders

Hair shaft characteristics can be seen easily at higher magnifications through a videodermoscope. Hair shaft disorders, such as monilethrix (hair shaft beading) [36–38], trichorrhexis nodosa (brush-like fractures) [38], trichorrhexis invaginata (hair shaft nodes) [1,36], and pili torti (twisted hair shaft) [1,36] can be diagnosed

conveniently without the help of hair mounts and microscopes.

Monilethrix

This congenital hair shaft disorder is characterized by regularly spaced elliptical nodes and internodes (intermittent constrictions of hair shafts). The term *regularly bended ribbon sign* has been coined for this finding [37,38] (Fig. 4.14A and B).

Trichorrhexis Nodosa

Trichorrhexis nodosa is characterized by nodes located along the hair shafts. These nodes represent multiple longitudinal splits of the hair shaft, which on higher magnification are seen as brush-like ends (Fig. 4.15A and B). These nodes are fragile, causing hair shaft breakage. Trichoscopy shows the nodes clearly and detailed brush-like fibers at higher magnification [7,39].

Trichorrhexis Invaginata

Trichorrhexis invaginata, or bamboo hair, on trichoscopy is seen as hair shaft telescoping into itself. At lower magnification, this is seen as multiple nodes along the hair shaft. The nodes are weak areas and tend to easily fracture. The fractured proximal end appears cupped. This finding is called "golf-tee hairs" [7,39–41].

Pili Torti

Pili torti can be genetic or acquired in origin. Dermoscopy reveals flattened and irregularly twisted hair shafts.

Pili Annulati

Trichoscopy in pili annulati is characterized by alternating dark and light bands. The lighter bands are shorter than the darker area [7,36].

Other Scalp Conditions

Differentiating Scalp Psoriasis From Seborrheic Dermatitis

Localized scalp psoriasis sparing other body areas may be easily confused with seborrheic dermatitis. Differentiation on dermoscopy can be done by looking for

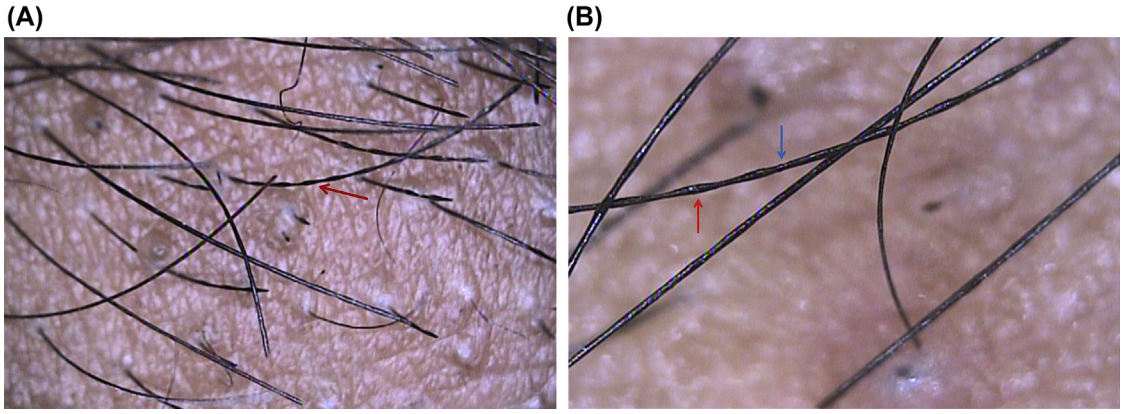


FIGURE 4.14 Monilethrix: (A) Hair shafts broken at the weaker internodes can be seen (*red arrow*). (B) Beaded hair shafts with regularly spaced nodes (*red arrow*) and internodes (regularly bended ribbon sign; *blue arrow*).

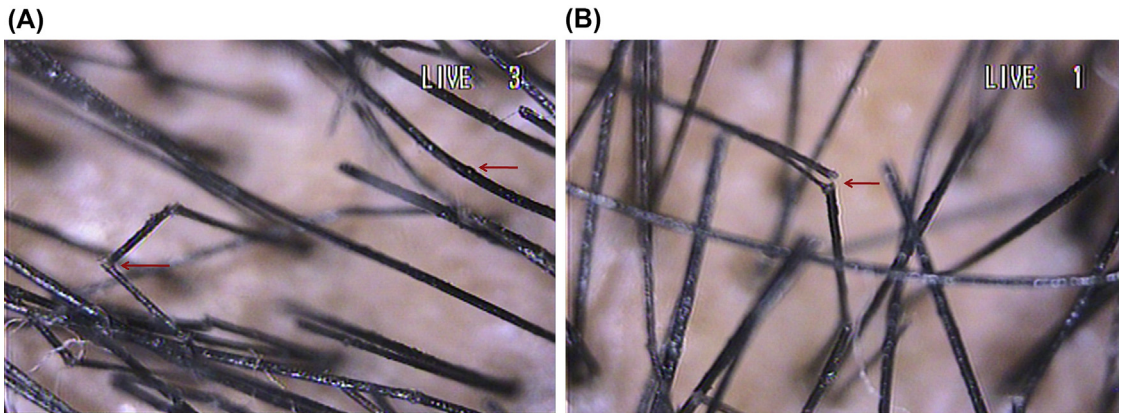
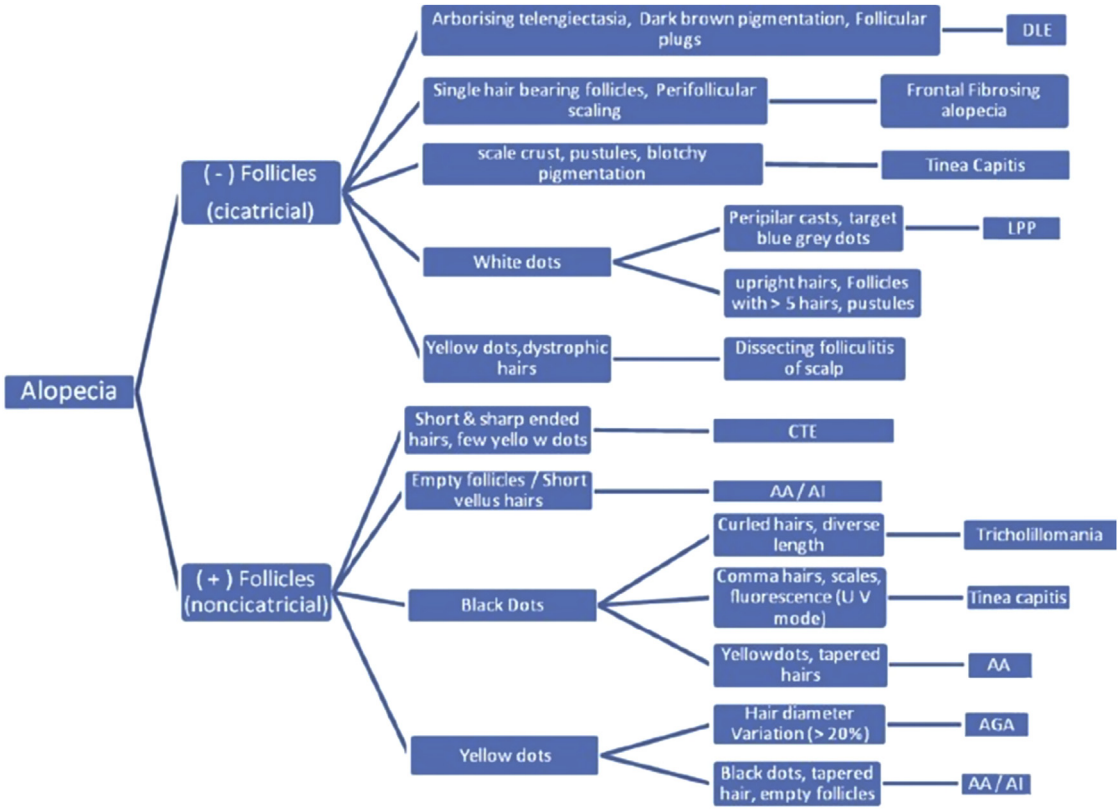


FIGURE 4.15 Trichorrhexis nodosa: Multiple nodes along individual hair shafts that represent brush-like longitudinal splitting of the shafts.

TABLE 4.1 Algorithmic Approach for Diagnosis of Cicatricial and Noncicatricial Alopecia



DLE, Discoid lupus erythematosus; *LPP*, lichen planopilaris; *CTE*, chronic telogen effluvium; *AA*, alopecia areata; *AI*, alopecia incognito; *AGA*, androgenetic alopecia; *UV*, ultraviolet.
From Kharkar V. Overview of trichoscopy. In: Khopkar U, editor. Dermoscopy and trichoscopy in diseases of the brown skin. 1st ed. New Delhi: Jaypee; 2012. p. 169–81.

the vascular patterns and types of scales. Psoriasis is characterized by an extensive array of red dots, globules, and glomerular vessels [2,7,42]. The red dots appear as twisted capillary loops on higher magnification. These vascular findings correspond to the dilated capillaries seen in the dermal papillae on histopathology. The number of twisted loops correlates with disease severity [2].

Seborrheic dermatitis is characterized by thin arborizing capillaries and atypical red vessels [7]. In scales are dry, silvery white in psoriasis and greasy, yellowish in seborrheic dermatitis [7]. A study by Kim et al. found no significant difference in the frequency and characteristics of the scales in both of the conditions on dermoscopy. It was concluded that vascular patterns are more valuable for differentiation [42]. An algorithmic approach to trichoscopy aided diagnosis of alopecia [13] (Table 4.1).

CONCLUSION

In this chapter, we have attempted to cover the trichoscopic evaluation and findings in the most common hair and scalp conditions; however, much remains to be seen and explored. It hereby needs to be mentioned that most of the dermoscopic studies conducted across the world pertain predominantly to tumoral and some nontumoral conditions affecting the skin, mainly melanoma. Trichoscopy has recently been in vogue because it is simple to perform and gives gratifying results in terms of quick and easy diagnosis. Moreover, easy retrieval of data at a later stage is possible for comparative analysis. The patient can be provided with a printed report, thus escalating the standards of consultation, follow-up, and overall patient satisfaction. We intend to continue our exploration and hope to come up with trichoscopic findings in a wider spectrum of diseases in the future.

Abbreviations

AA Alopecia areata
AGA Andrgenetic alopecia
DLE Discoid lupus erythematosus
FAGA Female androgenetic alopecia
FFA Frontal fibrosing alopecia
LPP Lichen planopilaris
PL Polarized light