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RECENT INNOVATIONS IN NON-INVASIVE IMAGING TECHNIQUES IN DERMATOLOGY

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Abstract
Recent advancements in non-invasive imaging technologies have revolutionized the field of dermatology by enabling accurate, real-time visualization of skin structures without the need for surgical intervention. These techniques, ranging from reflectance confocal microscopy to optical coherence tomography, provide clinicians with powerful tools for diagnosing, monitoring, and managing a wide array of dermatological conditions, including skin cancers, inflammatory diseases, and vascular abnormalities. The integration of artificial intelligence has further enhanced diagnostic precision and workflow efficiency. As patient demand for minimally invasive procedures grows, these innovations reshape dermatological practice by improving outcomes, reducing discomfort, and enabling early detection of skin pathologies (1).
Keywords: Non-invasive imaging, Dermatology, Skin diagnostics, Skin cancer detection,Optical coherence tomography (OCT)

1. DERMOSCOPY

Dermoscopy, also known as epiluminescence microscopy, has become a cornerstone in the evaluation of pigmented lesions. Recent innovations have focused on digital dermoscopy and the incorporation of machine learning algorithms to improve lesion classification and reduce inter-observer variability. Hybrid dermoscopy systems now combine polarized and non-polarized light, enhancing the visualization of both surface and deeper skin structures. Furthermore, teledermoscopy enables remote diagnosis, significantly expanding access to dermatological care in underserved regions (2).

2. CONFOCAL LASER SCANNING MICROSCOPY (CLSM)

CLSM has emerged as a powerful tool for cellular-level imaging, offering horizontal optical sectioning of the epidermis and superficial dermis. Innovations in reflectance confocal microscopy (RCM) have improved resolution and contrast, facilitating the differentiation between benign and malignant lesions with near-histological accuracy. Recent developments include the combination of CLSM with Raman spectroscopy to simultaneously assess morphological and biochemical features of skin lesions, offering a dual-modality approach.

3. OPTICAL COHERENCE TOMOGRAPHY (OCT)

OCT provides cross-sectional imaging of the skin with micrometer resolution using near-infrared light. Its ability to image tissue up to 2 mm deep makes it particularly useful for evaluating inflammatory skin diseases, non-melanoma skin cancers, and vascular structures. Dynamic OCT (D-OCT), which visualizes microvascular flow, has shown promise in differentiating between basal cell carcinoma and benign lesions by assessing angiogenesis patterns. Further innovations include ultra-high-resolution OCT (UHR-OCT), which offers enhanced axial resolution for more detailed skin architecture analysis (3).

4. HIGH-FREQUENCY ULTRASOUND (HFUS)

HFUS operates at frequencies above 20 MHz, providing real-time imaging of the skin with a depth of penetration of up to several millimeters. Its application has expanded from tumor margin delineation to assessing inflammatory dermatoses, vascular anomalies, and cosmetic treatment outcomes [8]. Recent advances involve the integration of elastography with HFUS to assess tissue stiffness, aiding in the diagnosis of sclerosing disorders and skin fibrosis.

5. MULTIPHOTON MICROSCOPY (MPM)

MPM leverages nonlinear optical processes, such as two-photon excitation and second harmonic generation, to achieve high-resolution imaging of skin components with minimal photodamage. Its intrinsic contrast mechanisms enable label-free imaging of collagen, elastin, and cellular structures. Clinical MPM devices have been developed for in vivo imaging, particularly useful in monitoring melanoma and photoaging-related changes. Integration with AI-based image analysis tools is an emerging trend, enhancing diagnostic accuracy and workflow efficiency (4).

6. INTEGRATION WITH ARTIFICIAL INTELLIGENCE

The amalgamation of non-invasive imaging with AI is revolutionizing dermatological diagnostics. Deep learning algorithms trained on large image datasets can autonomously identify disease-specific patterns, outperforming dermatologists in some diagnostic tasks. AI-driven platforms are being developed for automated detection of melanomas using dermoscopic and CLSM images, with ongoing efforts to integrate real-time feedback mechanisms for clinical use (4).

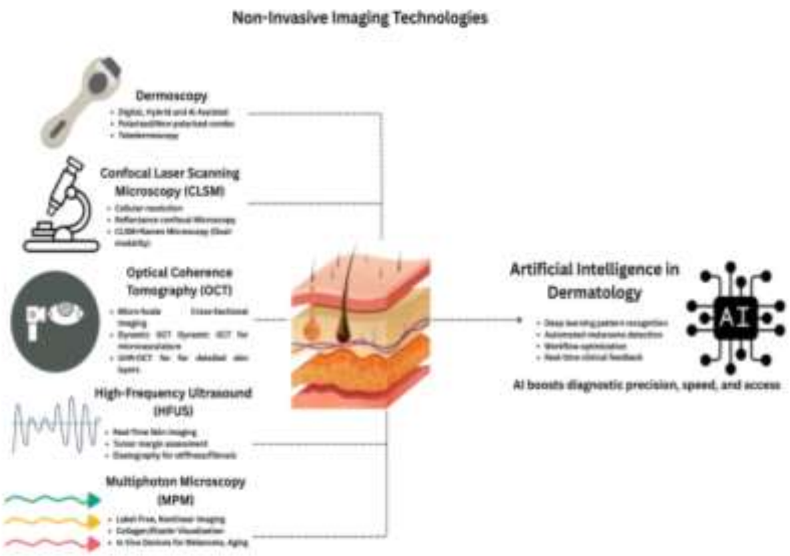

Figure 1: This diagram illustrates non-invasive imaging technologies in dermatology, including dermoscopy, CLSM, OCT, HFUS, and MPM. Each modality offers unique advantages for visualizing skin structure and pathology. Integration with artificial intelligence enhances diagnostic accuracy, enables automated melanoma detection, optimizes workflows, and improves clinical decision-making.

CONCLUSION

In conclusion, the continuous evolution of non-invasive imaging technologies in dermatology has significantly improved the accuracy and efficiency of skin disease diagnosis and monitoring. These advancements facilitate early detection and treatment and enhance patient comfort by reducing the need for invasive procedures. The integration of AI further augments these technologies, paving the way for more personalized and precise dermatological care.

REFERENCES

1. Tkaczyk E. Innovations and developments in dermatologic non-invasive optical imaging and potential clinical applications. Acta Derm Venereol. 2017 Jul 5;Suppl 218:5–13.
2. Kittler H. Evolution of the clinical, dermoscopic and pathologic diagnosis of melanoma. Dermatol Pract Concept. 2021 Jul;11(Suppl 1):e2021163S.
3. Hindelang B, Aguirre J, Schwarz M, Berezhnoi A, Eyerich K, Ntziachristos V, et al. Non-invasive imaging in dermatology and the unique potential of raster-scan optoacoustic mesoscopy. J EurAcad Dermatol Venereol. 2019 Jun;33(6):1051–61.
4. Rajpara SM, Botello AP, Townend J, Ormerod AD. Systematic review of dermoscopy and digital dermoscopy/ artificial intelligence for the diagnosis of melanoma. Br J Dermatol. 2009 Sep;161(3):591–604.
5.Balasamy S, Sundramoorthy AK. Non-invasive 3D imaging by ultrasound and photoacoustic tomography for cancer treatment. Oral Oncology Reports. 2024 Jun 1;10:100342.